

RESILIENCE PLANNING ANALYSIS: TOWN OF BLUFFTON, SC

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Photo: Bluffton, SC



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EXECUTIVE SUMMARY

The Town of Bluffton (Bluffton), in partnership with the College of Charleston and the South Carolina Sea Grant Consortium, conducted a Resilience Planning and Engagement Project (Resilience Analysis) to assess Bluffton's vulnerability to current and future environmental conditions, with a focus on flooding risks and the impacts of land development on resilience. The aim of the project was to identify flood hazards affecting key infrastructure, identify potential policy options for enhancing resilience, and ensure public input through community engagement efforts. The analysis involved mapping and modeling current flood risks, evaluating development scenarios through a build-out analysis, and assessing the role of wetlands in mitigating flood impacts.

The analysis involved multiple layers of data to assess current and future flood vulnerability, focusing on both parcel-based flood depth and potential future development. Digital Elevation Models (DEMs) and Digital Surface Models (DSMs) were used to represent the topography, while the First Street Foundation flood dataset was used to analyze flood depth across different flood scenarios. A buildout analysis demonstrated future development to understand the potential flood impacts, with additional focus on wetlands and elevation-based zoning to determine how limiting development in certain areas could reduce vulnerability and potential flood damage. Additionally, community outreach events were held to gather local input, and a flood reporter survey was used to document residents' experiences with past flooding.

Key Findings:

1. **Flood Vulnerability:** The analysis revealed significant flood risks for Bluffton's assets and infrastructure under both current and future conditions. Increased flood depths were projected for frequent flood events (1-in-2-year storm), with many parcels that currently experience minor flooding facing more severe inundation by 2053. The vulnerability was particularly notable for high-impact flood events (1-in-100-year and 1-in-500-year storms), which would affect parcels that are currently outside of major flood risk areas.
2. **Future Development Risks:** A buildout analysis projected that 99,423 additional parcels could be developed in Bluffton by 2053. However, this increase in development heightens flood risks, with over 63% of these parcels at risk from the 1-in-500-year flood event. Protection of wetlands and surrounding areas through buffers as well as implementation of elevation-based zoning could significantly reduce future flood vulnerability. After modeling the implementation of each of the policy options analyzed in this study, more parcels were available for development than are required based on active Planned Unit Development agreements.
3. **Role of Wetlands:** Wetlands play a crucial role in absorbing floodwaters, especially during higher intensity events where over half of the vulnerable developable lands are within wetland areas. By 2053, more than 20% of the flood risk from low intensity storm

events could be associated with areas near wetlands. Protecting these vital ecosystems through local ordinances could help mitigate the impacts of future flooding events, potentially reducing overall damage. Protecting wetlands plus a 50-ft buffer reduces more than 60% of the vulnerability of future development to the 1-in-100-year storm event.

4. **Elevation-Based Zoning:** Areas with lower elevations showed greater vulnerability to flooding. Conversely, high ground zones had very little flood risk, with less than 6% of flooding for the highest intensity storms in this area and no flooding for the lowest intensity storm. Damage models showed an even greater proportion of property-damaging floodwaters in low elevation zones. Implementing elevation-based zoning could drastically reduce the exposure of development to flood risks, ensuring that future growth occurs in safer, higher-elevation areas.
5. **Community Engagement:** Public input gathered during community engagement events, particularly after Tropical Storm Debby in August 2024, provided valuable insights into flood concerns in low-lying areas. These insights helped shape the flood risk assessment and reinforced the need for stronger flood management policies.

Conclusions: Bluffton is at increasing risk of flooding due to both current and future climate impacts. Bluffton's vulnerability is compounded by projected increases in development and changes in land use. Protecting wetlands and implementing strategic growth policies, such as elevation-based zoning, could help reduce these risks and safeguard Bluffton's infrastructure and natural resources. Furthermore, community feedback has underscored the importance of addressing local flood concerns in future resilience strategies.

Recommendations:

1. **Strengthen Wetlands Protection:**
Consider adopting a wetland overlay zoning district (e.g. marsh migration overlay) or expansion of the Preserve (PR) District to safeguard flood-prone ecosystems. Use permitting requirements to guide development away from sensitive areas.
2. **Implement Elevation-Based Zoning:**
Limit development in low-lying areas by incorporating elevation into zoning criteria, following models from Charleston, SC, and Norfolk, VA.
3. **Update Flood Management Policies:**
Enhance Bluffton's 2021 Flood Damage Prevention Ordinance to ensure that new developments adhere to stricter flood protection standards.
4. **Offer Financial Incentives for Resilient Development:**
Strengthen the Transfer of Development Rights (TDR) program and consider tax or fee incentives for projects in low-risk zones. Explore impact or conservation fees for developments in sensitive areas.

5. Expand Land Acquisition and Partnerships:

Work with land trusts to secure key wetlands and floodplains. Use conservation tools and funding strategies to grow Bluffton's Land Acquisition Fund and prioritize high-impact parcels.

By implementing these recommendations, Bluffton can enhance its resilience to future flooding events and protect valuable ecosystems while balancing developmental goals.

BACKGROUND

The Town of Bluffton (Bluffton, Figure 1) is one of the fastest growing municipalities in South Carolina, with a 1,233% growth increase since 2000 (Town of Bluffton, 2022). In 2020, Bluffton had a population estimate of 34,493 based on the 2020 US Census Bureau projections (US Census Bureau, 2020). Out of 50,000 acres of land (not including waterways and marshes, ~14,000 acres), 10,344 acres of undeveloped open space remain (Town of Bluffton, 2022).

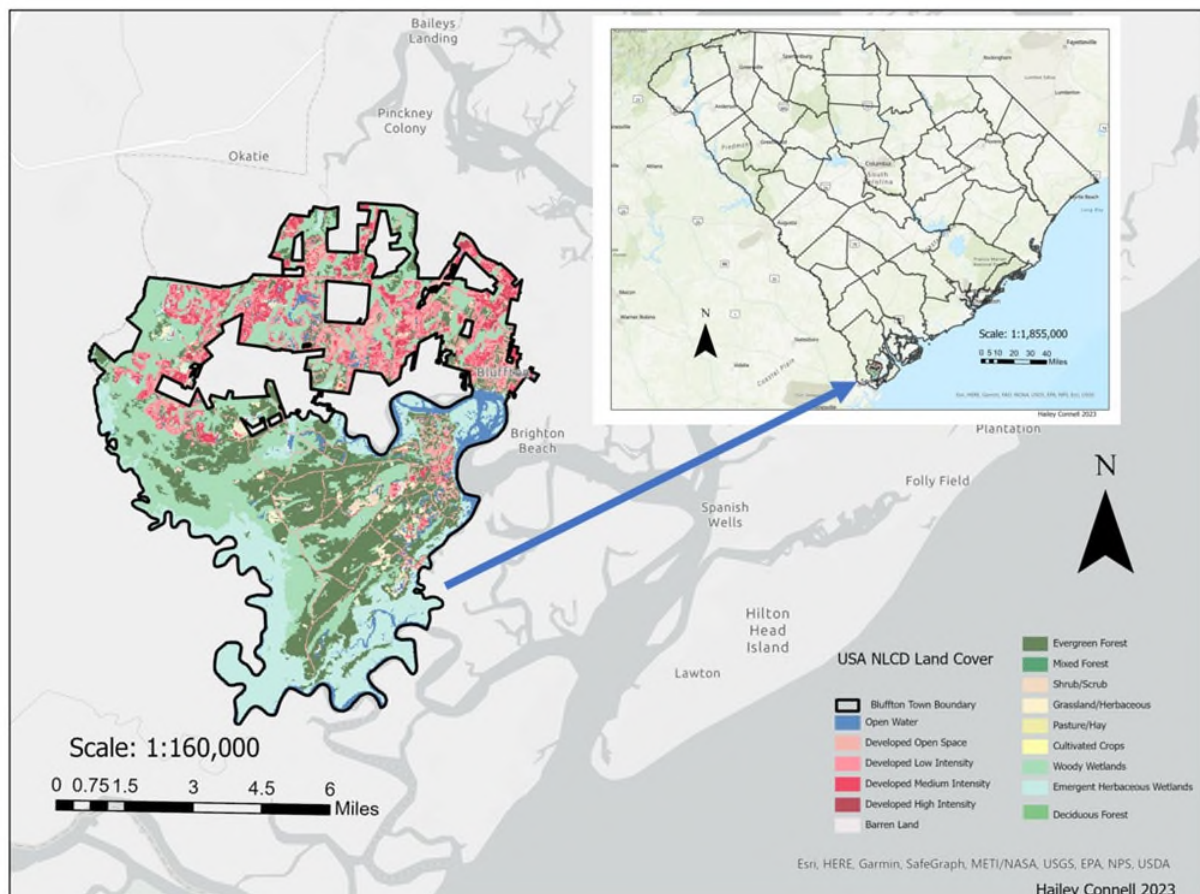


Figure 1: Town of Bluffton with land cover displayed

Within Bluffton's Comprehensive Plan, sections on natural resources and land use highlight the importance of locating areas for conservation and stormwater infiltration and preparing joint land use plans for undeveloped lands to address density and environmental protection (Town of

Bluffton, 2022). This is also shown in the May River Watershed Action Plan, though this plan centers mainly on water quality (fecal coliform, *E. coli.*, bacteria loading, etc.) and recommendations for land use alteration to negate the contamination impact of stormwater (Town of Bluffton, 2020).

Hazards and Land Use Change

The Fort Pulaski National Oceanic and Atmospheric Administration (NOAA) Tide Gauge was established in 1935 and is located approximately 7 miles south of Bluffton. This gauge is the closest tidal monitoring station to Bluffton, and because of its long-term, quality-controlled recording history, it is commonly used to represent trends throughout Beaufort County. The recorded mean daily tide range at the station is 6.92 feet. Since the station was established, the relative mean sea level has risen on average 0.14 inches per year, or 1.4 inches per decade (NOAA, 2025) (Figure 2). As sea levels continue to rise, records of high tide flooding also rise on all U.S. coastlines. These events are defined as a daily rise in water level above the minor flooding threshold set locally by NOAA's National Weather Service (Fly et al., 2017).

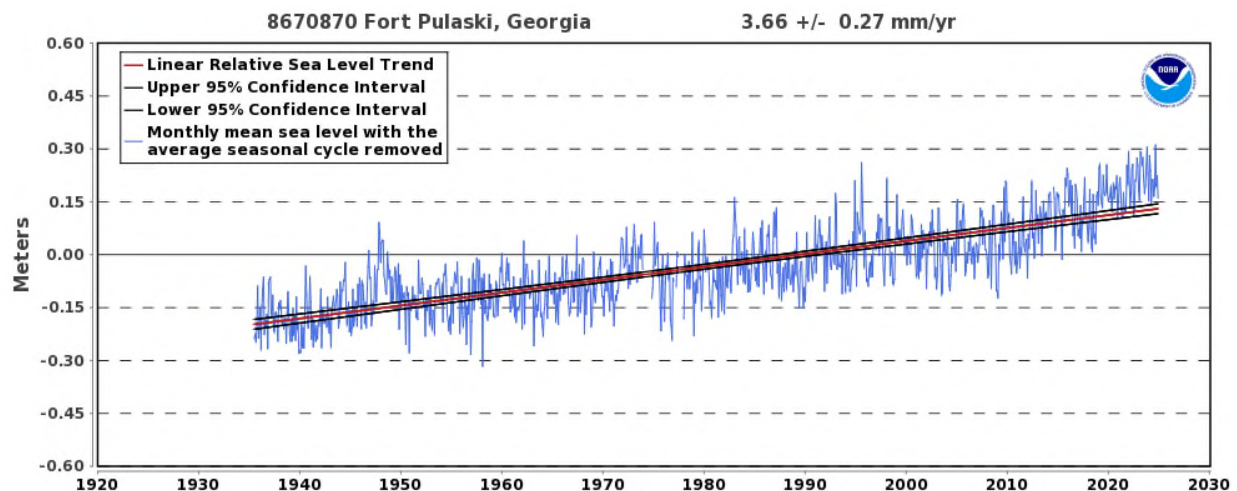


Figure 2: Rising mean sea levels recorded at NOAA's Fort Pulaski, GA Tide Station (NOAA, 2025)

An analysis of coastal South Carolina by the US Army Corps of Engineers (USACE) (Table 1) identified Bluffton as a high-risk coastal hazard area (USACE, 2022). The study focused on storm surge and sea level rise as those hazards were identified as the greatest threat to negatively impact coastal populations and infrastructure in the region. Of note is the increasing damage rating for North and East Bluffton when projecting out from Existing Infrastructure Damage to Future Infrastructure Damage. These results highlight the need for investigating the vulnerability of future development to coastal hazards, expanding the breadth of traditional vulnerability assessments which focus only on existing community assets.

Table 1: Future flood cost and damage rating for areas of Beaufort County with Bluffton areas shaded (USACE, 2022, Table 4-16)

County	Census Place or Location Name	State	Identified as Existing High-Risk Location	Identified as Future High-Risk Location	Existing Infrastructure Damage (\$)	Damage Rating	Future Infrastructure Damage (\$)	Damage Rating
Beaufort	Hilton Head Island	SC	X	X	\$159,517,000	High	\$313,723,000	High
Beaufort	Port Royal	SC	X	X	\$10,755,000	Med	\$21,752,000	Med-High
Beaufort	Beaufort	SC	X	X	\$7,198,000	Med	\$14,811,000	Med
Beaufort	Shell Point	SC	X	X	\$1,361,000	Low	\$2,729,000	Low
Beaufort	Burton	SC	X	X	\$1,109,000	Low	\$3,661,000	Low-Med
Beaufort	Bluffton	SC	X	X	\$575,000	Low	\$2,093,000	Low
Beaufort	Yemassee	SC	n/a	n/a	\$91,000	Low	\$235,000	Low
Beaufort	North Beaufort	SC	n/a	n/a	\$3,072	Low-Med	\$6,253	Med
Beaufort	East Beaufort and St. Helena	SC	n/a	n/a	\$24,206	Med-High	\$41,094	High
Beaufort	Dataw Island	SC	n/a	n/a	\$5,532	Low-Med	\$8,267	Med
Beaufort	Fripp Island	SC	n/a	n/a	\$8,401	Med	\$17,567	Med-High
Beaufort	North Bluffton	SC	n/a	n/a	\$23,898	Med-High	\$56,558	High
Beaufort	East Bluffton	SC	n/a	n/a	\$9,634	Med	\$19,611	Med-High

Figure 3 shows areas of development and general land use change within Bluffton and in the surrounding watersheds from 2001 to 2024. There is a significant increase in high density areas resulting in much higher levels of impervious surface across the study area.

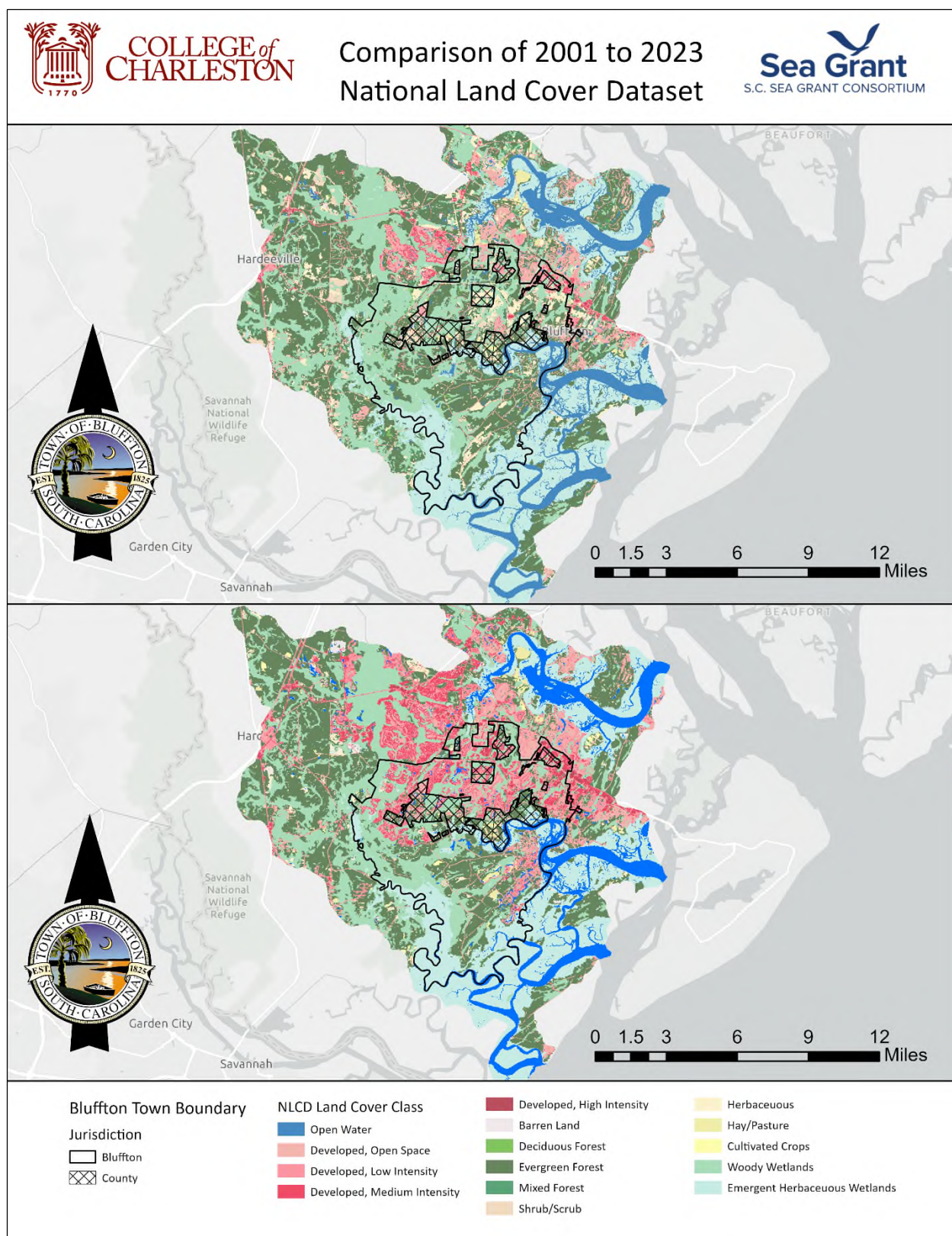


Figure 3: Change in land use from National Land Cover Dataset (NLCD) 30m data from 2001 (above)-2024 (below)

Resilience Planning Analysis

In order to assess Bluffton's vulnerability to current and future environmental conditions along with its changing landscape, Bluffton entered into an agreement with the College of Charleston, with the support of the South Carolina Sea Grant Consortium (S.C. Sea Grant Consortium), to conduct a Resilience Planning and Engagement Project ("Resilience Analysis"). The goal of the Resilience Analysis was to determine the flood vulnerability of Bluffton's assets and infrastructure within key watersheds. Bluffton's aim was to leverage the latest methods of coastal scientific analysis to inform effective policies and resilience plans. Bluffton also wanted to ensure that public input was considered in this project with ample community engagement opportunities.

A project team was formed with researchers from the College of Charleston and S.C. Sea Grant Consortium to conduct this interdisciplinary project. The S.C. Sea Grant Consortium led the community engagement components and provided project management, while the College of Charleston performed the mapping, modeling, and discussion of results. As a result of the U.S. Supreme Court's *Sackett vs. Environmental Protection Agency (EPA)* decision, Bluffton identified wetlands as particular features of interest. Bluffton staff requested an additional assessment of options for local wetlands protection ordinances in South Carolina. The project team partnered with the National Sea Grant Law Center to conduct this assessment.

While previous studies have identified sea level rise and tidal flooding as top concerns in coastal areas, Bluffton is fairly unique in that it has relatively high ground areas relative to neighboring Lowcountry communities. To assess current and future risk from flooding, a range of modeled storm events from lower intensity to higher intensity events were analyzed across the landscape (1-in-2-yr, 1-in-20-yr, 1-in-100-yr, and 1-in-500-yr storm events). These events were intersected with the property parcels within and surrounding Bluffton to investigate development vulnerability to flood hazards. In addition to current and future flood conditions, current and future development conditions were analyzed within this study. A buildout analysis was conducted to project areas of potential development by subdividing developable parcels to the maximum allowable density within the geographic information systems (GIS) framework. This allowed researchers to overlay potential development areas with flood hazards and conduct if/then scenarios to analyze changes in vulnerability with changing development patterns. The scenarios included analyzing the impact of protecting wetlands from future development and implementing elevation-based zoning. These analyses are described in the Methods and Results sections, with discussion following. Results are presented as mapping products as well as tables and charts describing the number of parcels and estimated damages of each storm event under each policy scenario. A review of land acquisition processes and policy options as well as local financial incentives to guide development away from areas vulnerable to flooding is described in the Discussion section as well.

METHODS

Study Area

For this study, the datasets collected were based on Hydrologic Unit Codes (HUC-12), using the watershed boundaries that cross or contain Bluffton jurisdictional boundaries (Figure 4). Studying flooding using the watershed boundaries ensures that all the data collected will account for water

movement that crosses political boundaries and offers a more accurate representation of hydrological processes. The five (5) different watersheds that make up the study area include the Upper New River-Atlantic Intracoastal Waterway, the Lower New River-Atlantic Intracoastal Waterway, the Cooper River-Calibogue Sound, the May River, and the Colleton River. The analysis of current development flood vulnerability was conducted for the full study area, while the maximum buildout flood vulnerability was performed within the confines of Bluffton's boundary, as this was the area with established Development Agreements in place. A Development Agreement is a legally binding agreement between local government (such as Bluffton) and property owner(s) for long-term development of large tracts of land. Each of Bluffton's Development Agreements provides for maximum build out and includes general uses, density, and general site layouts.

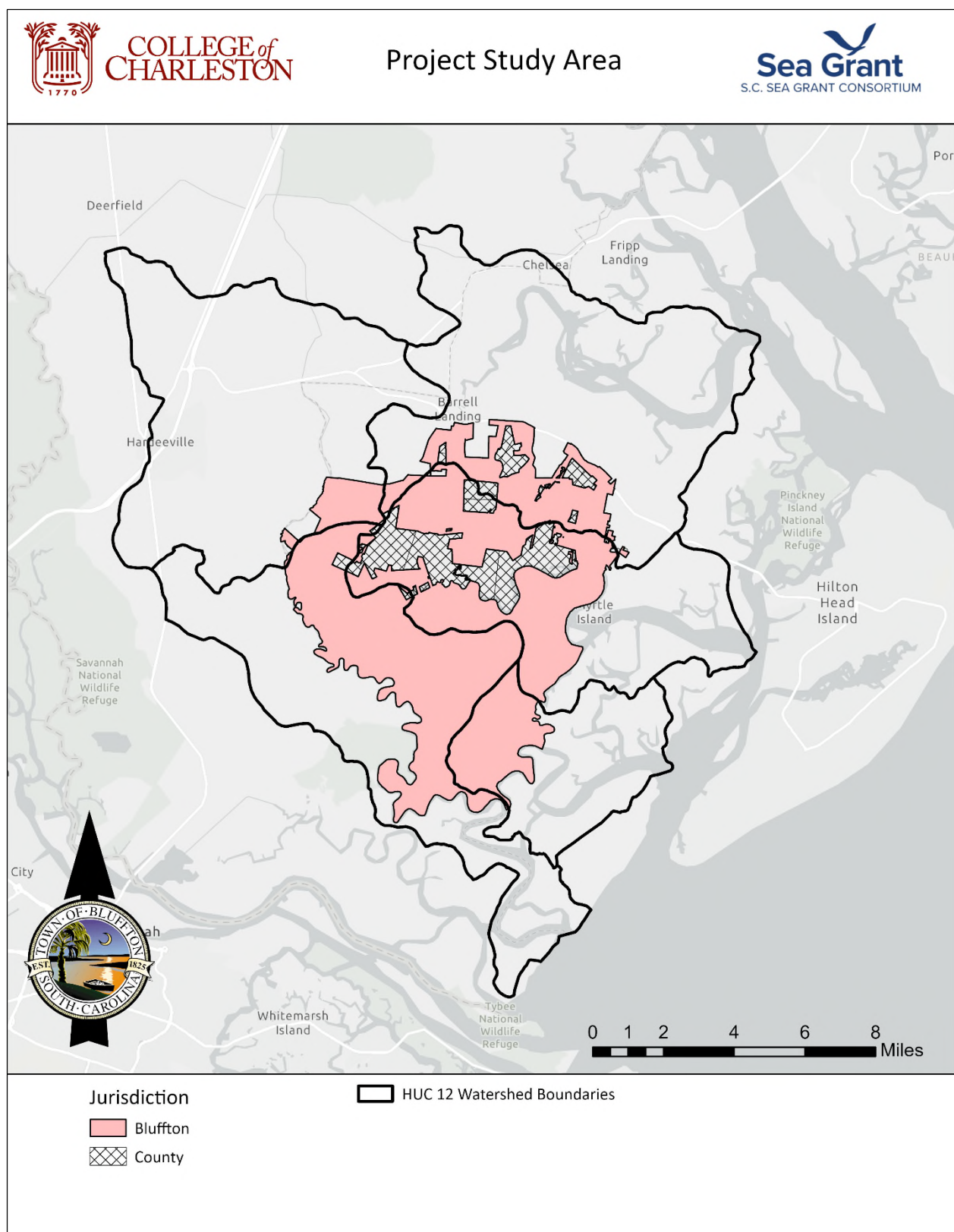


Figure 4: Project study area represented by HUC-12 boundaries with Bluffton and Beaufort County jurisdictions shown

Community Engagement

Bluffton incorporated community engagement as a core component of this assessment to ensure the knowledge and perspectives of residents were documented. The methodology for this aspect was established based on discussions during the project meeting held on June 3, 2024. During this meeting, Bluffton identified key locations to hold three (3) community outreach events that would ensure broad representation from citizens. Bluffton also agreed on the scope of work and goals of the outreach events. To inform residents of these events, [a website](#) was created for the project with event details and social media posts. Bluffton created a flyer, press release, and additional notifications. Outreach events took place at the Bluffton Rotary Community Center on July 18, 2024, from 6 to 7 PM, Pritchardville Elementary School on August 20, 2024, from 6 to 7 PM, and at the Historic Bluffton Arts & Seafood Festival on October 19, 2024, from 10 AM to 5 PM (Figure 5).



Figure 5: Photos taken from outreach event at the Historic Bluffton Arts & Seafood Festival (Photo credit SC Sea Grant)

Maps of Bluffton were divided according to the broader community boundaries expected to be represented at each event. However, residents from various areas attended all the outreach events, so maps of the entire Bluffton area were included to ensure full coverage. Maps of specific communities were also provided to help participants easily identify areas of concern. These unofficial boundaries and communities of interest were identified by Bluffton during a project meeting. Figure 6 shows an example of the maps provided. Attendees were provided with circle stickers to mark specific parcels, road sections, wetlands, or any other areas they wished to provide feedback on, along with adhesive note pads to document their comments. This approach enabled community members to share their personal experiences with flood hazards, providing a sense of involvement by their local government.

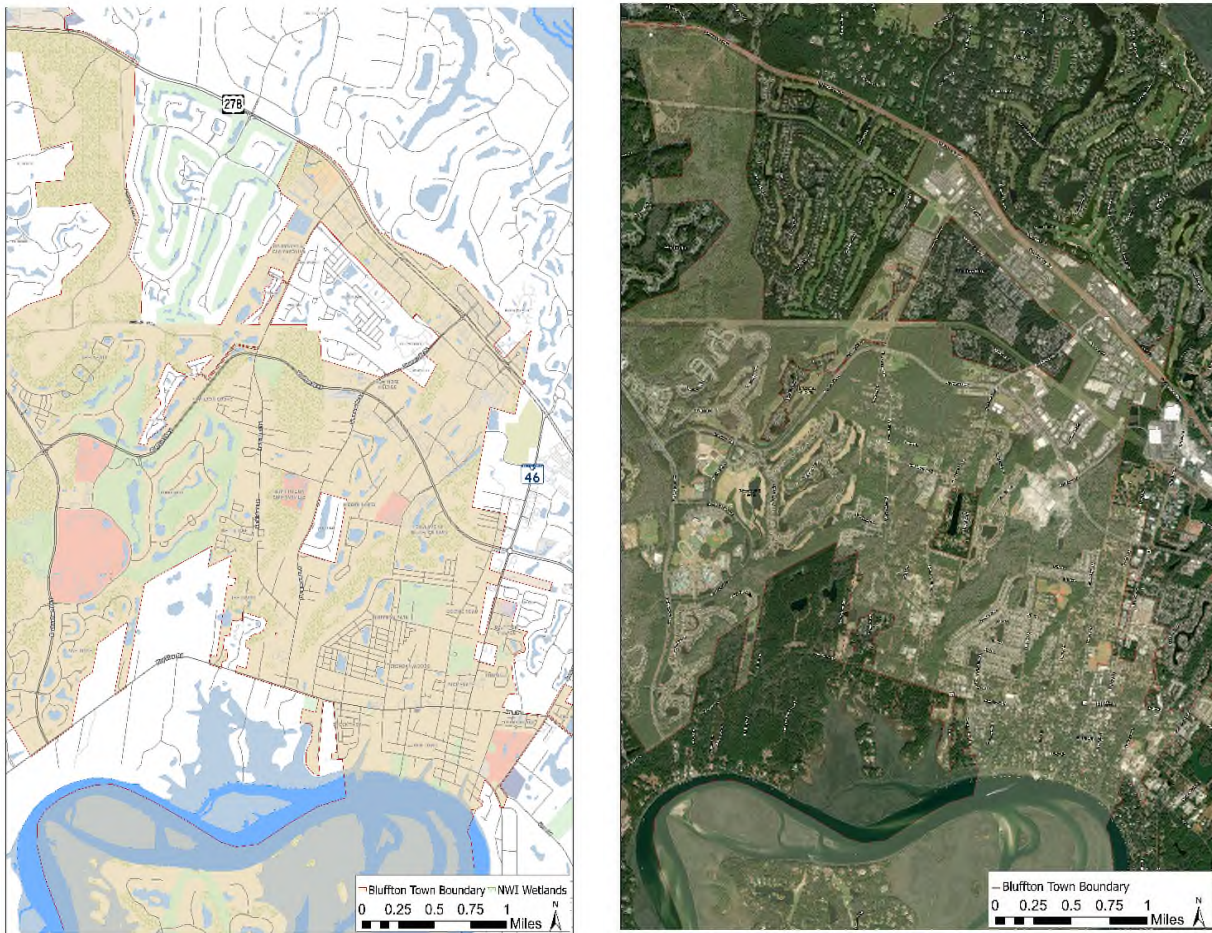


Figure 6: Example of maps created for outreach events

Flood Reporter Survey

A flood reporter survey was created to document past floods experienced by Bluffton residents. This was built using Survey123, an ArcGIS software that captures on-the-ground data from residents to track flood information temporally and spatially. The survey included questions about the timing of the flooding, water depth and movement, and provided space for residents to upload photos for visual documentation. Because Survey123 can download spatial information directly from submissions, an ArcGIS layer was created with all information automatically linked to the submitters identified location. Paper surveys were distributed and gathered from the outreach events which were manually entered into the layer, separating markers by survey versus outreach event as well as date of survey event. Additionally, signs were created and printed by the S.C. Sea Grant Consortium Communications Team, which asked residents to “tell us about flooding in your community” with a QR code directing them to the flood reporter survey. These signs were displayed in strategic locations by Bluffton staff throughout the study area. Additionally, an online viewer was created to display the community’s input for Bluffton staff.

Selection of Vulnerability Metrics

Vulnerability metrics were curated through a review of literature and selected in collaboration with Bluffton, ensuring the resulting models were scientifically and practically applicable. Correspondence via emails and meetings with Bluffton Town staff of the Watershed Management Division led to the creation of a Coastal Vulnerability Form for Bluffton. The primary purpose of this form was to gather detailed input on which factors Bluffton considered most crucial in assessing its specific vulnerabilities to coastal hazards and to determine what data, other than elevation and imagery, should be included in the model.

Through a literature review of common and applicable metrics used for areas such as coastal South Carolina, the form was divided by different physical, socio-economic, and ecological characteristics that totaled 21 possible metrics. Each metric was accompanied by a brief description and an explanation of its importance in the context of coastal vulnerability. This ensured that participants understood the significance of each factor before assigning it a rank. The ranking system allowed respondents to score each metric on a scale from 0 (not essential) to 4 (most important), offering a structured way to assess which factors had the most significant local impact. The Coastal Vulnerability form was created and distributed by Bluffton's Project Manager to groups including Town Council members, Bluffton Senior Staff, Emergency Management, Growth Management, and the Watershed Management Division.

Policy (*Adapted from National Sea Grant Law Center Report [NSGLC-24-04-06]*)

The National Sea Grant Law Center "Options for Local Wetlands Protection Ordinances in South Carolina Advisory Report" includes a review of federal regulations of wetlands and implications of the recent *Sackett v. EPA* U.S. Supreme Court decision. This includes a discussion of the pre-*Sackett* legal landscape of wetlands and jurisdictional determinations of wetlands in Bluffton. The report also examines existing wetlands regulations in South Carolina and examples of local wetlands protections in the Southeast region and across the United States. The report provides municipal options to protect wetlands, and key elements that should be considered if a municipality decides to develop local wetlands protections are explained. An overview of the results of this report can be found in the Discussion section. See Figure 7 for a diagram of waterway and wetland protections based on U.S. Supreme Court rulings through 2023.

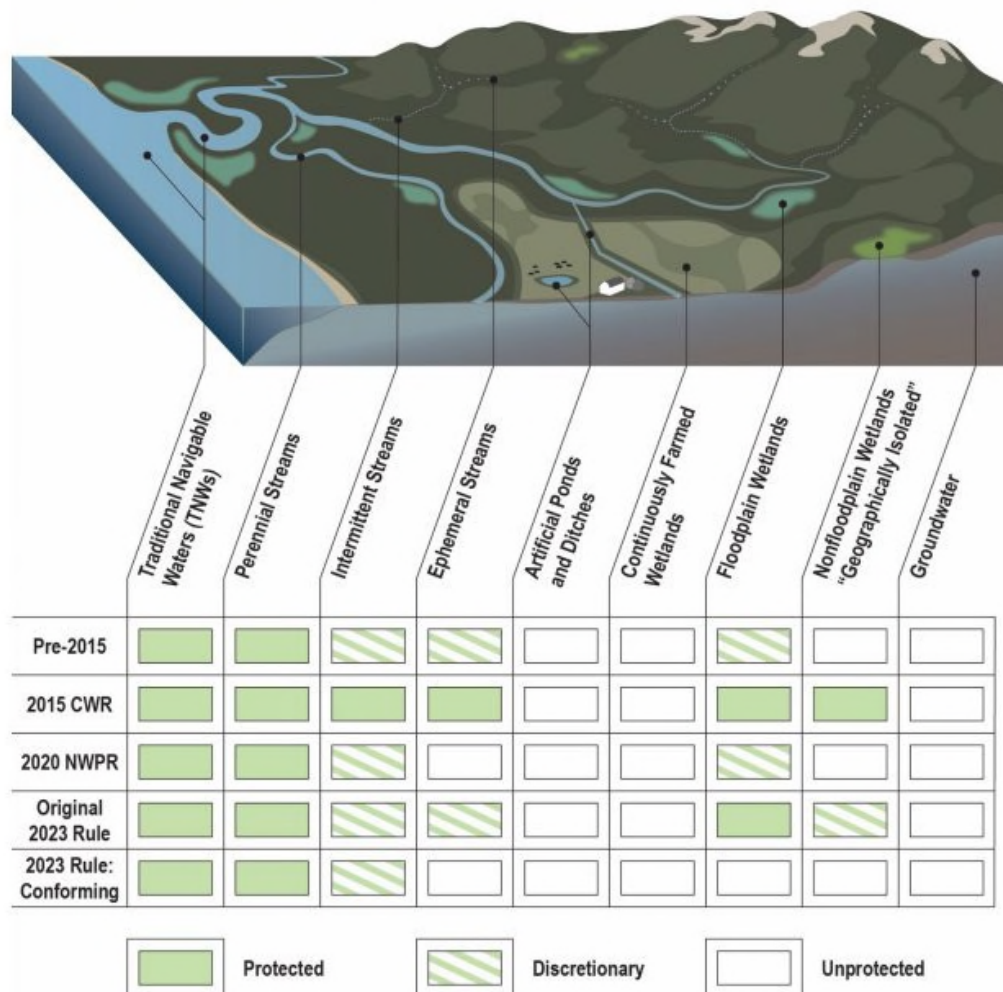


Figure 7: Wetland protection definition through the different U.S. Supreme Court rulings through 2023 (Sullivan & Gardner, 2023)

Mapping & Modeling

See Appendix E for detailed mapping & modeling methods

Flood vulnerability was analyzed using the First Street Foundation flood dataset with five modeled storm scenarios ranging from higher frequency, lower impact events such as the 1-in-2-yr storm to moderate (1-in-20-yr storm) to lower frequency, higher impact events such as the 1-in-100-yr and 1-in-500-yr storm. These storms were modeled for climate conditions in the year 2023 as well as projected climate conditions in year 2053 to give two time points of vulnerability. The analysis was separated into a review of the flood vulnerability of the existing development to-date in Bluffton as well as a prospective analysis of the vulnerability of future development zones. Each assessment was performed for every property parcel, with future development parcels created via a buildout analysis, which simulates the subdivision of all developable parcels into their maximum

development density. Future development vulnerability was summarized based on number of subdivided parcels touched by flood waters as well as the estimated damages that would occur if there were a home built on that property. If/then scenarios were run to show the ways different policy options could reduce the flood vulnerability of future development within Bluffton. These policy options included wetland protections, wetland buffers, and elevation-based zoning.

RESULTS

Community Engagement

Each community outreach event was attended by members of the community, with a suspected increase in participation at the second event due to Tropical Storm Debby impacting the area on August 8, 2024. Both SC Sea Grant Consortium and the College of Charleston were represented at all events, as well as the Watershed Management Staff to ensure all parties behind the research project were available for questions. There was also an increase in the flood report survey submissions around the time of Tropical Storm Debby.

Figure 8 shows the data layered over the basic digital elevation model (DEM), showing the clustering of flood concern in the low-lying areas, as well as an example of the type of information linked to each data point. The example data point shown in Figure 8 includes information such as the depth of floodwater, duration of the event, extent of water movement, and any infrastructure affected (e.g., roads, homes). This detailed local knowledge provides real-world insights, enabling a more accurate and community-informed assessment of flood risks. A total of 89 surveys were completed with a heat map created (Figure 9) to show the density of where locals reported flood issues. This is another tool that Bluffton can use when visualizing flooding issues.

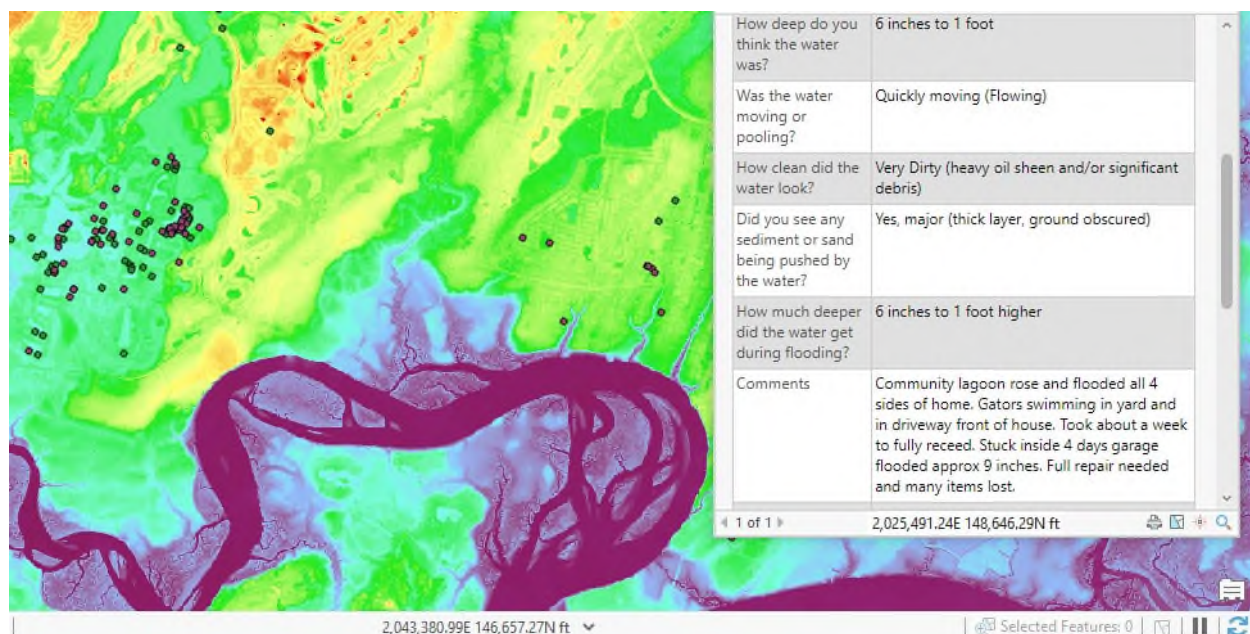


Figure 8: Community flood submissions with example submission in right dialogue box

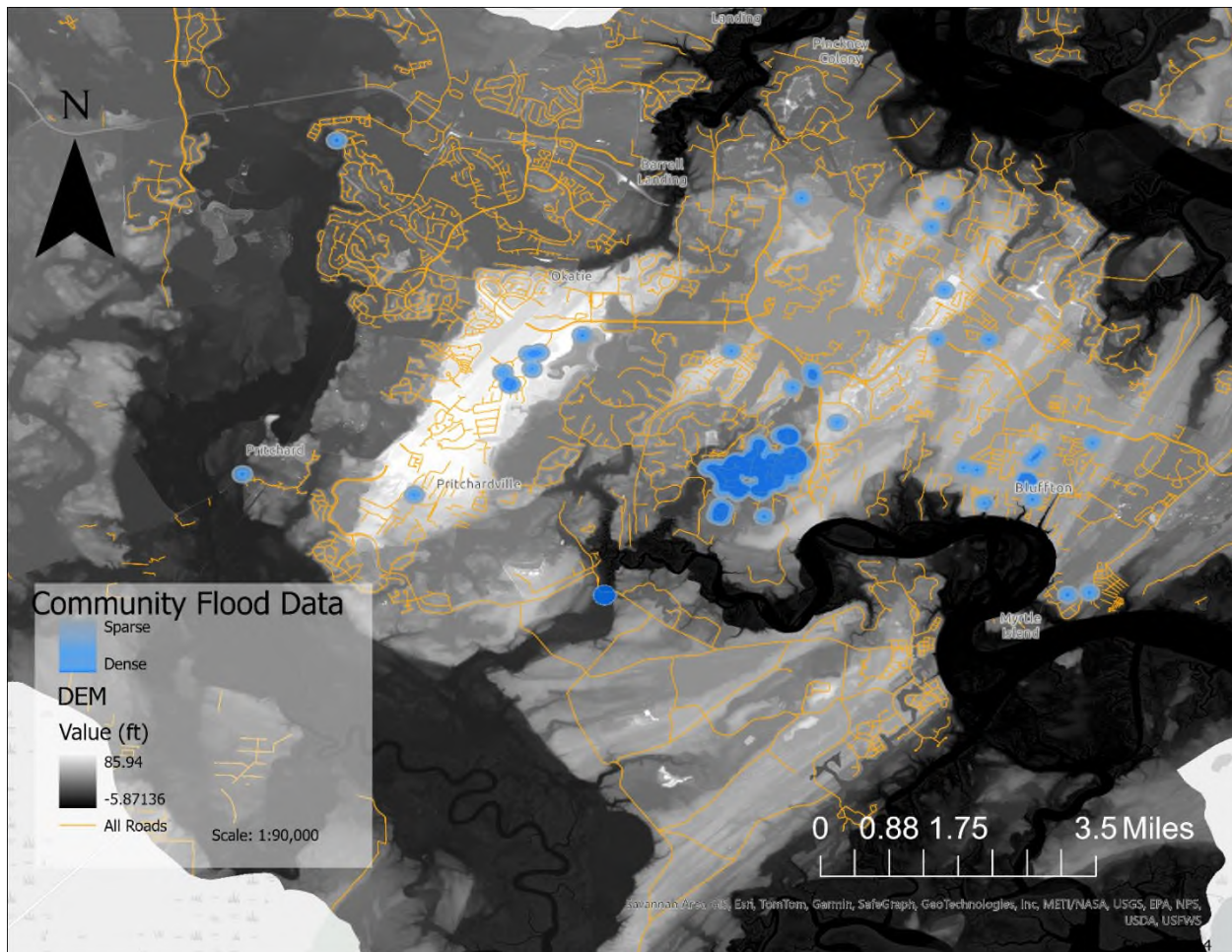


Figure 9: Heat map of community flood submissions with high and low elevations displayed showing clustering in low elevations

Selection of Vulnerability Metrics

A total of 22 responses were collected from the various Bluffton departments and Council members shown in Figure 10. The results of the Vulnerability Metrics Form shown in Figure 11 provide a clear overview of how Bluffton prioritized vulnerability metrics. Several of the following top concerns were identified as being feasible within the time constraints of this analysis: Wetland Loss, Flooding/Inundation, Rainfall-runoff, Storm Frequency, and Intensity. Of the top two concerns for Bluffton staff, water quality was outside of the scope of this analysis, while Evacuation Routes is a component of an analysis that is forthcoming from the South Carolina Office of Resilience (SCOR). However, addressing flooding issues in Bluffton will also provide significant benefits to water quality by limiting runoff pollution, protecting natural filtration systems such as wetlands and riparian zones, preventing erosion, and preserving aquatic ecosystems.

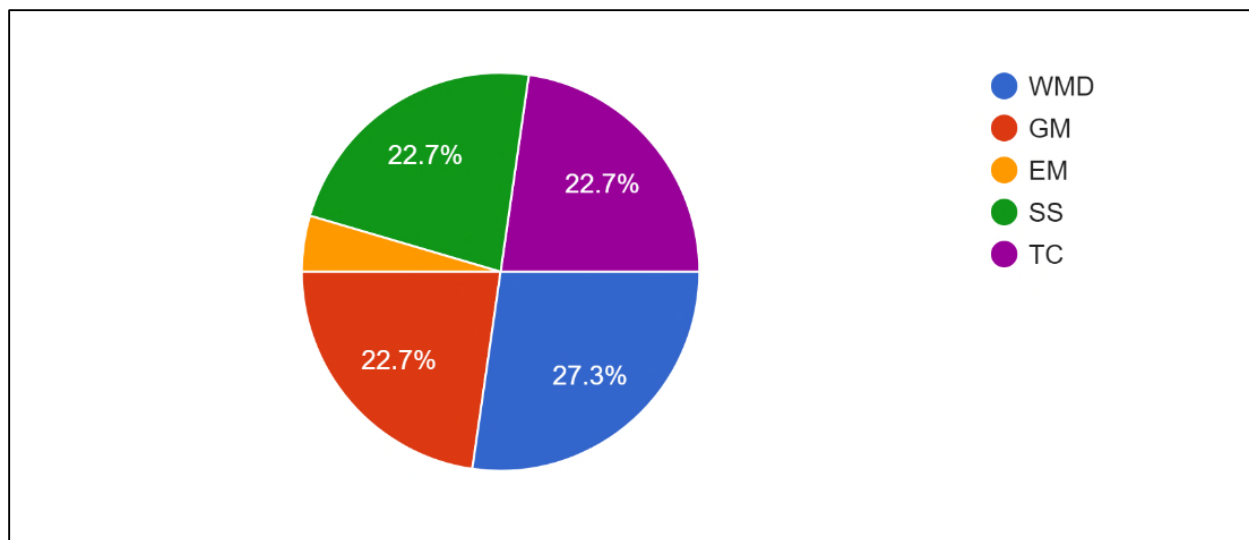


Figure 10: Distribution of responses from local government groups. WMD = Watershed Management Division, GM = Growth Management, EM = Emergency Management, SS = Senior Staff, and TC = Town Council

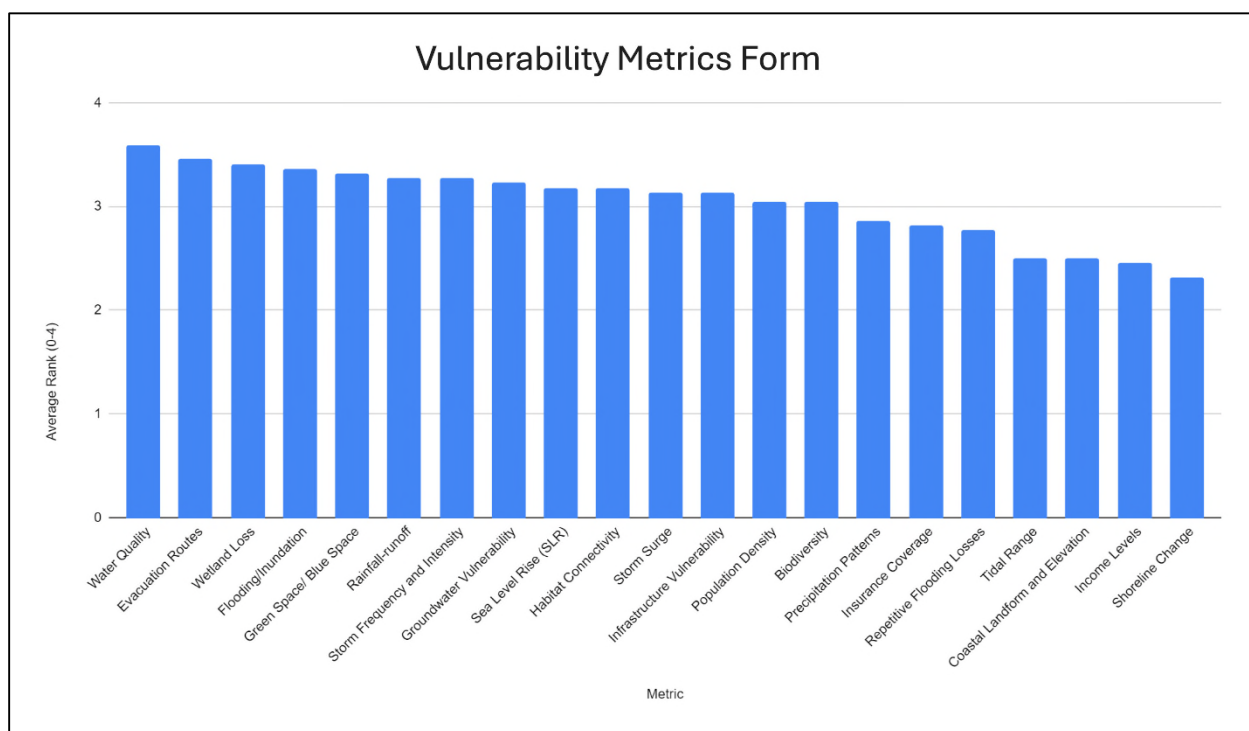


Figure 11: Final average ranks of all metrics in the Vulnerability Metrics Form

Mapping & Modeling

A total of 99,423 parcels were generated by subdividing remaining developable land within Bluffton's development areas to the maximum allowable density. Of those developable parcels, 43% were susceptible to flooding by the 1-in-100-yr storm in year 2023 conditions, rising to 60% of parcels for the 1-in-500-yr storm. When analyzing future conditions, many of the currently developed areas see a shift in flood inundation from minor or no flooding in 2023 to more severe depths of flooding in 2053. This trend was similar for future development, with the lowest intensity event (1-in-2-yr storm) having a 42% increase in parcels covered by the 2053 event versus the 2023.

The number of developable parcels generated by the buildout analysis (99,423) far exceeded the number of remaining residential dwelling units under development agreements (5,903). This surplus of available land allowed for scenario planning to determine the flood risk reduction different policy applications would have in Bluffton based on the location of future development in relation to flood hazards. Wetlands accounted for just over half of the vulnerable lands within development areas for all but the smallest storm scenario (1-in-2-yr). The 1-in-100-yr storm in year 2023 conditions resulted in 23,733 parcels flooded within wetland areas, resulting in an estimated \$1.84 billion in damages if those parcels were developed. Protecting wetlands plus a 50-ft buffer protects 25,986 potential parcels that would be flooded with an estimated damage value of \$1.99 billion if those parcels were developed and experienced that size storm event. Within the 50-ft buffer zone itself (excluding wetlands), 2,253 potential parcels experienced flooding by the 1-in-100-yr storm with an associated \$153.3 million of estimated damages. When analyzing elevation zones within each development area, the flood risk is almost entirely within the lower two out of three elevation zones. The high elevation zone contained less than 6% of flooded parcels and less than 3% of damages for each storm event. If policies were implemented prioritizing high elevation zones or protecting wetlands plus a 50-ft buffer, there would be more parcels available for development than are required based on active Planned Unit Development agreements as of December 2024.

Land Use and Flow Direction

Figure 12 shows the difference between impervious and pervious surface between the years 2001 and 2024 in the watersheds within and surrounding Bluffton, using NLCD (National Land Cover Database) data. Another aspect to note is the general water flow direction, which the arrows in the figure represent. Understanding the complexities of water flow at a watershed level helps understand where potential runoff will lead (Ongaga et al., 2024). This information is important for the study of both water quantity as well as water quality.

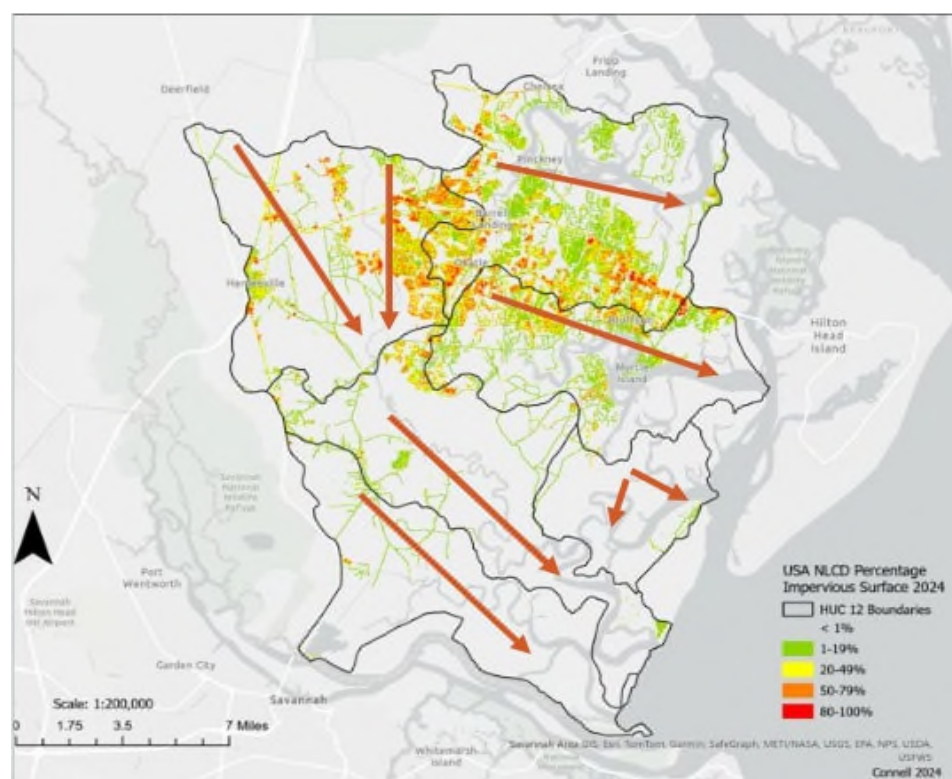
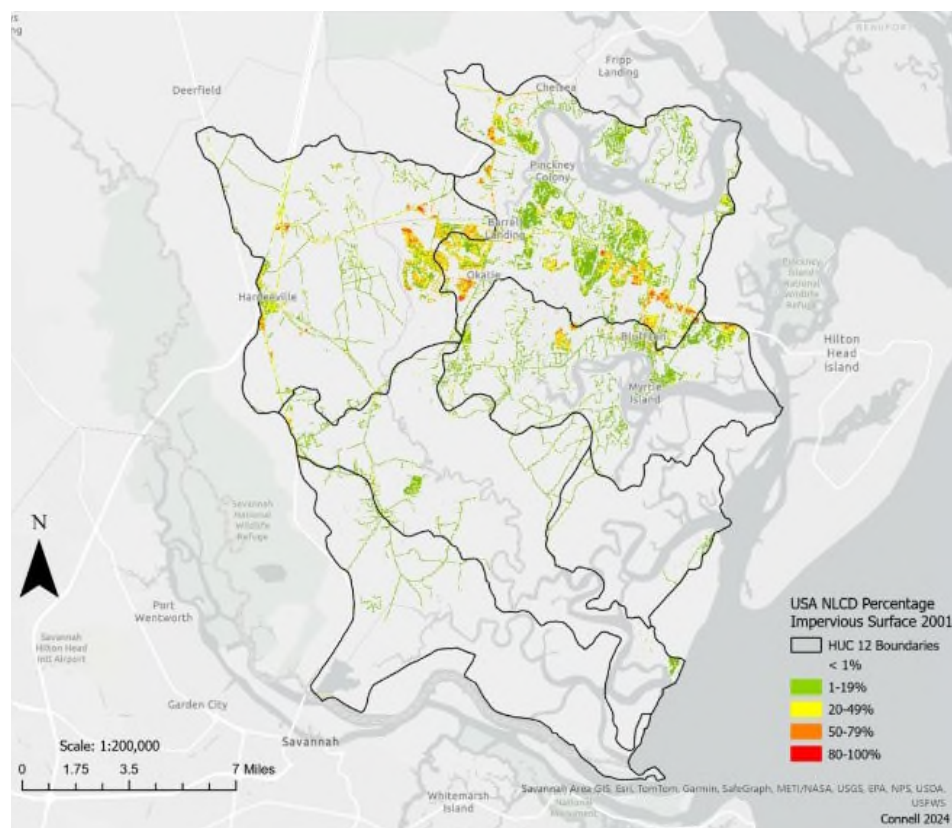


Figure 12: Impervious surface in 2001 (above) versus 2024 (below) from US NLCD. Red arrows represent the predominant direction of water movement through each HUC-12 watershed

Current Development Flood Vulnerability

Results indicate an escalating severity of flood depths across all scenarios between 2023 and 2053. For higher-frequency events (1-in-2-yr storm), many parcels experiencing minor flooding in 2023 are projected to face more inundation by 2053. The driver of this increased inundation is the increased level of precipitation expected for each storm scenario by 2053, which is incorporated into the flood models used in this study. This progression highlights areas where previously manageable events may increasingly disrupt properties, infrastructure, ecosystems, and daily life of Bluffton citizens. In the less frequent, high-impact flood scenarios (1 in-100-yr and 1-in-500-yr storms), the analysis reveals a stark rise in flood depths, exposing parcels previously outside major flood risk to considerable future hazard. Figure 13 shows the difference between a 1-in-2-yr flood scenario (a flood event that has a 50% chance of occurring each year) and a 1-in-100-yr flood scenario (a flood that has a 1% chance of occurring in any given year) in 2023, showcasing the expansion of the number of parcels effected between the least and most likely flood occurrences under current conditions. See Appendix A for parcel maps of vulnerability for each flood scenario and year conditions for the study area.

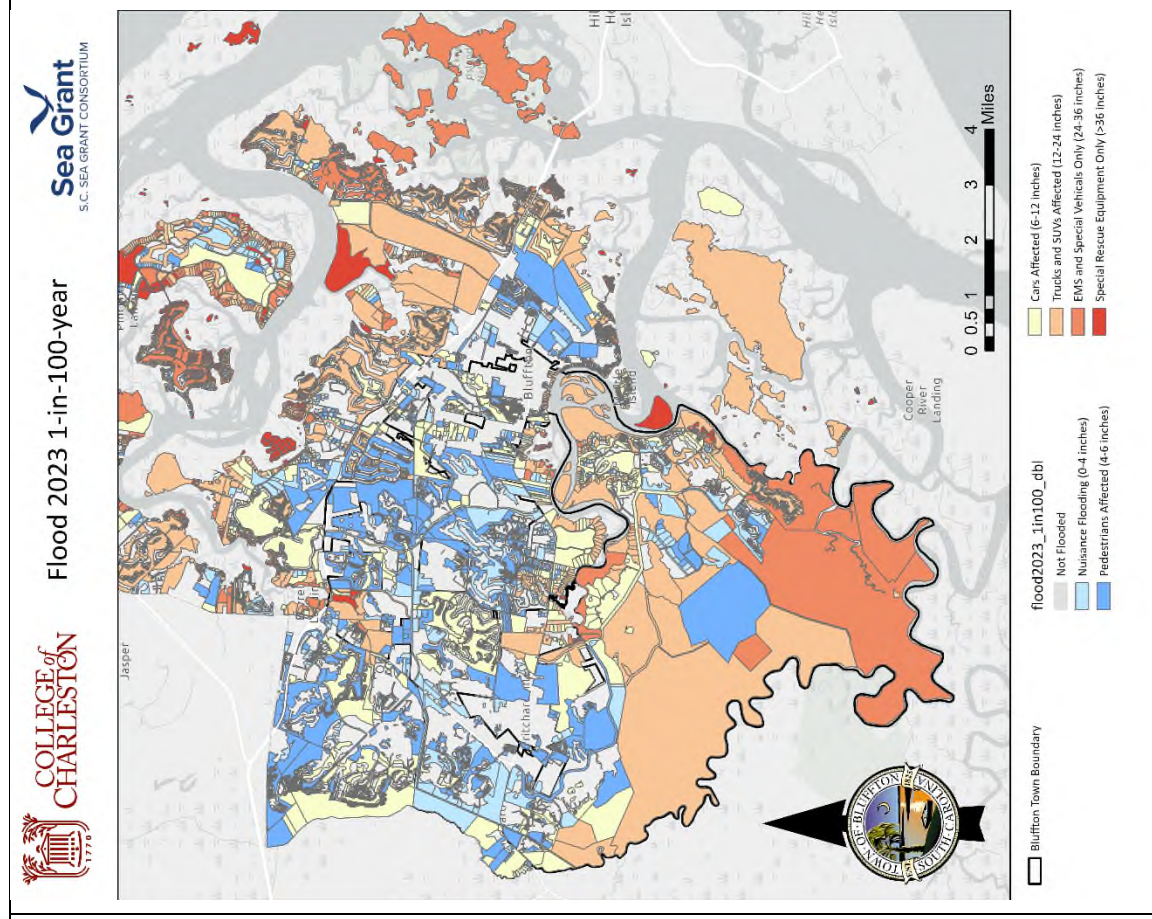
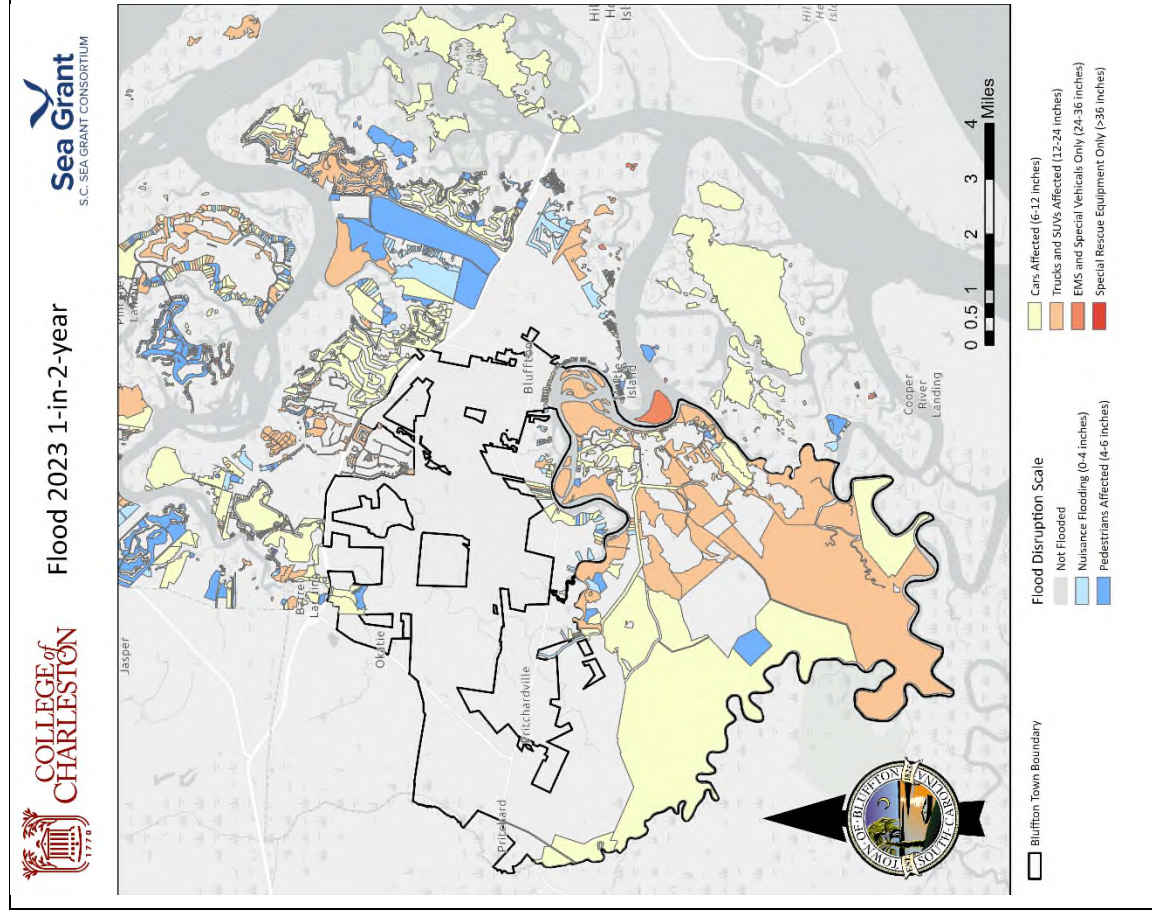


Figure 13: 1-in-2-yr versus 1-in-100-yr flood scenarios for 2023

Maximum Buildout Flood Vulnerability

A total of 99,423 parcels were generated by subdividing remaining developable land within Bluffton's development areas to the maximum allowable density (Figure 14). See Appendix B for results presented for each PUD. For the 1-in-100-yr storm with 2023 conditions, 42,852 parcels (43%) experienced some level of flooding. The parcels containing flood waters increased with each increasing storm scenario intensity, with the 2053 storm conditions increasing the vulnerability compared to the 2023 conditions. The proportion of parcels that experienced an increase in flooding from 2023 to 2053 storm scenarios declined with each progressively larger storm event, with a 42% increase in the 1-in-2-yr storm and a 27% increase for the 1-in-20-yr storm, declining down to 8% and 4% increases for the 1-in-100-yr and 1-in-500-yr storms respectively (Table 2, Figure 15). This indicates that future conditions will yield a greater increase in flood impacts from storms that are more likely to occur on a year-to-year basis relative to current impacts from these events. The 2053 storm conditions covered 5% (4,514) of the total buildout parcels in the 1-in-2-yr storm while the 1-in-500-yr storm covered 63% (62,454) of the total buildout parcels. This highlights the need for strategic growth in these areas to reduce vulnerability to future flood hazards.

Table 2: Vulnerable buildout parcels for each flood scenario and each study year with the percentage increase in parcels when going from 2023 to 2053 conditions

Year	1-in-2	1-in-20	1-in-100	1-in-500
2023	3,182	22,137	42,852	59,825
2053	4,514	27,052	46,082	62,454
<i>Percent Increase 2023-2053</i>	42%	22%	8%	4%

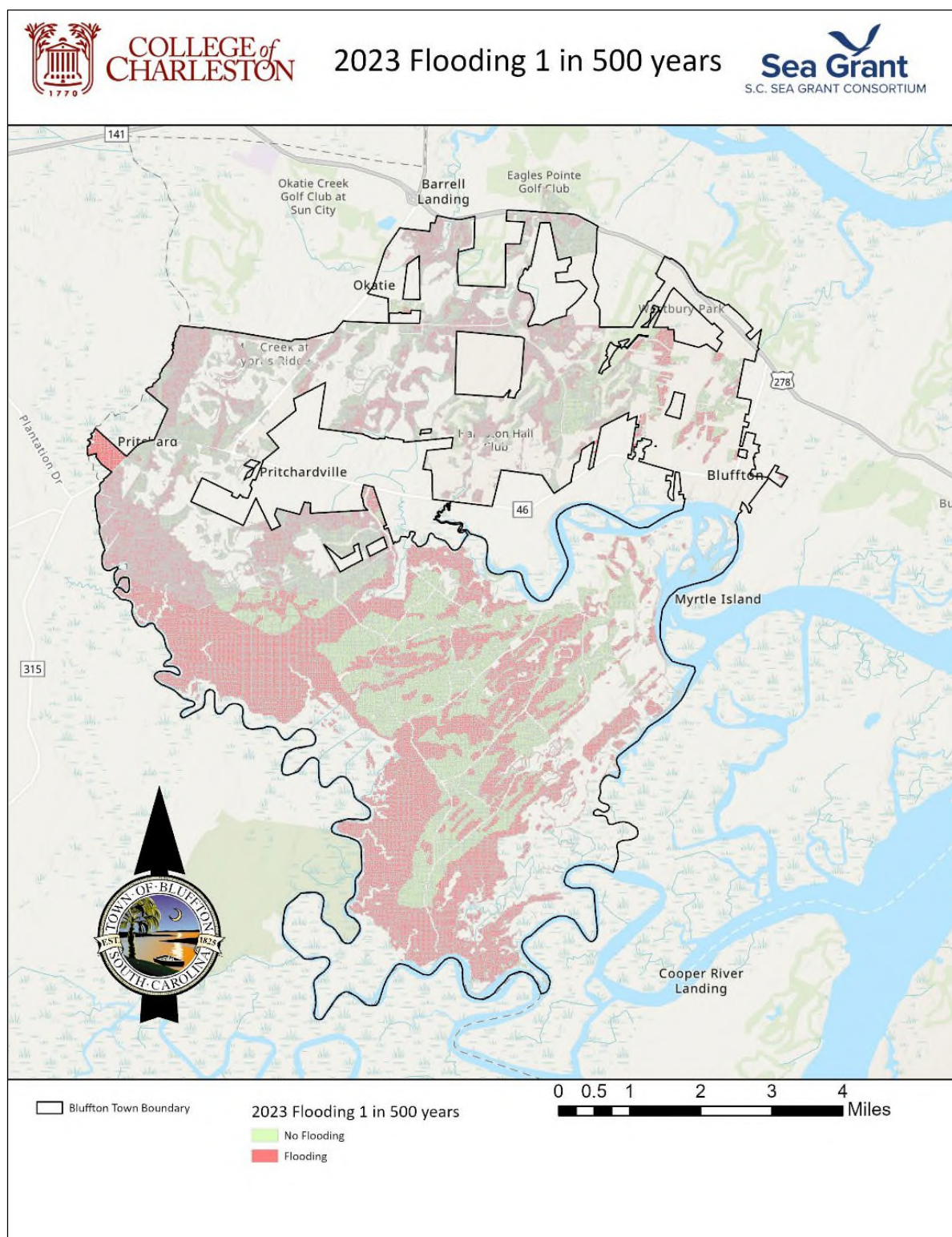


Figure 14: Parcels touched by flood waters of the 1-in-500-yr storm event (red) and those not touched by those flood waters (green) for year 2023 flood conditions

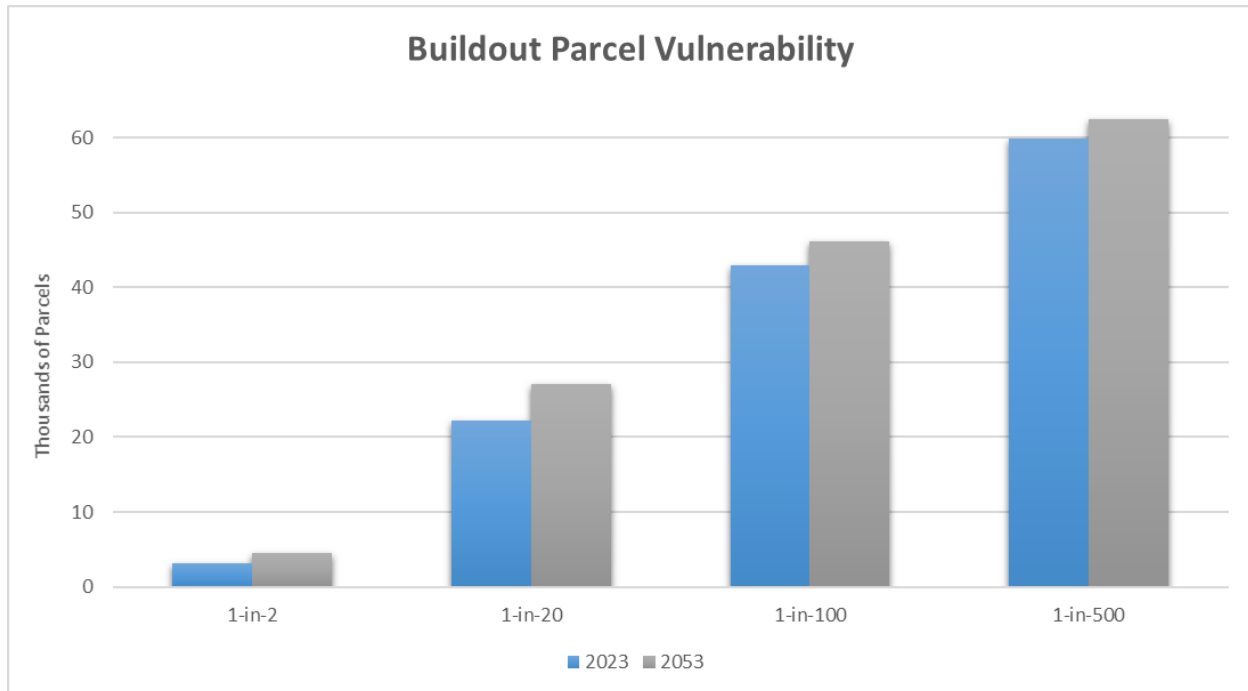


Figure 15: Vulnerable buildout parcels (thousands) for each flood scenario with year 2053 flood conditions shown in addition to year 2023 flood conditions

Forested Wetlands Analysis

When analyzing the buildout parcels that cover the wetlands in Bluffton, these parcels represent just over half of the vulnerability for all but the lowest intensity event (1-in-2-yr) (Figure 16). As climate conditions worsen in the year 2053, a greater number of buildout parcels are impacted by each storm event, while the proportion of parcels that fall within wetland areas for those future events remain relatively constant. Only 8% of the 1-in-2-yr storm vulnerability is within wetland areas for the year 2023; however, that proportion grows to 23% for the year 2053. For parcels inundated by the 1-in-100-yr storm, 55% (23,733) were within wetland areas accounting for an estimated \$1.84 billion in damages if those parcels were developed and impacted in year 2023 conditions. The damage models showed similar trends with roughly equal proportions of damage within and outside of wetlands as the parcel analysis revealed. For the highest intensity scenario (1-in-500-yr storm) in 2023 conditions, roughly \$3.11 billion in damages were accounted for by the parcels within wetlands versus \$2.94 billion in damages outside of wetlands. These numbers rose by roughly \$475 million for wetlands and \$420 million for non-wetlands when accounting for year 2053 conditions. These results indicate that, while lower severity events are distributed across the landscape, wetland areas are critical to absorbing the waters of higher intensity events.

There were ample buildout parcels available in non-wetland areas to fully reach the development goals of each PUD without future wetland development. Buckwalter PUD had the lowest proportion of available non-wetland parcels compared to remaining dwelling units in the PUD agreement, yet still had five times more buildout parcels available in non-wetland areas than are required (Table 3). See Appendix C for results presented for each PUD.

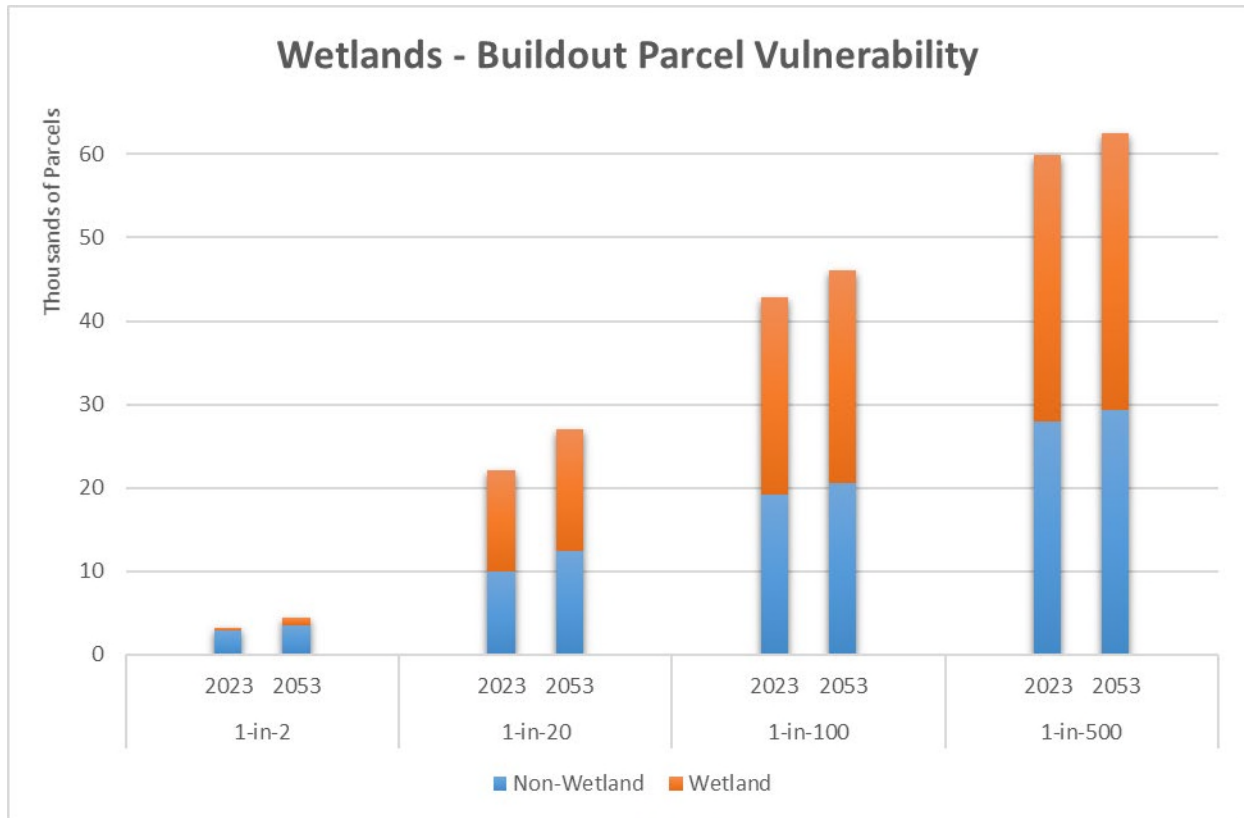


Figure 16: Vulnerable buildout parcels (thousands) for each flood scenario and each study year with parcels within freshwater wetlands (orange) shown in addition to those outside of those wetlands (blue)

Table 3: Planned Unit Developments analyzed with non-wetland parcels shown for each, remaining dwelling units from each Development Agreement, and the percent of those remaining units that would be reached with only non-wetland buildout parcels

Planned Unit Development	Non-Wetland Available	Remaining Dwelling Units	Proportion Non-Wetland
Buckwalter	10,960	2,176	504%
Jones Estate	4,597	413	1,113%
New Riverside	10,408	724	1,438%
Palmetto Bluff	28,335	2,515	1,127%
Shultz Tract	604	66	915%
Village at Verdier	200	9	2,222%

Because Bluffton lies slightly inland, the wetlands that now fall under unprotected land have increased, based off National Wetlands Inventory data showing emergent wetlands within Bluffton's boundary (Figure 17). Several of these wetland areas are already slated as potential medium density residential and commercial land use zones. The current definition of WOTUS allows the development of these areas shown in Figure 17 from a federal perspective, despite the potential hazards that may occur.

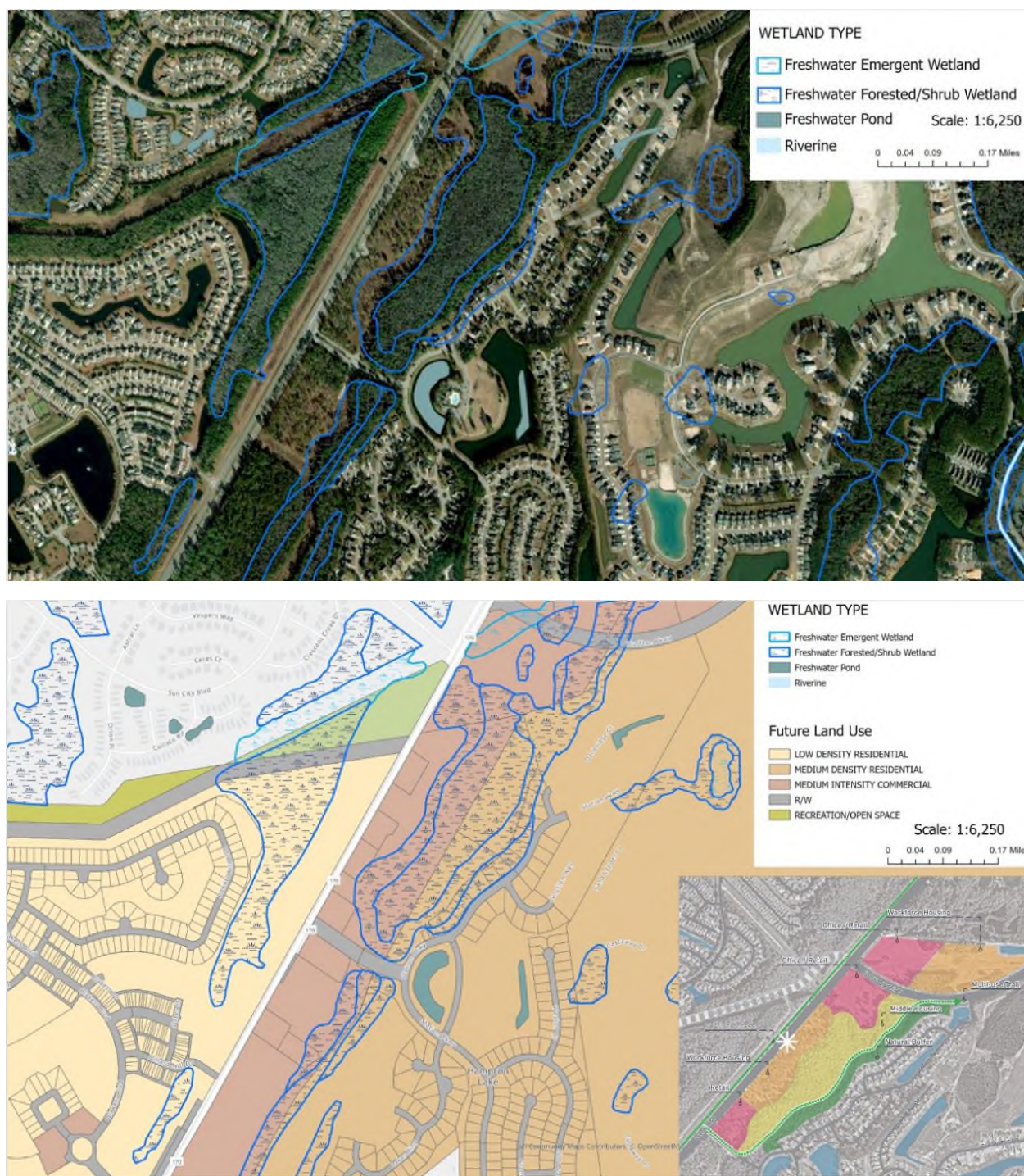


Figure 17: Overlay of unprotected emergent wetland over hybrid imagery (top) and future land use plans (bottom)

Wetland Buffers

An analysis of buffer zones surrounding wetlands was conducted for a 25-ft buffer, 50-ft buffer, and 100-ft buffer using the 1-in-100-yr storm scenario with 2023 conditions. Over 1/3 of all available buildout parcels were vulnerable to floodwaters within each buffer distance. Protecting wetlands plus a 50-ft buffer protects 25,986 potential parcels that would be flooded with an estimated damage value of \$1.99 billion if those parcels were developed and experienced this size storm event. Within the 50-ft buffer zone itself, 2,253 potential parcels experienced flooding with an associated \$153.3 million of estimated damages. Going from a 25-ft to a 50-ft buffer increases modeled protections by an additional 1,098 parcels and \$75.5 million of potential damages. Increasing the buffer size to 100-ft adds additional protection to 1,784 potential parcels with \$129.2 million in estimated damages compared to the 50-ft buffer; however, the proportion of total parcels protected is slightly less in this zone (33% compared to 36%). There were substantial buildout parcels available in areas outside of wetlands and a 50-ft buffer to fully reach the development goals of each PUD (Table 4).

Table 4: Planned Unit Developments analyzed with remaining dwelling units from each Development Agreement, parcels available outside of a 50-ft wetland buffer shown for each, and the percent of those remaining units that would be reached with only non-buffer buildout parcels

Planned Unit Development	Remaining Dwelling Units	Available Outside 50-ft Buffer	Proportion Available Outside 50-ft Buffer
Buckwalter	2,176	9,004	414%
Jones Estate	413	4,185	1013%
New Riverside	724	8,833	1220%
Palmetto Bluff	2,515	26,208	1042%
Shultz Tract	66	539	817%
Village at Verdier	9	187	2078%

Elevation Analysis

Subdividing each development zone into elevation groups of low (Marginal Land), moderate (Moderate Risk), and high elevation (Low Risk) reveals distinct patterns in the vulnerability of developable land within Bluffton's boundaries (Figure 18). For all but the highest intensity event, the majority of vulnerable buildout parcels fall within the Marginal Lands of Bluffton, with 92% of the vulnerable parcels within this category for the lowest intensity event (1-in-2-yr storm). The Moderate Risk category holds an increasing proportion of vulnerability as the storm intensity increases. This could be due to the number of Marginal Lands being close to fully occupied with flood waters during higher intensity events and therefore water reaching higher elevations during those events. For the year 2053, 85% of buildout parcels in Marginal Lands were covered by flood conditions for the 1-in-100-yr storm, with 94% covered by the 1-in-500-yr storm. The Low-Risk group showed very little vulnerability for each of the flood scenarios, with 0 parcels affected by the 1-in-2-yr storm and only 6% for the highest 1-in-500-yr storm, with numbers rising by 1-3 percentage points with each rising level of storm severity. The damage models showed an even greater proportion of damage accounted for by Marginal Lands, with 74% of damages occurring within this category for the 1-in-20-yr storm and an average of 58.5% of damages for the 1-in-

500-yr storm, with those damages coming from 41.5% of parcels flooded by that event. The Low-Risk areas accounted for an even smaller proportion of damage than the parcels analysis showed, with only 3% of the damage in this elevation group for the 1-in-500-yr storm. This indicates that, while any flood waters on a property are impactful, the lower elevation groups are experiencing greater flood depths and therefore greater flood damage in these models.

Enough available land exists within the Low Risk zone to meet all PUD agreements, while a combination of Low and Moderate Risk parcels contains at least six times more parcels than are required in each area (Table 5). See Appendix D for results presented for each PUD.

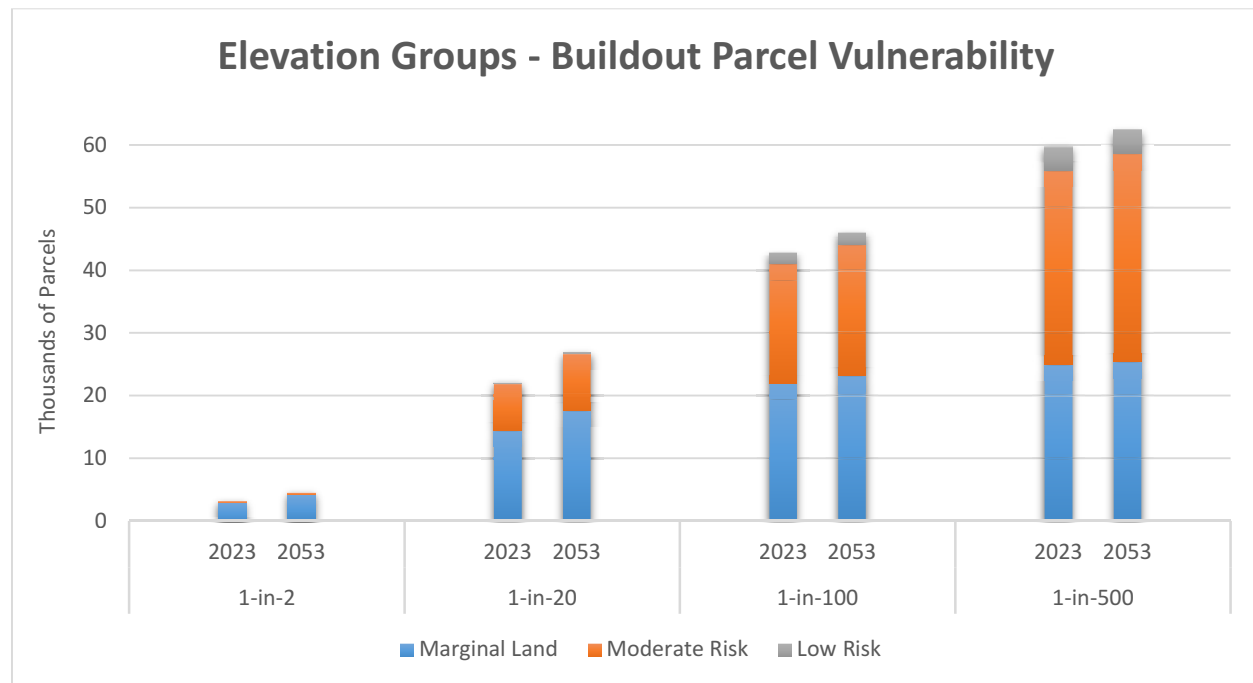


Figure 18: Vulnerable buildout parcels (thousands) for each flood scenario and each study year with parcels from each elevation group that are touched by that flood condition shown

Table 5: Planned Unit Developments analyzed with Low and Moderate Risk parcels shown for each, remaining dwelling units from each Development Agreement, and the percent of that maximum that would be reached with Low Risk as well as Low and Moderate Risk buildout parcels

Planned Unit Development	Remaining Dwelling Units	Low Risk Available	Proportion Low Risk	Moderate Risk Available	Proportion Low + Moderate Risk
Buckwalter	2,176	2,923	134%	18,669	992%
Jones Estate	412	1,045	254%	1,779	685%
New Riverside	724	2,880	398%	10,857	1,897%
Palmetto Bluff	2,515	8,976	357%	22,444	1,249%
Shultz Tract	66	176	267%	721	1,359%
Village at Verdier	9	40	444%	241	3,122%

DISCUSSION

This section contains recommendations by College of Charleston faculty and partners

Overall, Bluffton has several options to enact protections for non-jurisdictional wetlands and other vulnerable areas. These include but are not limited to: providing protections by amending existing zoning codes, establishing overlay districts and elevation-based zoning, adopting wetland-specific ordinances, strengthening floodplain management policies, establishing public-private and non-profit partnerships, strengthening/implementing financial incentives, implementing land acquisition policy options, and applying for land acquisition grant programs with the help of organizations, like The Nature Conservancy and The Open Land Trust. The exact framework for resilience initiatives in Bluffton will depend on how restrictive Bluffton wants to be regarding development, how much power their zoning/development authority has, and the municipality's staff and financial capacity to implement and enforce programs and policies.

Zoning and Overlay Recommendations

The evaluation of forested wetlands and elevation zones within Bluffton's boundaries highlights the resilience benefit of additional policy protections, while maintaining the ability to reach development goals established through PUD agreements. Locally protecting freshwater wetlands, which recently lost federal protection, could cut the vulnerability of Bluffton's future development in half. Additionally, elevation-based zoning has the potential to dramatically reduce the vulnerability of future development. The clustering of community flood submissions in low lying areas further supports the argument for elevation-based zoning by Bluffton, as it highlights current flood vulnerabilities that could potentially be avoided in future development areas with strategic growth planning. The City of Charleston, SC is an example of a municipality in South Carolina that is recommending elevation-based zoning for future consideration (City of Charleston, 2021). The City of Norfolk, VA underwent an ordinance rewrite to protect sensitive areas as well as incentivize development in higher elevations of the municipality through coastal resilience and upland resilience overlays (Pew, 2019).

For local governments where state wetland regulations are either in flux after *Sackett* or are being drastically rolled back, adopting comprehensive zoning ordinances may not be feasible. In the final report by the National Sea Grant Law Center, overlay zoning districts, which layer additional environmental protections on top of existing zoning, seem to be one of the more feasible solutions for Bluffton. Dekalb County, GA, uses this method to protect environmentally sensitive areas, and the local board defines what qualifies as "environmentally sensitive" based on local needs (DeKalb County, Georgia, n.d.). This flexibility could be key for Bluffton, where specific environmental issues, such as flooding and wetland preservation, need a targeted approach (Drescher et al., 2014). Overlay districts allow municipalities to address these concerns without navigating hurdles that may arise in zoning changes. Overlays or other forms of permitting requirements do not restrict or prohibit all forms of development but rather require local approval prior to beginning a project to ensure sensitive areas are protected. Additionally, as Bluffton already has a historical preservation overlay and a Preserve District, establishing a wetlands protection overlay may comply well with the zoning code. Although Bluffton's Preserve District allows for very little development and therefore protects wetland areas within the district, Bluffton might consider expanding the

coverage of the Preserve District to cover other sensitive environmental areas through a Zoning Map amendment.

Lastly, a different overlay that Bluffton could consider implementing is a marsh migration area overlay district, which would help designate areas that can support future marsh migration as resource protection through shoreland zoning. Flood protection-based requirements as shown in an example from Hilton Head Island were deemed another viable option for Bluffton based on the municipal structure for the Town of Hilton Head Island (n.d.). Like the overlay, this option doesn't require a large change in Bluffton's ordinance or zoning in order to adopt and reach their goals, like other more burdensome policy tools may. The use of overlay zoning districts and flood protection requirements presents a viable and less disruptive solution. The National Sea Grant Law Center found that these strategies have been successfully implemented in other local governments, allowing them to protect environmentally sensitive areas (DeKalb County, Georgia, n.d.). By adopting similar approaches, this is a possible avenue for Bluffton to effectively safeguard its wetlands while maintaining political and developmental flexibility. For example, Bluffton's updated 2021 flood damage ordinance, which does not restrict development within flood hazard areas, could be adapted to provide wetlands protection, similar to Hilton Head's ordinance.

Per the final report by the National Sea Grant Law Center, wetlands protection at the municipal level varies widely from very restrictive of all development to not very restrictive. Some municipalities, like Tampa, FL do not limit development as much as simply impose additional requirements/approval for developers to get prior to beginning their activities. The level of protection often depends on whether there are state-level protections and requirements in place. In Washington and Virginia, the state has provided requirements and model ordinances for municipalities to adopt which allows for these ordinances to be more comprehensive and for development to be more restricted at the local level. These models are not replicable everywhere as not every state has deferred such power to the local level. As federal and state wetlands regulations continue to change, it will be up to municipal governments to find and adopt the best fit for them when they want to further protect these vital resources.

Financial Incentive Recommendations

Bluffton may also consider strengthening local financial incentive programs to guide development away from vulnerable areas susceptible to flooding and to protect wetlands. Bluffton could enhance its current Transfer of Development Rights (TDR) program by offering more significant development density incentives in receiving areas to ensure that growth is concentrated in appropriate zones. At the same time, Bluffton could narrow the areas designated as "sending areas" to focus on the most flood-prone or environmentally sensitive lands.

Other incentives might include tax abatements (tax breaks), streamlined permitting processes, or discounted application fees for development that occur outside vulnerable areas. Bluffton could also consider impact fees, special study fees, or environmental protection fees for development in sensitive areas. These measures would discourage growth in wetlands while helping offset the costs of structural flood protection and conservation initiatives.

Land Acquisition Policy Options and Recommendations

In addition to regulatory strategies, land acquisition remains a critical tool for advancing conservation and flood mitigation goals in Bluffton. Among available approaches, maintaining and strengthening partnerships with land trusts operating in this area of the state, such as the Open Land Trust (OLT) and The Nature Conservancy (TNC), stand out as particularly effective. These partners bring technical expertise, funding mechanisms, and longstanding experience in negotiating with private landowners and securing conservation easements to protect critical floodplains and wetland systems.

Fee simple acquisitions—such as Bluffton’s 44-acre purchase from Palmetto Bluff—should continue to be pursued for high-priority parcels, particularly those vulnerable to flooding. Partnering with TNC and OLT to jointly fund and manage future acquisitions would increase Bluffton’s capacity to conserve key properties while minimizing municipal financial burden.

Bluffton may also benefit from articulating a long-term vision for land use and growth over a 50-year planning horizon. Incorporating projections for sea-level rise, storm surge, and other climate-related risks into future land use decisions will provide a forward-looking framework to guide sustainable development. Land use planning should align with existing state and regional conservation resources, including the South Carolina Conservation Bank map, the Southeast Conservation Adaptation Strategy (SECAS) blueprint, and the South Atlantic Salt Marsh Initiative (SASMI) map.

A flexible suite of acquisition options can further support Bluffton’s conservation objectives. For example, Bluffton could consider using rolling easements to protect coastal and flood-prone lands. These easements provide flexibility by allowing conservation protections to migrate inland as the landscape changes due to sea-level rise or erosion, offering long-term resilience benefits. The inland shift could be guided by a clear benchmark, such as the average elevation of the highest daily tides (the mean higher high water, or MHHW), to ensure consistency and transparency over time.

To guide land acquisition investment, a tiered approach based on risk and opportunity may be helpful. In lower-risk scenarios, the purchase of conservation easements can reduce land value and attract conservation-minded buyers. In medium-risk situations, Bluffton may benefit from coordinating with partner organizations to acquire land for public use, with the potential for state or federal reimbursement. For higher-risk or more complex acquisitions, Bluffton could consider purchasing large tracts outright, then selling portions of the land under conservation easements to offset costs.

Bluffton should maximize credit under the FEMA Community Rating System (CRS) by ensuring that conserved land, including those tied to development agreements, are eligible. Doing so could reduce flood insurance premiums and enhance Bluffton’s overall resilience. Large tracts such as Palmetto Bluff should be prioritized as undeveloped lands become more limited.

Finally, Bluffton may consider strengthening its Land Acquisition Fund by identifying new and diversified revenue sources. Potential mechanisms include a small fee on home sales in new

Planned Unit Developments (PUDs), conservation contributions in development agreements, and permit-linked development fees. Simultaneously, optimizing future PUD layouts by encouraging cluster development and maximizing open space preservation could enhance ecological function while maintaining allowable density.

Review of Local/State and Federal Land Acquisition Programs

Collaborating with land trusts which are eligible to apply for many of these grants, are effective strategies Bluffton can take to leverage existing funding opportunities.

State Grant Programs:

1. [Beaufort County Green Space Program](#)
 - Supports land conservation and preservation in Beaufort County.
 - Continue submitting applications to this program, especially for corridor preservation along the May River.
2. [South Carolina Conservation Bank \(SCCB\)](#)
 - Provides grants for the voluntary conservation of natural resources, working lands, and historic sites.
3. [South Carolina Office of Resilience \(SCOR\) Buyout Program](#)
 - Focuses on relocating residents from flood-prone areas and restoring the natural function of floodplains.
4. [South Carolina Resilience Revolving Fund](#)
 - Assists local governments and homeowners with acquiring and restoring flood-prone properties.
5. [South Carolina Lowcountry Sentinel Landscape](#)
 - Supports conservation in ecologically significant areas to sustain military readiness while protecting natural resources.

Federal Grant Programs:

1. [Section 319 Nonpoint Source \(NPS\) Program](#)
 - Improves water quality by addressing nonpoint source pollution, including from septic systems.
2. [Coastal Wetlands Conservation Grant Program](#)
 - Funds acquisition, restoration, and management of coastal wetlands ecosystems.

3. [North American Wetlands Conservation Act \(NAWCA\) Program](#)
 - Supports conservation of wetlands and migratory bird habitats across North America.
4. [Land and Water Conservation Fund \(LWCF\) Program](#)
 - Provides funding for the acquisition of land for parks, outdoor recreation, and public access.
5. [Flood Mitigation Assistance \(FMA\) Program](#)
 - Funds flood mitigation projects, including voluntary property acquisitions, to reduce long-term flood damage.

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APPENDICES

Appendix A: Current Development Flood Vulnerability Result

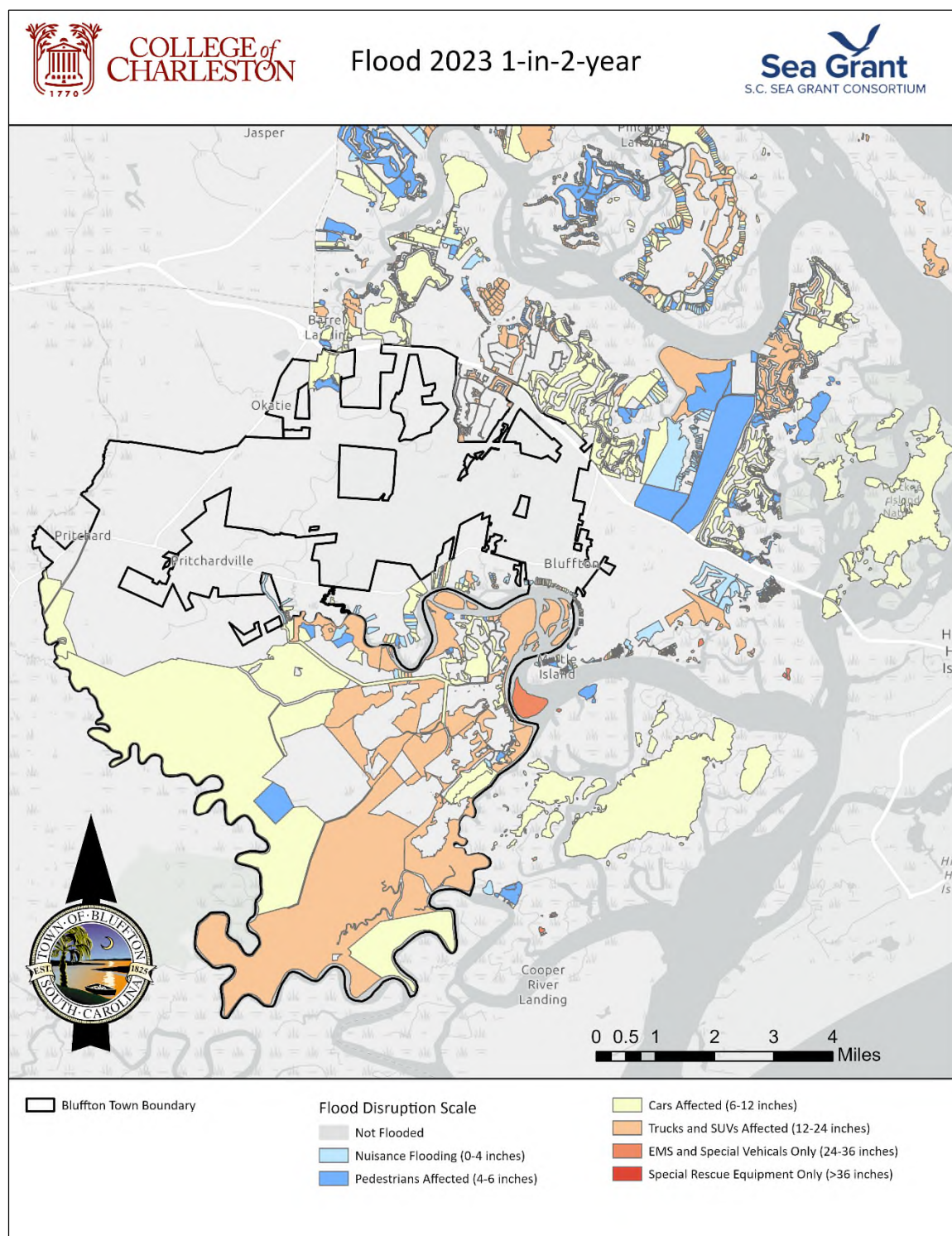


Figure 19: Current development parcel vulnerability to the 1-in-2-yr storm in 2023 conditions

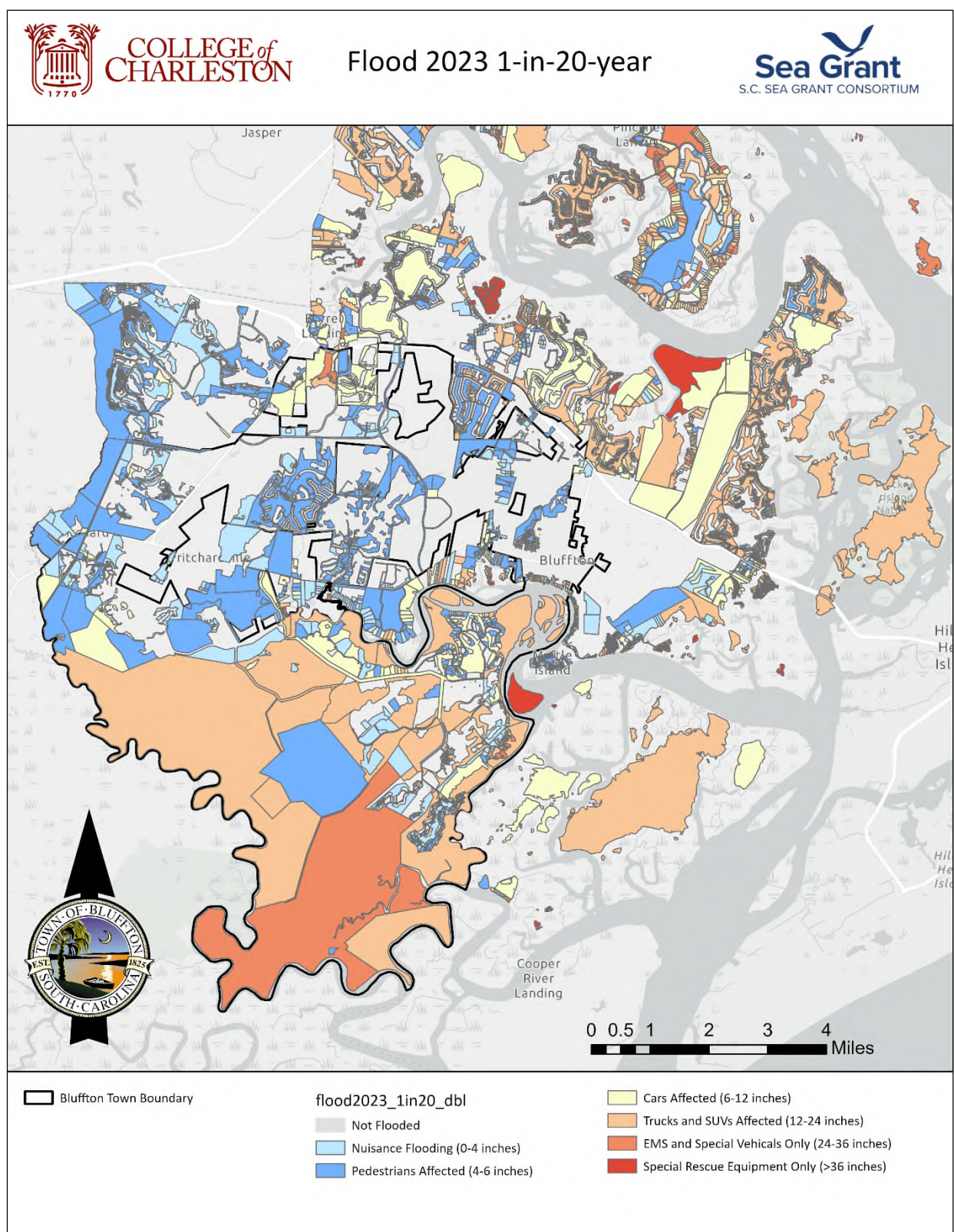


Figure 20: Current development parcel vulnerability to the 1-in-20-yr storm in 2023 conditions

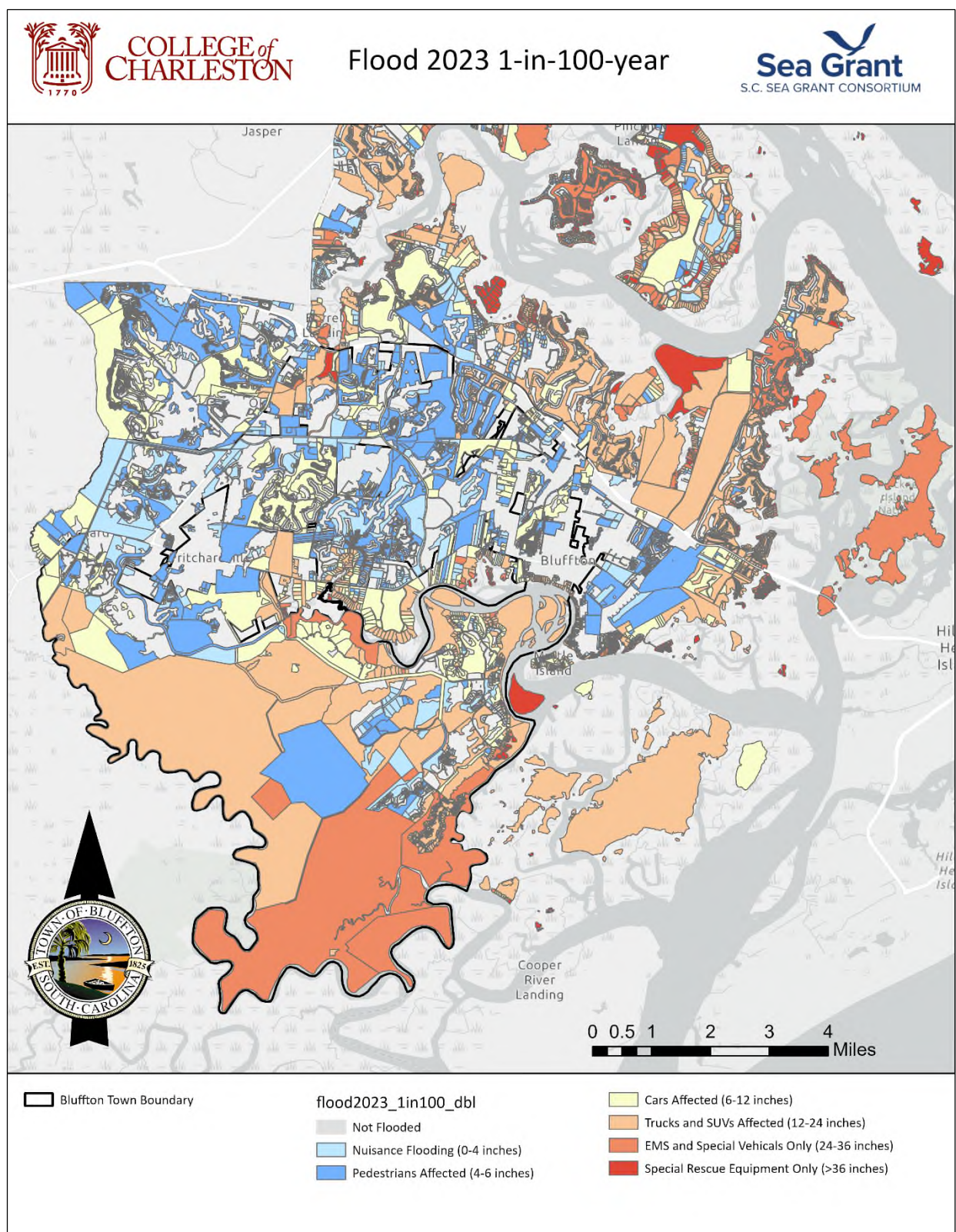


Figure 21: Current development parcel vulnerability to the 1-in-100-yr storm in 2023 conditions



Flood 2023 1-in-500-year

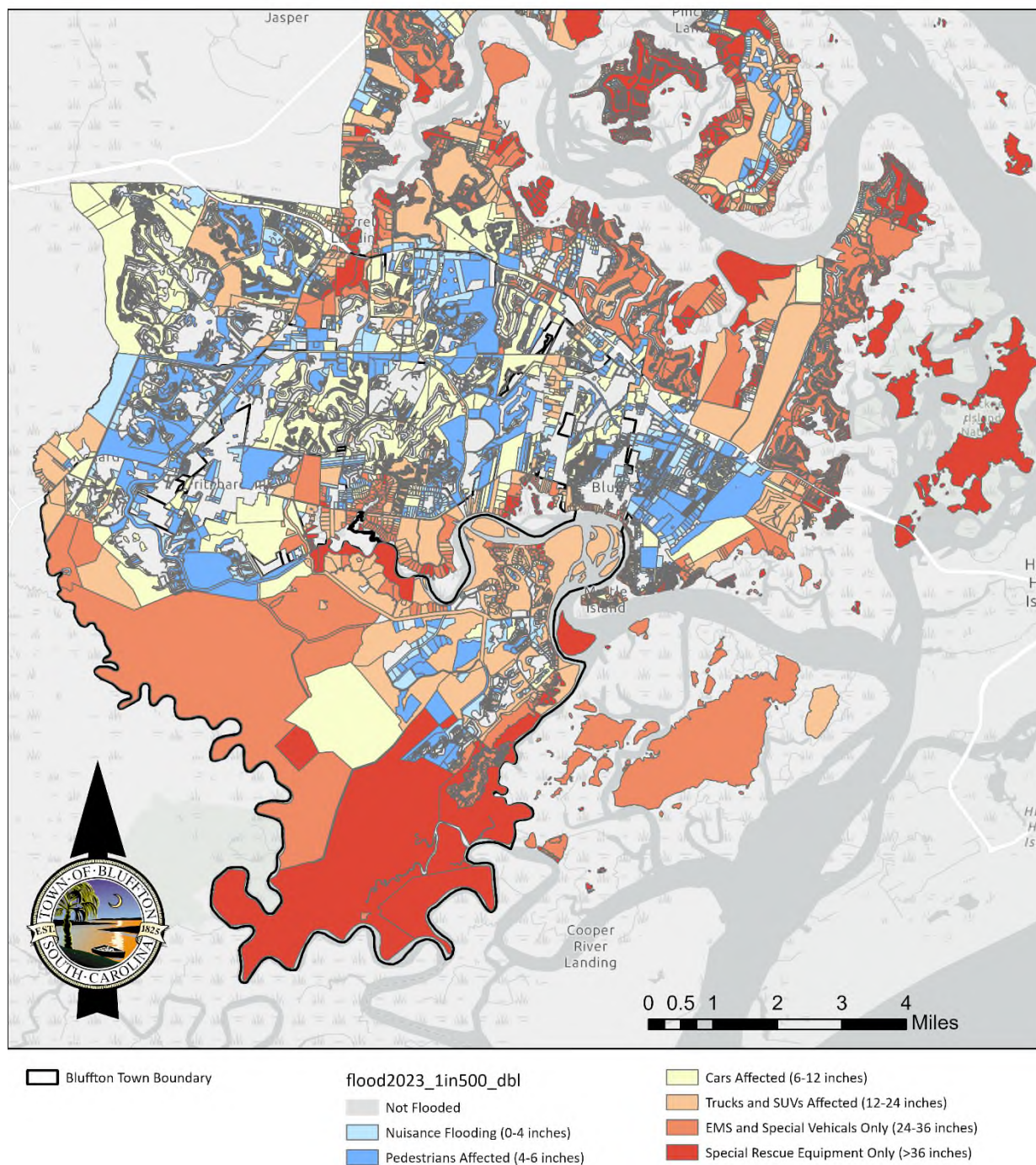


Figure 22: Current development parcel vulnerability to the 1-in-500-yr storm in 2023 conditions



Flood 2053 1-in-2-year

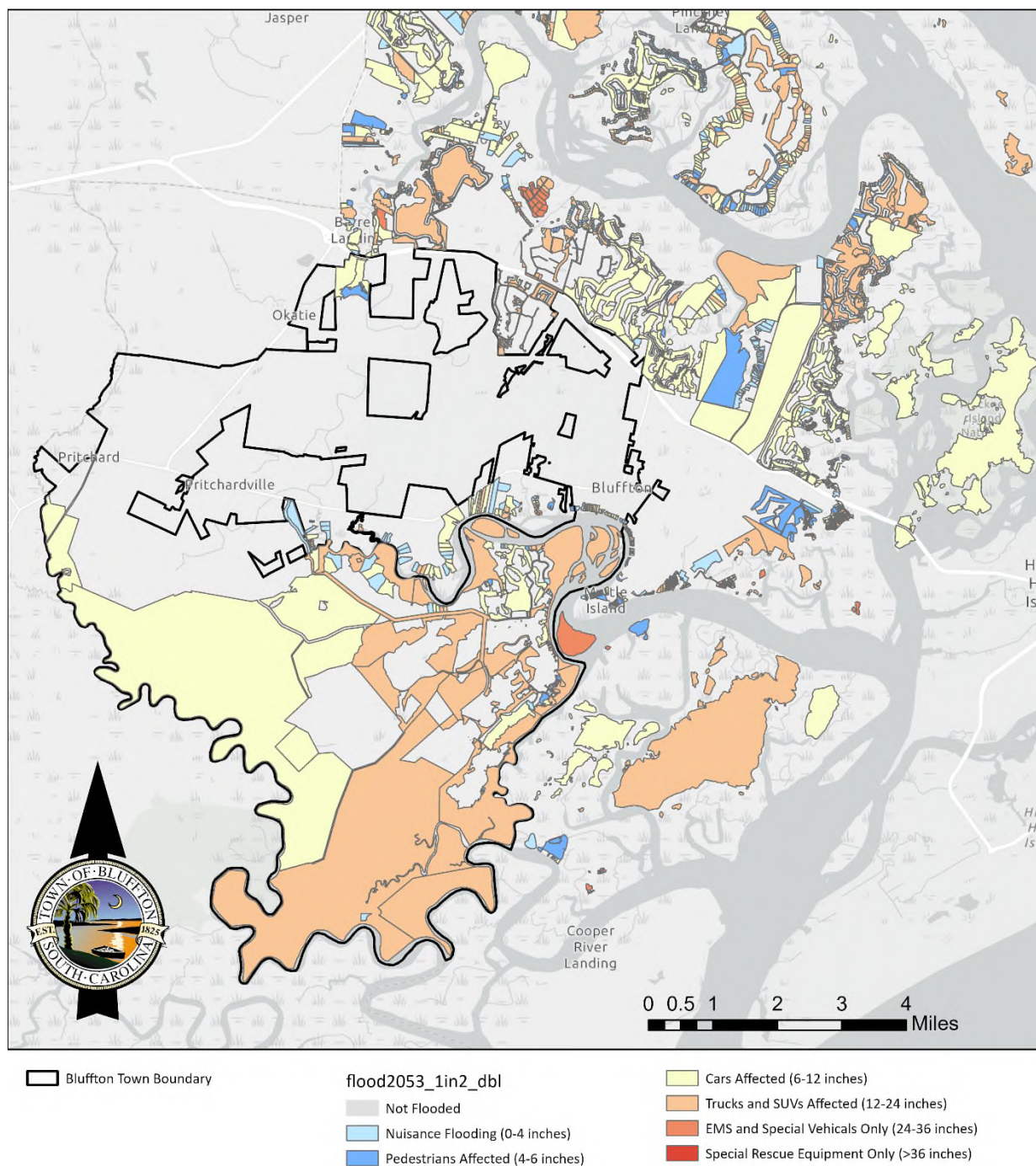


Figure 23: Current development parcel vulnerability to the 1-in-2-yr storm in 2053 conditions



Flood 2053 1-in-20-year

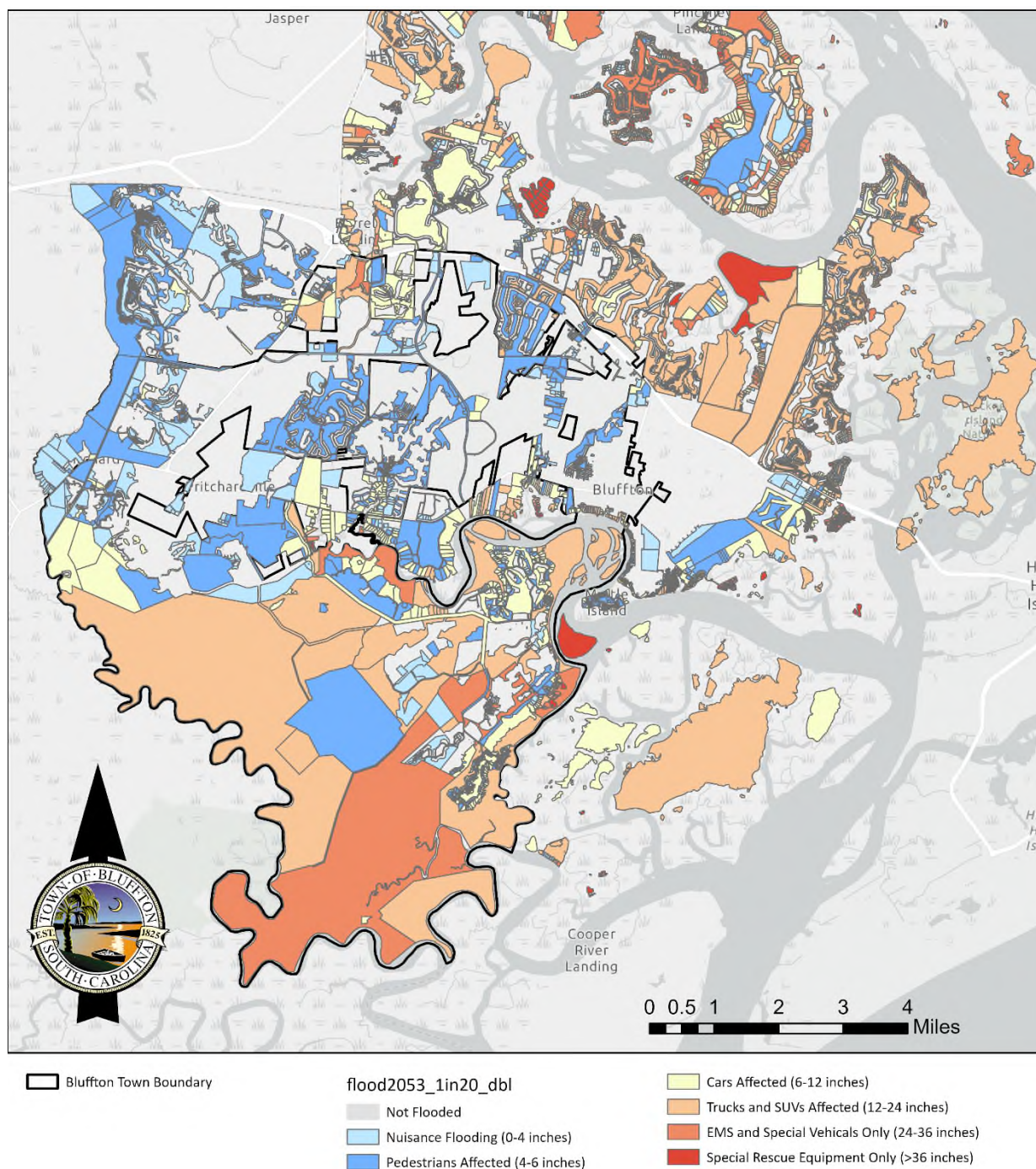


Figure 24: Current development parcel vulnerability to the 1-in-20-yr storm in 2053 conditions

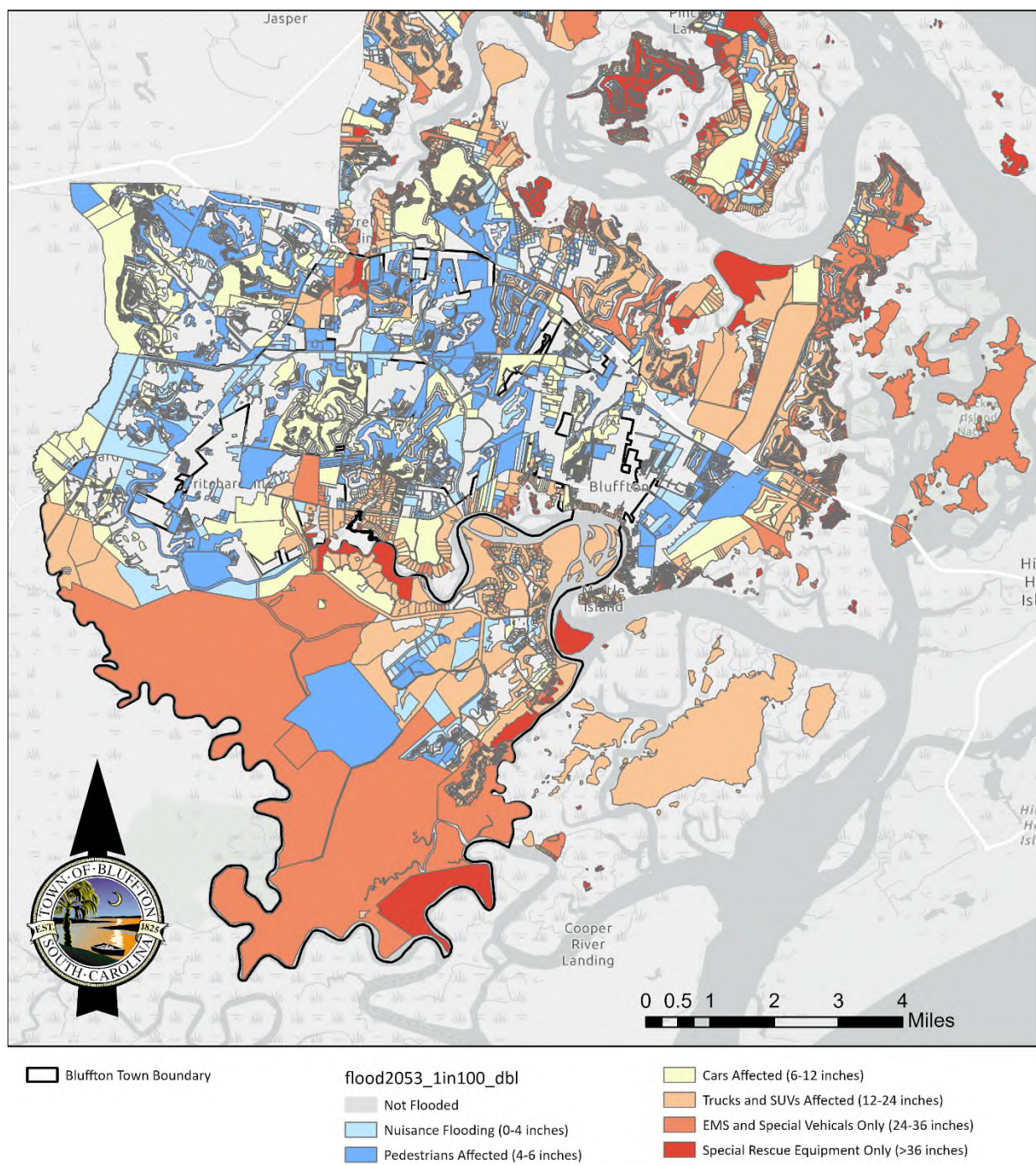


Figure 25: Current development parcel vulnerability to the 1-in-100-yr storm in 2053 conditions



Flood 2053 1-in-500-year

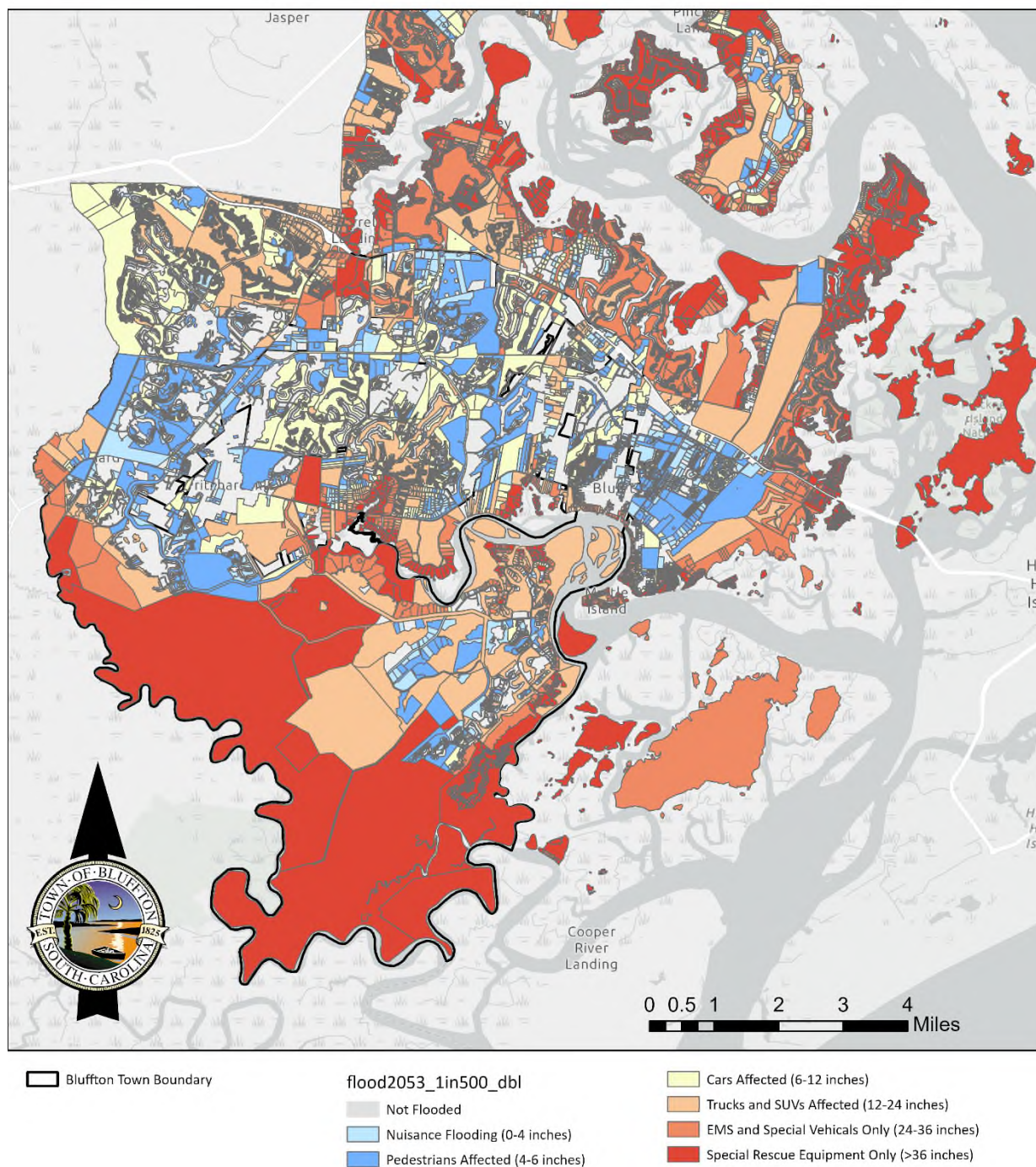


Figure 26: Current development parcel vulnerability to the 1-in-500-yr storm in 2053 conditions

Appendix B: Maximum Buildout Flood Vulnerability Results

This appendix contains results of the maximum buildout flood vulnerability analysis for each Planned Unit Development (PUD) considered within this study. Results are displayed as number of buildout parcels which are touched by flood waters in each of the model scenarios for each study year (2023, 2053).

Please note: the vertical scale bar displaying number of parcels has a different range for each chart, with Schultz Tract and Village at Verdier in hundreds of parcels versus thousands for the other PUDs in this study.

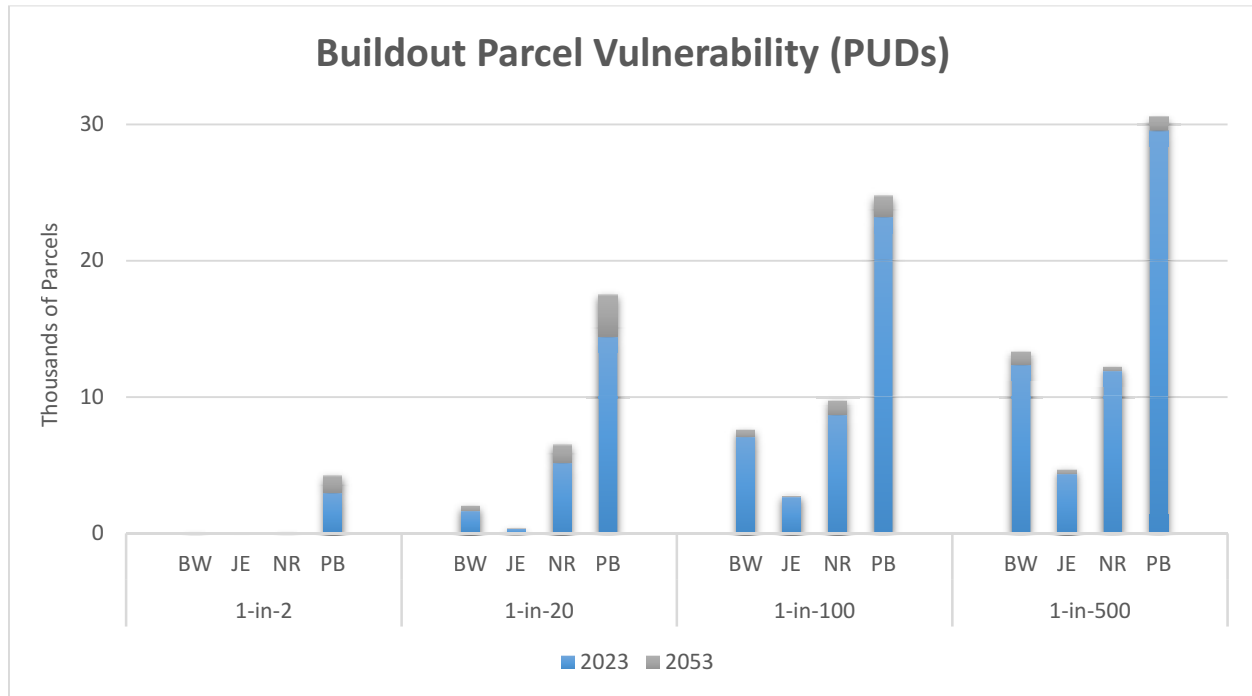


Figure 27: Vulnerable buildout parcels (thousands) for each flood scenario with year 2053 flood conditions shown in addition to year 2023 flood conditions (larger PUDs shown). BW = Buckwalter, JE = Jones Estate, NR = New Riverside, PB = Palmetto Bluff

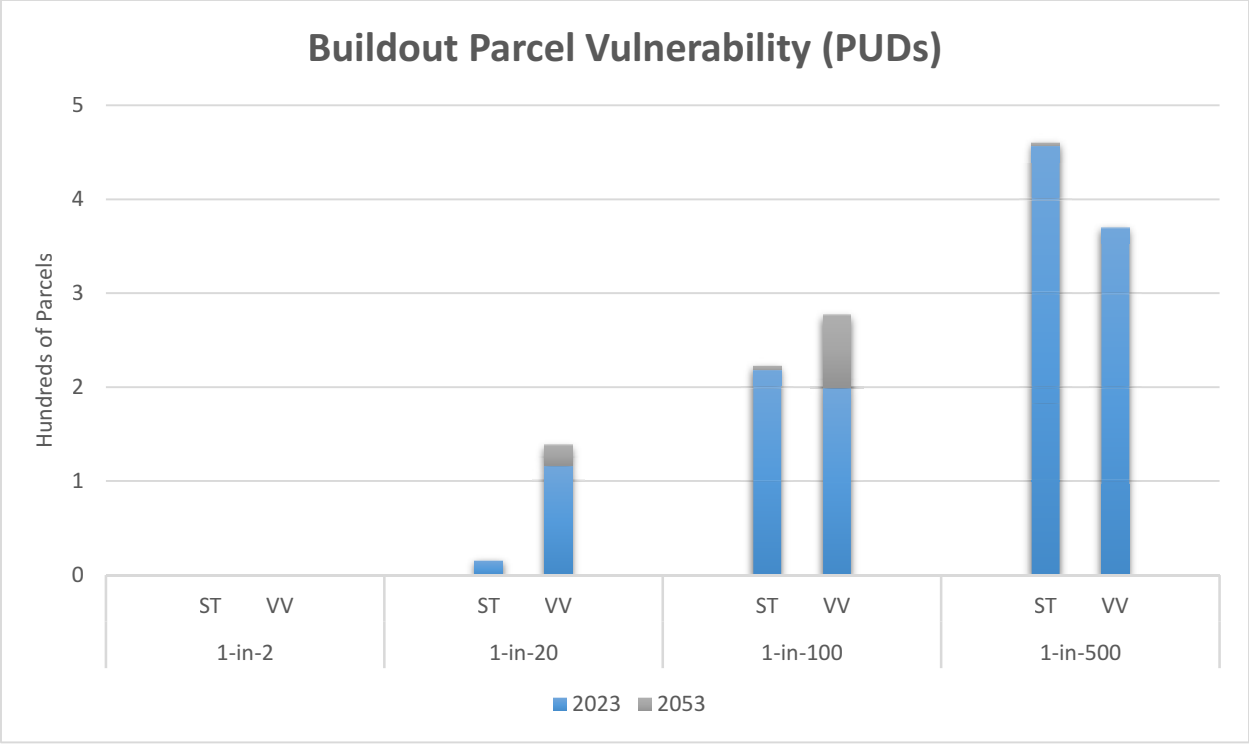


Figure 28: Vulnerable buildout parcels (hundreds) for each flood scenario with year 2053 flood conditions shown in addition to year 2023 flood conditions (smaller PUDs shown). ST = Schultz Tract, VV = Village at Verdier

Appendix C: Forested Wetlands Analysis Results

This appendix contains results of the forested wetlands analysis for each Planned Unit Development (PUD) considered within this study. Results are displayed as number of buildout parcels which are touched by flood waters in each of the model scenarios for each study year (2023, 2053).

Please note: the vertical scale bar displaying number of parcels has a different range for each PUD so that the full range of data can be best visualized for each figure. A major point of difference is that the vertical scales for Schultz Tract and Village at Verdier are in hundreds of parcels versus thousands for the other PUDs in this study.

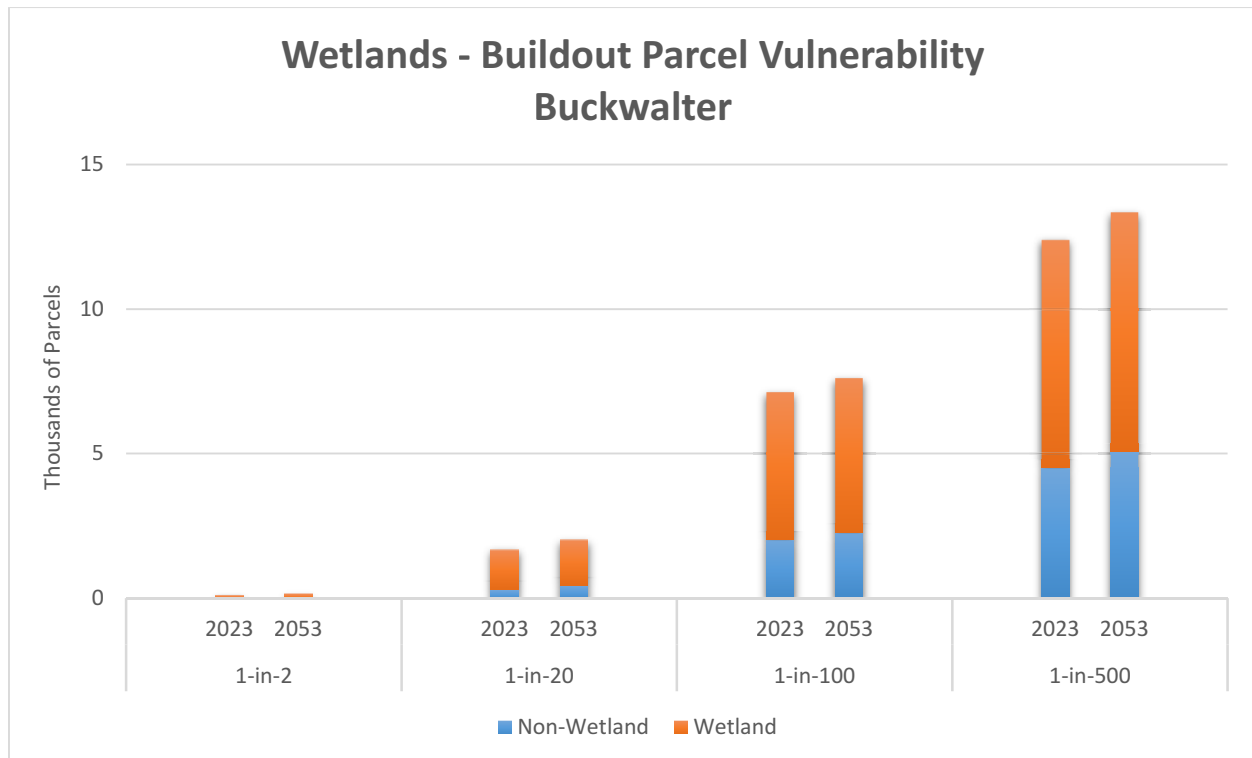


Figure 29: Vulnerable Buckwalter buildout parcels (thousands) for each flood scenario and each study year with parcels within freshwater wetlands (orange) shown in addition to those outside of those wetlands (blue)

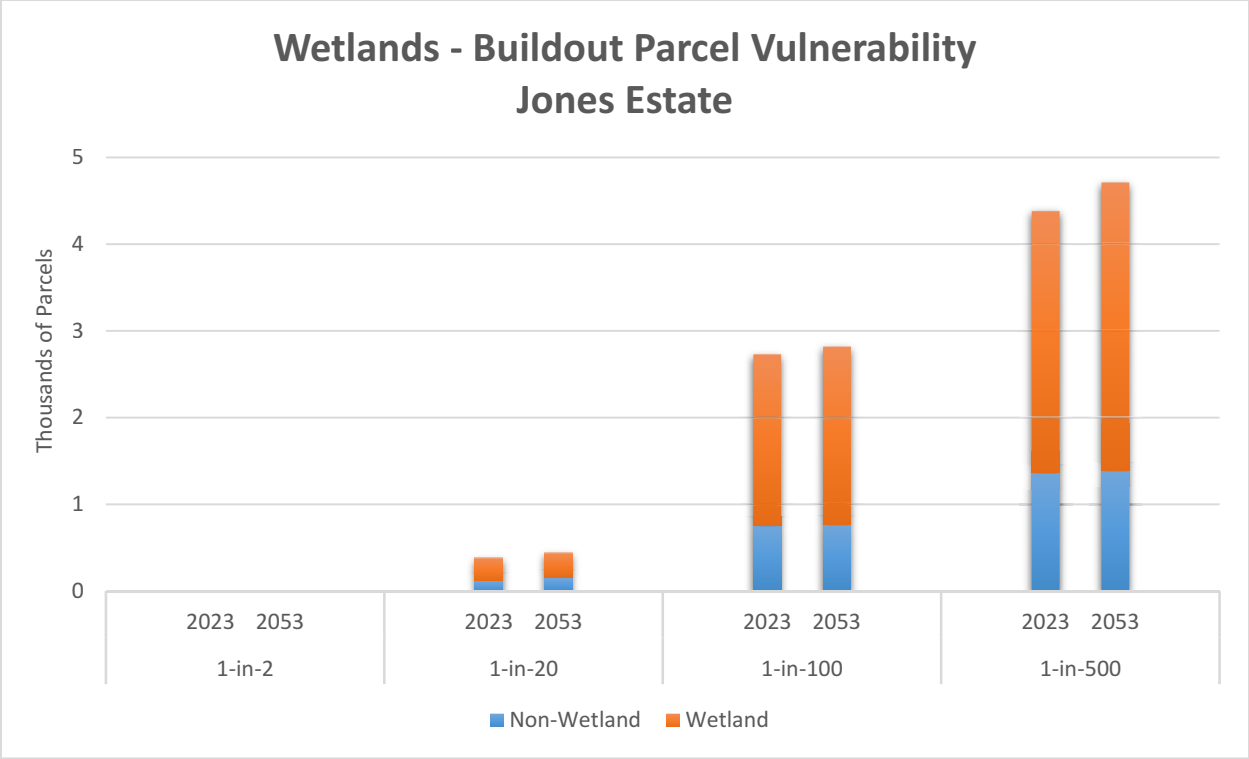


Figure 30: Vulnerable Jones Estate buildout parcels (thousands) for each flood scenario and each study year with parcels within freshwater wetlands (orange) shown in addition to those outside of those wetlands (blue)

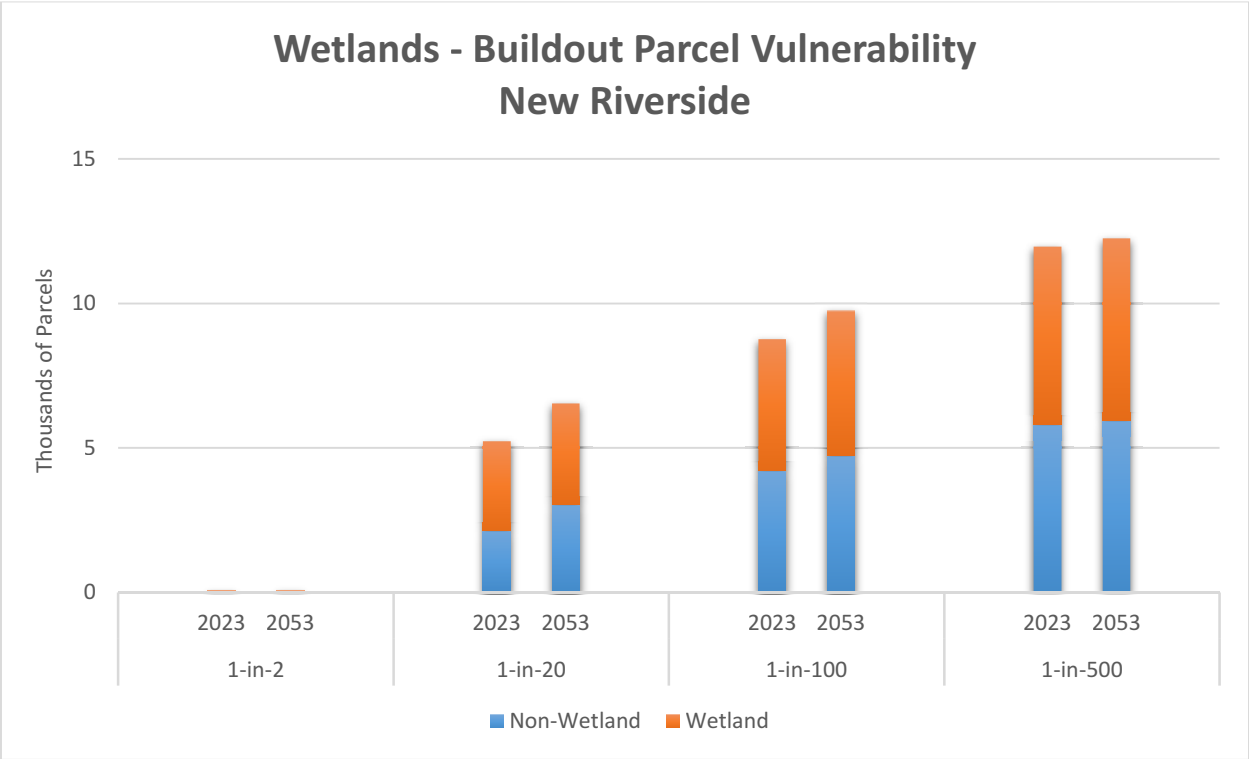


Figure 31: Vulnerable New Riverside buildout parcels (thousands) for each flood scenario and each study year with parcels within freshwater wetlands (orange) shown in addition to those outside of those wetlands (blue)

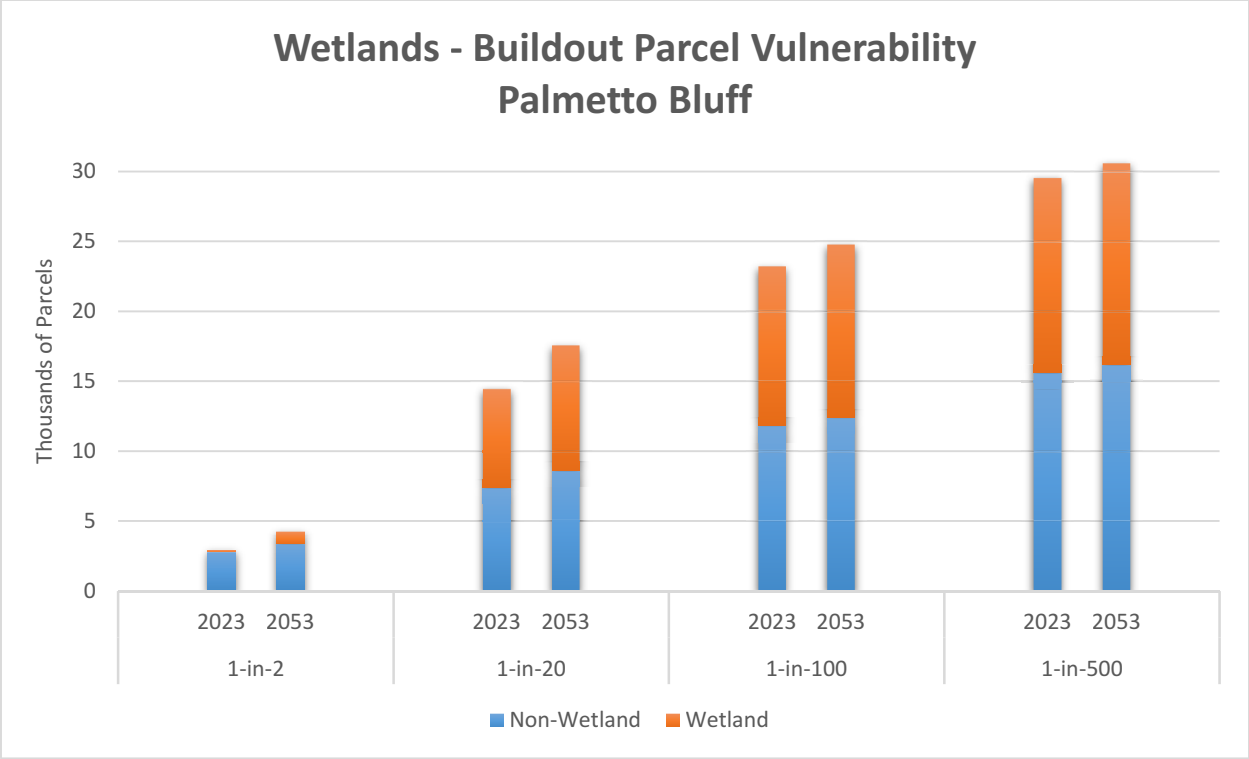


Figure 32: Vulnerable Palmetto Bluff buildout parcels (thousands) for each flood scenario and each study year with parcels within freshwater wetlands (orange) shown in addition to those outside of those wetlands (blue)

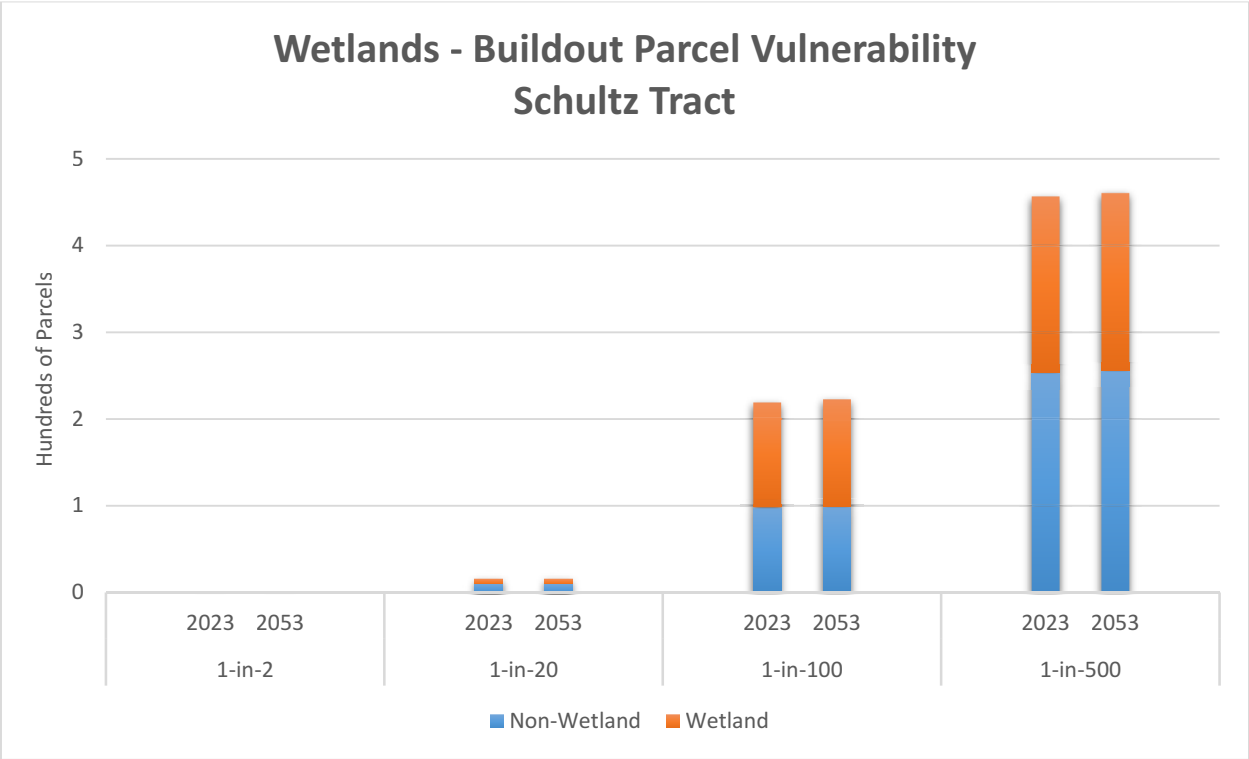


Figure 33: Vulnerable Schultz Tract buildout parcels (hundreds) for each flood scenario and each study year with parcels within freshwater wetlands (orange) shown in addition to those outside of those wetlands (blue)

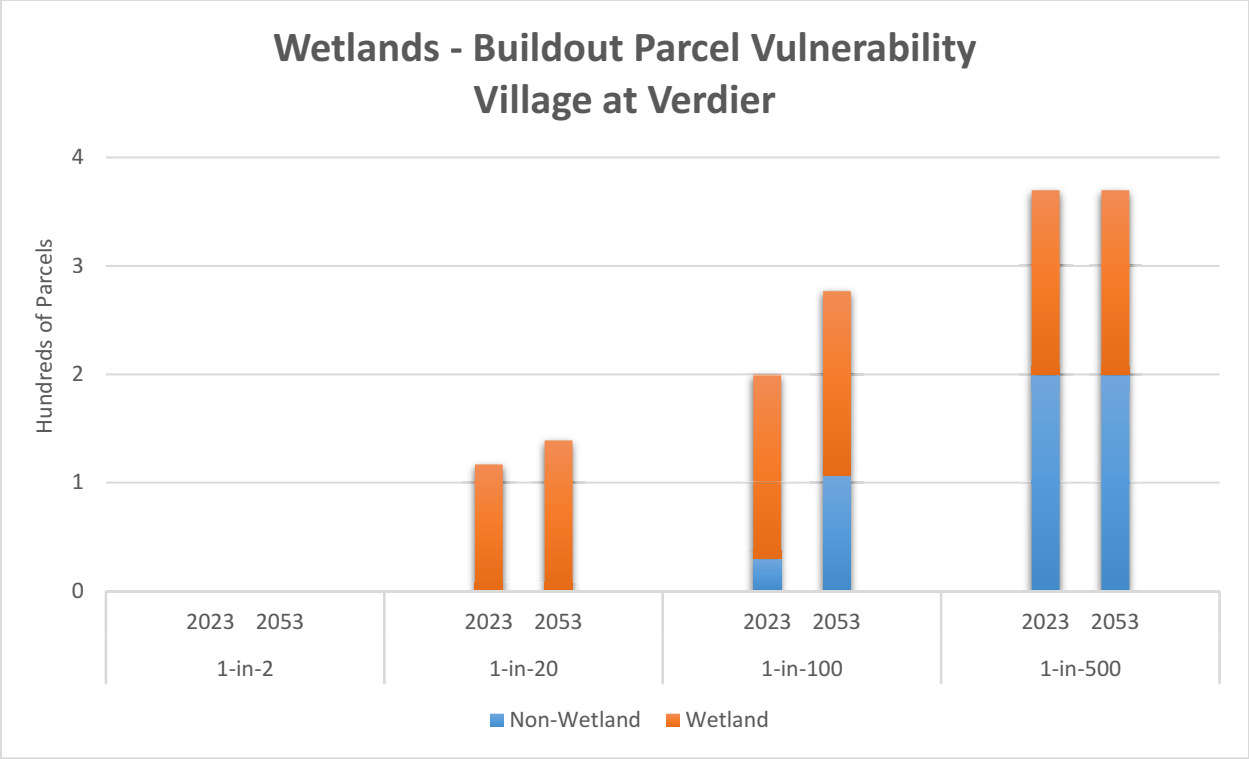


Figure 34: Vulnerable Village at Verdier buildout parcels (hundreds) for each flood scenario and each study year with parcels within freshwater wetlands (orange) shown in addition to those outside of those wetlands (blue)

Appendix D: Elevation Analysis Results

This appendix contains the results of the elevation analysis for each Planned Unit Development (PUD) considered within this study. Results are displayed as number of buildout parcels which are touched by flood waters in each of the model scenarios for each study year (2023, 2053).

Please note: the vertical scale bar displaying number of parcels has a different range for each PUD so that the full range of data can be best visualized for each figure. A major point of difference is that the vertical scales for Schultz Tract and Village at Verdier are in hundreds of parcels versus thousands for the other PUDs in this study.

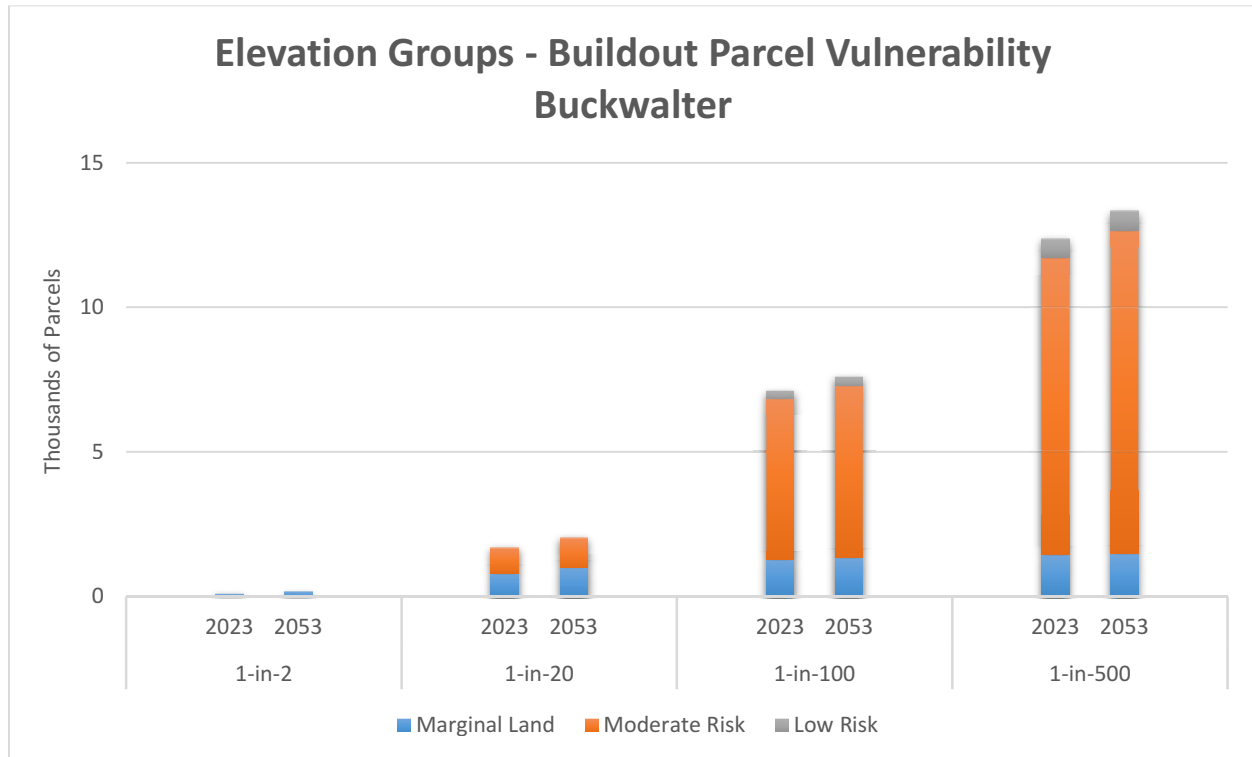


Figure 35: Vulnerable Buckwalter buildout parcels (thousands) for each flood scenario and each study year with parcels from each elevation group that are touched by that flood condition shown

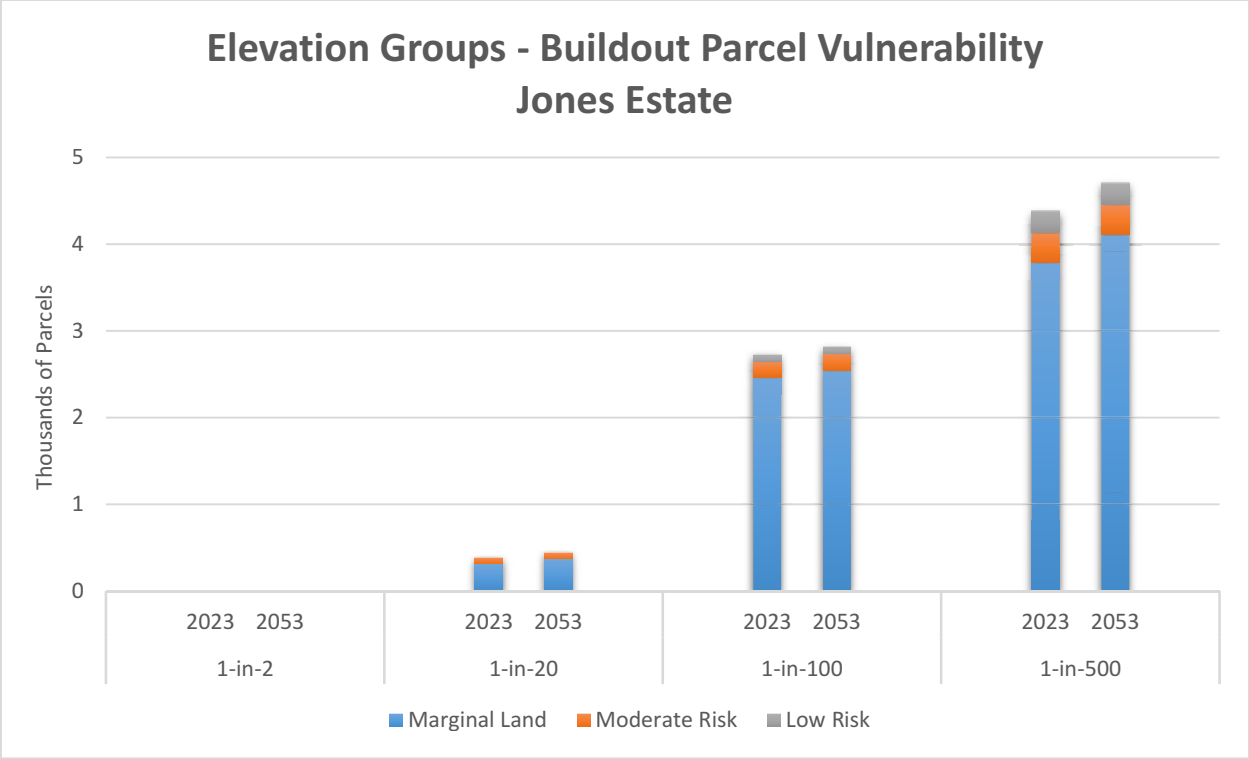


Figure 36: Vulnerable Jones Estate buildout parcels (thousands) for each flood scenario and each study year with parcels from each elevation group that are touched by that flood condition shown

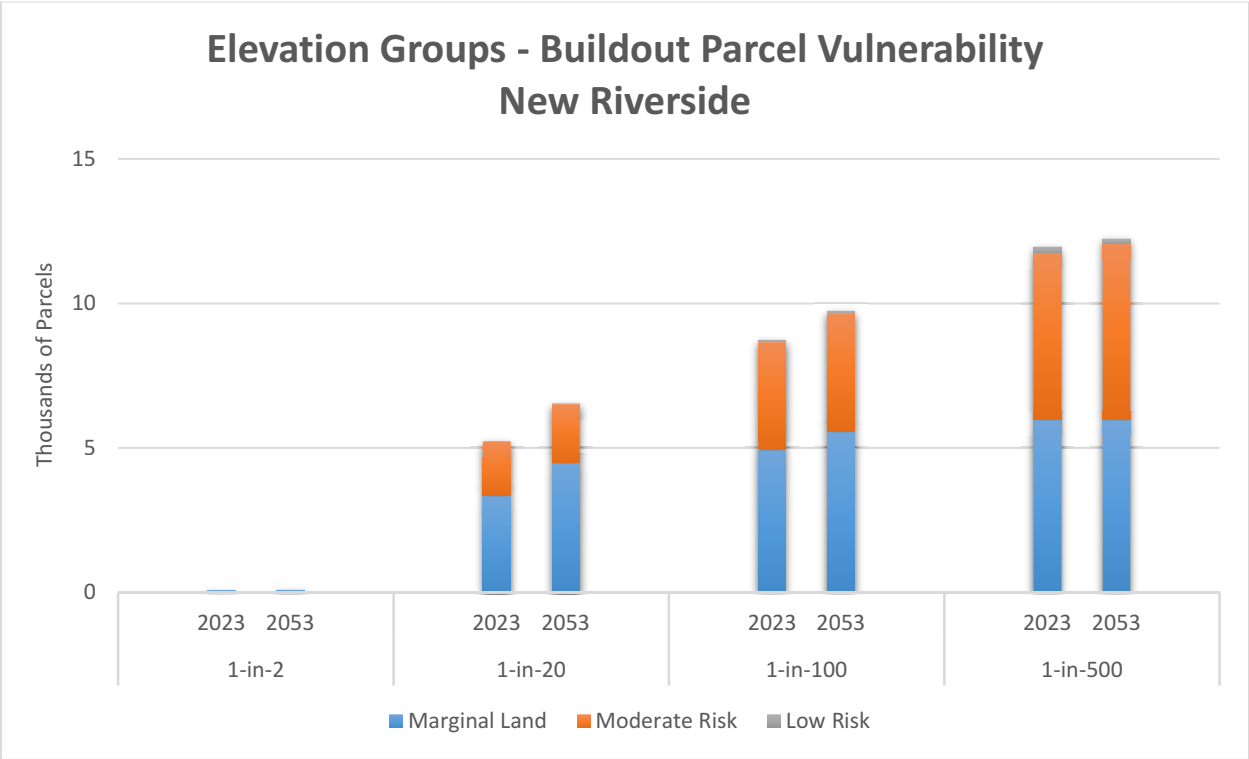


Figure 37: Vulnerable New Riverside buildout parcels (thousands) for each flood scenario and each study year with parcels from each elevation group that are touched by that flood condition shown

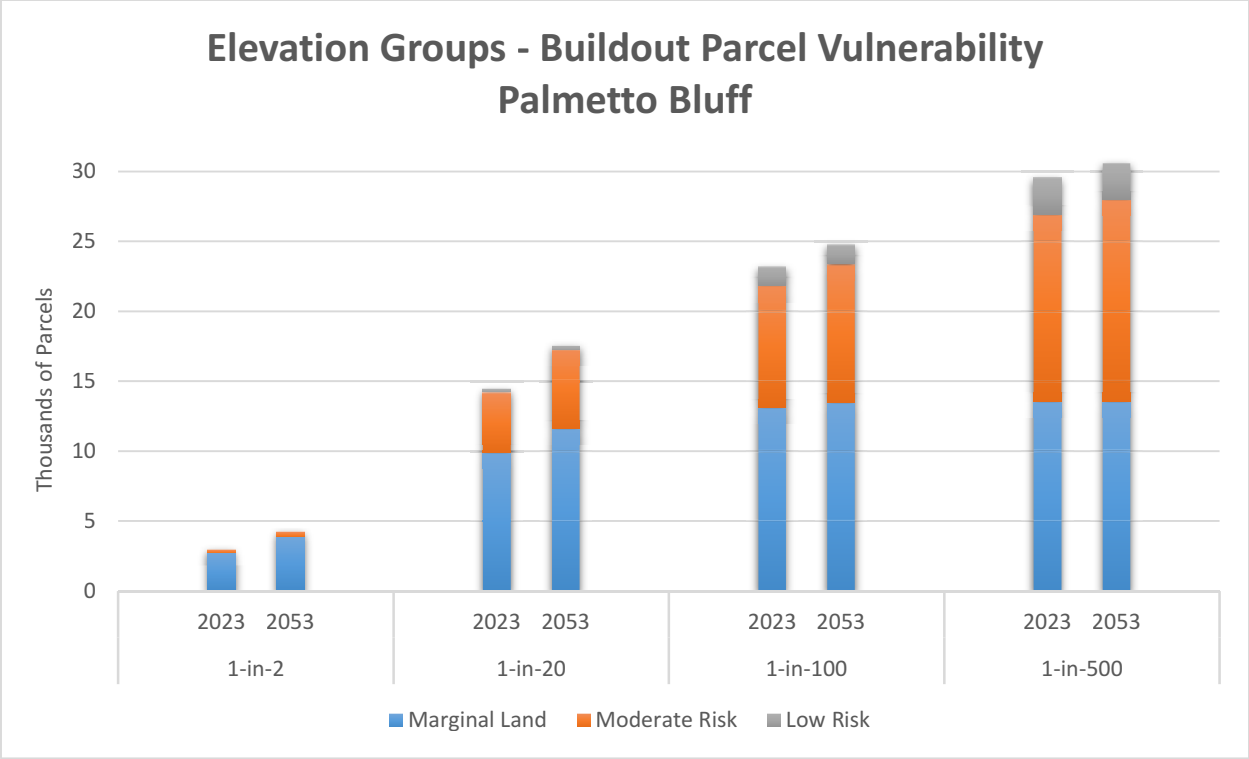


Figure 38: Vulnerable Palmetto Bluff buildout parcels (thousands) for each flood scenario and each study year with parcels from each elevation group that are touched by that flood condition shown

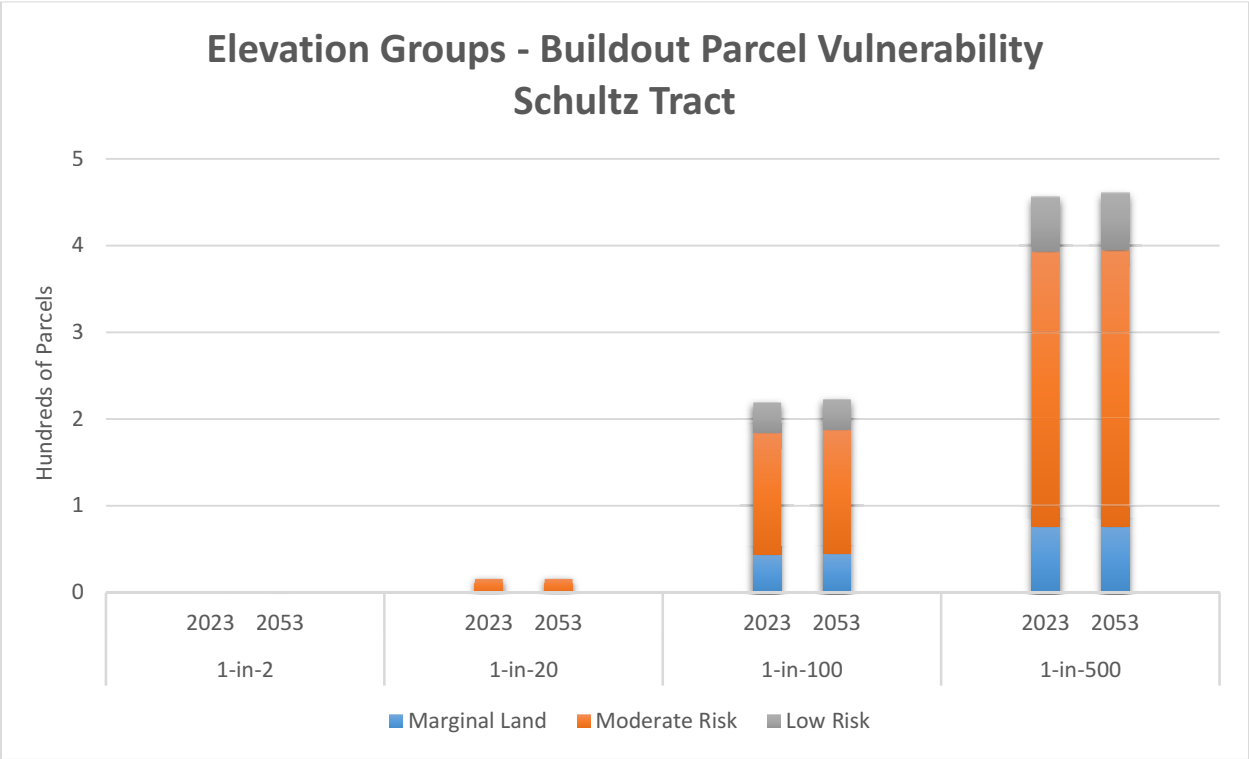


Figure 39: Vulnerable Schultz Tract buildout parcels (hundreds) for each flood scenario and each study year with parcels from each elevation group that are touched by that flood condition shown

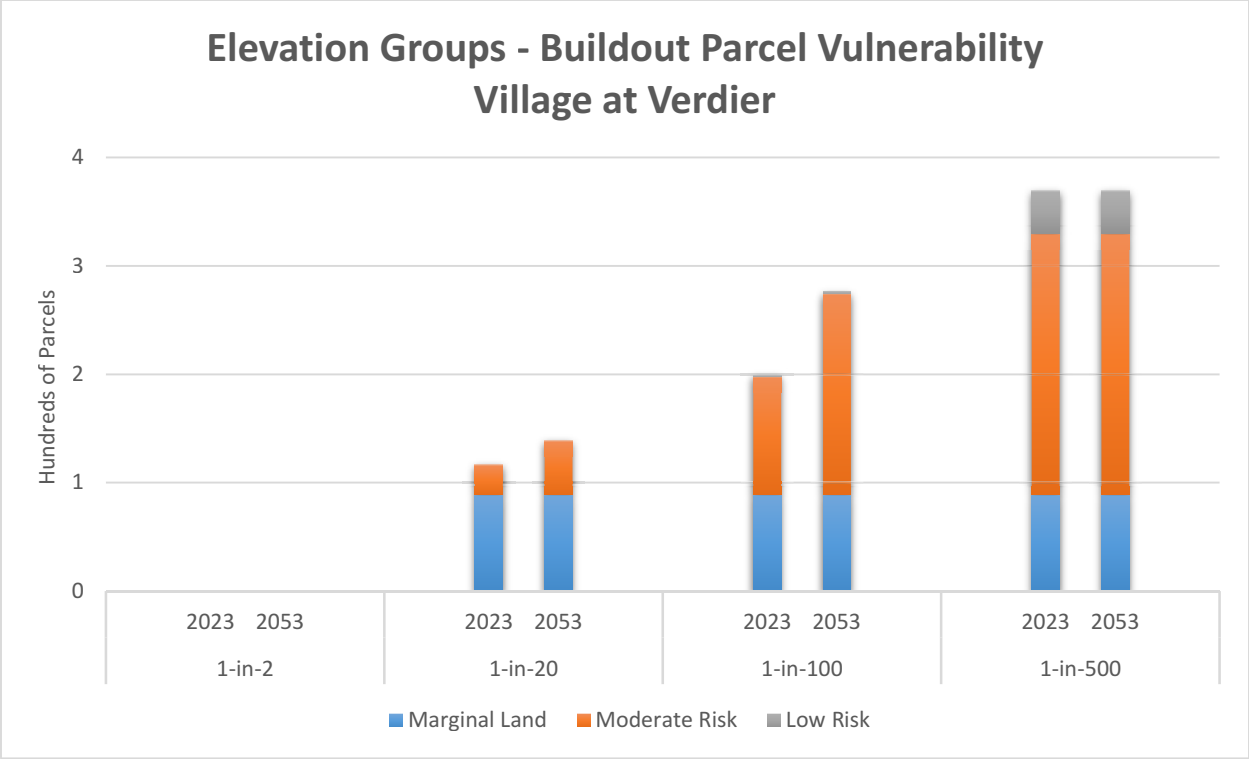


Figure 40: Vulnerable Village at Verdier buildout parcels (hundreds) for each flood scenario and each study year with parcels from each elevation group that are touched by that flood condition shown

Appendix E: Mapping and Modeling Methods

Vulnerability Mapping

Digital Elevation Models (DEMs) and Digital Surface Models (DSMs) were created for the full study area (see Appendix F). The DEM represents the most accurate and up to date geomorphological representation of Bluffton and surrounding HUC-12 boundaries. A contextual analysis was additionally performed using NLCD (National Land Cover Database) data from 2001 and 2024 to analyze changing development conditions.

The flooding data selected for this analysis was the First Street Foundation flood dataset obtained via use agreement from the South Carolina Office of Resilience (SCOR). Provided by this state agency, the dataset is regarded as an authoritative model for flood risks in the region, having been used for the state's Strategic Statewide Resilience and Risk Reduction Plan. Its credibility as a vetted source helps to minimize potential disputes related to flood mapping. To determine the mean flood depth per parcel to understand what areas of Bluffton had the most susceptibility to inundation, zonal statistics were applied to SCOR First Street flood data. This data includes scenarios for 1-in-2-, 1-in-20-, 1-in-100-, and 1-in-500-year flooding for the years of 2023 and 2053, resulting in comparison of current and future conditions.

Current Development Flood Vulnerability

Parcel-based flood depth analysis for Bluffton highlights areas most susceptible to flooding, both now and under future projections. Using zonal statistics with flood data and Bluffton parcel data, mean flood depths per parcel were calculated across flood scenarios of 1-in-2-, 1-in-20-, 1-in-100-, and 1-in-500-year flooding for 2023 and 2053. Flood depths were categorized based on the College of Charleston's Flood Disruption Scale, which describes flood disruption based on impacts to access the parcel. The lowest flooding hazard (0–4 inches of flood depth) represents nuisance flooding while the most extreme flooding (over 36 inches) indicates potentially life-threatening conditions that could necessitate emergency rescue. This classification offers a real-world understanding of the severity of projected flood depths, emphasizing that future conditions may require significant adaptation and planning to manage both everyday flooding and more extreme events. Tabular analyses were generated summarizing the extent of flooding across various land use categories obtained from Bluffton's GIS data. This dataset provides insights into Bluffton's current flood exposure and its expected increase under future climate conditions.

Maximum Buildout Flood Vulnerability

A buildout analysis was conducted to analyze the potential future flood vulnerability of Bluffton. The purpose of the buildout analysis was to simulate the subdivision of all developable parcels into their maximum development density in order to run future flood vulnerability models as well as if/then scenarios. Since it is impossible to forecast the exact location of future development, the analysis was run for all developable parcels regardless of the cap on maximum dwelling units. Maximum dwelling units refer to the highest number of individual residential units allowed to be built on a specific piece of land, as defined by Bluffton's zoning regulations. All of the development agreements have had residential development occur since the agreement was executed, so the number of remaining dwelling units for each development area was obtained from Bluffton as of December 2024. The number of remaining dwelling units (homes that have yet to

be built but are authorized in the agreement) were utilized to determine whether certain policy conditions would still allow the necessary development to occur within each Planned Unit Development (PUD).

To obtain maximum buildout conditions, the active PUD agreements within Bluffton's jurisdiction were obtained from Bluffton staff as well as the municipality's website. Maximum allowed density for single family residential units was obtained from each PUD agreement, which designates the smallest home lot size and therefore the maximum number of homes that are allowable per acre (e.g. 1/4-acre lot size = 4 homes per acre). Parcels coded as R/W (right of way) were first removed from the parcel database. Parcels within zoning categories of PUD (Planned Unit Development), AG (Agricultural), and RG (Residential General) were isolated for analysis, as those zoning districts have established maximum density of development standards either through Development Agreements or the Unified Development Ordinance (UDO). Only parcels equal to or greater than five (5) acres were included in the buildout analysis, as that is the standard size used for these analyses representing likely areas for subdivision. Next, the following National Wetlands Inventory (NWI) categories were grouped to represent either SC Department of Environmental Services Critical Area or open water inland systems and therefore unlikely to be subdivided for development: Estuarine and Marine Deepwater, Estuarine and Marine Wetland, Freshwater Pond, Lake, Riverine. The Erase tool was used to remove any parcels or segments of parcels which overlapped those features.

The remaining parcels were then subdivided based on the maximum allowed density obtained from the zoning documents (e.g. 8 dwelling units per acre = 1/8-acre subdivided parcels) resulting in buildout parcels. The water layer from the 2021 NOAA Coastal Change Analysis Program (C-CAP) land cover data was then isolated and any buildout parcels still overlapping water features were removed. Next, the buildout parcels were intersected with road network data and any areas of overlap were removed. This resulted in the maximum buildout for each of the development areas of Bluffton with maximum allowed densities established. The maximum buildout performed here produced far more parcels than what will be realized within Bluffton's boundaries; however, it demonstrates the locations of potential development. Next, the average depth of flooding for each flood scenario for the years 2023 and 2053 was assigned to each buildout parcel using the zonal statistics tool. An additional analysis was conducted to determine buildout parcels with and without any level flooding.

To calculate potential damage if every parcel were developed, there first needed to be a home value assigned to each of the buildout parcels. This home value was assigned by downloading the U.S. Census Bureau 2021 American Community Survey (ACS) 5-year Block Group Dataset for the area and assigning the average home value for each Block Group to the buildout parcel contained within it. A Jupyter Notebook was then written to recreate depth-damage-curves from the USACE Economic Guidance Memorandum (EGM) 04-01, Generic Depth-Damage Relationships for Residential Structures with Basements. These curves assign a generalized percentage of damage which would result from different depths of flooding depending on the size and type of the home, which is based on actual losses from flood events. Since the development in this analysis is theoretical and it is unknown the size of these future buildings, the damage

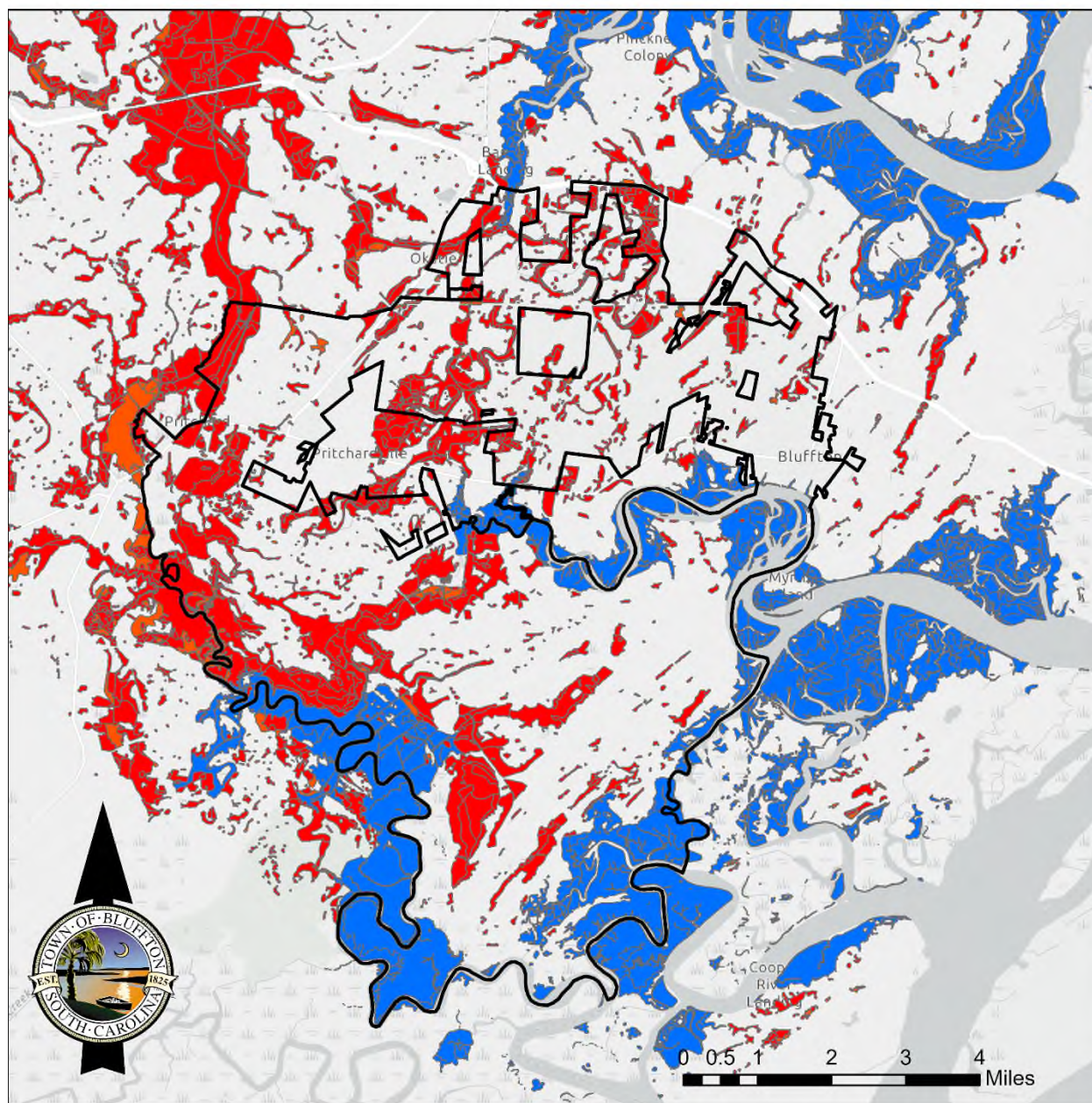
functions for 1-story and 2 or more story structures without basements were averaged to result in a single depth-damage-curve for the study area. This methodology assumes half of the future structure will be 1-story structures and half will be 2 or more stories. It also assumes that all homes are slab on grade. A USACE Chief of Economics confirmed the validity of this application. Potential flood damage for each scenario was then calculated by multiplying the average flood depth by the depth-damage-curve for each buildout parcel.

Forested Wetlands Analysis

An analysis was conducted to determine the potential vulnerability reduction resulting from limiting future development within wetland areas that are no longer protected because of the *Sackett* decision. The buildout parcels from the Maximum Buildout Flood Vulnerability analysis were overlaid with the following NWI categories representing freshwater wetlands: Freshwater Emergent Wetland, Freshwater Forested/Shrub Wetlands (Figure 41). The total damages for each scenario were calculated for the buildout parcels overlaying those wetland features demonstrating the potential damages reduced by limiting future development in these areas.



Bluffton National Wetlands Inventory (NWI)



Bluffton Town Boundary

Bluffton NWI Delineation

Wetland Type

- Estuarine and Marine Wetland
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland

Figure 41: National Wetlands Inventory (NWI) categories within and surrounding the Town of Bluffton

Elevation Analysis

An additional analysis was conducted to determine the potential vulnerability reduction resulting from prioritizing development in upland zones within each development area. The average elevation was first calculated for each of the buildout parcels by using the zonal statistics tool on the DEM created in prior steps. Next, the mean and standard deviation of elevations within each development zone (e.g. individual PUDs, AG, or RG) were calculated with buildout parcels assigned to categories of low, moderate, or high elevation. Low elevation parcels were defined as those with an elevation of more than one standard deviation less than the mean, moderate elevation parcels had an elevation within one standard deviation +/- of the mean, and high elevation parcels had an elevation greater than one standard deviation higher than the mean. These zones were labeled Marginal Land for low elevation, Moderate Risk for moderate elevation, and Low Risk for high elevation (Figures 42 and 43). The total damages for each scenario were then calculated for the buildout parcels in each elevation category within each development zone.



Elevation Zones

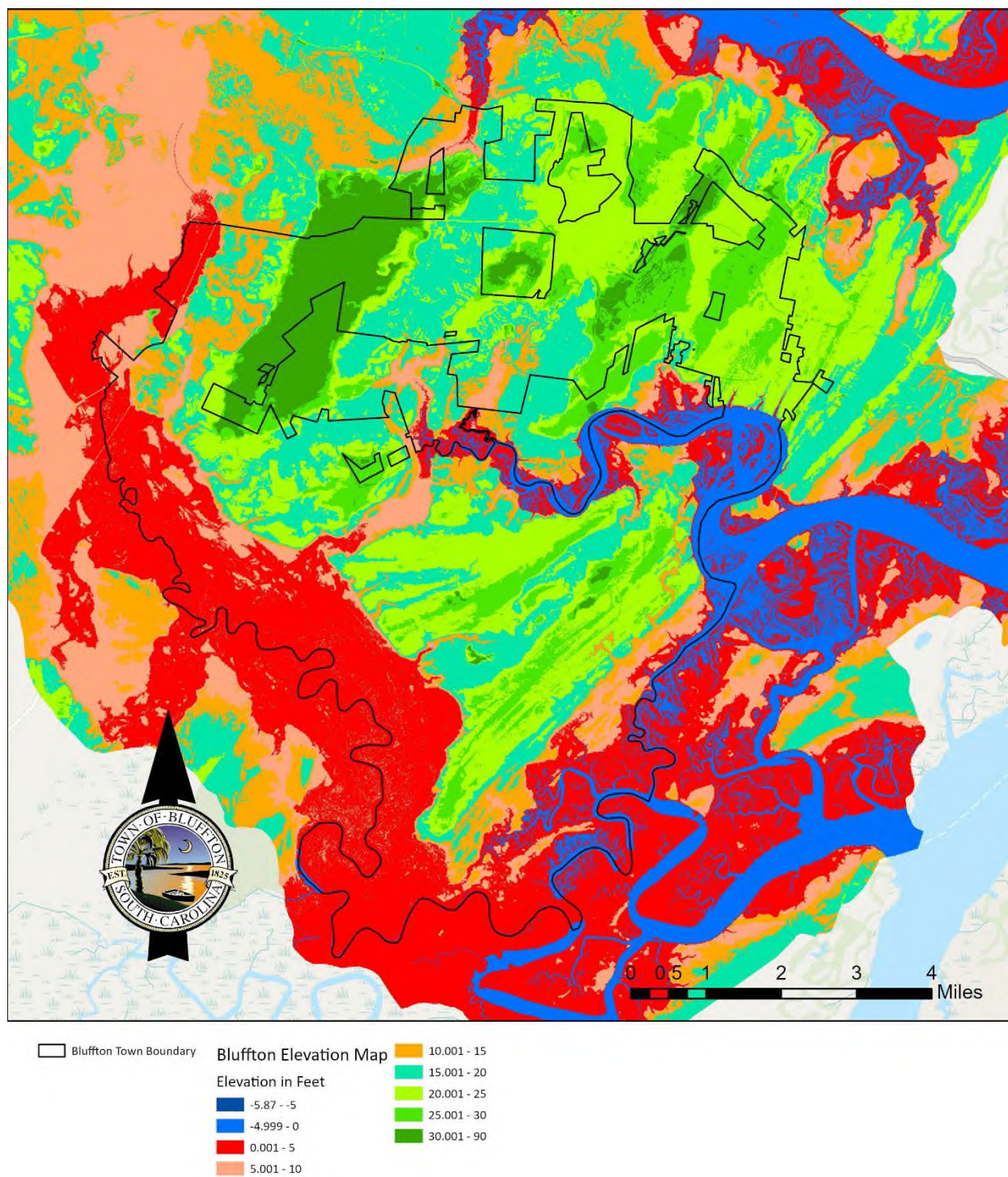


Figure 42: Elevations within and surrounding Bluffton



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Bluffton Elevation Group

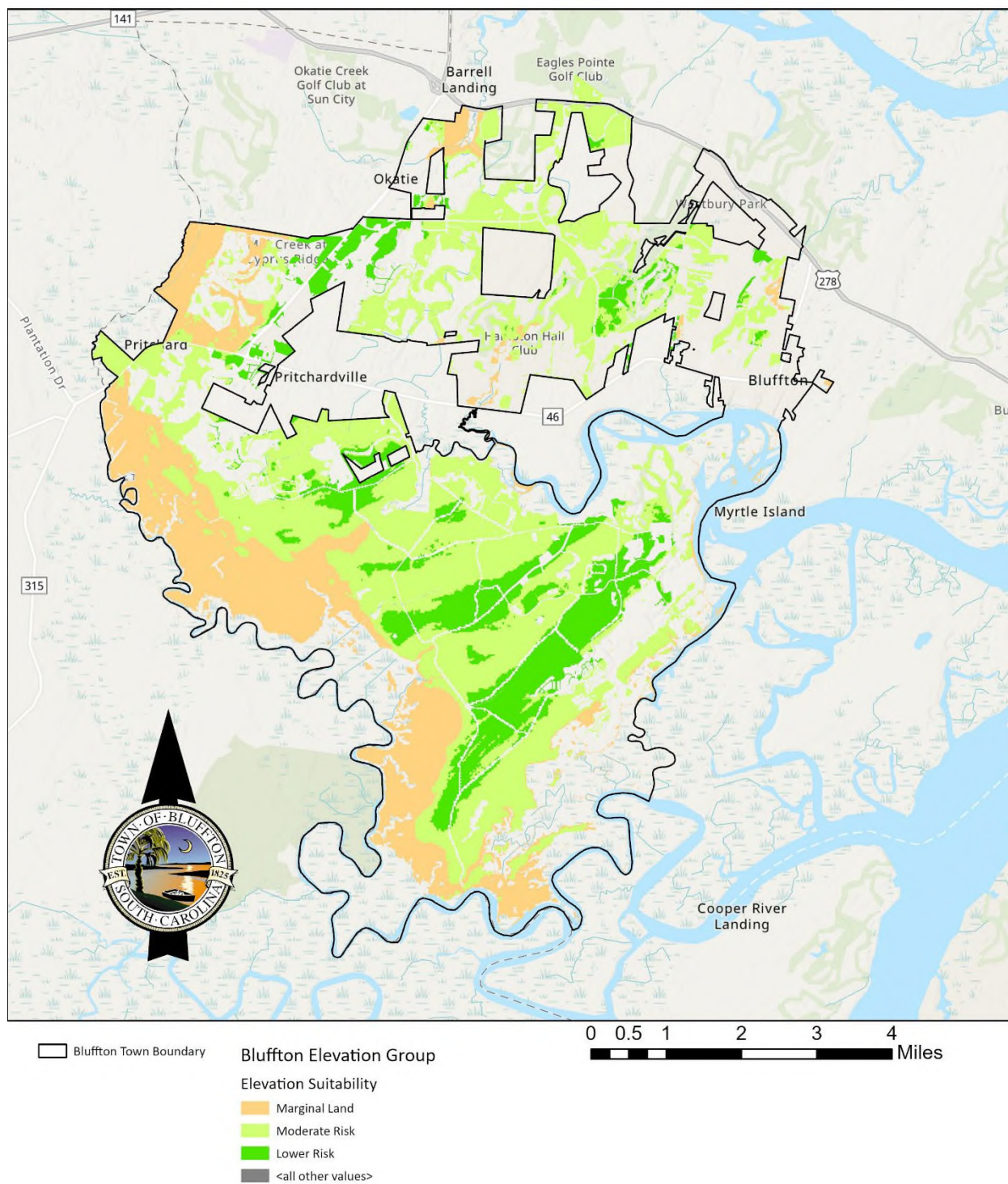


Figure 43: Elevation groups generated for buildout analysis

Appendix F: Digital Elevation Models (DEMs) and Digital Surface Models (DSMs)

DSMs, including an all-points DSM, upper story DSM, mid-story DSM, and lower story DSM were produced. Simultaneously, the generation of DEMs such as the Last Return DEM, Ground Return DEM, was created to capture current terrain characteristics precisely (Tanim et al., 2023). LiDAR data was accessed from South Carolina LiDAR Data Access. Desired data was obtained by selecting Beaufort County and navigating to Data Access, NOAA LAS Bulk Download. This dataset included data for the entire state of SC. Data for Bluffton was downloaded from Block 6, based on information provided by the 2020 USGS Lidar: Savannah Pee Dee, SC website. After downloading the LiDAR data files, they were extracted and converted to LAS format for usability. The resolution is 2 points per square meter, with a 0.71-meter nominal point spacing.

The Geoprocessing Tool used to create the DEM and DSM from the las data points was the LAS Dataset to Raster tool. Due to the flat topography and nature of LAS data, the chosen interpolation type of Binning, cell assignment of Inverse Distance Weighting (IDW), and Void Fill Method of Natural Neighbor was chosen. In order to achieve maximum resolution from the DEM and DSM raster, a sampling value of 2 was chosen, due to the data's 0.71-meter nominal point spacing, converted to feet and adjusted to minimize interpolation error.

Appendix G: Supplemental Information

What was the approximate time of the flooding

-Please select-

Please provide the location where flooding was seen*

• Enter an address to zoom to that property

• Click and drag to move the map and zoom in until the blue arrow is on the location here.

Find address or place

GA 25

US 17

US 17

SC 176

Map data © OpenStreetMap contributors, CC BY-SA

Powered by Esri

If you have a photo of the flooding you can upload it here

If you have a photo taken at approximately the place and time entered above, please upload it here.

Drop image here or select image

Optional second view

If you have another photo taken at approximately the same place and time, please upload it here.

Drop image here or select image

How deep do you think the water was?

Use the dropdown below

No water

Was the water moving or pooling?

Not moving (pooling)

Slowly moving

Quickly moving (Flowing)

Town of Bluffton Flood Observations

This form is for residents of the Town of Bluffton to document floods within Bluffton, SC. The data collected from residents will help researchers assist the town with understanding how flooding occurs and help improve scientific flood models. To report damage, please also fill out the Town's Damage Reporting Form.

Please use a new sheet for each flooding event you are documenting and note in the comments section any additional observations.

If you would like to fill out the survey or report damage electronically, please use this QR code: 

Please provide your name
(First Last - e.g. Jane Doe)

What was the date of the flooding event
Date Format: MM/DD/YYYY

What was the approximate time of the flooding

☐ Morning

☐ Midday

☐ Afternoon

☐ Evening

☐ Night

☐ All day

☐ Multiple days in a row

Please provide the location where flooding was seen
Enter an address, cross street, landmark, or other geographic specifier

How deep do you think the water was?

☐ No Water

☐ 0-4 inches

☐ 4-6 inches

☐ 6 inches to 1 foot

☐ 1-2 feet

☐ 2-3 feet

☐ Above 3 feet



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Figure 44: Online (left) Survey123 form and paper (right) form for community flood observations

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