Hurricane Impacts In Northwest Florida

Impact Analysis to Inform a Comprehensive Post-Disaster Redevelopment Strategy

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Haas Center
UNIVERSITY of WEST FLORIDA

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Introduction

In the wake of both Hurricane Irma and Hurricane Michael, the Economic Development Administration (EDA), part of the U.S. Department of Commerce, has awarded the Emerald Coast Regional Council (ECRC) financial assistance to develop a recovery plan for the West Florida Region following a major hurricane. The scope of this project includes determining what the economic impacts are after a hurricane hits, which sectors are the most vulnerable to serious devastation after a hurricane, how to mitigate disaster and catalyze recovery.

Figure A. Emerald Coast Regional Council covers seven Northwest Florida counties: Escambia, Santa Rosa, Okaloosa, Walton, Bay, Washington, and Holmes.

To promote a faster recovery time for the communities within the region, this project must be able to identify methods to take preemptive measures before a hurricane makes landfall. In order to create a comprehensive hurricane recovery plan, ECRC must be able to forecast to what extent and where negative impacts are most likely to occur. As such, ECRC commissioned the Haas Center for the research and analysis portion of discovering the total economic impact of a major hurricane on the Northwest Florida Region.

The following provides determinants for the potential physical impacts and economic losses following a major hurricane. Considerations include physical damage to public, private and residential buildings and facilities, such as schools, apartment complexes and grocery stores. Additionally, the recovery time and ability for complete resurgence and revitalization in the economic activity and growth of regional communities are explored. Economic losses, including the loss of jobs and subsequent increase in local job loss and unemployment, as well as the interruptions to economic activity caused by the repair of necessary economic instruments such as the reconstruction of basic municipal infrastructure and commercial buildings, are explored.

Methodology

About the Hazus model

Hazus is a geographic information system (GIS model) made available by the Federal Emergency Management Agency (FEMA). Hazus incorporates peer-reviewed methodology to model the impacts for several types of natural disasters: flooding, hurricanes, coastal surges, tsunamis and earthquakes. Additionally, Hazus models predictors for damages and losses associated with natural disasters.[1]

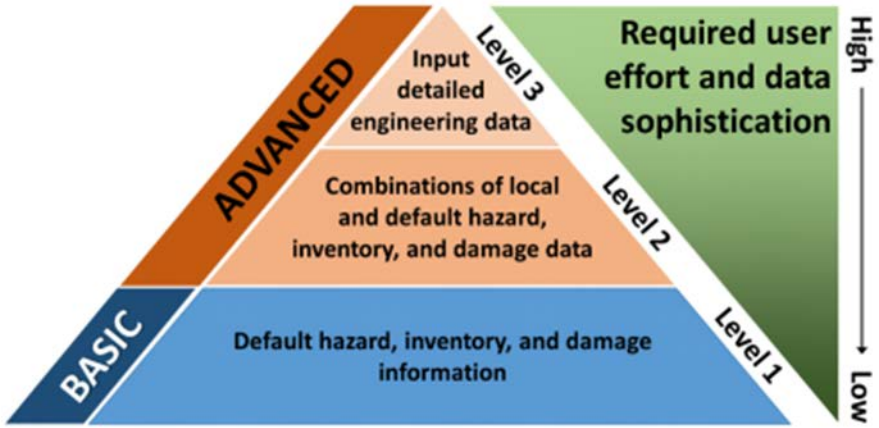


Figure B. The image shows the difference between the levels.
Source. FEMA

Hazus can provide different simulations using a combination of several factors and is an incredibly useful tool for disaster mitigation planning. The outcomes that Hazus provides can help researchers and mitigation planners determine possible economic losses, social impacts and likely physical damage as a result of a specified disaster. Once the model is created, a detailed report of estimated losses caused by a combination of the wind and flood loss is produced. Since Hazus is programmed with infrastructure and building data for the entire United States, models can estimate specific damage made to those structures. While Hazus is not programmed with every dataset that may help to accurately model a disaster, the program allows for the manual entry of data related to a region of interest. With greater manual data accuracy, the better the model can create an effective mitigation plan. The Hurricane model creates hazard data for the wind speed of a hurricane as well as storm surges that may result from a hurricane.

[1] Vickery, P. J., et al. "HAZUS-MH Hurricane Model Methodology. I: Hurricane Hazard, Terrain, and Wind Load Modeling." *NATURAL HAZARDS REVIEW*, no. 2, 2006, p. 82. *EBSCOhost*, search.ebscohost.com/login.aspx?direct=true&db=edsbl&AN=RN187561008&site=eds-live.

The default data provided by Hazus for all disaster types include seven separate data sets for inventory data: general building stock, essential facilities, high potential loss facilities, hazardous material facilities, transportation systems and demographics. The general building stock (GBS) includes residential, commercial, industrial, agricultural, religious, government and educational building types. Essential facilities refer to medical care facilities and hospitals, fire and police stations, emergency centers, schools and other facilities essential to the welfare of communities. High potential risk facilities include nuclear power plants, dams, levees, and military installations or any facility that would result in heavy losses if damaged. Hazardous material facilities refer to facilities that include the storage of corrosives, explosives, flammable materials, radioactive materials and toxins. Transportation systems encompass infrastructures relating to travel such as highways, bridges, tunnels, railways, ports and ferries and airports.

Appropriate model data is different for each type of hazard. The types of results gathered by the finished model can be filtered by building type or damage type. FEMA has written materials that are designed to give mitigation ideas to Hazus modelers that would help in the prevention of major damage caused by several types of natural hazards.

Once loss estimations are obtained, there are two types of scenarios that Hazus can filter the results through – deterministic and probabilistic. A deterministic scenario considers the impact of a single-risk scenario, while a Probabilistic scenario considers the associated impacts of many thousand potential storms that have tracks and intensities reflecting the full spectrum of Atlantic or Central Pacific hurricanes. The hurricane-related hazards considered in the Hurricane Model include estimates of casualties, damages and losses. Resultant wind losses are comprised of wind pressure, wind-borne debris missiles, tree blowdown and rainfall. The effects of storm duration are also included in the model by accumulating damage over the life of each storm. Coastal storm surge is only incorporated in the deterministic model.

Deterministic scenarios are run with a reliance on historical data as well as scientific data, such as the laws of physics or similarly relevant sets of factual data. Deterministic modeling in Hazus analyzes a single scenario with no variables and allows the user to observe the resulting event. It does not consider the full range of possible scenarios or give the likelihood of the outcomes given by the event. Deterministic approaches are best used when evacuation and mitigation plans are being developed for specific events, whereas probabilistic approaches are more appropriate to model the possible outcomes of an event which has not yet happened to the area of interest.

Probabilistic scenarios develop average yearly losses, expected loss distribution, and considers variables as well as relevant sets of factual data. Probabilistic scenarios allow Hazus users to evaluate the statistical likelihood that an event will occur and the impacts that would result from the event. It considers the full range of possible scenarios and

gives the likelihood of each outcome, based on the known data and the unknown variables, as well as both historical and scientific data.

Probabilistic scenarios utilize a return period, also known as a recurrence interval or repeat interval, is an average time or an estimated average time between events such as hurricanes, earthquakes, floods, landslides, or a river discharge flows to occur. The most common misconception is that a 100-year event will only occur once per century, but that is not true. There is a small probability that such an intense event could occur every year. If a 100-year event happened last year, it can happen again before the next century, or even this year. It is also possible for such an event to not occur within a 100-year period. As illustrated by the Global Facility for Disaster Reduction and Recovery (GFDRR), the city of Houston, Texas, USA, has experienced 500-year floods three years in a row, including one caused by Hurricane Harvey. This prompted a revision of the city's zoning regulations to account for changes in the flood drainage basins around Houston and provides an apt example as to how to evaluate probabilistic scenarios.

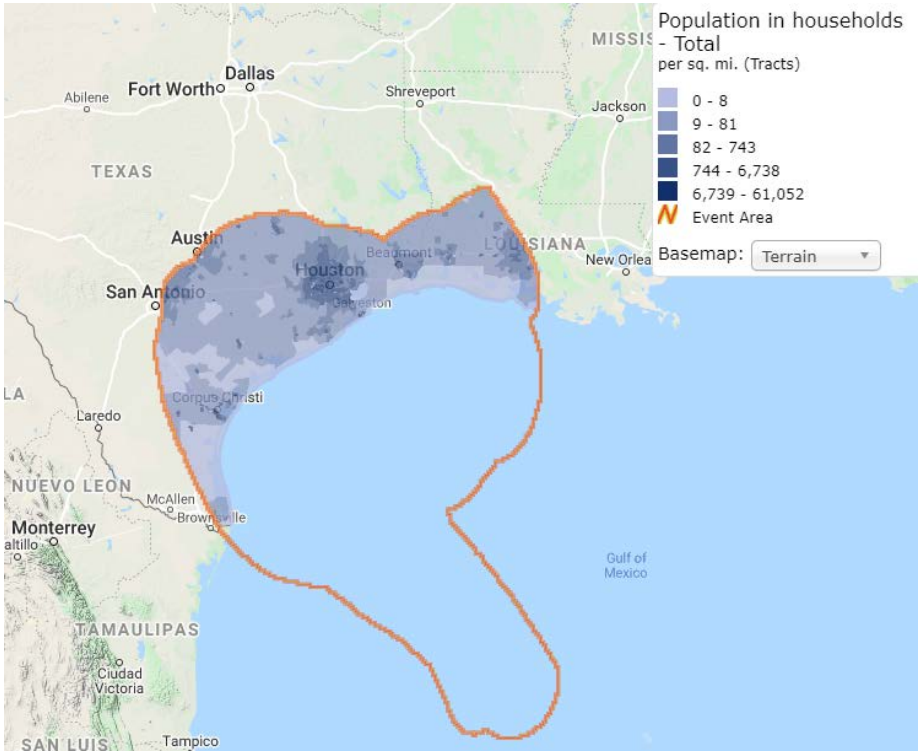


Figure C. Hurricane Harvey's Path and Population Impacted

Source. U.S. Census Bureau, Center for Economic Studies, LEHD (OnTheMap for Emergency Management)

Economic Impact Model and Assumptions.

REMI (Regional Economic Models Inc.), Policy Insight is probably the most widely applied regional economic policy analysis model. Uses of the model to predict the regional economic and demographic effects of policies cover a range of issues. The model is used by government agencies on the national, state, and local level, as well as by private consulting firms, utilities, and universities.

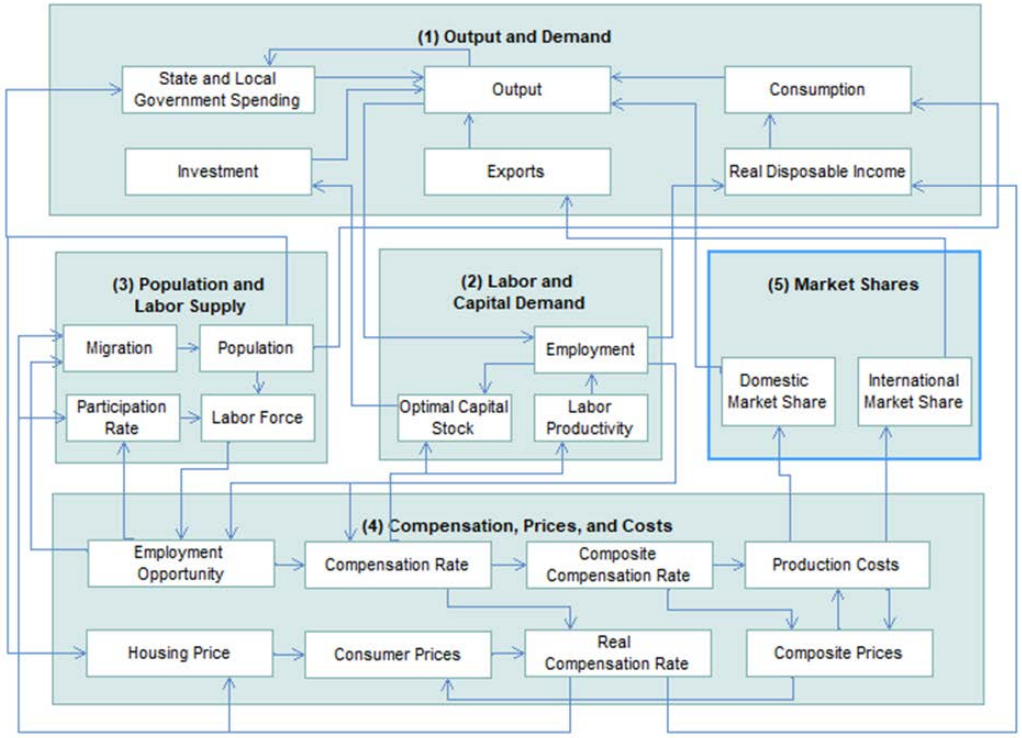


Figure D. REMI Model Linkages

Econometric simulation models combine the sector detail and geography detail of input/output models but provide for functioning economic linkages between sectors and regions over time. The current study utilizes REMI PI+ Version 2.3.1 in a 67-county Florida, 23-sector econometric model. It incorporates the basic input/output linkages, but also incorporates several econometrically estimated parameters. For example, interregional migration in response to changes in economic opportunities, in generating impact results. Due to these between-sector linkages, the model incorporates general equilibrium tendencies as the economy responds to shocks over time. That is, changes in spending in a region affect not just conditions in that market, but also in other markets within the region (economists term this phenomenon as "general equilibrium") and outside the region (trade and migration in response to changes in economic opportunities).

LITERATURE REVIEW

Results of REMI model analysis are reported in terms of employment, non-farm employment, population increases or decreases, labor force (population 16 years and older), Gross State Product (the value of all goods and services in the

economy), output (which can be thought of as sales), personal income (including wages, transfer payments, proprietor incomes, etc.) and disposable personal income (the net of personal income after taxes).

To date, published forecasts for economic impact analyses of natural disasters are sparse. However, Hazus is a broad disaster mitigation program and not specific to any one natural disaster. In an earthquake economic impact analysis performed by Kroll and Lu (2017)[2] analyses were performed through REMI with Hazus output. Among the indicators for economic impact were building damage, output losses, employment change, population change, government spending, government revenue sources and business costs. Additionally, economic forecasts were produced for the immediate future and longer terms (10 years, 20 years).

The state of Georgia released a five-year hazard mitigation plan that incorporated Hazus modeling into the state's current hazard mitigation plan.[3] Among the disaster scenarios investigated were hurricanes. However, detailed methodology, such as economic impact analysis specific to hurricane disaster mitigation, was not disclosed within Georgia's plan.

In contrast, the state of Texas Comptroller's Office performed an economic impact forecast to determine the future impacts of Hurricane Harvey on the regions where the storm made landfall.[4] Utilizing REMI, the analyses projected the economic impact following three years after the hurricane made landfall. Among assumptions that were built into the model included industry-specific inactivity, with weighting differentiation depending upon competition within the industry and logistics network location. For example, it was assumed that the hospitality industry could be excluded from productivity loss analyses due to an influx of evacuees. In total, it was projected that there would be a net gain of $800 million dollars to the economy over three years. However, when analyzing the economic impact of Hurricane Irma on Pinellas County, the hospitality industry was included in the estimated $56 million sales loss from the storm.[5]

[2] Kroll, Cynthia, and Lu, Bobby. "Estimating Economic Impacts of Multi-Hazards in USGS HayWired Scenario Using Remi PRELIMINARY RESULTS." ABAG and MTC REMI User's Conference, 25 October, 2017, Charleston, South Carolina. Conference Presentation.
[3] Georgia Emergency Management and Homeland Security Agency (GEMA/HS). *Georgia Hazard Mitigation Strategy Standard and Enhanced Plan Effective March 18, 2019 – March 17, 2024.* 2019, Print: https://gema.georgia.gov › document › publication › download
[4] Texas Comptroller of Public Accounts. *Fiscal Notes, A Review of the Texas Economy from the Office of Glenn Hagar, Texas Comptroller of Public Accounts.* "A Storm to Remember: Hurricane Harvey and the Texas Economy." February, 2018, Print: https://comptroller.texas.gov/economy/fiscal-notes/2018/special-edition/docs/fn.pdf
[5] Tampa Bay Regional Planning Council. "Regional Economic Impact Analysis Program Featuring REMI Policy Insight® and IMPLAN®." November, 2018. http://www.tbrpc.org/wp-content/uploads/2018/11/2018-Pinellas-County-Hurricane-Irma-Impact-Analysis.pdf

Also included in our review was a Hillsborough County, Florida economic impact forecast following category 3 and 5 hurricanes.[6] Although this study provided a comparatively more in-depth review of methodology (REMI along with the MEMPHIS model), overall literature reviews provided greater support for using Hazus in conjunction with REMI.

In a 2017 REMI webinar, Peter Evangelakis, Ph.D., presented an economic impact analysis of hurricanes in Hillsborough County (Tampa Bay, FL).[7] Five different hurricane components were assumed, using REMI for Hillsborough County in 2017: two-week economic shutdown (power outages, business closure); one year $10 billion loss and immediate capital stock restoration (structural damage); long-term insurance premium increases for both households and businesses (production costs), and long-term business and/or population decreases (migration).

Hurricane Impact

4 Main Stages

1. Baseline (GDP level before the hurricane)
2. Loss (sustained major loss of GDP)
3. Recovery (rebuilding efforts take effect)
4. New Equilibrium (may be several years later)

Source. REMI

Beginning with a two-week economic shutdown, a decrease in sales was estimated across all industries. In a two-week timeframe, approximately 4% of yearly sales would be lost. During this period, it was projected that there would be approximately $8.6 billion loss in output. Correspondingly, employment losses of about 60,000 jobs would be incurred. With less need for nonresidential capital (as businesses shutdown), there would be a slight disinvestment in capital on its own. Following the two weeks, businesses would re-open, returning to roughly normal levels during the twelve months that follow the hurricane. However, the long-term new equilibrium would be slightly lower than pre-hurricane levels.

While the two-week shutdown looked at an indirect effect on capital, the $10 billion loss describes a direct effect of a hurricane on capital stock in both residential (housing) and nonresidential (commercial, infrastructure). Due to deficits in what is needed by the community, investments in capital stock spike, following the initial loss. From the residential side, people that stay in the area with homes that are damaged or destroyed begin the rebuilding process. Over the following eight years, it was projected that the need for capital stock would return to equilibrium. Due mainly to

[6] Tampa Bay Regional Planning Council. "Economic Analysis of a Hurricane Event in Hillsborough County, Florida." February, 2009. https://www.hillsboroughcounty.org/library/hillsborough/media-center/documents/emergency-management/21--pdrp-economic-analysis-of-a-hurricane.pdf

[7] Evangelakis, Peter. "The Economic Impact of Hurricanes: The Four Major Impact Phases." REMI, Webinar, 29 September, 2017, https://owl.purdue.edu/owl/research_and_citation/mla_style/mla_formatting_and_style_guide/mla_works_cited_other_common_sources.html

construction increases, there is a positive output impact in the short and medium-term. As a result, there is an increase in construction employment, which corresponds to an increase in the population. Accordingly, there are increases in spending across other industries including retail trade and intermediate inputs such as manufacturing.

HAZUS Scenario	SSHWS	# of Weeks Business Closed	Annual % of Lost Sales
20 Years	Category 2	1	1.92%
100 Years	Category 3	1.5	2.88%
500 Years	Category 5	2.5	4.81%
1,000 Years	Category 5	3	5.77%

Table 1. Assumptions for the Probabilistic Economic Impact Modeling

The next two assumptions (increase in insurance premiums and migration from the hurricane-effected areas), although potentially useful in describing factors that may contribute to a decrease in output, were objectively difficult to quantify. The methodology utilized to determine the percentage increase in insurance premiums and determinants for the number or percentage of business and residents that may relocate following a hurricane was not disclosed. As such, the use of these two assumptions would not be appropriate for the purposes of this economic impact analysis.

Across all assumptions, it was predicted that there would be an initial loss in population. This reduction was attributed to output losses. It was further predicted that there would be some population gains over time, possibly attributable to the increase in construction efforts (rebuilding infrastructure, dwellings and commercial properties). However, it was estimated that there would remain 16,000 fewer residents in the Hillsborough area over the 10 years following the hurricane.

ECRC ASSUMPTIONS

The economic impact of a Hurricane was modeled using REMI PI+ version 2.3 for each of the seven counties. The REMI model was selected due to the dynamic impacts across sectors that would likely take place over time. The direct inputs were modeled in 2019, but impacts were provided until 2023 (a five-year period). The modeled results include five different scenarios (Probabilistic Table 1; Deterministic Table 10) ranging in Saffir Simpson Hurricane Wind Scale (SSHWS) or strength of the storm. The use of two assumptions were made to model the natural disaster impacts. First, the economic loss due to foregone sales was assumed, resulting in immediate job loss. The assumption was made that sales were lost across industries for several weeks, based on storm strength, in which business would have been shut down. Second, we would use the direct impacts to structures, as provided by the Hazus model.

County	Input	20 yr	100 yr	500 yr	1,000 yr
Bay	Non-Residential	-0.003	-0.252	-1.019	-1.432
Escambia	Non-Residential	-0.023	-0.942	-3.237	-4.576
Holmes	Non-Residential	0.000	-0.007	-0.041	-0.069
Okaloosa	Non-Residential	-0.008	-0.345	-1.427	-1.944
Santa Rosa	Non-Residential	-0.008	-0.220	-1.006	-1.383
Walton	Non-Residential	-0.006	-0.143	-0.765	-0.901
Washington	Non-Residential	0.000	-0.008	-0.055	-0.067
Bay	Residential	-0.127	-0.880	-3.120	-4.413
Escambia	Residential	-0.248	-2.386	-8.000	-11.074
Holmes	Residential	-0.002	-0.014	-0.046	-0.071
Okaloosa	Residential	-0.197	-1.366	-4.427	-6.121
Santa Rosa	Residential	-0.165	-1.382	-4.659	-6.540
Walton	Residential	-0.054	-0.451	-1.596	-2.369
Washington	Residential	-0.003	-0.019	-0.069	-0.132

Table 2. Impact Assumptions from Probabilistic Hazus Results in $ Billions

The third assumption was that there would be an immediate response to rebuilding residential and commercial damaged structures. The REMI PI+ model allows for lagged response to rebuilding capital structures, but this option was not selected. Utilizing the immediate response input generates a positive impact on the region as construction induces spending and creates jobs. When a lagged response is chosen, the majority of the rebuilding takes place in year two instead of year one. The dollar amount of rebuilding residential and non-residential structures in each county, for each scenario, was based on estimates from the HAZUS model (Probabilistic Table 2; Deterministic Table 11). Both assumptions together show the true net impact that occurs in year one after different classifications of storms. These results are most striking in the largest scale hurricanes, where the capital stock disaster is so widespread that robust rebuilding in year one often generates a positive job impact. Deterministic impact results begin on page 22.

Impact of Hurricanes in Northwest Florida

Before Hurricane Michael hit in October 2018, it had been 13 years[8] since a Category 3 or higher hurricane made landfall on the Gulf Coast of Florida (see Figure D). According to the National Weather Service, Michael was the first hurricane to make landfall in the United States as a category 5 since Hurricane Andrew in 1992, and only the fourth on record.[9] Michael is also the strongest hurricane landfall on record in the Florida Panhandle and only the second known category 5 landfall on the northern Gulf coast.

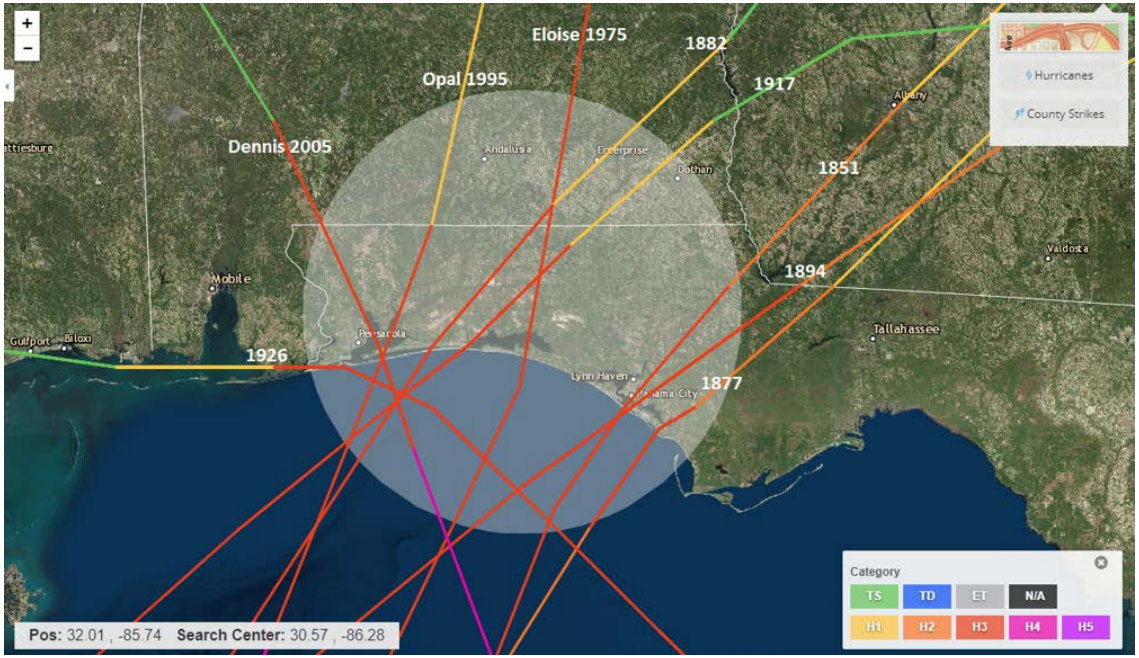


Figure E. Graphic depicting all tropical cyclones (category 3 or higher) to have made landfall over the Florida Panhandle before Hurricane Michael.

Source. National Weather Service

Those impacts were devastating. Michael caused at least $25 billion in total economic impact and resulted in 16 deaths. In Florida, the hurricane resulted in more than 31,000 individual applications to FEMA, nearly $148 million in household and individual dollars allocated for assistance, and $544 million in public assistance grants obligated. The SBA gave out $644.7 million disaster loans, while an estimated $224.1 million in claims was paid to 4,270 National Flood Insurance Program policyholders. The disaster negatively impacted the ability of Bay County to do business – in Quarter 4 of 2018, taxable gross sales was down nearly 10% over the previous year, while the state improved its taxable sales over the year by 6.75%. If Bay County had been expected to have increased its sales like the State of Florida by 6.75% over the year, then an estimate of sales impact is that the storm provided -15.35% in less Gross Sales. This result, alongside other studies covered earlier in this report, help to

[8] The previous year, Hurricane Ivan made landfall in Gulf Shores, AL, leaving significant destruction across Florida's Escambia and Santa Rosa counties.
[9] The others are the Labor Day Hurricane in 1935 and Hurricane Camille in 1969.

provide useful benchmarks to this study's assumptions about the impact on sales of communities directly affected by hurricanes.

Reading the Results

As noted in the methodology section, each of these tables provide results for each applicable hurricane scenario for each individual county. The assumptions for sales decline are assumed as discussed, where the building impact description comes from the Hazus model. In addition, these results are the **net impact** of destruction and rebuilding. As an example, if Bay County were modeled with *only* the sales lost from the hurricane, it would have assumed that nearly 6,400 jobs were lost. However, rebuilding and recovery is also anticipated to start within the same calendar year. A robust recovery effort is assumed to support more than 3,200 jobs. Thus, the net impact means that while many jobs are lost, construction and recovery mitigate some of that total loss. Each results table includes the 20-year, 100-year, 500-year, and 1,000-year probabilistic scenarios. See tables 1 and 2 for a reminder of the assumptions that support each scenario and modeling choices.

Probabilistic Scenarios

ESCAMBIA

Table 3 outlines the assumptions specific to Escambia County for each of the probabilistic hurricane scenarios. The net impact results of a 20-year storm is greater in both jobs and GDP than any other storm. In the first year of this storm, Escambia County is projected to lose nearly 4,800 jobs and $374 million in GDP.

In the case of the 1,000-year storm, it produces a net gain in jobs during year one with 1,537 net new jobs. The 1,000-year storm also raises GDP by $82 million. These gains are generated because recovery is modeled as starting as soon as clean up and recovery is possible. Although the 1,000-year storm would cause more destruction and economic loss than any of the other storms listed, the assumed immediate influx of construction and other relief-related efforts would outweigh the negative impacts of the storm. Job gains are largely supported into the long-term by the extended timeline required for such a recovery effort (i.e., construction spending, purchasing materials and home goods, and increased accommodations needs of out-of-area workers).

Impact Assumptions				
Inputs (2019 Impacts)	**20 yr**	**100 yr**	**500 yr**	**1,000 yr**
Output - Lost Sales (Percent)	-1.92%	-2.88%	-4.81%	-5.77%
Residential (2019 $ Billions)	-0.27	-2.57	-8.61	-11.92
Non-Residential (2019 $ Billions)	-0.02	-1.01	-3.48	-4.92

Impact Results by Type of Storm in Escambia County					
Impact (Jobs)	**2019**	**2020**	**2021**	**2022**	**2023**
20 yr	-4,791	304	309	349	317
100 yr	-4,068	4,327	4,478	4,131	3,469
500 yr	-631	14,892	15,453	14,100	11,800
1,000 yr	1,537	20,702	21,524	19,647	16,461
Impact (GDP $2019 Millions)	**2019**	**2020**	**2021**	**2022**	**2023**
20 yr	-374	26	25	28	26
100 yr	-325	327	340	317	268
500 yr	-76	1,120	1,172	1,080	908
1,000 yr	82	1,556	1,632	1,504	1,266

Table 3. Economic Impact Results for Escambia County

SANTA ROSA

Table 4 highlights the impact results by type of probabilistic storm for Santa Rosa County. It also outlines the specific assumptions that were made based on this county's regional economy and profile of capital stock. Like Escambia County (Table 3), in the first year of a 20-year or 100-year storm scenarios, the county's expected job losses would be substantial. It is projected that 1,317 jobs would be lost for a 20-year storm and 824 jobs for a 100-year storm, during year one. Recovery and rebuilding begin to generate positive job growth in the second year, which is sustained through 2023. The first year also sees a net decline in sales between $50 and $93 million due to business closures.

For the 500-year and 1,000-year scenarios, both see a net positive job gain in year one because of the large influx of spending on recovery efforts. Moreover, spending is so substantial that it increases the region's gross sales by $108 million and $205 million, respectively. Those recovery efforts continue over the five-year period, with spending slowing down – though still substantial – by year five.

Impact Assumptions				
Inputs (2019 Impacts)	**20 yr**	**100 yr**	**500 yr**	**1,000 yr**
Output - Lost Sales (Percent)	-1.92%	-2.88%	-4.81%	-5.77%
Residential (2019 $ Billions)	-0.18	-1.49	-5.01	-7.04
Non-Residential (2019 $ Billions)	-0.01	-0.24	-1.08	-1.49

Impact Results by Type of Storm in Santa Rosa County					
Impact (Jobs)	**2019**	**2020**	**2021**	**2022**	**2023**
20 yr	-1,317	194	171	164	138
100 yr	-824	1,789	1,791	1,626	1,360
500 yr	1,102	6,146	6,256	5,668	4,766
1,000 yr	2,286	8,626	8,801	7,975	6,712
Impact (GDP $2019 Millions)	**2019**	**2020**	**2021**	**2022**	**2023**
20 yr	-93	16	14	14	11
100 yr	-50	140	142	130	110
500 yr	108	481	495	452	382
1,000 yr	205	675	696	636	1,266

Table 4. Economic Impact Results for Santa Rosa County

Escambia County and Santa Rosa County make up one metropolitan area – the Pensacola-Ferry Pass-Brent Metropolitan Statistical Area (MSA) – and thus it is intuitive that these two counties would have similar trends. They are the only two counties in which recovery efforts are so amplified for the worst scenarios that job and sales immediately become positive.

OKALOOSA

Table 5 details the impact results in both jobs and sales lost for Okaloosa County for each of the hurricane probabilistic scenarios modeled. The assumptions specific to this county and its economy are outlined in the top third of the table. Okaloosa County hurricane impacts generate an anticipated job loss between 1,624 and 2,883 in year one. Recovery efforts in year two generate a positive job impact for all probabilistic scenarios.

Table 5 also breaks down the impacts of the hurricane scenarios by Gross Domestic Product. In the year of the hurricane, it is projected that Okaloosa County would lose between $100 million and $235 million in sales. In 2020, the sales impacts become positive for all probabilistic scenarios, though some are substantially higher (e.g., 1,000-year impacts, $819 million) than others. Positive GDP impacts are generated through year five after the hurricane.

Impact Assumptions				
Inputs (2019 Impacts)	**20 yr**	**100 yr**	**500 yr**	**1,000 yr**
Output - Lost Sales (Percent)	**-1.92%**	**-2.88%**	**-4.81%**	**-5.77%**
Residential (2019 $ Billions)	**-0.21**	**-1.47**	**-4.76**	**-6.59**
Non-Residential (2019 $ Billions)	**-0.01**	**-0.37**	**-1.54**	**-2.09**

Impact Results by Type of Storm in Okaloosa County					
Impact (Jobs)	**2019**	**2020**	**2021**	**2022**	**2023**
20 yr	**-2,777**	**192**	**199**	**210**	**184**
100 yr	**-2,883**	**1,925**	**1,985**	**1,827**	**1,527**
500 yr	**-2,153**	**6,550**	**6,799**	**6,201**	**5,178**
1,000 yr	**-1,624**	**9,104**	**9,468**	**8,632**	**7,209**
Impact (GDP $2019 Millions)	**2019**	**2020**	**2021**	**2022**	**2023**
20 yr	**-233**	**19**	**19**	**20**	**18**
100 yr	**-235**	**175**	**181**	**168**	**141**
500 yr	**-155**	**590**	**616**	**567**	**477**
1,000 yr	**-100**	**819**	**857**	**789**	**664**

Table 5. Economic Impact Results for Okaloosa County

WALTON

Walton County's net economic impacts are documented by probabilistic hurricane scenario in Table 6. Its assumptions for lost sales, residential and non-residential stock impacts are detailed in the top third of the table.

Walton County is projected to lose between 639 and 1,149 jobs in the year that a hurricane strikes the county. Recovery begins that year as modeled due to the immediate recovery spending but does not begin to generate positive job growth until 2020. Similarly, Walton is modeled to lose between $57 million and $108 million in the year of the hurricane. Sales related to recovery and reconstruction begin the same year, but do not generate positive GDP impacts until the year after the storm. In that year, positive sales are projected to be between $8 and $322 million.

Impact Assumptions				
Inputs (2019 Impacts)	**20 yr**	**100 yr**	**500 yr**	**1,000 yr**
Output - Lost Sales (Percent)	-1.92%	-2.88%	-4.81%	-5.77%
Residential (2019 $ Billions)	-0.06	-0.48	-1.72	-2.55
Non-Residential (2019 $ Billions)	-0.01	-0.15	-0.82	-0.97

Impact Results by Type of Storm in Walton County					
Impact (Jobs)	**2019**	**2020**	**2021**	**2022**	**2023**
20 yr	-1,039	72	58	61	53
100 yr	-1,149	620	605	548	448
500 yr	-894	2,262	2,270	2,032	1,666
1,000 yr	-639	3,298	3,309	2,951	2,412
Impact (GDP $2019 Millions)	**2019**	**2020**	**2021**	**2022**	**2023**
20 yr	-98	8	6	6	5
100 yr	-108	62	60	54	45
500 yr	-83	221	222	201	166
1,000 yr	-57	322	324	292	240

Table 6. Economic Impact Results for Walton County

BAY

Table 7 provides the probabilistic impact assumptions and outcomes on GDP and jobs for Bay County. Job losses would range between 2,618 – 3,413 within the first year of the hurricane. By year five, however, there is an anticipated net increase in jobs of 179 (20-year hurricane) – 6,828 (100-year hurricane), linked to storm intensity.

Regarding GDP, probabilistic scenarios predicted the greatest first year losses with a 100–year storm ($295 million). By year two, the largest second year gains in GDP were projected to be $665 million in the 1,000-year storm scenario. Across all scenarios, year five GDP moves closer to year two estimates. For example, in the 20–year storm scenario, the GDP for both years (2020 and 2023) are positive $15 million.

Impact Assumptions				
Inputs (2019 Impacts)	**20 yr**	**100 yr**	**500 yr**	**1,000 yr**
Output - Lost Sales (Percent)	-1.92%	-2.88%	-4.81%	-5.77%
Residential (2019 $ Billions)	-0.14	-0.95	-3.36	-4.75
Non-Residential (2019 $ Billions)	0.00	-0.27	-1.10	-1.54

Impact Results by Type of Storm in Bay County					
Impact (Jobs)	**2019**	**2020**	**2021**	**2022**	**2023**
20 yr	-3,006	154	155	191	179
100 yr	-3,413	1,616	1,662	1,560	1,311
500 yr	-3,054	6,030	6,252	5,744	4,785
1,000 yr	-2,618	8,586	8,934	8,196	6,828
Impact (GDP $2019 Millions)	**2019**	**2020**	**2021**	**2022**	**2023**
20 yr	-253	15	13	16	15
100 yr	-295	128	129	123	104
500 yr	-287	468	484	449	376
1,000 yr	-264	665	692	641	537

Table 7. Economic Impact Results for Bay County

WASHINGTON

Washington County's year one net job losses ranged from 167 (20-year storm) – 421 (1,000-year storm). Unlike all other counties in this analysis, Washington County is the only area that is projected to have jobs loss across all years of interest following a 20-year storm. All other probabilistic storm categories projected between 8 – 74 jobs increase by year 2023.

The impact on GDP following a hurricane in Washington County was arguably the most conservative, compared to all other counties. Losses in year one ranged from $9 million to $23 million. By year two, only the 20-year storm had a projected loss ($1 million). Moreover, it was projected that the GDP for years three through five would go unchanged. That is, there would be no net GDP gain or loss for both the 20 and 100-year storms. A 500-year storm was projected to maintain a positive $1 million GDP from years three to five. However, a 1,000-year storm would maintain a positive $3 million GDP from years three to five.

Impact Assumptions				
Inputs (2019 Impacts)	**20 yr**	**100 yr**	**500 yr**	**1,000 yr**
Output - Lost Sales (Percent)	-1.92%	-2.88%	-4.81%	-5.77%
Residential (2019 $ Billions)	0.00	-0.02	-0.07	-0.14
Non-Residential (2019 $ Billions)	0.00	-0.01	-0.06	-0.07

Impact Results by Type of Storm in Washington County					
Impact (Jobs)	**2019**	**2020**	**2021**	**2022**	**2023**
20 yr	-167	-8	-4	-2	-1
100 yr	-241	0	6	8	8
500 yr	-372	32	43	45	40
1,000 yr	-421	73	88	86	74
Impact (GDP $2019 Millions)	**2019**	**2020**	**2021**	**2022**	**2023**
20 yr	-9	-1	0	0	0
100 yr	-13	0	0	0	0
500 yr	-20	0	1	1	1
1,000 yr	-23	2	3	3	3

Table 8. Economic Impact Results for Washington County

HOLMES

Table 9 provides the probabilistic outcomes for the final county without a deterministic scenario. Year one jobs lost ranged between 101 – 256. The only storm that was forecasted to not have a net gain in jobs for Holmes County was the 20-year hurricane. Indeed, it was projected that there would be a net jobs loss of 0 by 2023. All other storms were projected to have net job gains between 7–50 by the fifth year following a hurricane.

Holmes County's probabilistic projections for GDP impact were the least substantial during year one, with projected losses between $5 million and $12 million. By year two, there was no projected GDP impact for both a 20-year and 100-year hurricane. By 2022, the GDP impact was projected to be stable into the fifth year, with impacts ranging from 0 - $4 million.

Impact Assumptions				
Inputs (2019 Impacts)	**20 yr**	**100 yr**	**500 yr**	**1,000 yr**
Output - Lost Sales (Percent)	**-1.92%**	**-2.88%**	**-4.81%**	**-5.77%**
Residential (2019 $ Billions)	**0.00**	**-0.02**	**-0.05**	**-0.08**
Non-Residential (2019 $ Billions)	**0.00**	**-0.01**	**-0.04**	**-0.07**

Impact Results by Type of Storm in Holmes County					
Impact (Jobs)	**2019**	**2020**	**2021**	**2022**	**2023**
20 yr	**-101**	**-6**	**-3**	**-1**	**0**
100 yr	**-145**	**1**	**5**	**7**	**7**
500 yr	**-223**	**22**	**32**	**34**	**31**
1,000 yr	**-256**	**41**	**54**	**56**	**50**
Impact (GDP $2019 Millions)	**2019**	**2020**	**2021**	**2022**	**2023**
20 yr	**-5**	**0**	**0**	**0**	**0**
100 yr	**-7**	**0**	**0**	**1**	**1**
500 yr	**-11**	**2**	**3**	**3**	**3**
1,000 yr	**-12**	**3**	**4**	**4**	**4**

Table 9. Economic Impact Results for Holmes County

Deterministic Scenarios

HAZUS Scenario	SSHWS	# of Weeks Business Closed	Annual % of Lost Sales
Deterministic	High Category 3	2	3.85%

Table 70. Deterministic Impact Assumptions for the Economic Impact Modeling

The following provides clarification for deterministic impact results for Escambia, Santa Rosa, Okaloosa, Walton, and Bay counties. Counties of interest excluded from the deterministic scenarios were those that are not coastal counties, since the deterministic scenarios include storm surges. Deterministic scenarios utilized assumptions for a single impact scenario for a SSHWS High Category 3 hurricane (i.e., Category 3 hurricane with sustained winds of 129 mph), including a 2-week business closure, and a 3.85% annual sales loss across all counties with deterministic scenarios. All dollar amounts are given in 2019 dollars.

Compared to all other counties with deterministic scenarios, Escambia County is projected to have the greatest losses for construction, jobs, and GDP in year one of a High Category 3 hurricane. It was forecasted that Escambia would suffer $4.10 billion loss in residential construction and a loss of $1.44 billion in non-residential construction (2019 dollars). In addition, Escambia's year one job losses were projected to be 4,563. Years two through five projected net gains in jobs, with the greatest net gains occurring in year three (7,139). The GDP impact for year one was projected to have a net loss of $368 million. Just as with jobs projections, years two through five were anticipated to have a positive impact on GDP, with the greatest net gains occurring in year three ($544 million). By year five, the net gains in GDP are projected to reach $424 million, resulting in a $100 million decline between years two and five. Compared to all other counties, Escambia is projected to have the greatest losses in GDP between years four and five ($80 million decline).

Across all measures, Santa Rosa County is forecasted to have the second smallest impact from a High Category 3 hurricane. Anticipated construction losses were totaled $2.02 billion in residential construction and $0.40 billion in non-residential losses. Although year one job losses would total 1,030, years two though five would include net gain in jobs, with years two and three nearly tied for the largest number of net job gains for Santa Rosa County (2,456 and 2,466, respectively). Regarding GDP, year one had a loss of $61 million and positive GDP growth in years two through five. Like jobs growth, GDP in years two and three were very similar ($193 million and $196 million, respectively).

Compared to all other deterministic scenarios, Okaloosa County is projected to have the second largest impact for construction losses. Residential and non-residential construction losses included $2.96 billion in residential and $0.81 billion in non-residential. Following the first year's 2,736 lost jobs, a net gain in jobs ranged from 3,133 (year five) to 4,117 (year three). Gross domestic product loss in year one was $214 million, followed by positive GDP growth. Year

three had the largest GDP ($374 million) for the county. Compared to all other counties, however, Okaloosa was projected to incur the second largest drop in GDP between years four and five ($290 million, $55 million difference).

To perform Walton County's deterministic scenario, it was modeled in Hazus with both Okaloosa and Walton counties combined, due to an inability for the Hazus model to populate Walton County's storm surge impacts as a sole county deterministic scenario. After the model was run with both counties included, Okaloosa's deterministic data were removed.

County	Input	Deterministic
Bay	Non-Residential	-0.592
Escambia	Non-Residential	-1.337
Okaloosa	Non-Residential	-0.750
Santa Rosa	Non-Residential	-0.375
Walton	Non-Residential	-0.635
Bay	Residential	-2.073
Escambia	Residential	-3.809
Okaloosa	Residential	-2.747
Santa Rosa	Residential	-1.881
Walton	Residential	-2.496

Table 11. Deterministic Impact Assumptions from Hazus Results in $ Billions

Compared to all other counties with deterministic scenarios, Walton was projected to have the smallest numbers in economic impact, across all measures. Walton County's deterministic impact analysis included losses of $1 billion in residential and $0.43 billion in non-residential construction. Following a deficit of 1,133 jobs in year one, net job gains ranged from 955 (year five) and 1,306 (year two). Consistent with jobs, GDP was projected to decline in year one (-$107 million), followed by GDP growth that ranged from $96 million (year five) and $129 million (year two).

Preceded by Escambia and Okaloosa counties, Bay is anticipated to have the third greatest construction dollars loss within the deterministic scenario - $2.23 billion in residential and $0.64 billion in non-residential construction dollars lost. The deterministic scenario projected job losses totaling 3,157 in the first year of High Category 3 hurricane, with a net gain in jobs of 3,112 by year five. Gross domestic product loss within year one totaled $285 million. Although year two would see a growth in GDP of $308 million, followed by $316 million in year three, considerable declines are projected for years four and five. Indeed, GDP is anticipated to fall from $316 million in year three to $293 million in year four ($23 million decline), with year five projected GDP at $245 million ($62 million decline between years four and five).

County	Impact Assumptions		2019	2020	2021	2022	2023
Escambia 	3.85% lost sales	Jobs	**-4,563**	**6,910**	**7,139**	**6,552**	**5,485**
	-$4.10 B in residential and -$1.44 B in non-residential	GDP $ 2019 Mil	-368	524	544	504	424
Santa Rosa 	3.85% lost sales	Jobs	**-1,030**	**2,456**	**2,466**	**2,242**	**1,880**
	-$2.02 B in residential and -$0.40 B in non-residential	GDP $ 2019 Mil	-61	193	196	180	151
Okaloosa 	3.85% lost sales	Jobs	**-2,736**	**3,984**	**4,117**	**3,758**	**3,133**
	-$2.96 B in residential and -$0.81 B in non-residential	GDP $ 2019 Mil	-214	361	374	345	290
Walton 	3.85% lost sales	Jobs	-1,133	1,306	1,298	1,166	955
	-1.00 B in residential and -0.43 B in non-residential	GDP $ 2019 Mil	-107	129	128	116	96
Bay 	3.85% lost sales	Jobs	**-3,157**	**3,945**	**4,068**	**3,740**	**3,112**
	-$2.23 B in residential and -$0.64 B in non-residential	GDP $ 2019 Mil	-285	308	316	293	245

Table 11. Deterministic Impact Results

Appendix A
Hazus Data Maps

In 2019, the Florida Division of Emergency Management (FDEM) developed deterministic and probabilistic hurricane scenarios for the Emerald Coast Region using FEMA's Hazus modeling software. Hazus incorporates peer-reviewed methodology to model the impacts of several types of natural disasters, including hurricanes, and is a useful tool for disaster mitigation planning.

Deterministic scenarios consider the impact of a single-risk scenario, while probabilistic scenarios consider the associated impacts of many thousand potential storms that have tracks and intensities reflecting the full spectrum of Atlantic or Central Pacific hurricanes.

Deterministic and probabilistic models are based on different methodologies and resulting data from the two model types is not meant for comparison. Deterministic scenarios incorporate both wind and storm surge. Probabilistic models only account for wind losses. Deterministic approaches are best used when evacuation and mitigation plans are being developed for specific events, whereas probabilistic approaches are more appropriate in modeling possible outcomes of future events.

Maps were created from the model results to illustrate:

1. Deterministic Model Storm Tracks;
2. Deterministic Model Storm Tracks, Essential Facilities, and Surge;
3. Deterministic Model Building-Related Economic Loss Estimates;
4. Deterministic Model Maximum Sustained Wind Speed;
5. Probabilistic Model Storm Tracks;
6. Probabilistic Model 100-Year Return Building-Related Economic Loss Estimates.

Note that Building-Related Economic Loss Estimates for the Bay County Deterministic Model were not mapped.

For more information on FEMA's Hazus program, visit www.fema.gov/hazus.

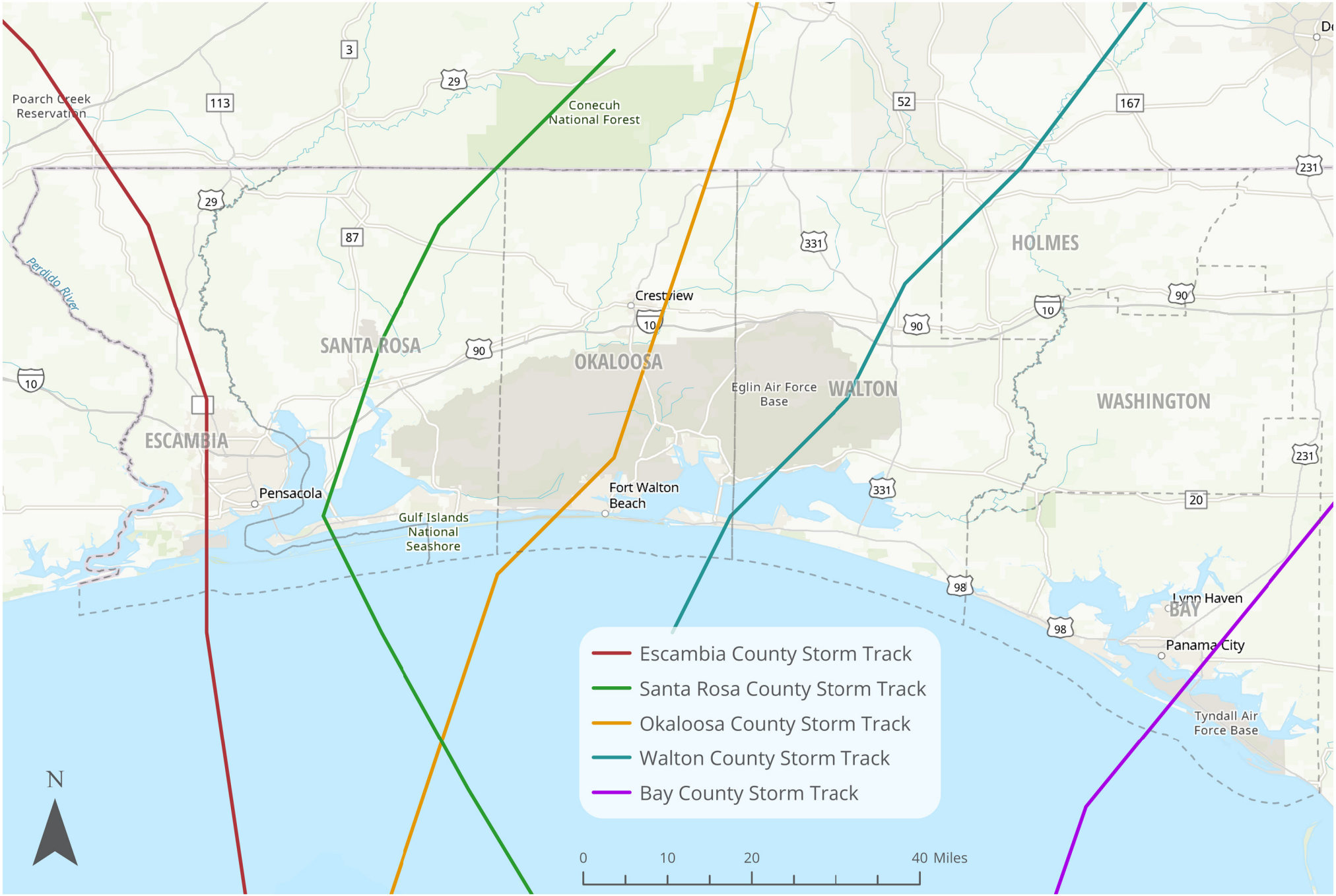
Hazus Deterministic Model

1. Storm Tracks
2. Storm Track, Essential Facilities, and Surge – Bay County
3. Storm Track, Essential Facilities, and Surge – Escambia County
4. Storm Track, Essential Facilities, and Surge – Okaloosa County
5. Storm Track, Essential Facilities, and Surge – Santa Rosa County
6. Storm Track, Essential Facilities, and Surge – Walton County
7. *Building-Related Economic Loss Estimates – Bay County (Not Mapped)*
8. Building-Related Economic Loss Estimates – Escambia County
9. Building-Related Economic Loss Estimates – Okaloosa County
10. Building-Related Economic Loss Estimates – Santa Rosa County
11. Building-Related Economic Loss Estimates – Walton County
12. Maximum Sustained Wind Speed – Bay County
13. Maximum Sustained Wind Speed – Escambia County
14. Maximum Sustained Wind Speed – Okaloosa County
15. Maximum Sustained Wind Speed – Santa Rosa County
16. Maximum Sustained Wind Speed – Walton County

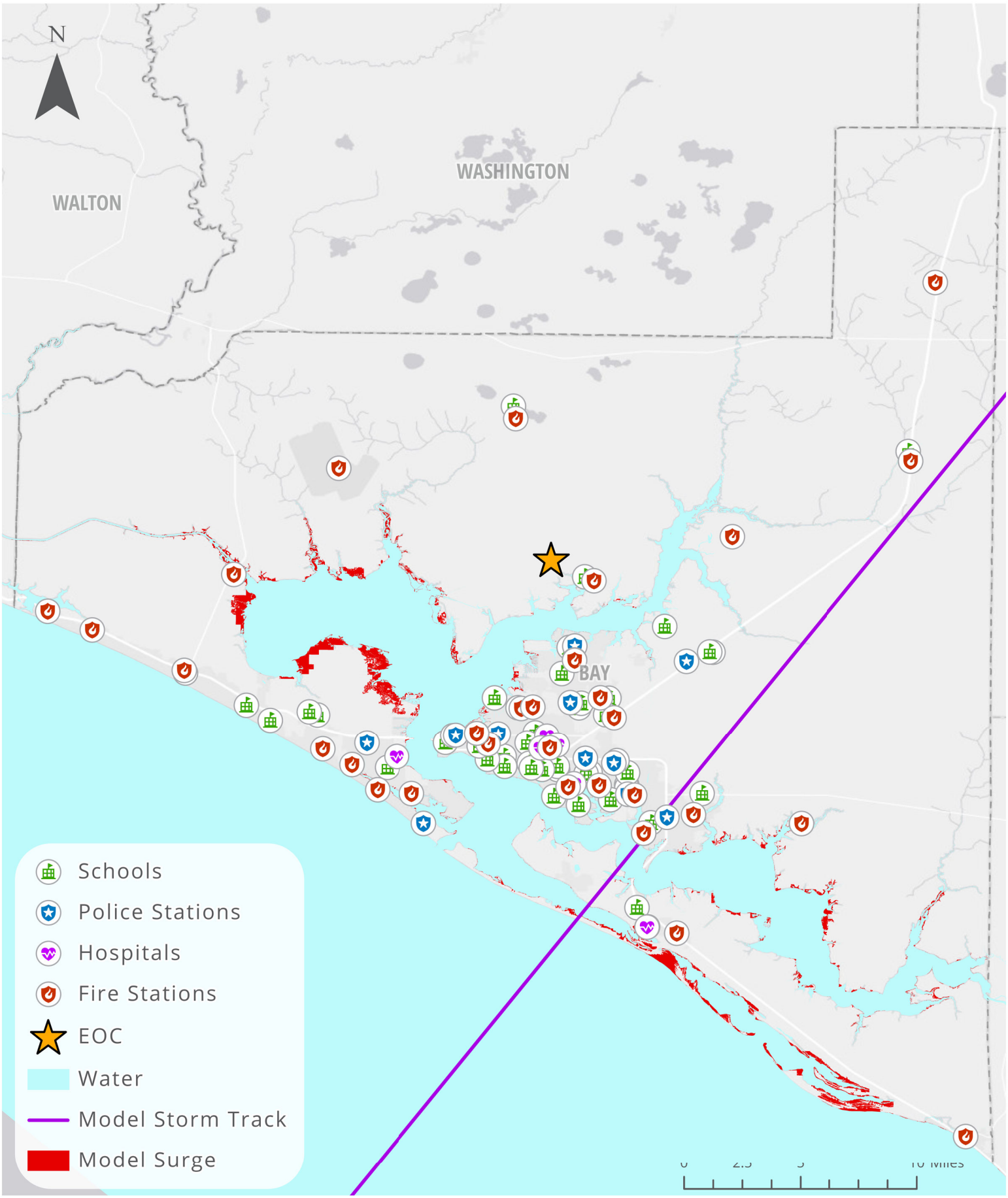
Hazus Probabilistic Model (100-Year Return)

17. Storm Tracks – Bay County
18. Storm Tracks – Escambia County
19. Storm Tracks – Holmes County
20. Storm Tracks – Okaloosa County
21. Storm Tracks – Santa Rosa County
22. Storm Tracks – Walton County
23. Storm Tracks – Washington County
24. Building-Related Economic Loss Estimates – Bay County
25. Building-Related Economic Loss Estimates – Escambia County
26. Building-Related Economic Loss Estimates – Holmes County
27. Building-Related Economic Loss Estimates – Okaloosa County
28. Building-Related Economic Loss Estimates – Santa Rosa County
29. Building-Related Economic Loss Estimates – Walton County
30. Building-Related Economic Loss Estimates - Washington

HAZUS Deterministic Model
Storm Tracks

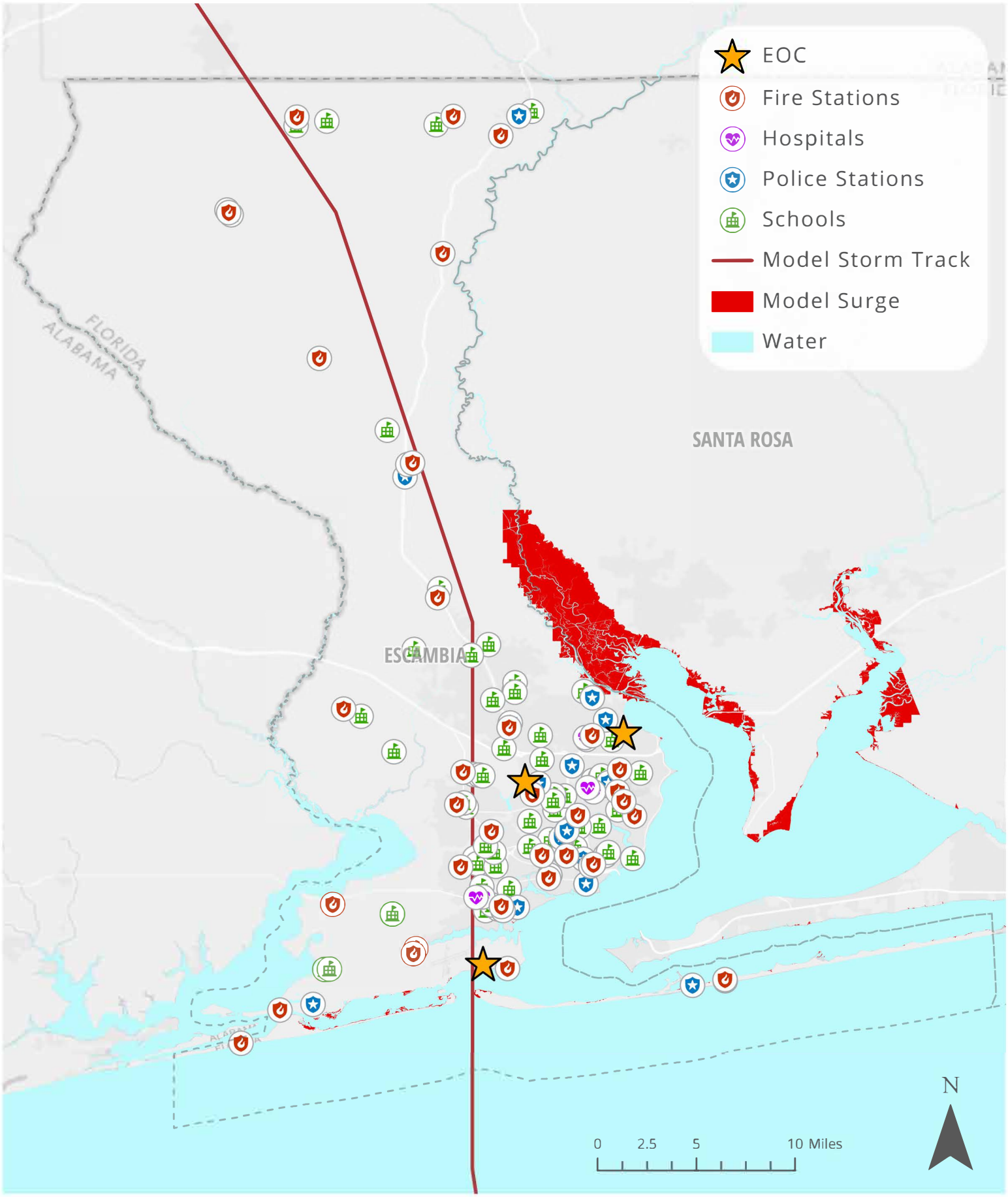


HAZUS Deterministic Model
Storm Track, Essential Facilities, and Surge - Bay County



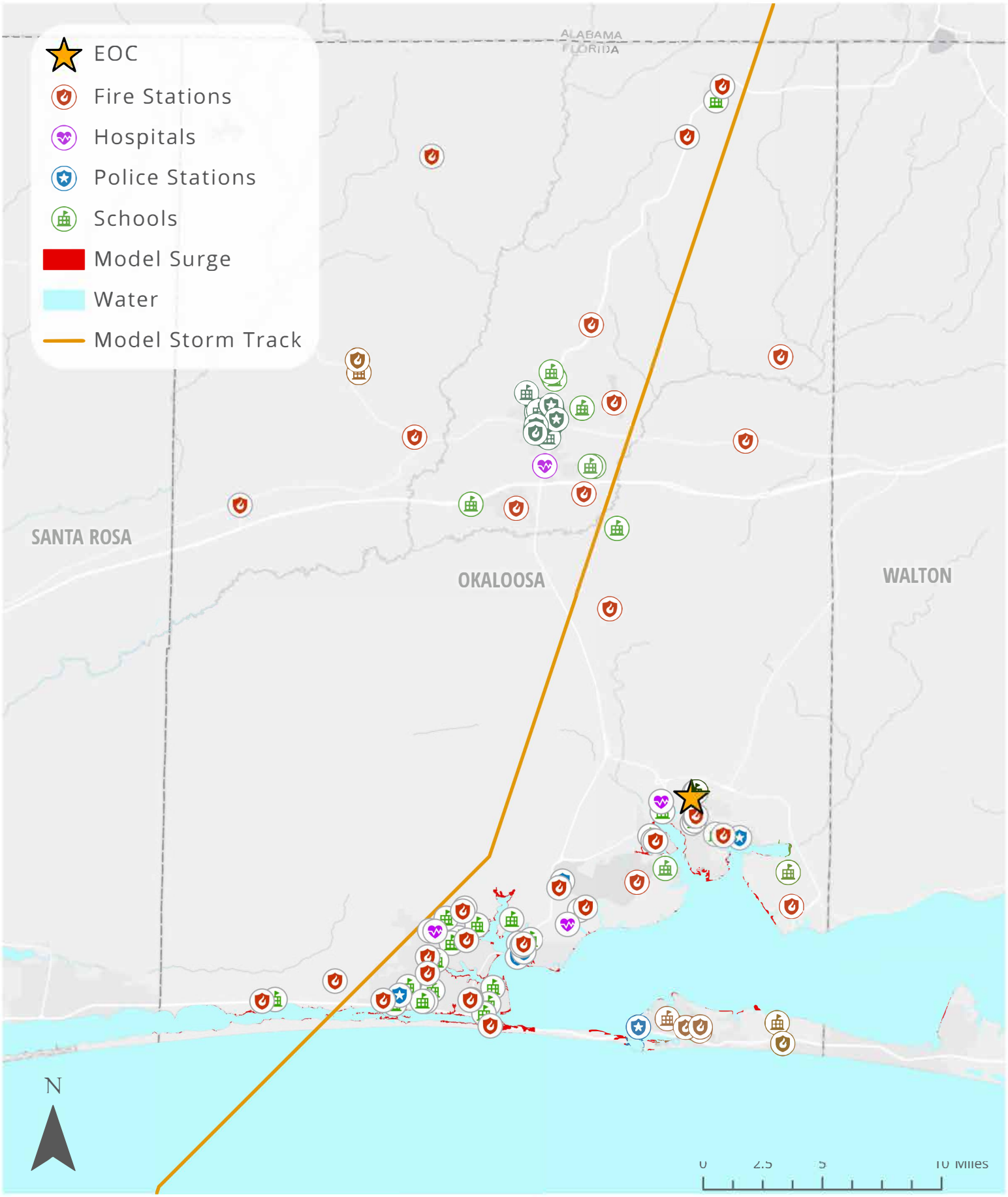
ECRC, FDEM 2019

HAZUS Deterministic Model
Storm Track, Essential Facilities, and Surge - Escambia County



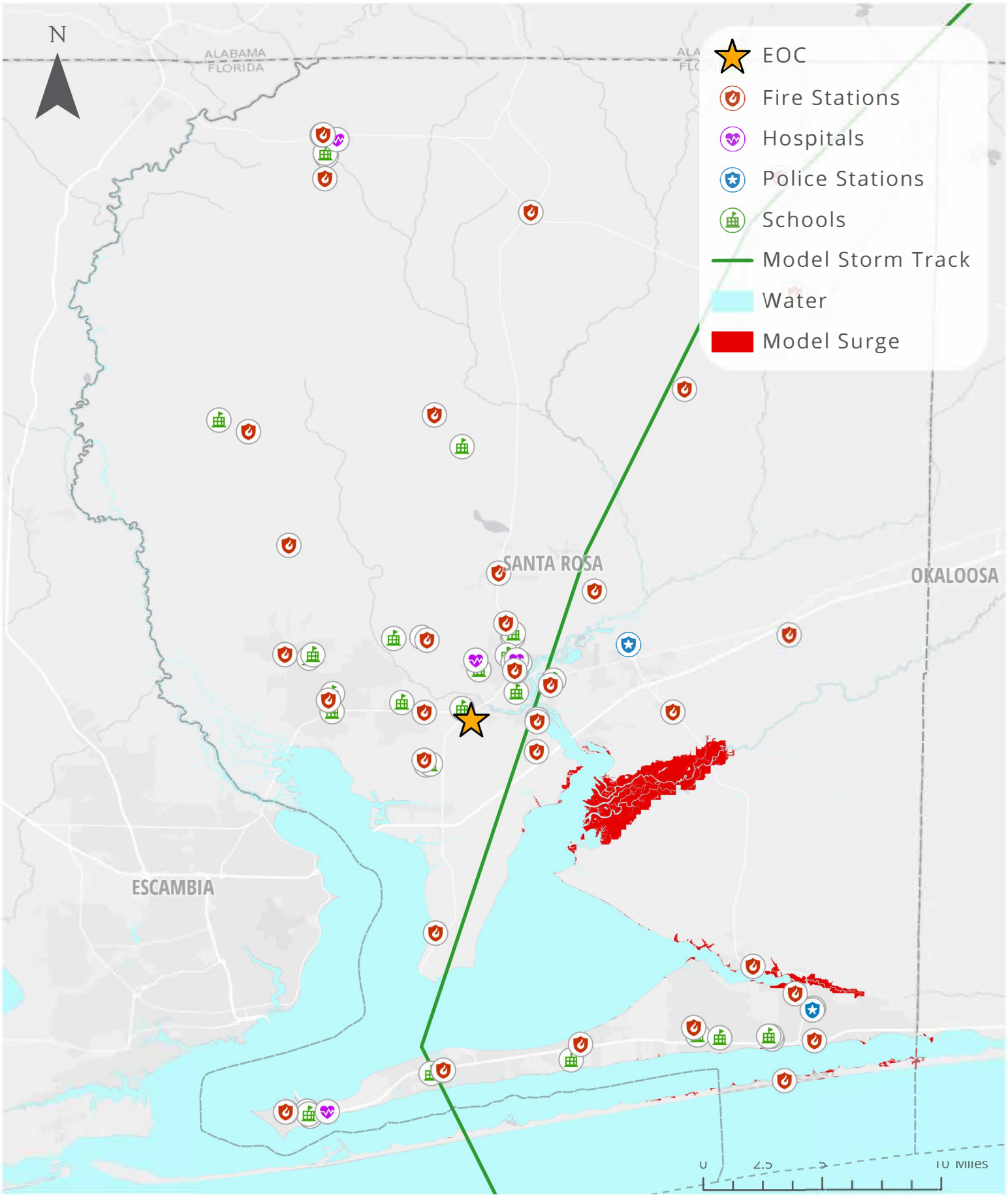
ECRC, FDEM 2019

HAZUS Deterministic Model
Storm Track, Essential Facilities, and Surge - Okaloosa County



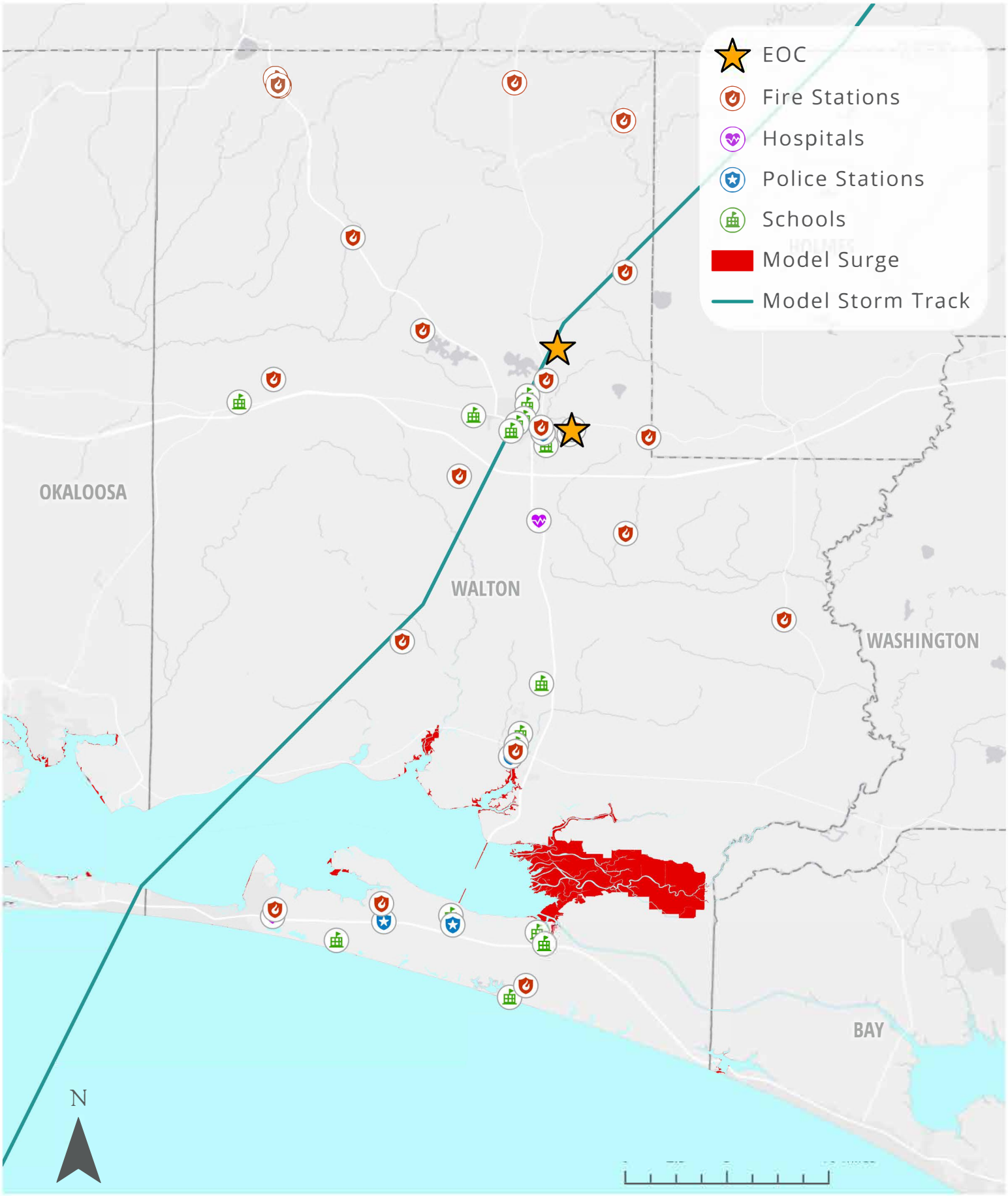
ECRC, FDEM 2019

HAZUS Deterministic Model
Storm Track, Essential Facilities, and Surge - Santa Rosa County



ECRC, FDEM 2019

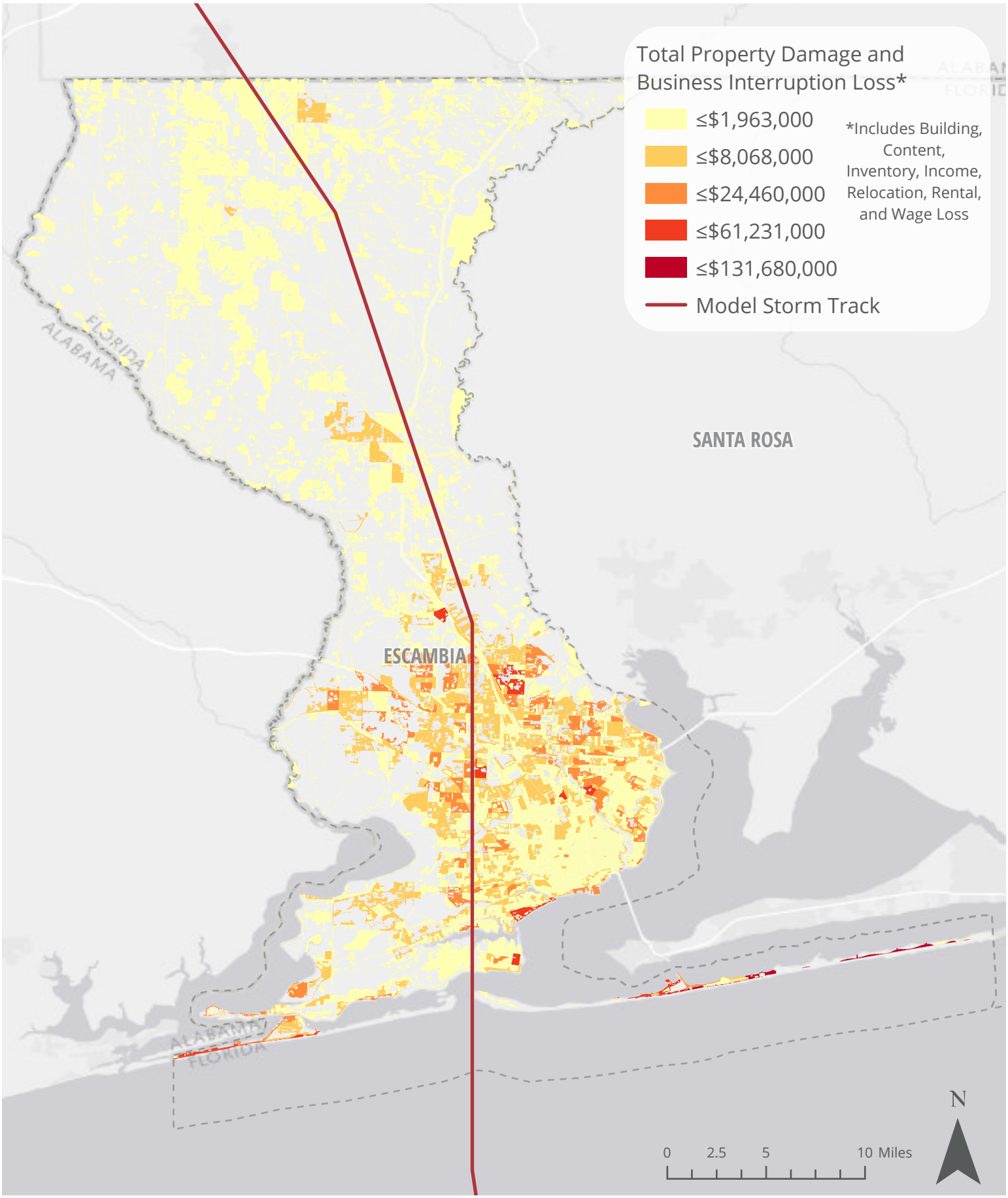
HAZUS Deterministic Model
Storm Track, Essential Facilities, and Surge - Walton County



ECRC, FDEM 2019

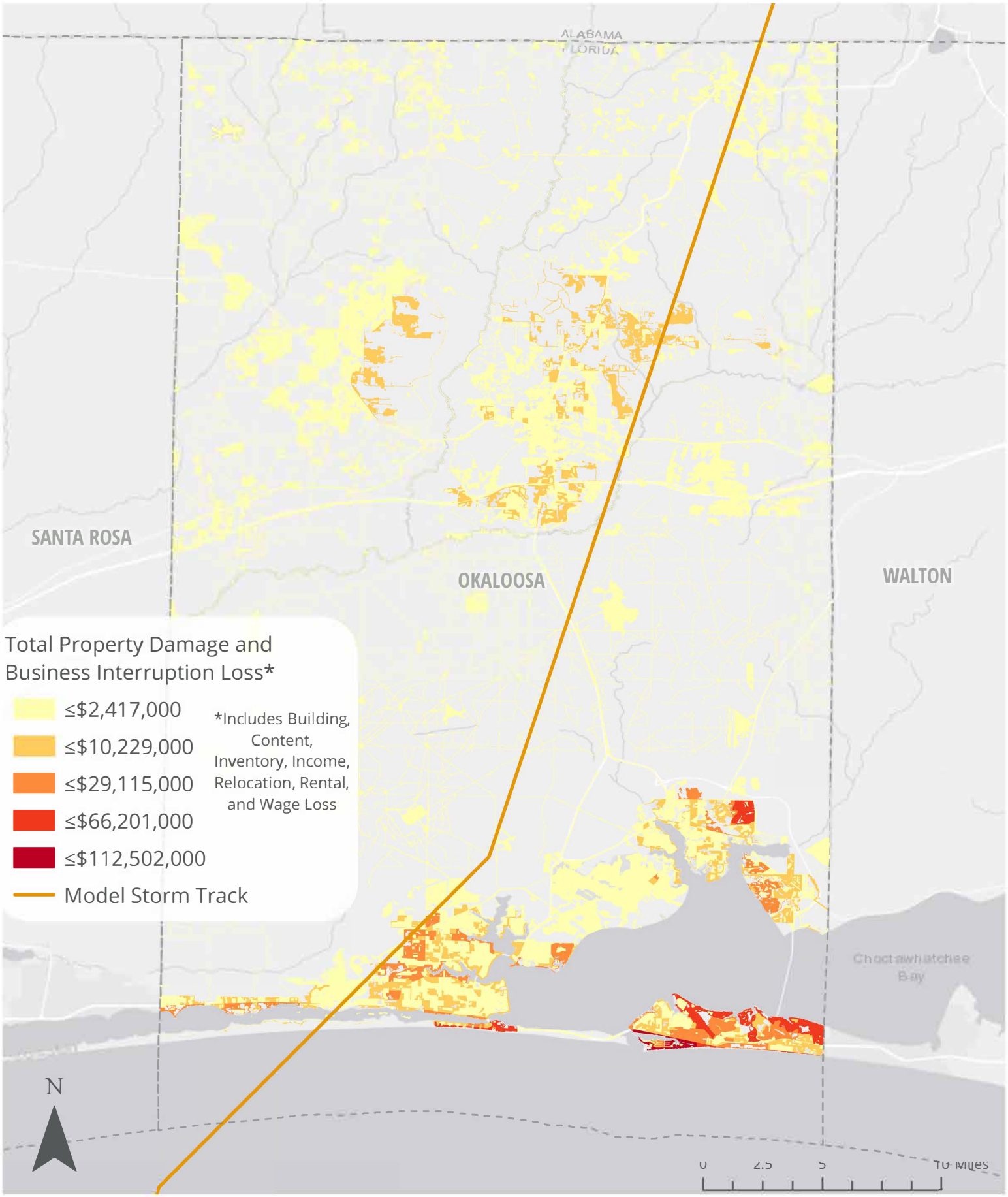
Building-Related Economic Loss Estimates – Bay County (Not Mapped)

HAZUS Deterministic Model
Building-Related Economic Loss Estimates - Escambia County



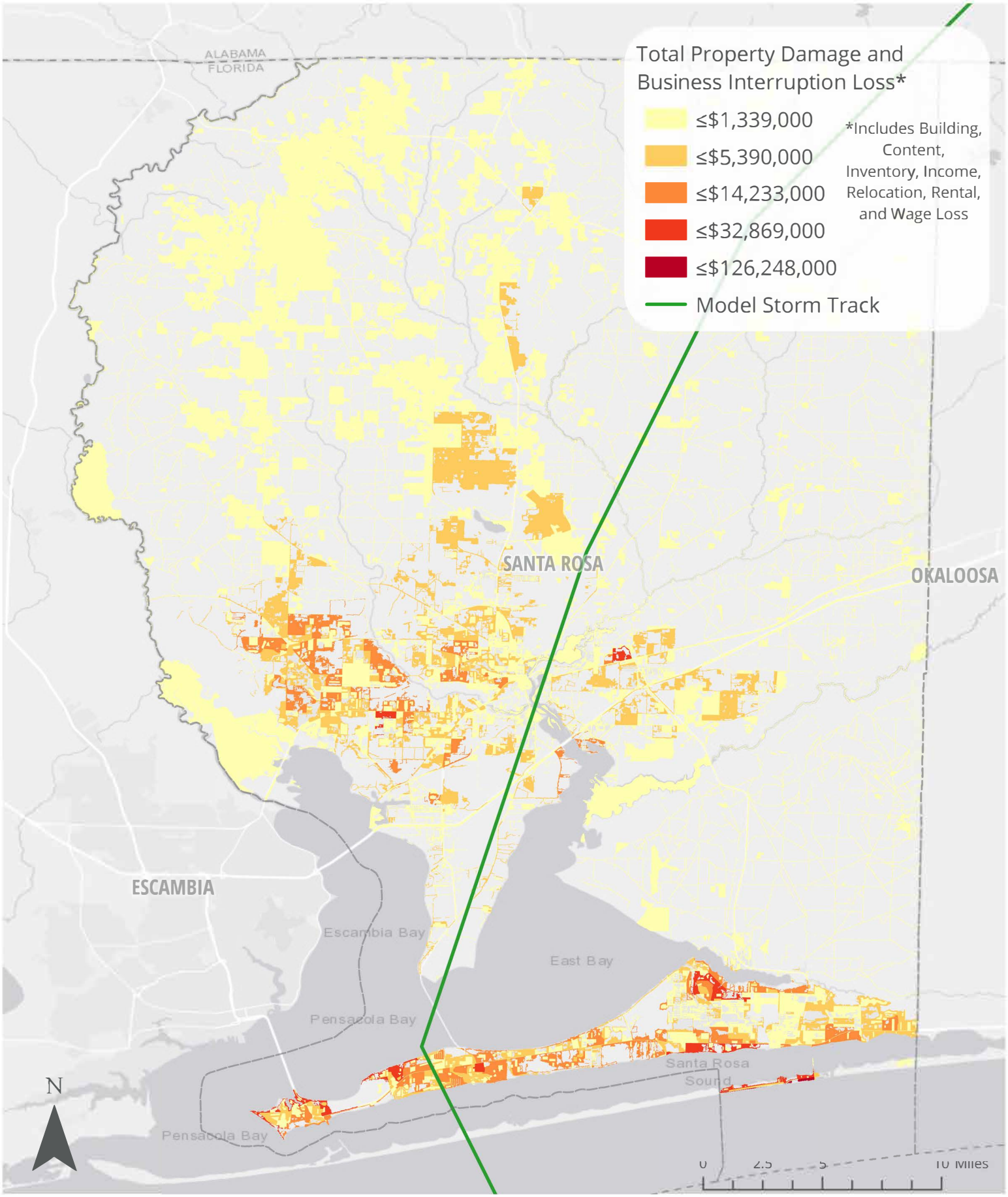
ECRC, FDEM 2019

HAZUS Deterministic Model
Building-Related Economic Loss Estimates - Okaloosa County

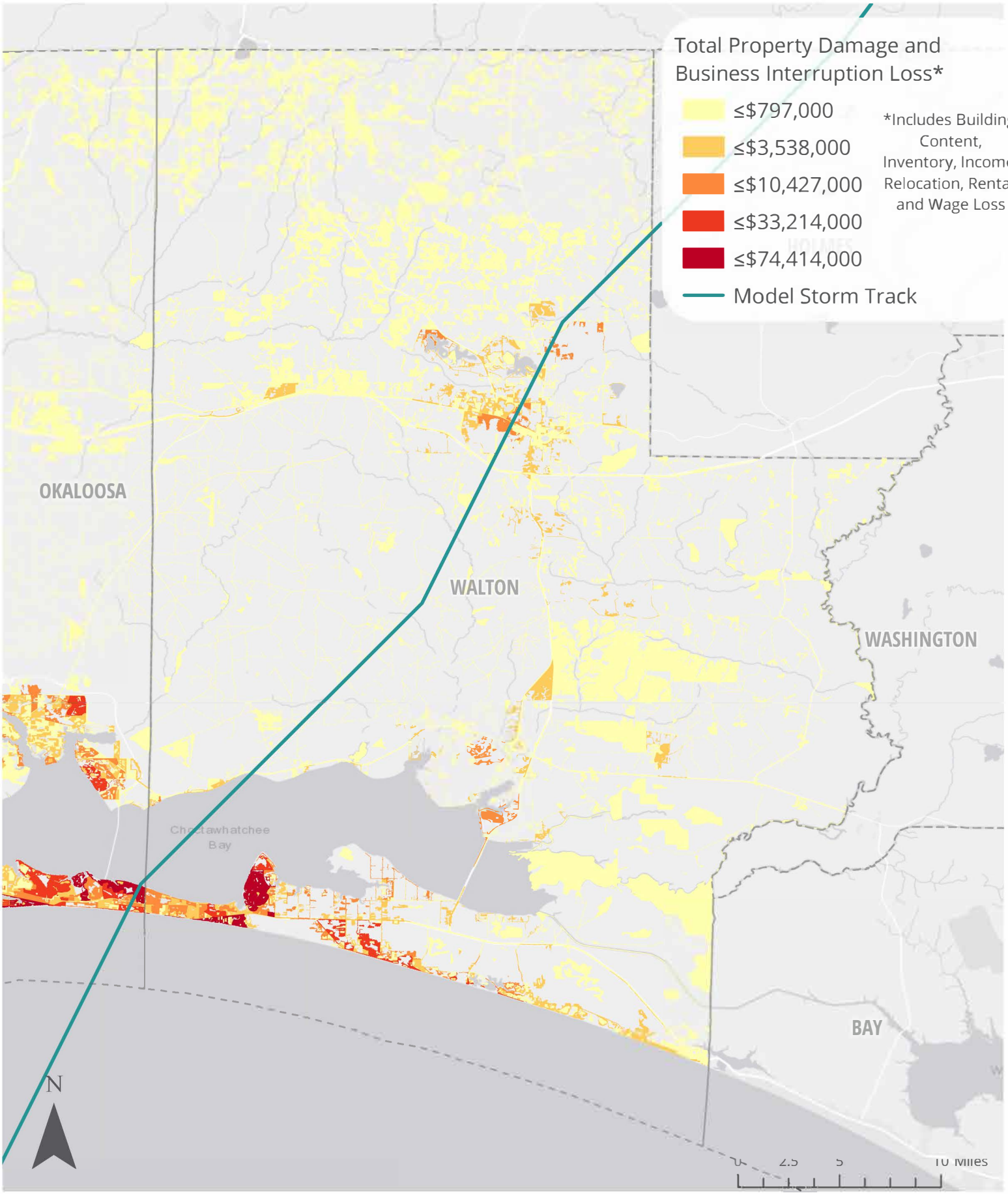


ECRC, FDEM 2019

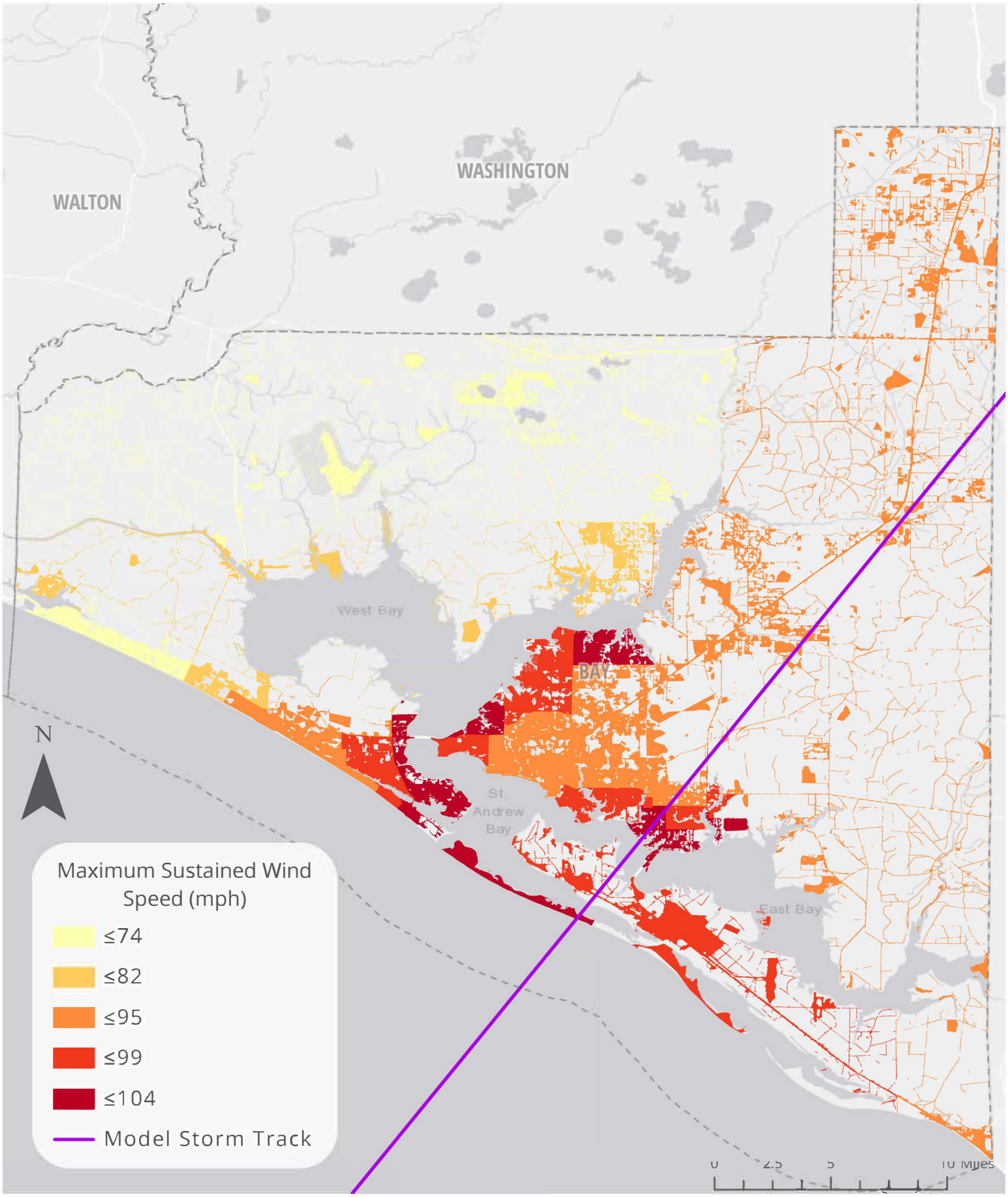
HAZUS Deterministic Model
Building-Related Economic Loss Estimates - Santa Rosa County



ECRC, FDEM 2019

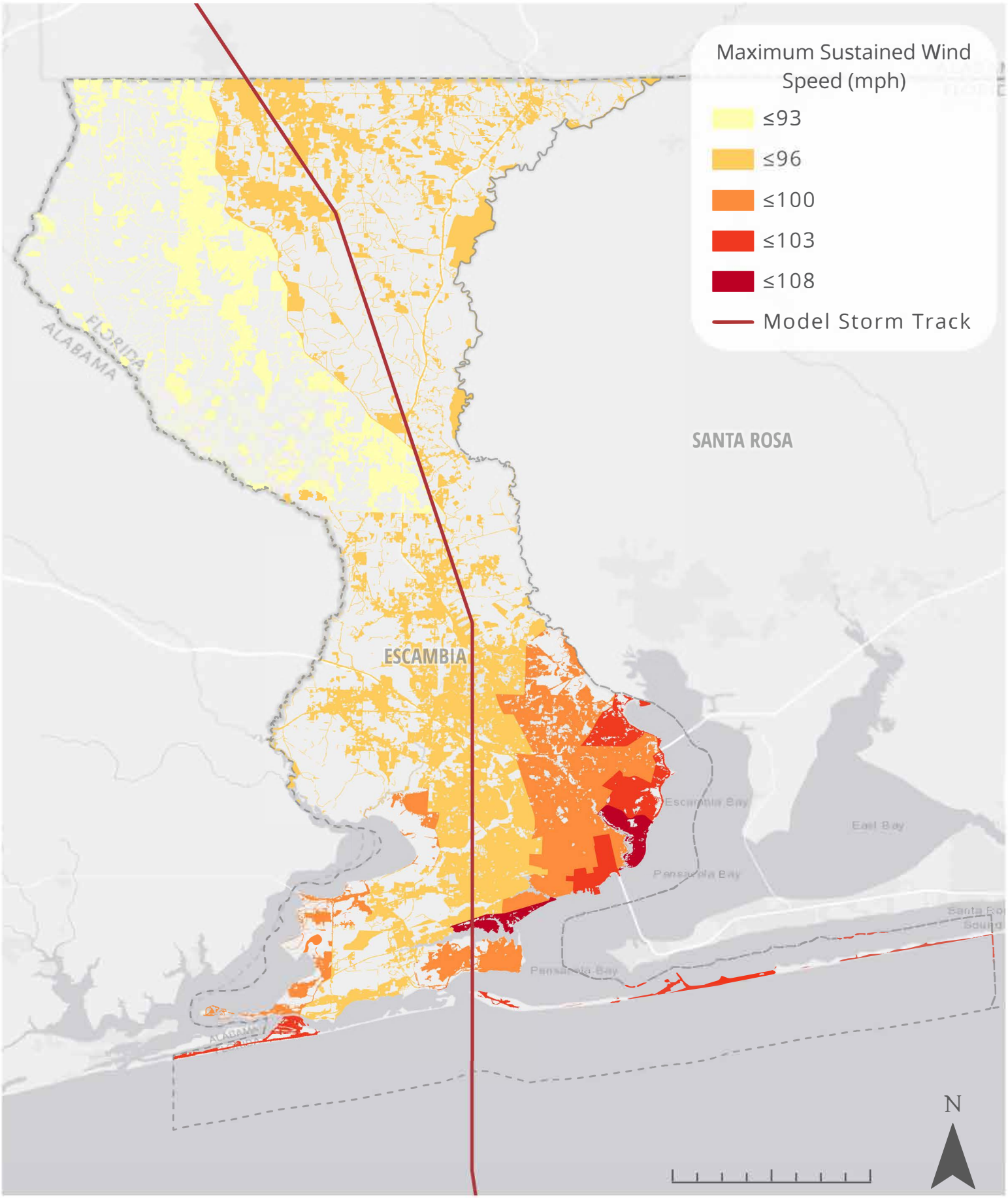

Total Property Damage and Business Interruption Loss*
≤$797,000
≤$3,538,000
≤$10,427,000
≤$33,214,000
≤$74,414,000
Model Storm Track
*Includes Building, Content, Inventory, Income, Relocation, Rental, and Wage Loss
OKALOOSA
WALTON
WASHINGTON
BAY
Choctawhatchee Bay
N
2.5
5
10 Miles

HAZUS Deterministic Model
Maximum Sustained Wind Speed - Bay County



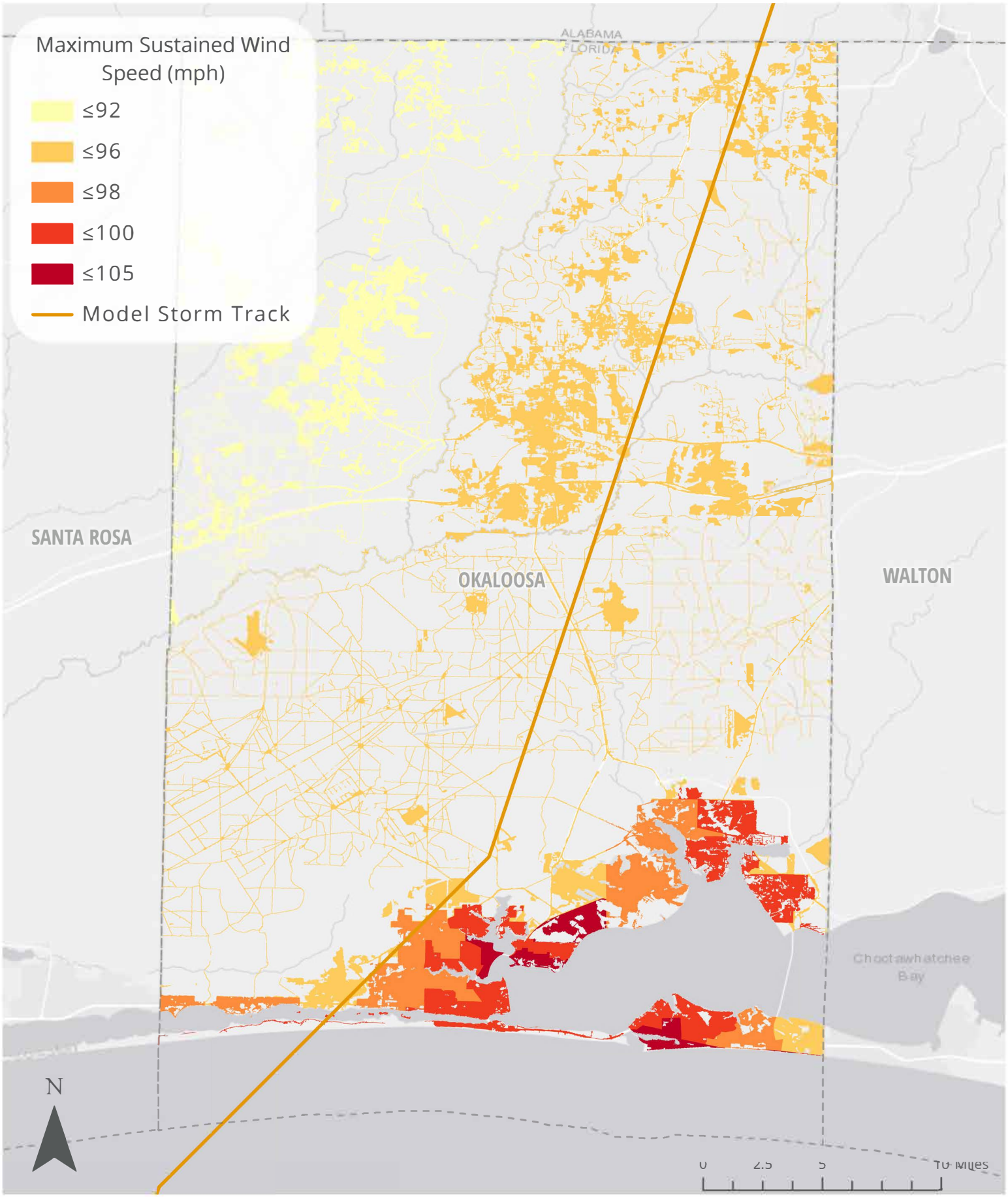
ECRC, FDEM 2019

HAZUS Deterministic Model
Maximum Sustained Wind Speed - Escambia County



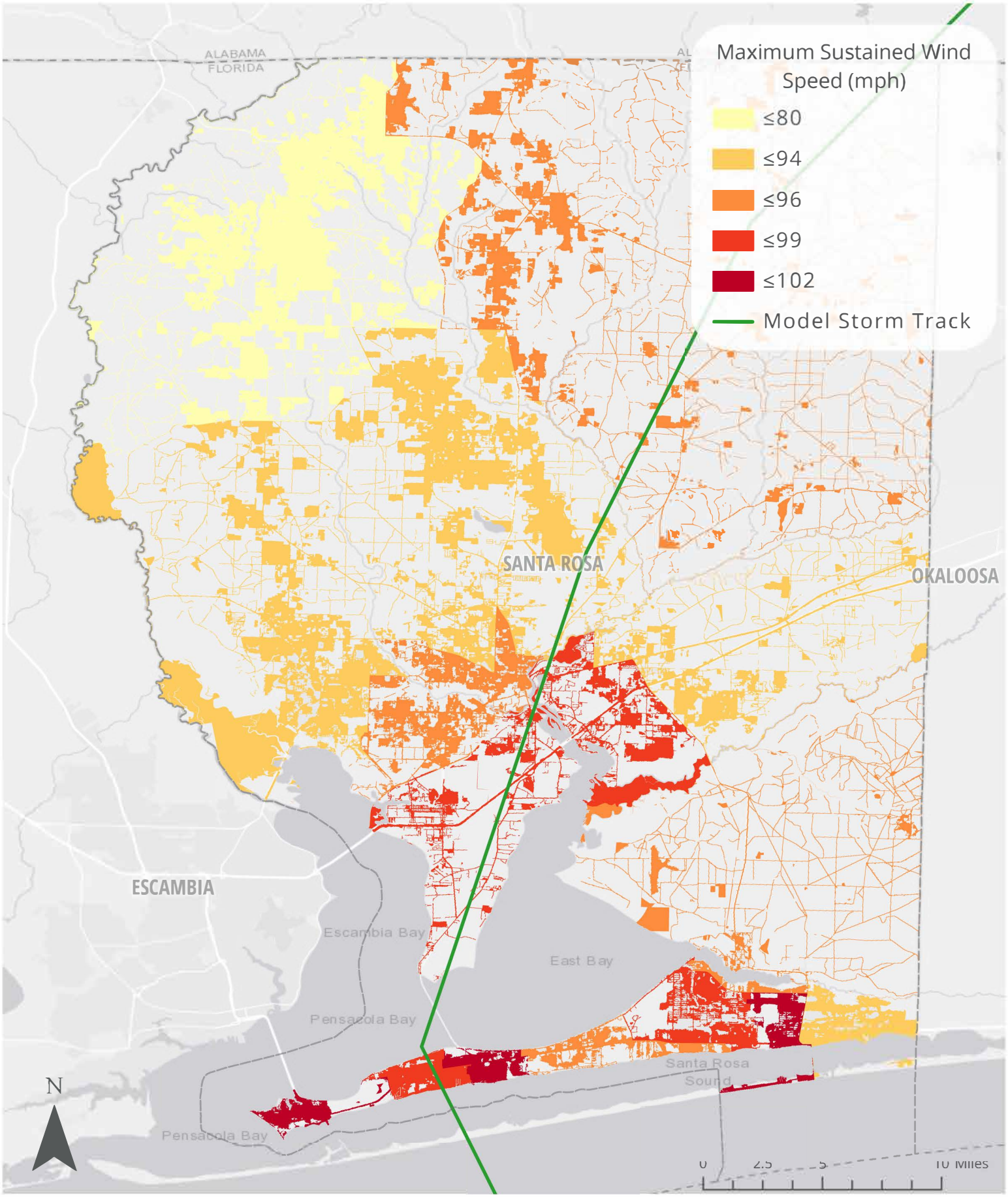
ECRC, FDEM 2019

HAZUS Deterministic Model
Maximum Sustained Wind Speed - Okaloosa County



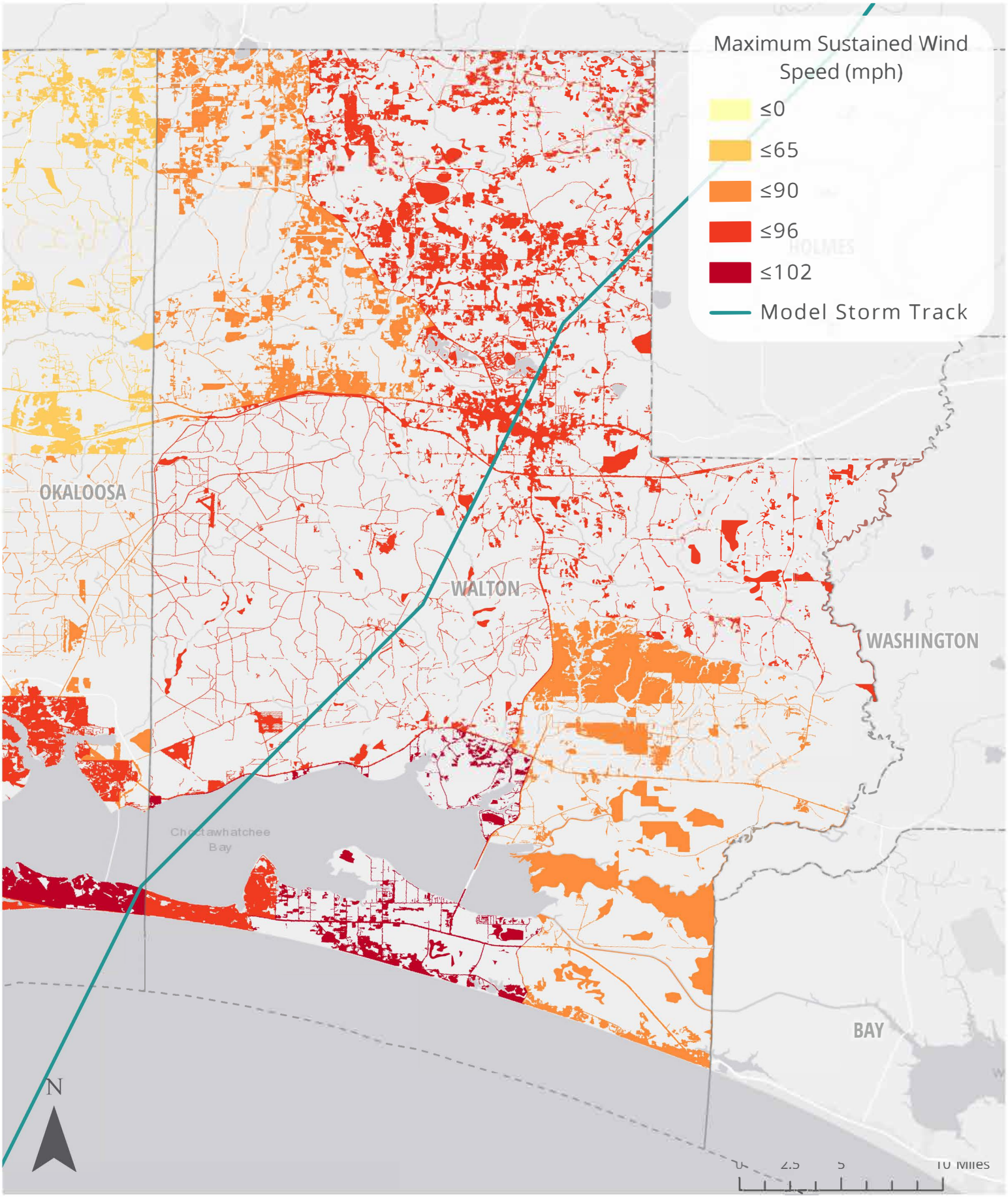
ECRC, FDEM 2019

HAZUS Deterministic Model
Maximum Sustained Wind Speed - Santa Rosa County



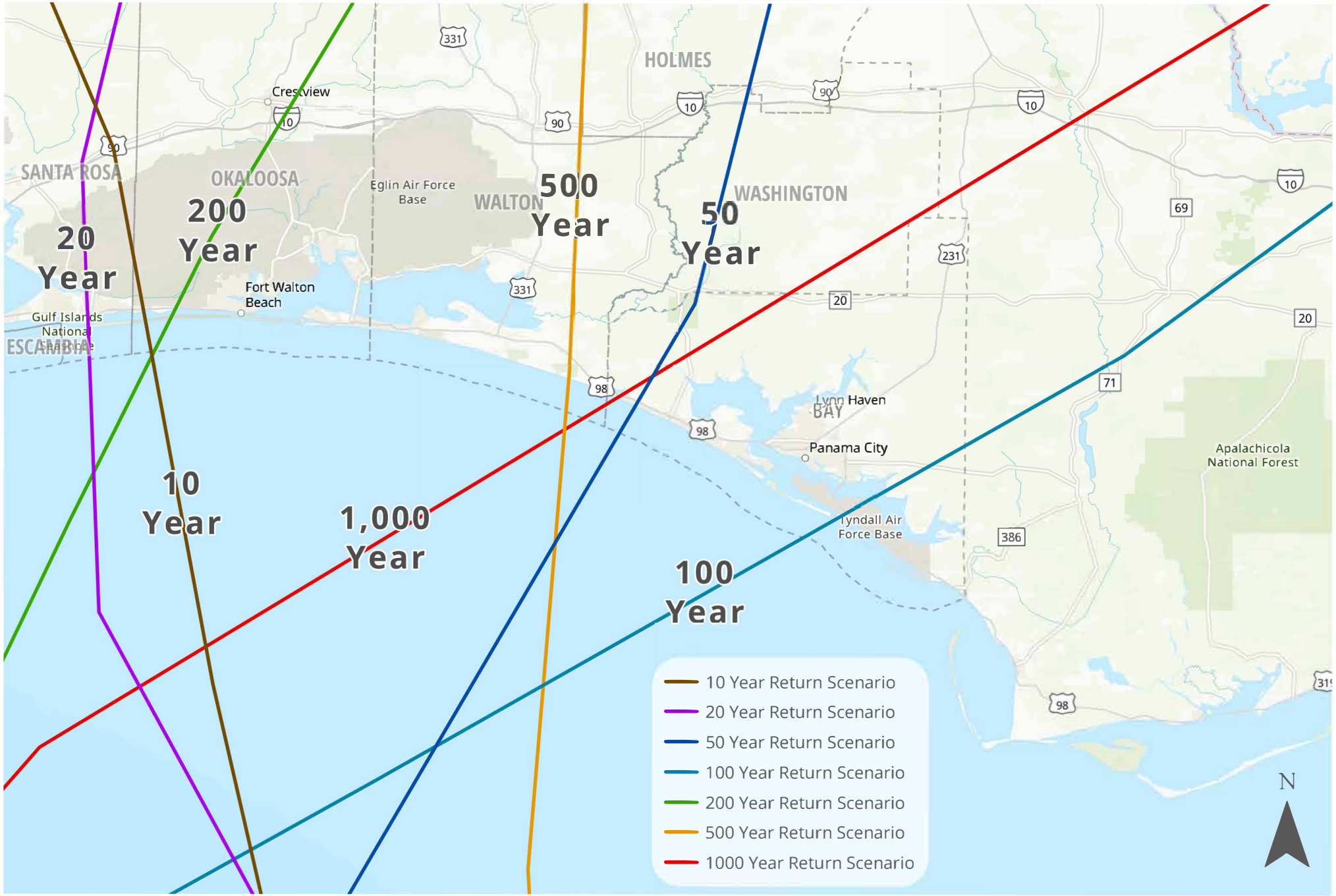
ECRC, FDEM 2019

HAZUS Deterministic Model
Maximum Sustained Wind Speed - Walton County



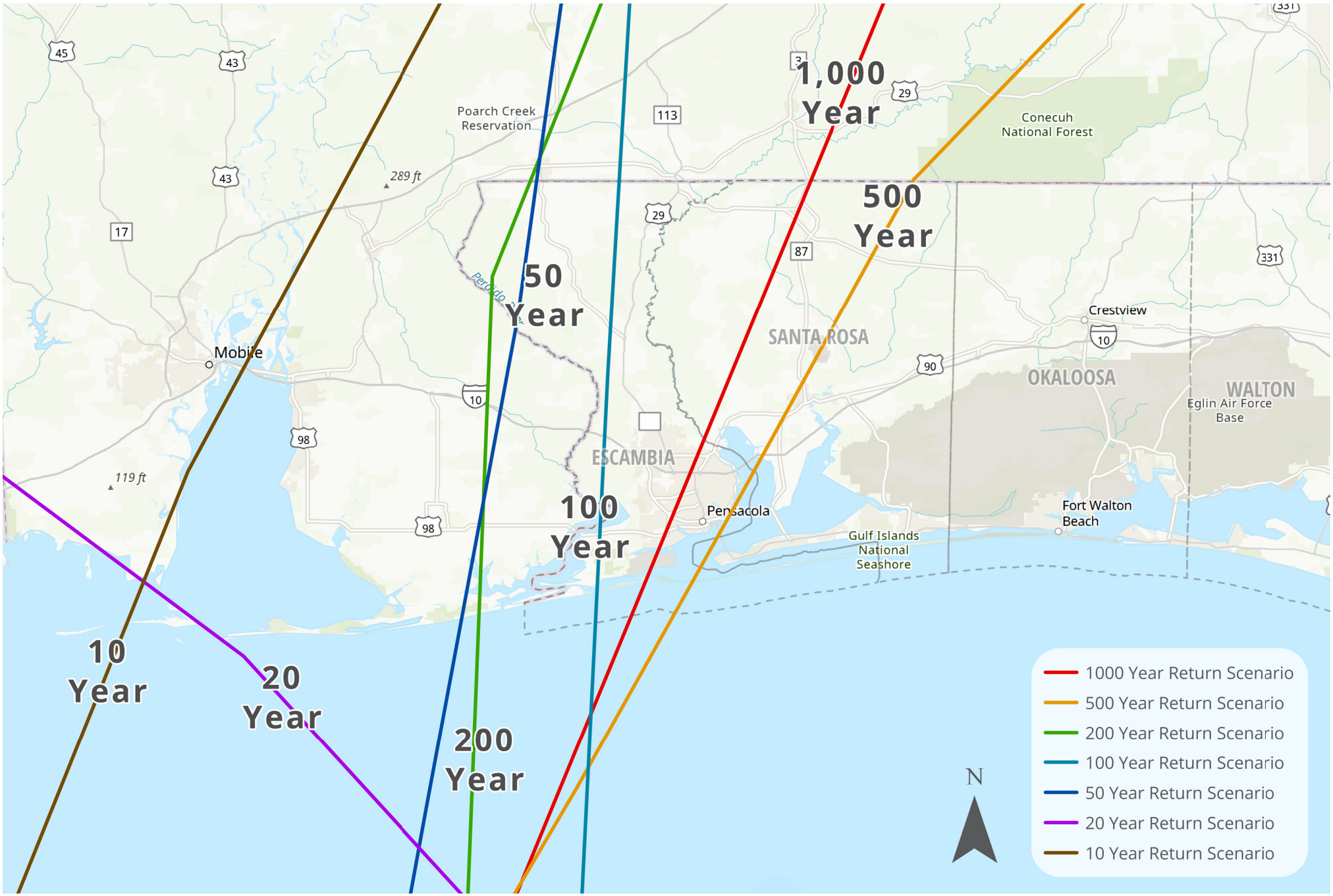
ECRC, FDEM 2019

HAZUS Probabilistic Model
Storm Tracks - Bay County



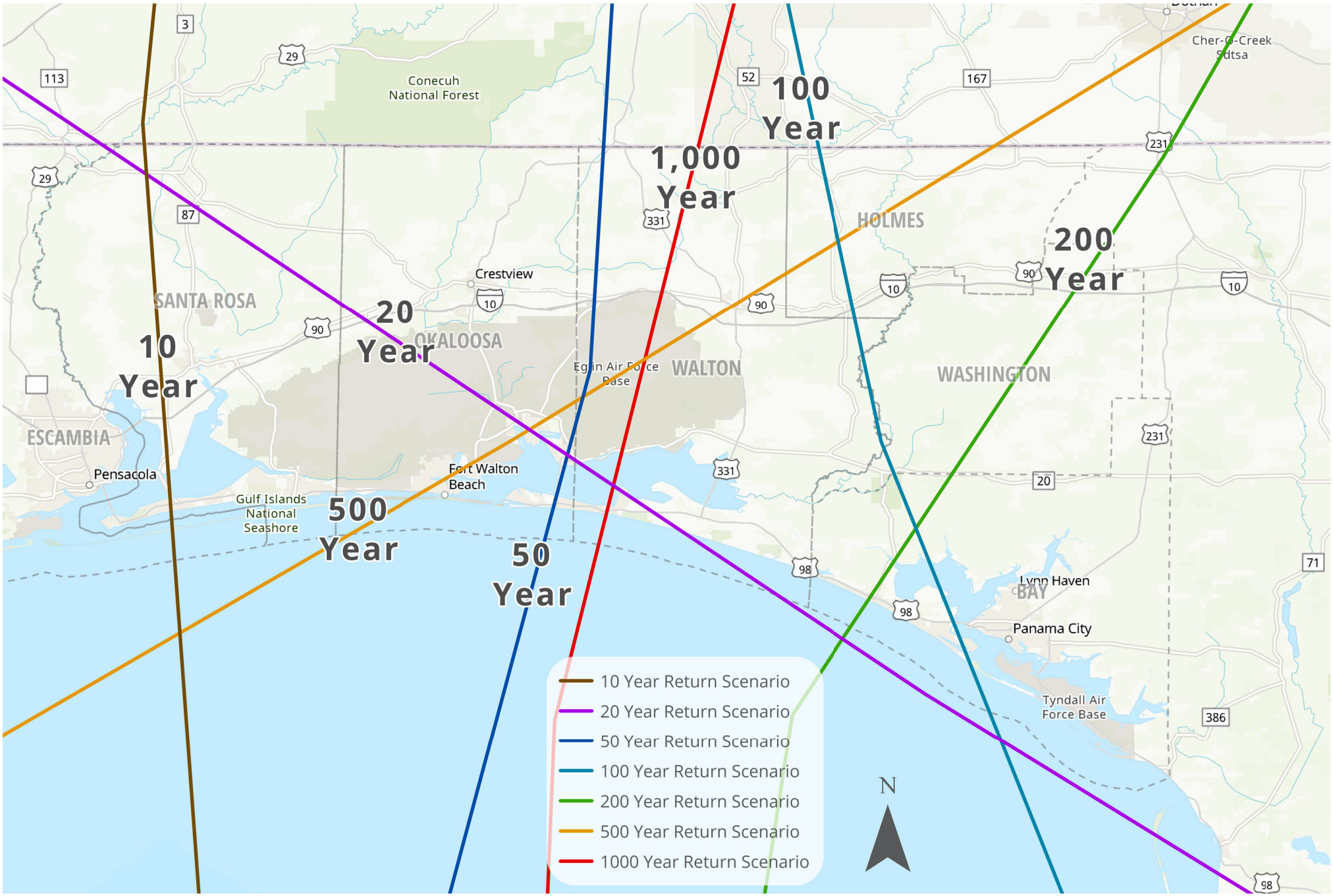
ECRC, FDEM 2019

HAZUS Probabilistic Model
Storm Tracks - Escambia County



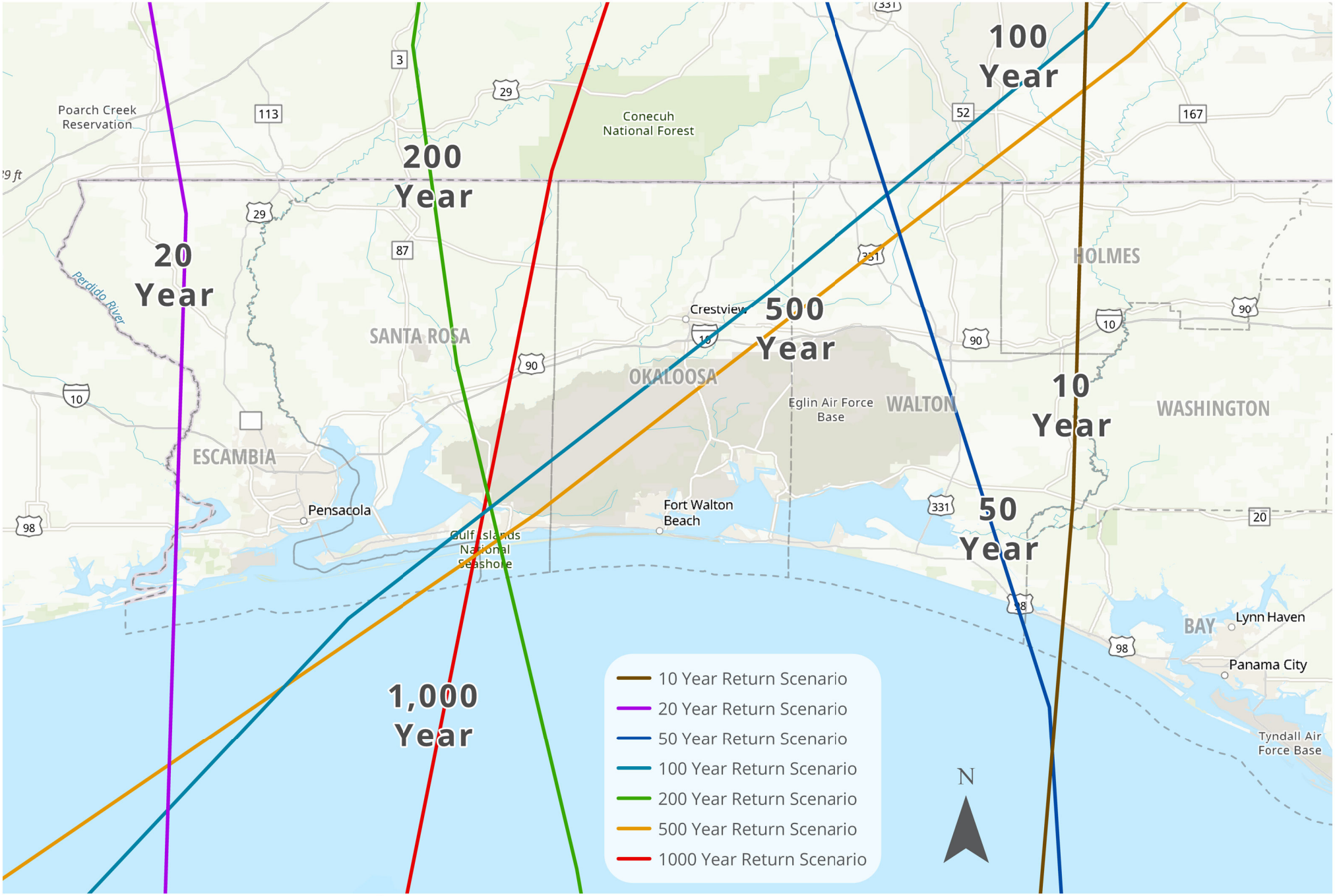
ECRC, FDEM 2019

HAZUS Probabilistic Model
Storm Tracks - Holmes County



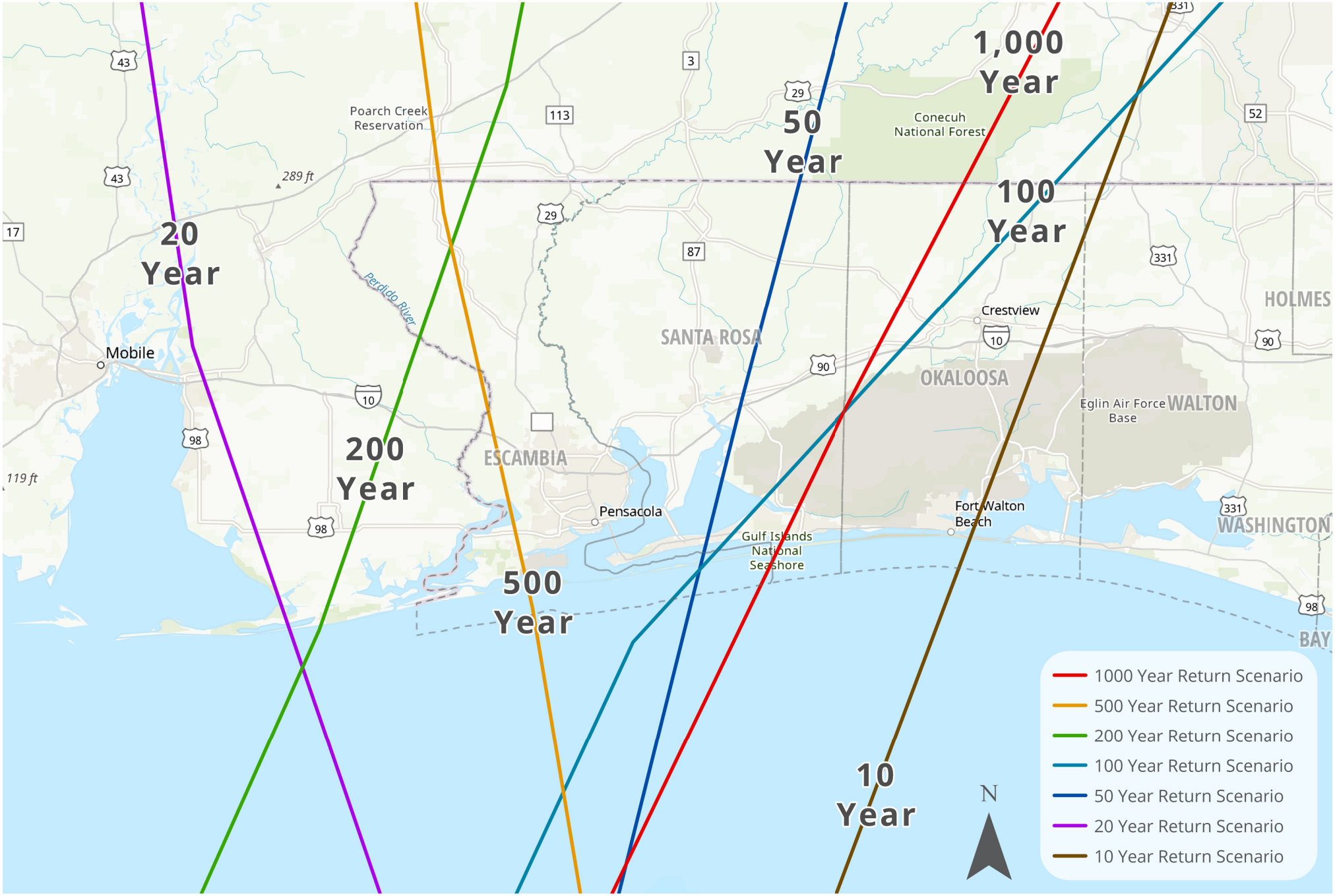
ECRC, FDEM 2019

HAZUS Probabilistic Model
Storm Tracks - Okaloosa County



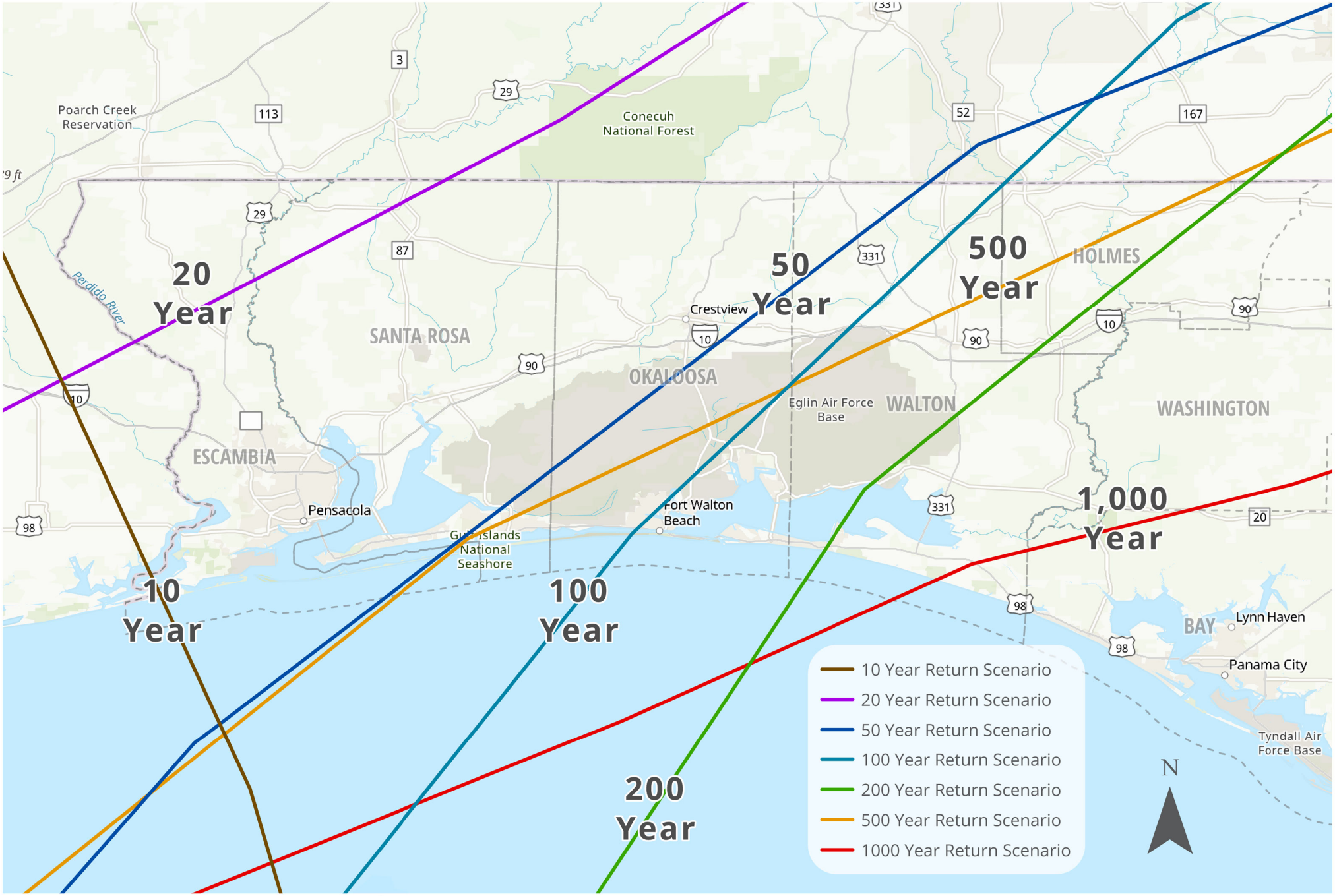
ECRC, FDEM 2019

HAZUS Probabilistic Model
Storm Tracks - Santa Rosa County



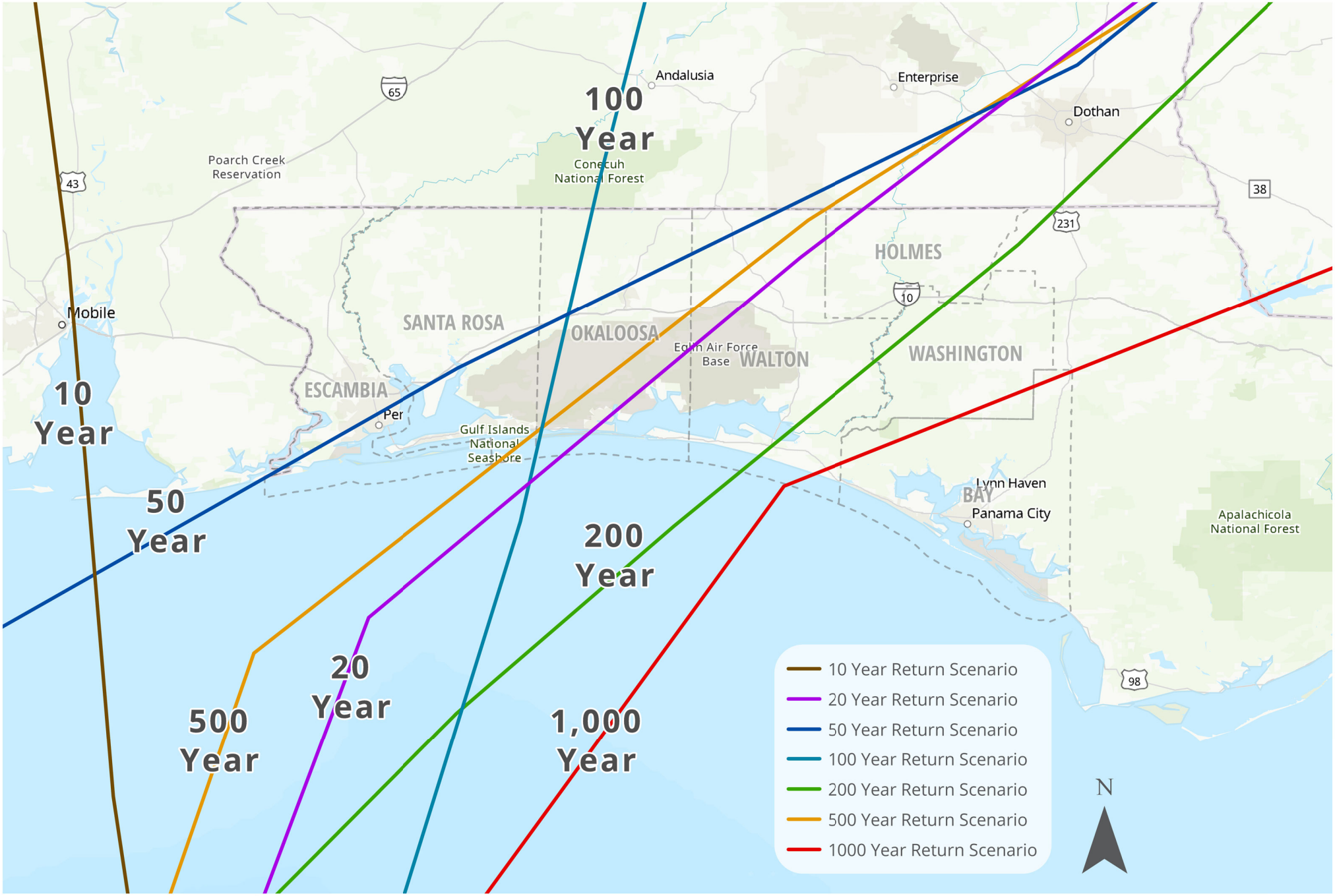
ECRC, FDEM 2019

HAZUS Probabilistic Model
Storm Tracks - Walton County



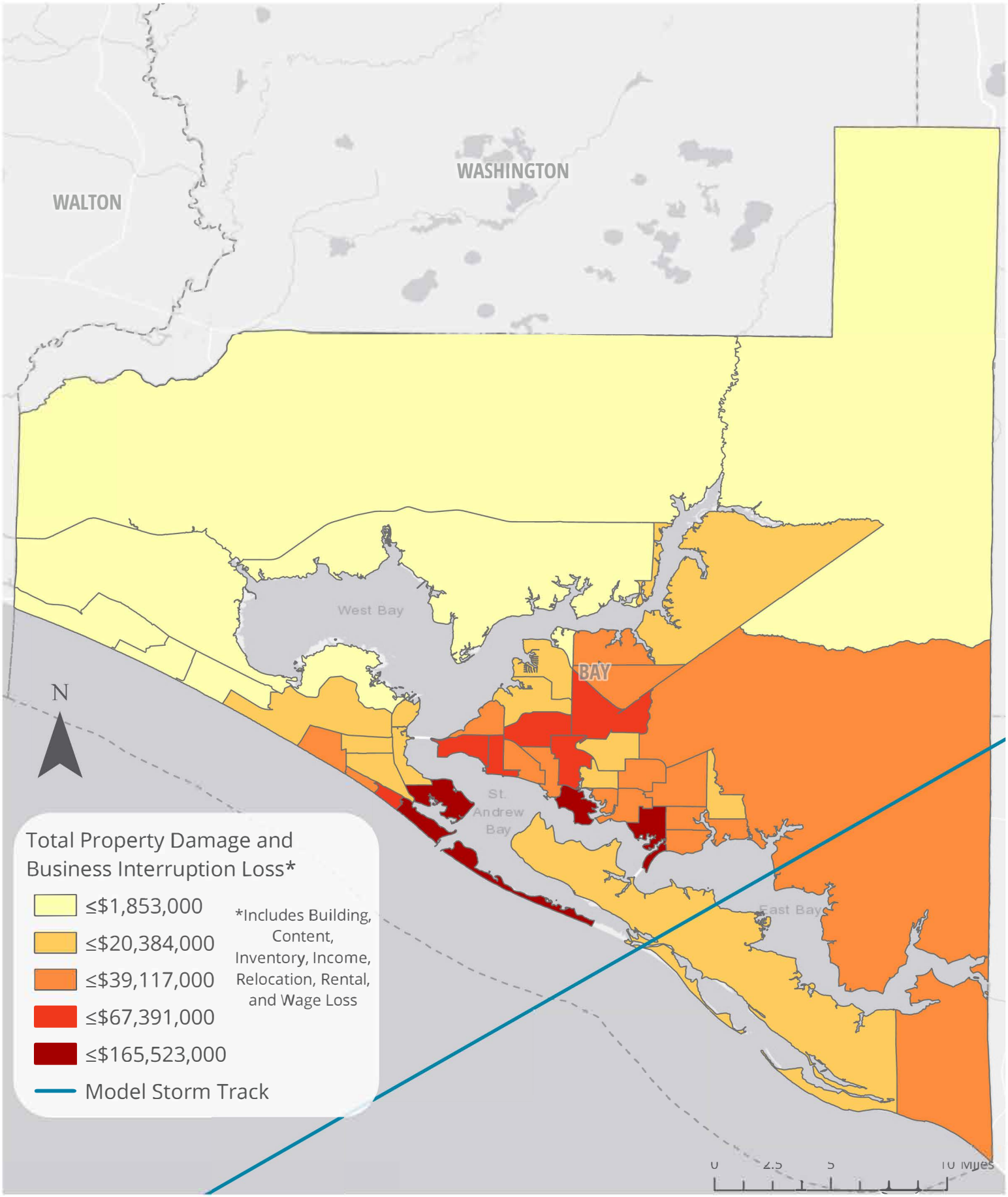
ECRC, FDEM 2019

HAZUS Probabilistic Model
Storm Tracks - Washington County



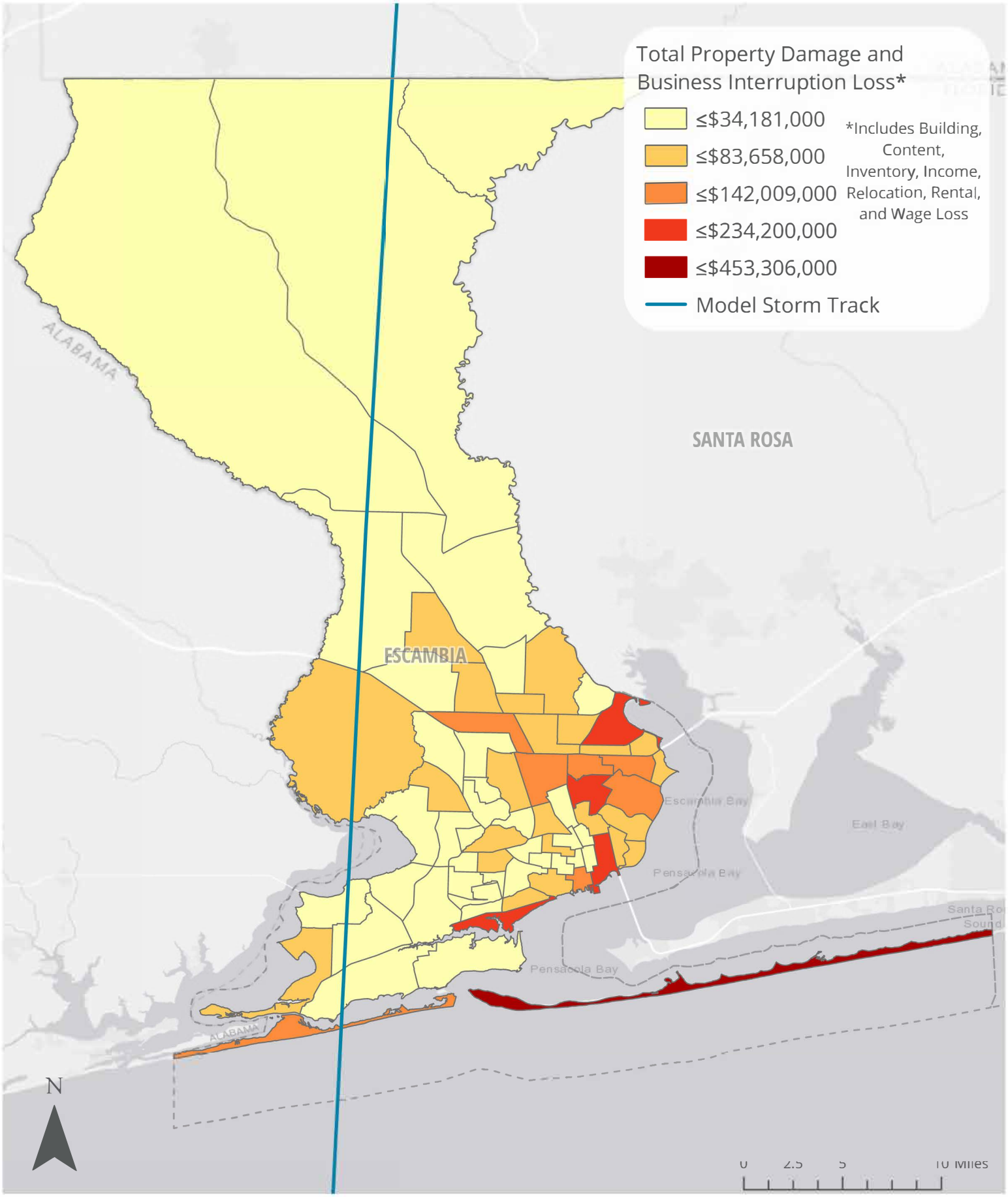
ECRC, FDEM 2019

HAZUS Probabilistic Model, 100-Year Return
Building-Related Economic Loss Estimates - Bay County



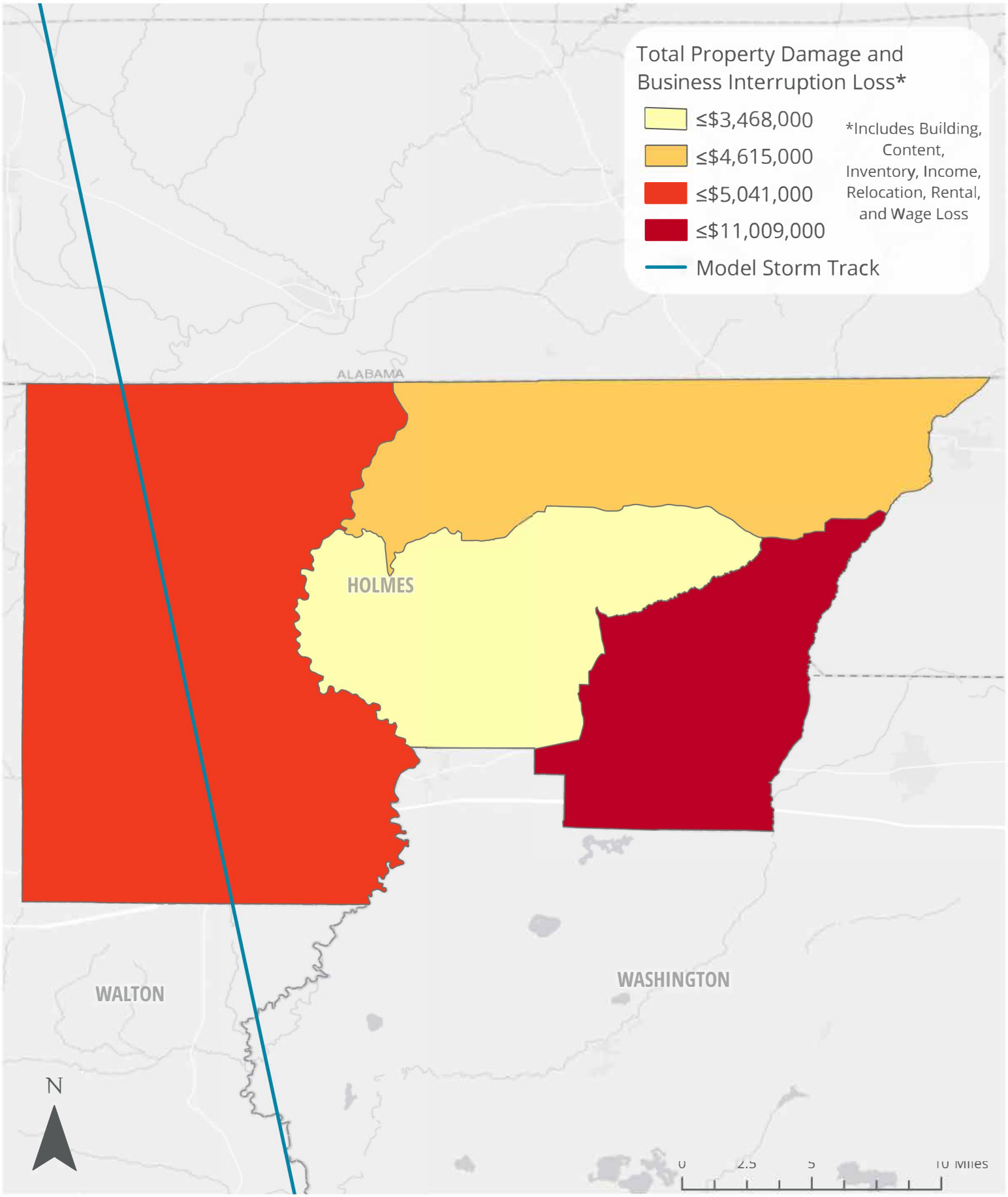
ECRC, FDEM 2019

HAZUS Probabilistic Model, 100-Year Return
Building-Related Economic Loss Estimates - Escambia County



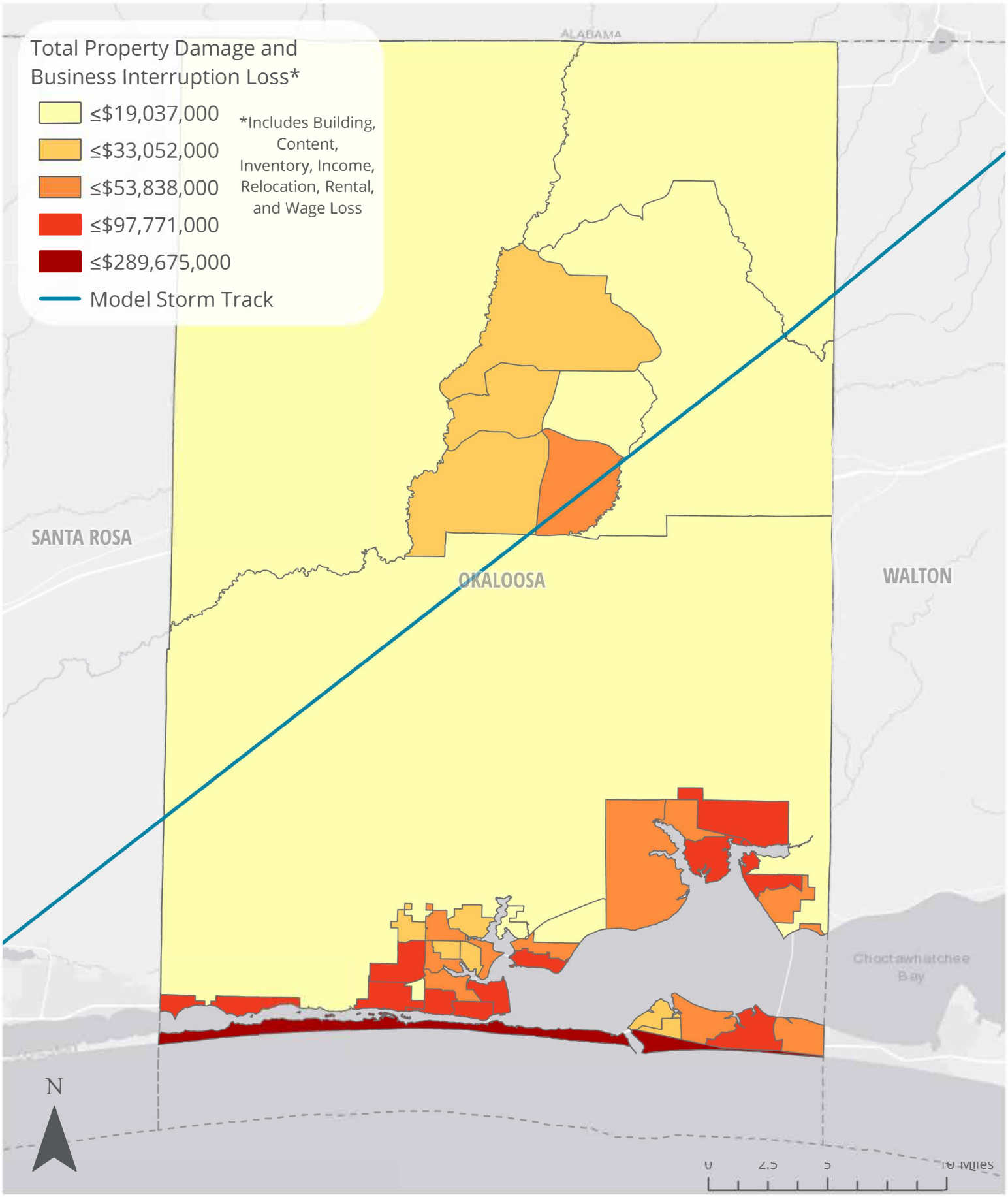
ECRC, FDEM 2019

HAZUS Probabilistic Model, 100-Year Return
Building-Related Economic Loss Estimates - Holmes County



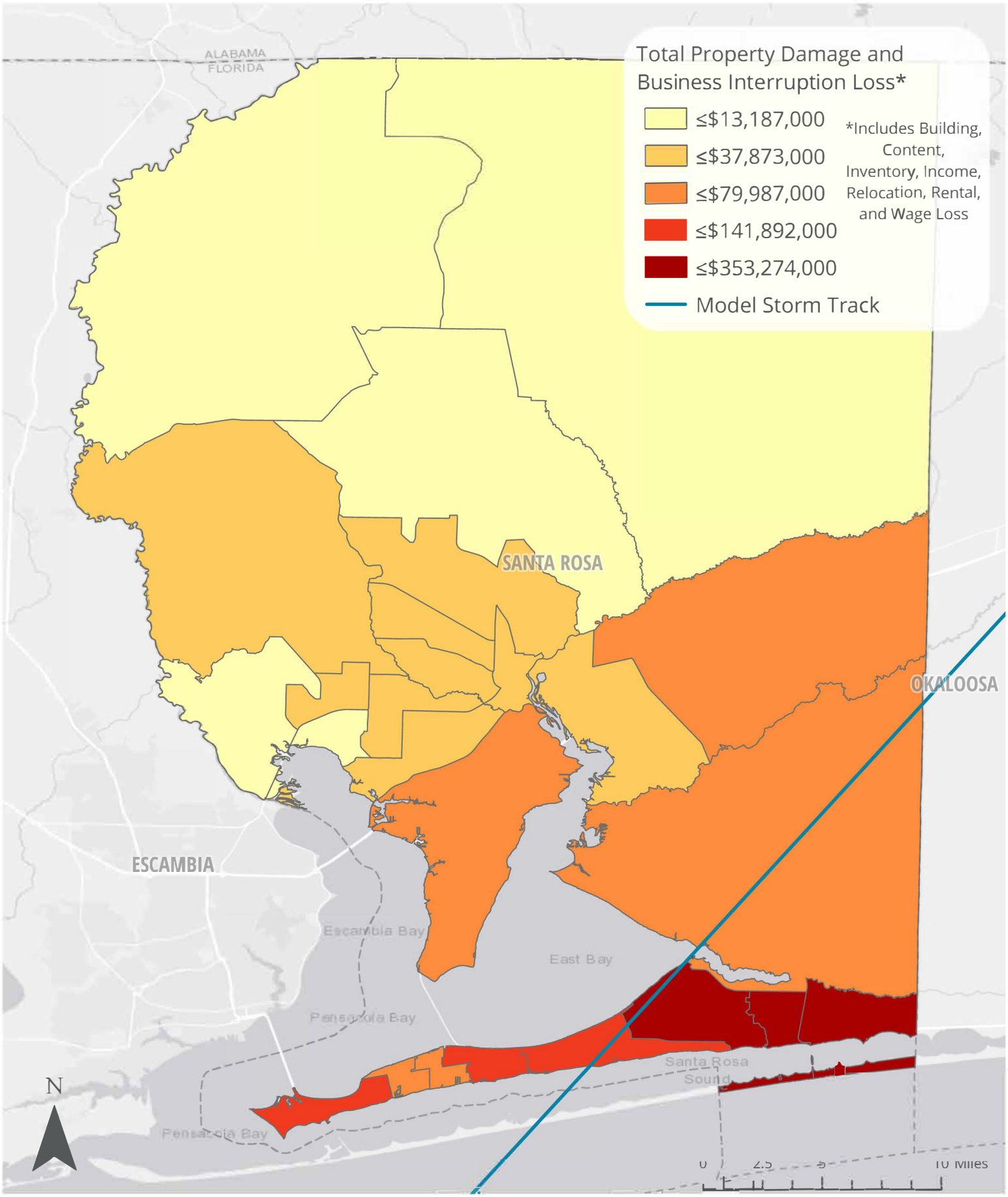
ECRC, FDEM 2019

HAZUS Probabilistic Model, 100-Year Return
Building-Related Economic Loss Estimates - Okaloosa County



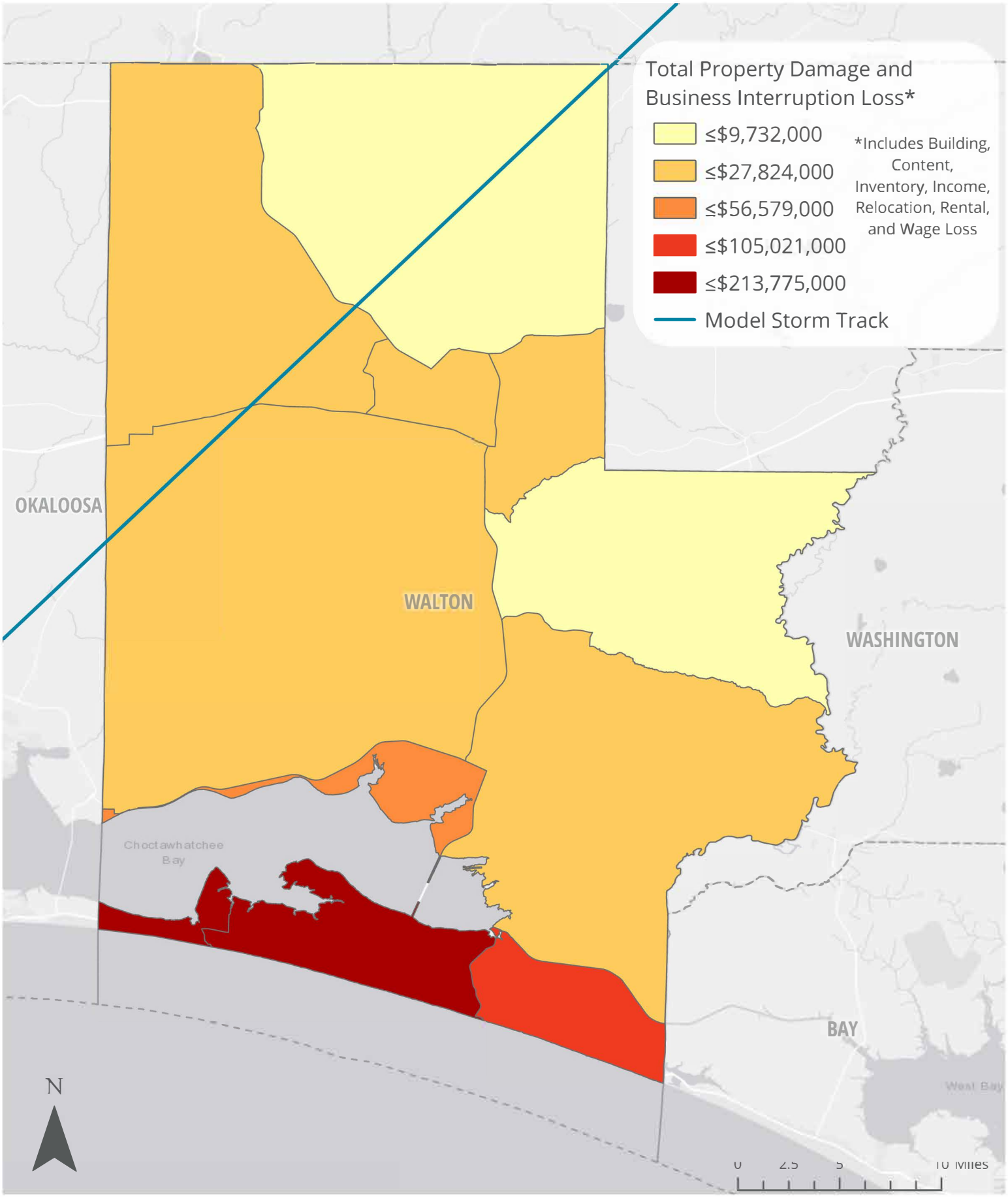
ECRC, FDEM 2019

HAZUS Probabilistic Model, 100-Year Return
Building-Related Economic Loss Estimates - Santa Rosa County



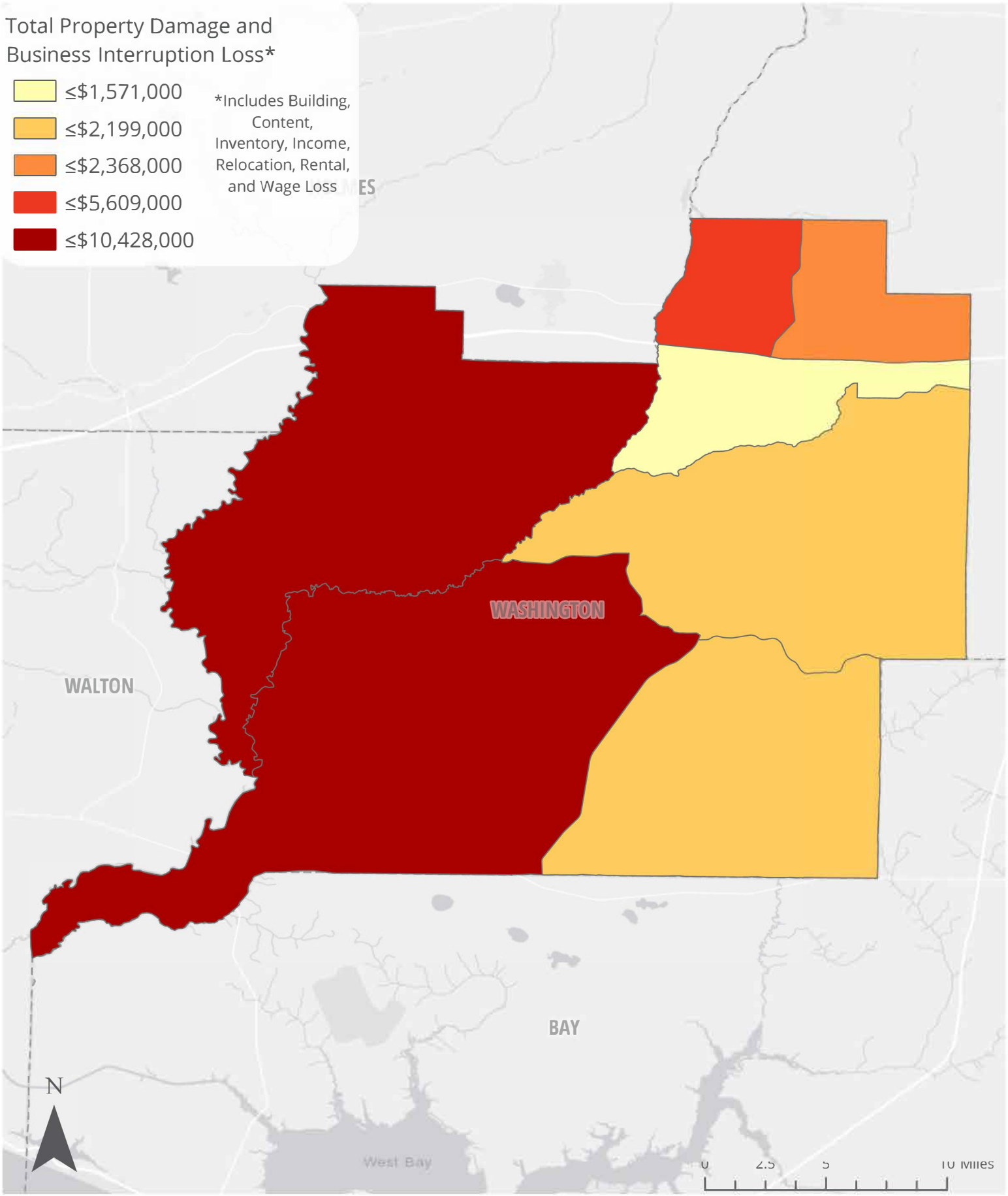
ECRC, FDEM 2019

HAZUS Probabilistic Model, 100-Year Return
Building-Related Economic Loss Estimates - Walton County



ECRC, FDEM 2019

HAZUS Probabilistic Model, 100-Year Return
Building-Related Economic Loss Estimates - Washington County



ECRC, FDEM 2019