RPS

Risk Reduction for Small Business Resiliency in RI

Exposure Analysis Report

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Prepared By

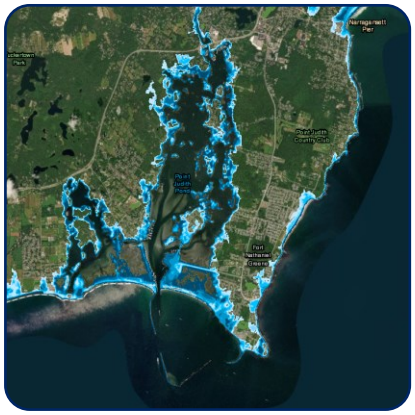
Matthew Frediani

Jeremy Fontenault

Matthew Bernardo

Project Manager:

Gabrielle McGrath



Local RI Office:

55 Village Square Drive,
South Kingstown, RI
02879

US Headquarters:

20405 Tomball Parkway,
Suite 200, Houston, TX
77070

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1 Introduction

To effectively tailor risk reduction guides to specific small businesses types, it is important to clearly understand the potential exposure of small businesses to extreme weather and climate-related hazards. Recently, the state and the University of Rhode Island (URI) led the development of several decision tools and datasets, including STORMTOOLS and related products developed for the Rhode Island Department of Emergency Management (RIDEM)'s assessment of wastewater collection and treatment infrastructure. The exposure analysis for this project leveraged these studies and other public sources of data to broadly characterize weather-related risks to the state's small business community.

After defining moderate and severe scenarios, the project team identified and assembled public datasets that were used to inform the exposure assessment. Data layers were arranged within a Geographic Information System (GIS) environment with small business assets categorized by location overlaid with flood data for each scenario. These maps were used to understand exposure of business infrastructure to both coastal and inland, moderate and severe impacts. These maps and their related statistics were prepared and used to help select four pilot areas for this project. Small businesses in the pilot areas will be assessed on their vulnerabilities in order to inform the creation of risk reduction guides.

2 Inputs

2.1 Data Sources

Data used to define the various hazard conditions or to define business locations and types were acquired and prepared for the exposure analysis (Table 2-1). GIS data were obtained from the Rhode Island Geographic Information System (RIGIS). Business data were acquired through personal communication requests with the respective organizations.

Table 2-1: Data sources used throughout exposure analysis.

Dataset	Source
STORMTOOLS	URI EDC, RIGIS
FEMA Flood Hazard Areas	RIGIS
RIDEM Riverine Flooding + 3 ft. Freeboard	RIGIS
Secretary of State Business List	Terrance Jackson Director of Information Technology Secretary of State's Office
Business List for RI Coastal Municipalities	Rhode Island Commerce Corporation (from Dun & Bradstreet)
E-911 Sites	RIGIS
RI Municipalities	RIGIS

2.1.1 Business Data

A database of businesses within Rhode Island registered with the Secretary of State's Office was obtained from the Secretary of State's Office (SOS) on August 7, 2018. This regularly-updated database includes all businesses that elect to register with the State. The database consists of the business name and addresses. Most are also classified with North American Industry Classification System (NAICS) codes, which classifies businesses into type categories. Some businesses are not required to register with the State, electing only to register with their local municipality and therefore are not included in this database. This database also includes businesses that would not be considered "small". For this project, a "small business" is defined as a business with less than 50 employees.

Other sources of business data were reviewed during this data acquisition phase. The RI E-911 data classifies building locations into broad categories that included commercial and industrial. The data from the SOS was the most comprehensive listing of businesses statewide, including nearly 46,000 unique business listings with NAICS business type descriptions. Even though this database does not contain all small businesses, it was determined to be sufficient for assessing the statewide exposure risk to extreme weather events.

Since this SOS businesses database did not include any location information, it was used in conjunction with the RI E-911 address location database. The E-911 point data represent every known building or structure in the state of Rhode Island. Geocoding the state database to the E-911 point data

paired locations with the addresses provided in the database. More about this process is discussed in section 2.3.

Additionally, later into the project, the Rhode Island Commerce Corporation (RICC) provided a database of businesses located within coastal municipalities. This data was compiled by Dun & Bradstreet, a firm specializing in business data analytics. This data set included business name and address, location information (based on an estimated location along the street based on its address), and an estimated number of employees. This dataset was not used in the exposure analysis due to the timing of receiving the data, the lack of full state coverage, and the lack of precision available in the business location. However, this database did include valuable business information and appeared to be a very comprehensive listing of businesses. This database will be used for the vulnerability assessment to identify additional businesses to visit and to verify the number of employees of a given businesses.

2.1.2 Hazard Data

Small business infrastructure that may be exposed to extreme weather and climate-related hazards was evaluated using a variety of GIS data sources.

To assess exposure to coastal flooding, geospatial datasets developed by the University of Rhode Island under the STORMTOOLS initiative were utilized. The data extend state-wide and show areas susceptible to inundation from storm surges of varying return periods with and without the addition of sea level rise. The mapping methodology is described by Spaulding and Isaji (2014) and utilizes output from high-fidelity computer modeling of hurricane storm surges completed by the US Army Corps of Engineers as part of the North Atlantic Comprehensive Coastal Study (NACCS; Cialone et al., 2015).

Inland flooding was addressed using maps created by the Federal Emergency Management Agency (FEMA). FEMA conducts flood hazard mapping as part of the National Flood Insurance Program (NFIP) and maintains a geospatial database of current flood hazard data for all communities in Rhode Island. In their mapping, FEMA identifies Special Flood Hazard Areas (SFHA), which are areas that will be inundated by flood events having a 1-percent chance of being equaled or exceeded in any given year. The 1-percent annual chance flood is also referred to as the base flood or 100-year flood and is typically labeled as Zone A and Zone AE on a Flood Insurance Rate Map (FIRM). For riverine (inland) flooding, FEMA flood zones are established through hydrologic or statistical modeling to determine discharge-frequency relationships within a watershed. FEMA flood zones also use hydraulic analyses to determine the extent of flooding (floodplain) and the flood elevations associated with each frequency studied.

Although flood zones mapped by FEMA do not account for uncertainties associated with future climate changes, in Rhode Island, expanded flood zones were mapped across the state as part of a 2017 study for the RIDEM. Using guidance from the Federal Flood Risk Management Standard (EO 13690), existing FEMA 100-year flood elevations were modified with 2- and 3- vertical feet of "freeboard," and the corresponding horizontal floodplain extent was mapped. The input data for the analysis were FEMA base flood elevations (BFEs), which are provided at each riverine transect. The complete mapping methodology is described in RIDEM (2017). The final products of this analysis are a series of GIS files (raster datasets) showing the floodplain under each scenario. In some rare circumstances, these floodplains with 2 or 3 feet of freeboard are smaller than the 100-year base flood plains from FEMA. This inconsistency was due to the coarse nature of the FEMA floodplain maps, which occasionally cover areas of higher elevation that would not flood at the base flood elevation assigned by FEMA.

Sources of data for wind exposure were analyzed, however no data was available that would provide insight into the spatial variability of wind exposure statewide, both in terms of wind speed and resulting damage and power outages. The Public Utilities Commission (PUC) considers the state equally exposed to wind. The PUC used to separate their outage data between coastal and inland, but they no longer do so because of little difference between the areas in recent years. The Project Team requested 8-hour and 24-hour power outage by town from the National Grid and will review this data once it is received. The Project Team also conducted a review of the NOAA STORMEVENTS data. This data captures different types of weather events (i.e. winter weather, blizzard, high wind, strong wind) with damage costs by county. Storm surge damage is combined with wind damage, and there is no way to separate the two. The spatial trend of the data is limited by the county. The determination was made not to consider a specific wind/power outage scenario in the Exposure Analysis. However, the National Grid data will be reviewed once it is received, and the businesses assessed during the Vulnerability Analysis will be asked extensive questions about the impacts of power outages to their operations.

2.2 Exposure Scenarios

The Steering Committee identified four exposure scenarios for this assessment; (i) moderate coastal flooding event, (ii) severe coastal flooding event, (iii) moderate inland flooding event, and (iv) severe inland flooding event (Table 2-2). The exposure analysis used two STORMTOOLS products representing moderate and severe coastal flood hazards. Exposure to moderate flooding was assessed using the 25-year return period water level, while severe flooding was represented with a 100-year return period water level and the addition of 2-feet of sea level rise. Inland exposure to moderate flooding was assessed using FEMA's 100-year floodplain (SFHA), which is the land area where the NFIP

floodplain management regulations are enforced and where the mandatory purchase of flood insurance applies. Exposure to severe inland flooding was assessed using the dataset that represents 100-year flooding plus 3-feet of freeboard.

Table 2-2: Hazard data used for each of the exposure scenarios.

Exposure Scenario	Dataset	Hazard Data Source
Moderate Coastal Flooding	25-Year Water Level + 0-ft of Sea Level Rise	STORMTOOLS
Severe Coastal Flooding	100-Year Water Level + 2-ft of Sea Level Rise	STORMTOOLS
Moderate Inland Flooding	100-Year Floodplain	FEMA
Severe Inland Flooding	100-Year Floodplain + 3-ft of Freeboard	FEMA/RIDEM

Each of the four exposure scenarios were assessed independently initially. The two moderate and two severe scenarios were also combined to consider the statewide exposure to these two levels of exposure.

2.3 Data Preparation

Hazard data was downloaded directly from RIGIS for each individual scenario. The STORMTOOLS data were downloaded as polygon data directly from RIGIS and required no further preparation. The FEMA Digital Flood Insurance Rate Map (DFIRM) data was downloaded as polygon data but required some filtering to narrow down the data to only include the inland, 100-year floodplain data. The DFIRM data was filtered by flood zone and static base flood elevation. Flood zones A, AE, AH, and AO were included. However, because AE flood zones are both coastal and inland, the AE flood zones were filtered based on the presence of a static base flood elevation. AE zones with a static base flood elevation represent coastal flood zones and were therefore excluded, resulting in only inland polygons. The RIDEM 100-year floodplain plus 3 feet of freeboard was downloaded as a raster grid. The grid was converted to a polygon representation of the flooded area.

The Secretary of State businesses database did not contain any location information other than the address, so the businesses were geocoded to the RI E-911 address location GIS database. Geocoding is the process of matching the address of the business to the proper address in the E-911 point data. The E-911 point data represent every known building or structure in the state of Rhode Island. Using the RIGIS E-911 address locator geocoding service, approximately 41,000 (89%) of the nearly 46,000 businesses were successfully located in the E-911 data. The remaining 5,000 were not able to be matched, either due to incomplete or incorrect address information or P.O. Box addresses that do not

match to a physical address location. This process resulted in one comprehensive GIS point dataset with the attributes from the state business database.

The most recent Rhode Island municipalities data was used to summarize data during the exposure analysis. This data contains multipart features for many municipalities, therefore was dissolved to contain only one feature per municipality.

All data was projected to NAD 1983 State Plane Rhode Island FIPS 3800 (US Feet) for the exposure analysis.

3 Exposure Analysis Methodology

The exposure analysis utilized different methods to determine business infrastructure that may be exposed to multiple defined hazard scenarios. It was first necessary to determine which businesses could be impacted by each of the exposure scenarios. Then, different methods were used to summarize the impacted businesses to identify areas of highest exposure. The number of impacted businesses were summarized by municipality. This data was then used to calculate the percentage of businesses impacted within a municipality and the percentage of businesses impacted over the entire state. Cluster maps were created as an indicator for areas containing a higher density of impacted businesses. Each method allowed for a different comparison of the level of exposure in certain geographies which was critical to the selection of the four pilot areas for the vulnerability assessment.

3.1 Determining Impacted Businesses

A geospatial overlay analysis was used to determine the impacted businesses. The business location points were overlaid with the various hazard areas for each of the four scenarios and again for the statewide-combined moderate and severe scenarios. Businesses that were located within the flood area were identified as being impacted, and those outside of the flood area were identified as having no impact. The level of impact was not assessed during this statewide exposure analysis.

3.2 Summarizing by Municipality

Results from the overlay analysis were used to determine the number of businesses impacted within each municipality. These counts were then used to determine the percentage of businesses impacted within a municipality and statewide. The municipality of each business point was assigned based on the RIGIS municipality GIS dataset. The count of impacted business within each municipality

was tallied and compared to the total number of businesses in each municipality and the total businesses within the entire state.

3.3 Cluster Analysis

A cluster analysis of the impacted businesses was conducted to identify the areas with the highest density of impacted businesses. The cluster analysis was used to identify the locations of high density areas, providing a higher level of detail than the summaries by municipality. The cluster analysis was conducted by aggregating points within a specified search area. For this assessment, a search area of 0.5 miles was used. If three or more impacted businesses were within 0.5 mile of one another, a cluster was formed. A single point representing the center of that cluster was created and assigned a count indicating the number of impacted businesses in that area.

4 Exposure Analysis Results

The results of the exposure analysis are presented in a series of tables and figures for each of the four exposure scenarios independently and for the two combined inland and coastal exposures using the moderate and severe scenarios (Table 4-1). A map showing the business locations and highlighting the businesses impacted by both the moderate and severe scenarios was prepared. A table summarizing the total number of businesses, the number of businesses impacted, the percentage of businesses impacted within the municipality, and the percentage of businesses impacted statewide was prepared showing both moderate and severe scenario results. Maps were prepared showing the percentage of the municipality's total businesses impacted within each municipality for moderate scenarios (left) and severe scenarios (right). Maps were prepared showing the percentage of the state's total businesses impacted within each municipality for moderate scenarios (left) and severe scenarios (right). Finally, maps showing clusters of impacted businesses were prepared for moderate scenarios (left) and severe scenarios (right).

Table 4-1: Exposure analysis results by scenario.

Result	Scenario		
	Inland	Coastal	Combined
Impacted Businesses Map	Figure 4-1	Figure 4-5	Figure 4-9
Summary Table	Table 4-2	Table 4-3	Table 4-4
Percent of Municipality Businesses Impacted	Figure 4-2	Figure 4-6	Figure 4-10
Percent of Statewide Businesses Impacted	Figure 4-3	Figure 4-7	Figure 4-11
Cluster Maps of Impacted Businesses	Figure 4-4	Figure 4-8	Figure 4-12

4.1 Inland Flooding Results

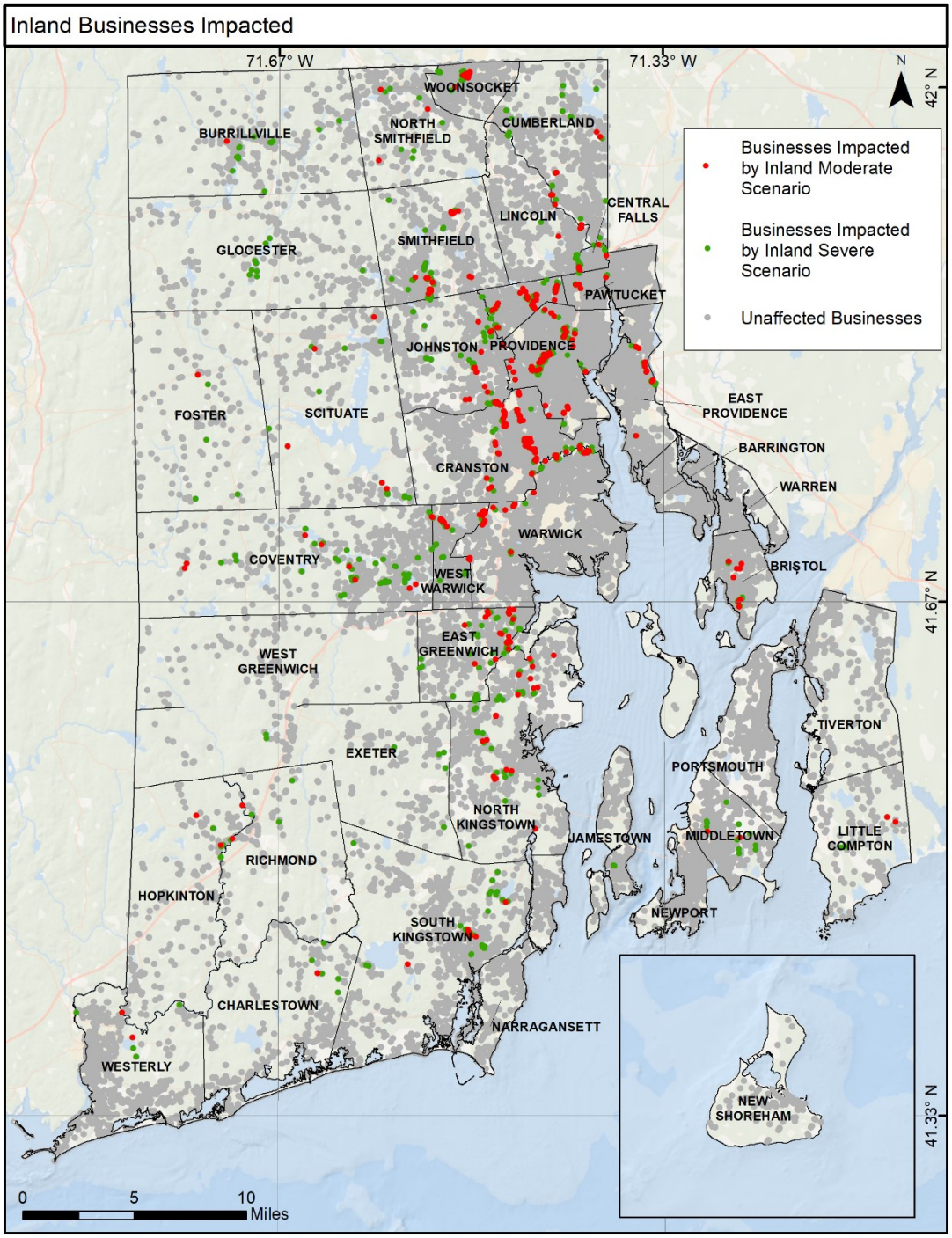


Figure 4-1: Rhode Island businesses impacted by moderate (red) and severe (green) inland flooding.

Table 4-2: Summary of exposure to inland flooding.

Town	Total Businesses	MODERATE			SEVERE		
		Impacted Businesses	Municipality % Impacted	State % Impacted	Impacted Businesses	Municipality % Impacted	State % Impacted
Barrington	656	0	0.00%	0.00%	0	0.00%	0.00%
Bristol	922	18	1.95%	0.04%	27	2.93%	0.07%
Burrillville	354	1	0.28%	0.00%	16	4.52%	0.04%
Central Falls	346	5	1.45%	0.01%	8	2.31%	0.02%
Charlestown	313	2	0.64%	0.00%	7	2.24%	0.02%
Coventry	911	10	1.10%	0.02%	82	9.00%	0.20%
Cranston	3,262	144*	4.41%	0.35%	141*	4.32%	0.34%
Cumberland	1,134	11	0.97%	0.03%	42	3.70%	0.10%
East Greenwich	1,005	72	7.16%	0.18%	176	17.51%	0.43%
East Providence	1,833	20	1.09%	0.05%	23	1.25%	0.06%
Exeter	292	0	0.00%	0.00%	10	3.42%	0.02%
Foster	156	1	0.64%	0.00%	6	3.85%	0.01%
Glocester	323	0	0.00%	0.00%	11	3.41%	0.03%
Hopkinton	232	6	2.59%	0.01%	18	7.76%	0.04%
Jamestown	377	0	0.00%	0.00%	7	1.86%	0.02%
Johnston	1,364	35	2.57%	0.09%	142	10.41%	0.35%
Lincoln	889	8	0.90%	0.02%	39	4.39%	0.10%
Little Compton	218	2	0.92%	0.00%	6	2.75%	0.01%
Middletown	832	2	0.24%	0.00%	22	2.64%	0.05%
Narragansett	728	0	0.00%	0.00%	0	0.00%	0.00%
New Shoreham	133	0	0.00%	0.00%	0	0.00%	0.00%
Newport	1,571	0	0.00%	0.00%	0	0.00%	0.00%
North Kingstown	1,424	19	1.33%	0.05%	73	5.13%	0.18%
North Providence	914	66	7.22%	0.16%	132	14.44%	0.32%
North Smithfield	448	3	0.67%	0.01%	8	1.79%	0.02%
Pawtucket	1,975	6	0.30%	0.01%	24	1.22%	0.06%
Portsmouth	690	0	0.00%	0.00%	0	0.00%	0.00%
Providence	7,011	106	1.51%	0.26%	270	3.85%	0.66%
Richmond	155	0	0.00%	0.00%	4	2.58%	0.01%
Scituate	385	5	1.30%	0.01%	19	4.94%	0.05%
Smithfield	1,039	62	5.97%	0.15%	112	10.78%	0.27%
South Kingstown	1,368	13	0.95%	0.03%	78	5.70%	0.19%
Tiverton	520	0	0.00%	0.00%	0	0.00%	0.00%
Warren	482	0	0.00%	0.00%	0	0.00%	0.00%
Warwick	3,835	54	1.41%	0.13%	120	3.13%	0.29%
West Greenwich	279	0	0.00%	0.00%	0	0.00%	0.00%
West Warwick	762	31	4.07%	0.08%	66	8.66%	0.16%
Westerly	1,031	2	0.19%	0.00%	6	0.58%	0.01%
Woonsocket	733	25	3.41%	0.06%	64	8.73%	0.16%

*In Cranston, the severe scenario contains less impacted businesses than the moderate due to differences in the floodplain polygons created by FEMA and RIDEM.

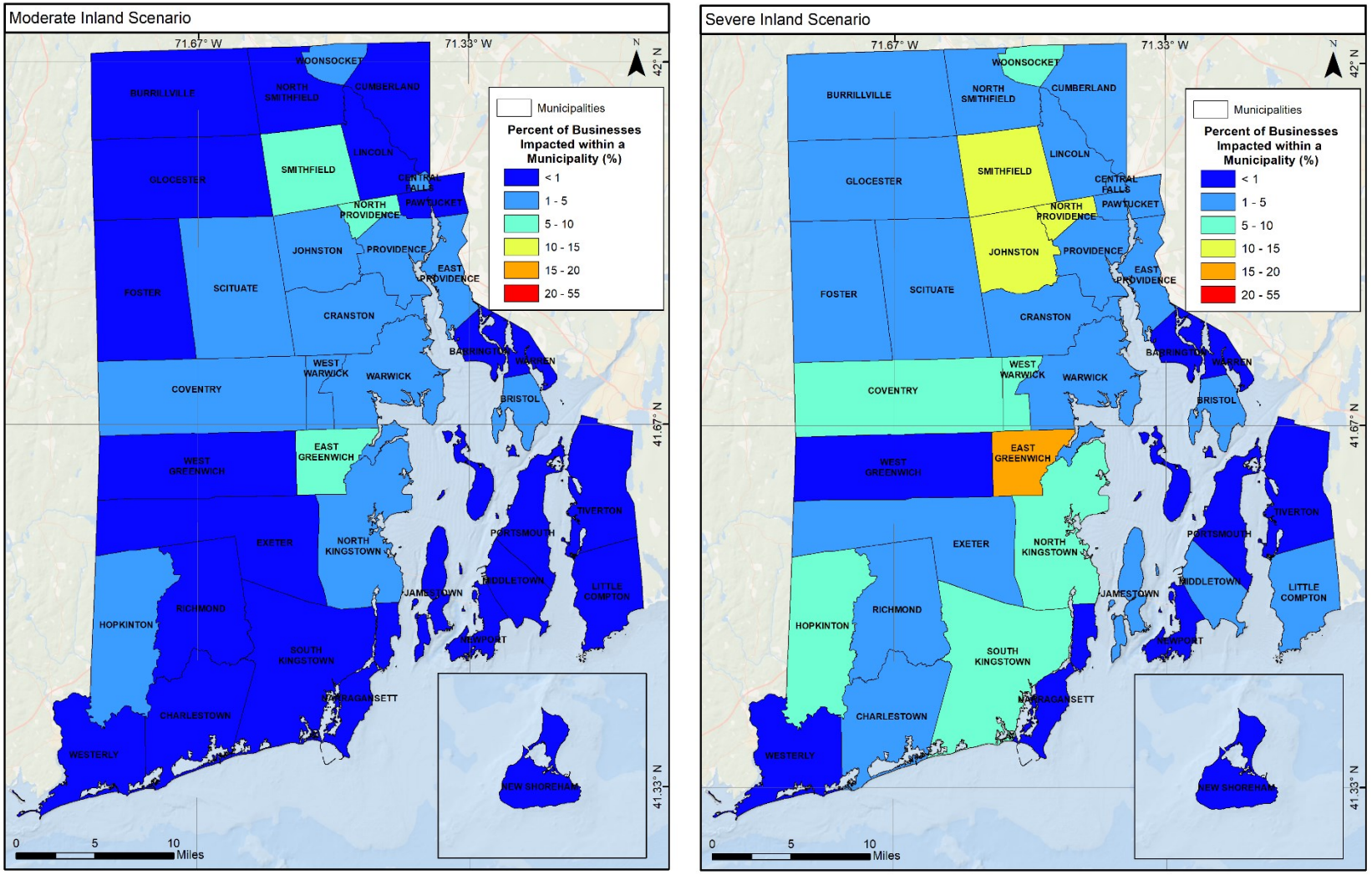


Figure 4-2: Percentage of municipality's businesses impacted from the moderate (left) and severe (right) inland scenarios.

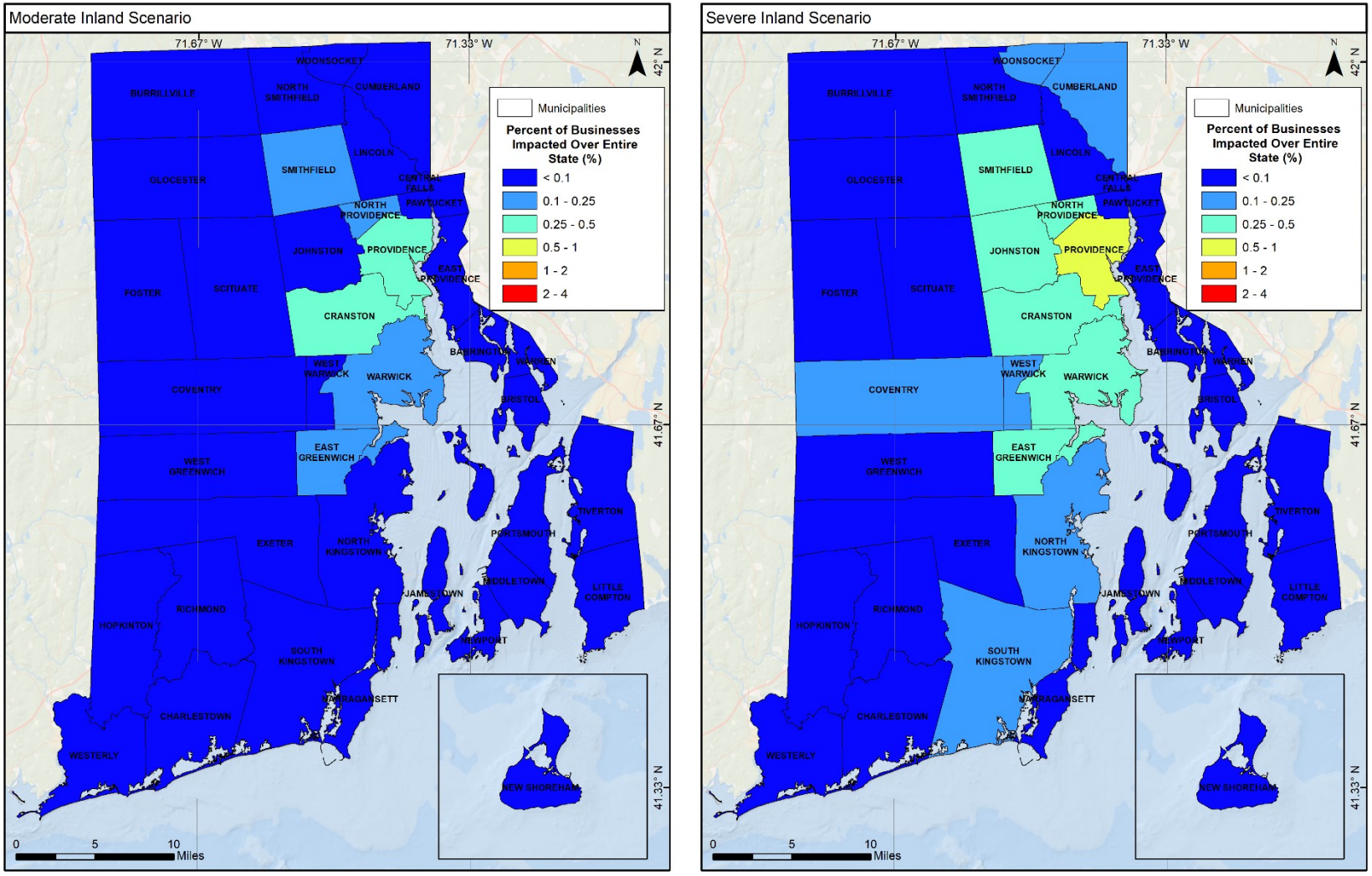


Figure 4-3: Percentage of state's businesses impacted from the moderate (left) and severe (right) inland scenarios.

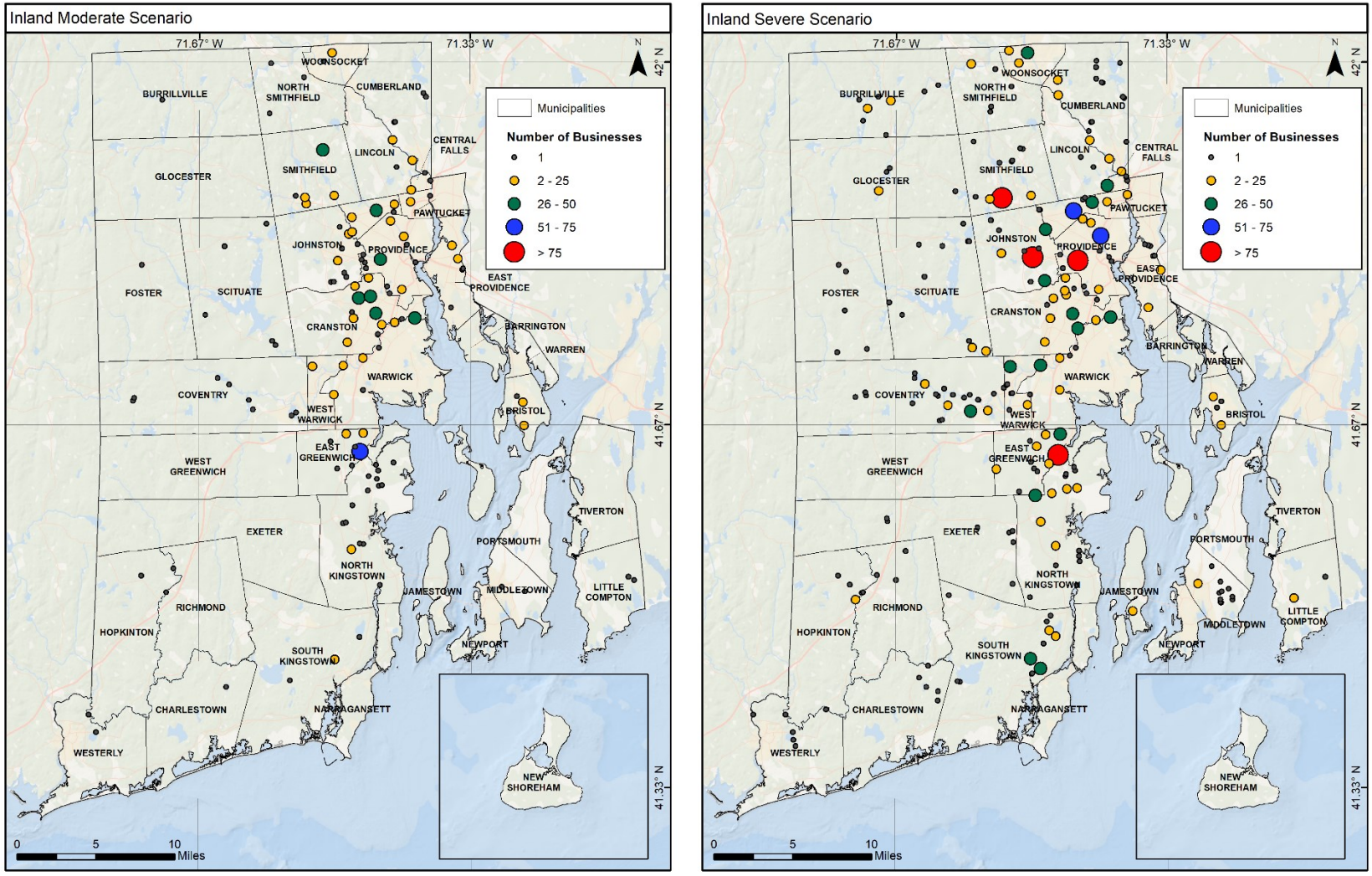


Figure 4-4: Cluster maps of businesses impacted from the moderate (left) and severe (right) inland scenarios.

4.2 Coastal Flooding Results

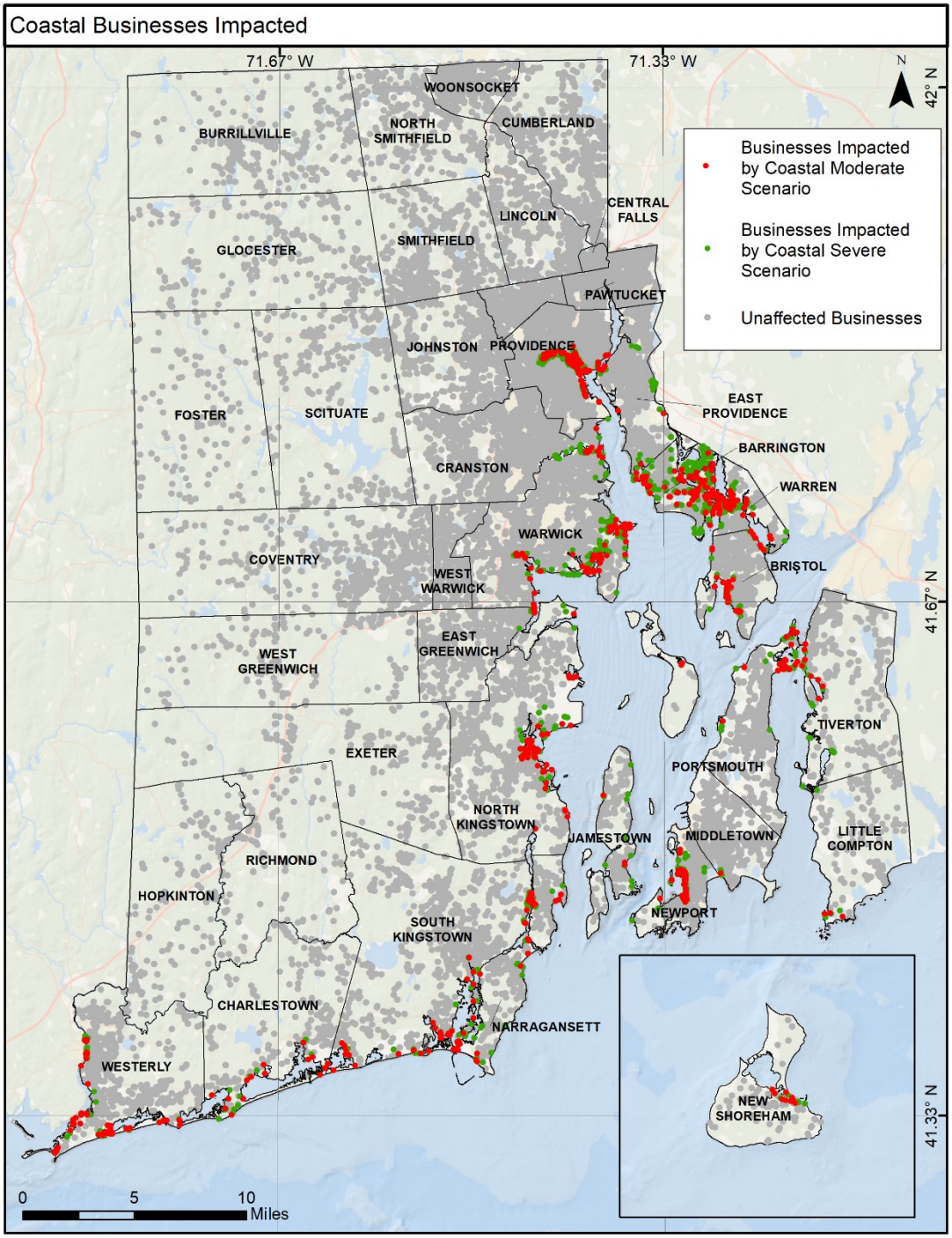


Figure 4-5: Rhode Island businesses impacted from moderate (red) and severe (green) coastal flooding.

Table 4-3: Summary of exposure to coastal flooding.

Town	Total Businesses	MODERATE			SEVERE		
		Impacted Businesses	Municipality % Impacted	State % Impacted	Impacted Businesses	Municipality % Impacted	State % Impacted
Barrington	656	134	20.43%	0.33%	343	52.29%	0.84%
Bristol	922	71	7.70%	0.17%	114	12.36%	0.28%
Burrillville	354	0	0.00%	0.00%	0	0.00%	0.00%
Central Falls	346	0	0.00%	0.00%	0	0.00%	0.00%
Charlestown	313	19	6.07%	0.05%	38	12.14%	0.09%
Coventry	911	0	0.00%	0.00%	0	0.00%	0.00%
Cranston	3,262	7	0.21%	0.02%	27	0.83%	0.07%
Cumberland	1,134	0	0.00%	0.00%	0	0.00%	0.00%
East Greenwich	1,005	12	1.19%	0.03%	19	1.89%	0.05%
East Providence	1,833	14	0.76%	0.03%	83	4.53%	0.20%
Exeter	292	0	0.00%	0.00%	0	0.00%	0.00%
Foster	156	0	0.00%	0.00%	0	0.00%	0.00%
Glocester	323	0	0.00%	0.00%	0	0.00%	0.00%
Hopkinton	232	0	0.00%	0.00%	0	0.00%	0.00%
Jamestown	377	4	1.06%	0.01%	17	4.51%	0.04%
Johnston	1,364	0	0.00%	0.00%	0	0.00%	0.00%
Lincoln	889	0	0.00%	0.00%	0	0.00%	0.00%
Little Compton	218	4	1.83%	0.01%	8	3.67%	0.02%
Middletown	832	1	0.12%	0.00%	12	1.44%	0.03%
Narragansett	728	57	7.83%	0.14%	98	13.46%	0.24%
New Shoreham	133	16	12.03%	0.04%	34	25.56%	0.08%
Newport	1,571	149	9.48%	0.36%	295	18.78%	0.72%
North Kingstown	1,424	113	7.94%	0.28%	155	10.88%	0.38%
North Providence	914	0	0.00%	0.00%	0	0.00%	0.00%
North Smithfield	448	0	0.00%	0.00%	0	0.00%	0.00%
Pawtucket	1,975	0	0.00%	0.00%	0	0.00%	0.00%
Portsmouth	690	29	4.20%	0.07%	69	10.00%	0.17%
Providence	7,011	1013	14.45%	2.48%	1370	19.54%	3.35%
Richmond	155	0	0.00%	0.00%	0	0.00%	0.00%
Scituate	385	0	0.00%	0.00%	0	0.00%	0.00%
Smithfield	1,039	0	0.00%	0.00%	0	0.00%	0.00%
South Kingstown	1,368	49	3.58%	0.12%	75	5.48%	0.18%
Tiverton	520	12	2.31%	0.03%	40	7.69%	0.10%
Warren	482	115	23.86%	0.28%	194	40.25%	0.47%
Warwick	3,835	94	2.45%	0.23%	235	6.13%	0.57%
West Greenwich	279	0	0.00%	0.00%	0	0.00%	0.00%
West Warwick	762	0	0.00%	0.00%	0	0.00%	0.00%
Westerly	1,031	99	9.60%	0.24%	141	13.68%	0.34%
Woonsocket	733	0	0.00%	0.00%	0	0.00%	0.00%

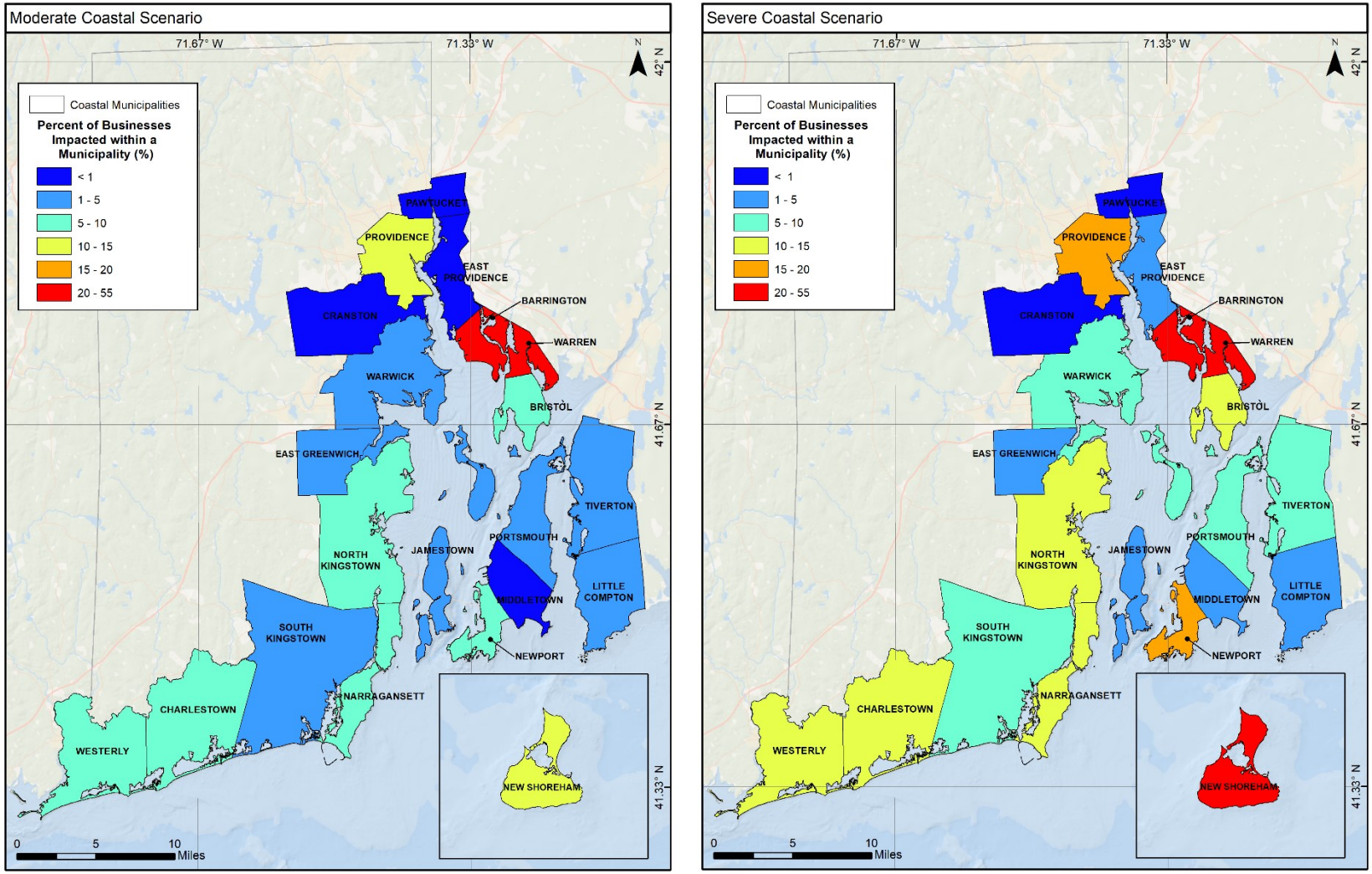


Figure 4-6: Percent of municipality's businesses impacted from the moderate (left) and severe (right) coastal scenarios.

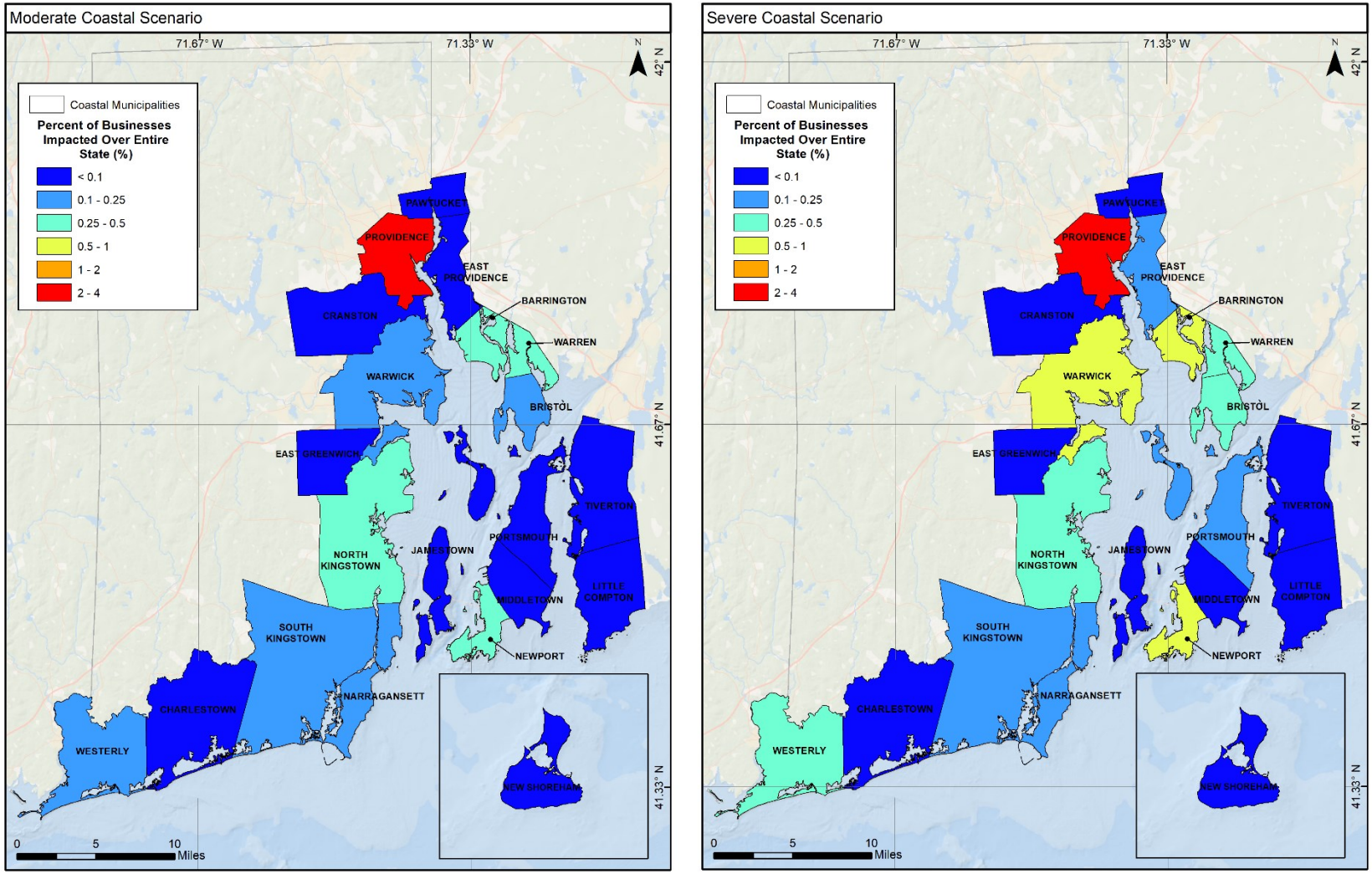


Figure 4-7: Percent of state's businesses impacted from the moderate (left) and severe (right) coastal scenarios.

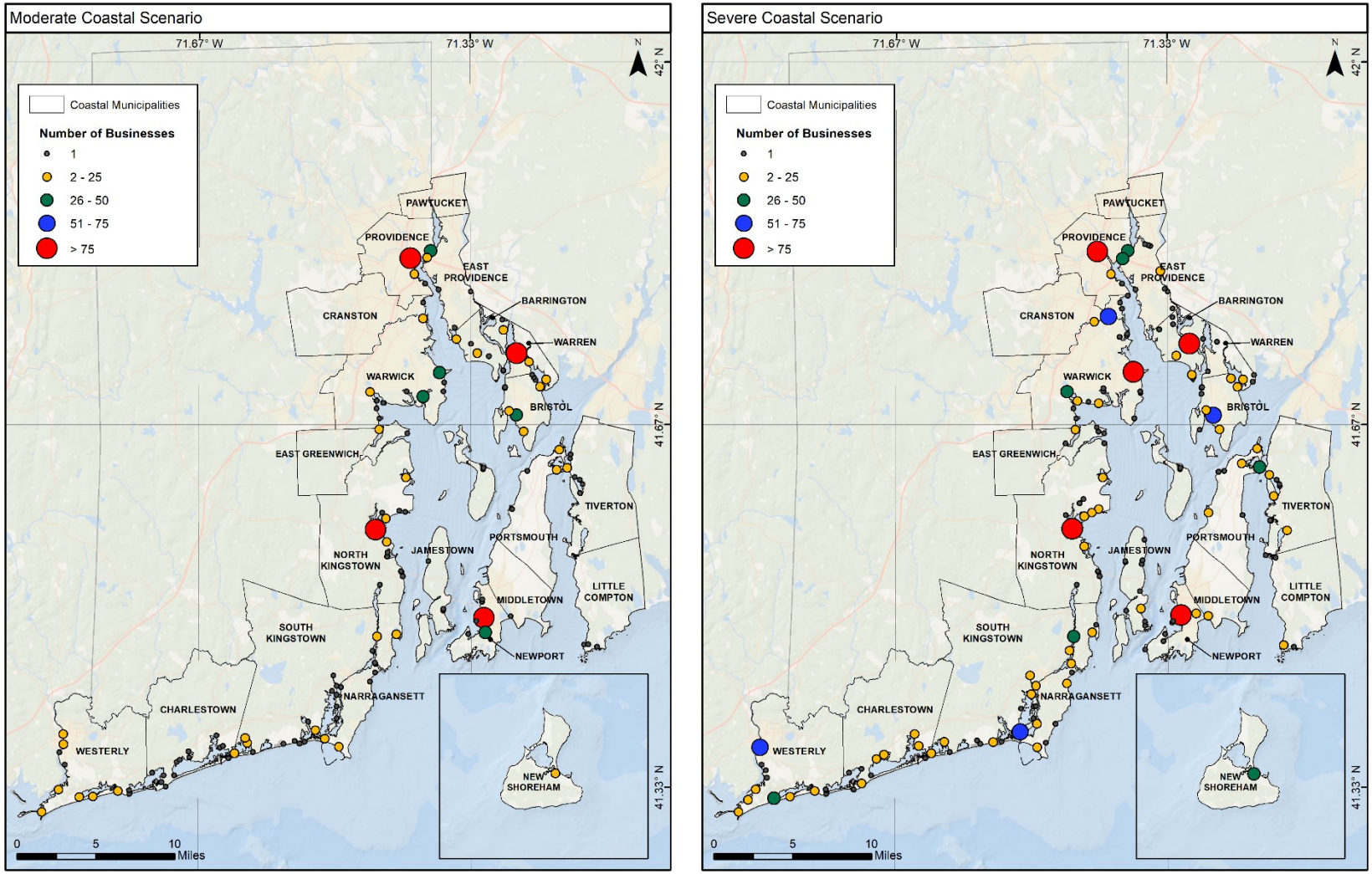


Figure 4-8: Cluster maps of businesses impacted from the moderate (left) and severe (right) coastal scenarios.

4.3 Combined Results

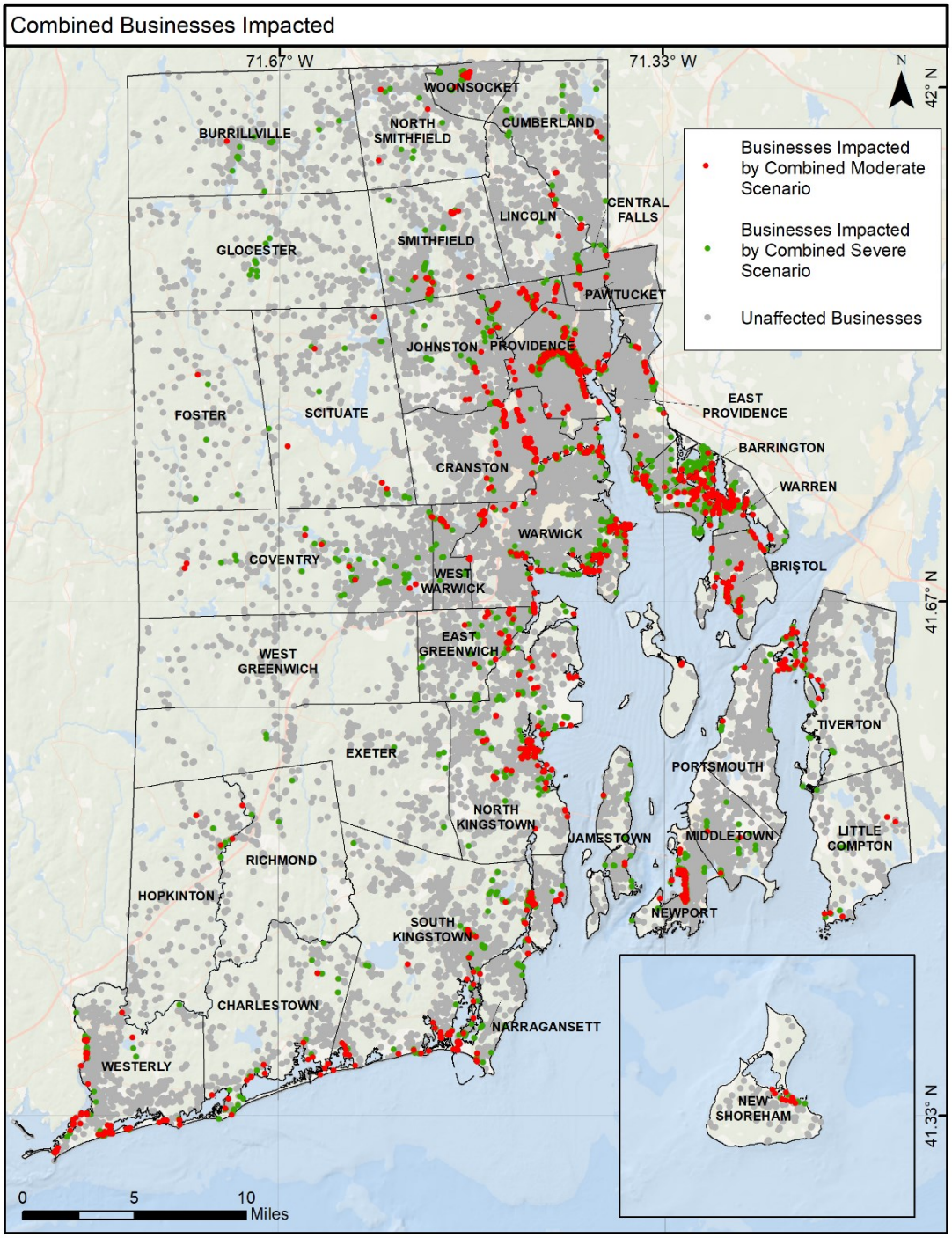


Figure 4-9: Rhode Island businesses impacted statewide from moderate (red) and severe (green) flooding

Table 4-4: Summary of exposure to both coastal and inland flooding combined.

Town	Total Businesses	MODERATE			SEVERE		
		Impacted Businesses	Municipality % Impacted	State % Impacted	Impacted Businesses	Municipality % Impacted	State % Impacted
Barrington	656	134	20.43%	0.33%	342	52.13%	0.84%
Bristol	922	85	9.22%	0.21%	135	14.64%	0.33%
Burrillville	354	1	0.28%	0.00%	15	4.24%	0.04%
Central Falls	346	2	0.58%	0.00%	8	2.31%	0.02%
Charlestown	313	20	6.39%	0.05%	45	14.38%	0.11%
Coventry	911	10	1.10%	0.02%	82	9.00%	0.20%
Cranston	3,262	151	4.63%	0.37%	155	4.75%	0.38%
Cumberland	1,134	11	0.97%	0.03%	41	3.62%	0.10%
East Greenwich	1,005	84	8.36%	0.21%	194	19.30%	0.47%
East Providence	1,833	34	1.85%	0.08%	91	4.96%	0.22%
Exeter	292	0	0.00%	0.00%	10	3.42%	0.02%
Foster	156	1	0.64%	0.00%	6	3.85%	0.01%
Glocester	323	0	0.00%	0.00%	11	3.41%	0.03%
Hopkinton	232	6	2.59%	0.01%	18	7.76%	0.04%
Jamestown	377	4	1.06%	0.01%	24	6.37%	0.06%
Johnston	1,364	33	2.42%	0.08%	137	10.04%	0.33%
Lincoln	889	8	0.90%	0.02%	39	4.39%	0.10%
Little Compton	218	6	2.75%	0.01%	14	6.42%	0.03%
Middletown	832	3	0.36%	0.01%	33	3.97%	0.08%
Narragansett	728	57	7.83%	0.14%	98	13.46%	0.24%
New Shoreham	133	16	12.03%	0.04%	34	25.56%	0.08%
Newport	1,571	150	9.55%	0.37%	295	18.78%	0.72%
North Kingstown	1,424	131	9.20%	0.32%	228	16.01%	0.56%
North Providence	914	65	7.11%	0.16%	132	14.44%	0.32%
North Smithfield	448	3	0.67%	0.01%	8	1.79%	0.02%
Pawtucket	1,975	6	0.30%	0.01%	24	1.22%	0.06%
Portsmouth	690	29	4.20%	0.07%	69	10.00%	0.17%
Providence	7,011	1082	15.43%	2.65%	1554	22.17%	3.80%
Richmond	155	0	0.00%	0.00%	4	2.58%	0.01%
Scituate	385	5	1.30%	0.01%	19	4.94%	0.05%
Smithfield	1,039	62	5.97%	0.15%	111	10.68%	0.27%
South Kingstown	1,368	62	4.53%	0.15%	153	11.18%	0.37%
Tiverton	520	12	2.31%	0.03%	40	7.69%	0.10%
Warren	482	115	23.86%	0.28%	194	40.25%	0.47%
Warwick	3,835	138	3.60%	0.34%	316	8.24%	0.77%
West Greenwich	279	0	0.00%	0.00%	0	0.00%	0.00%
West Warwick	762	31	4.07%	0.08%	66	8.66%	0.16%
Westerly	1,031	100	9.70%	0.24%	147	14.26%	0.36%
Woonsocket	733	25	3.41%	0.06%	64	8.73%	0.16%

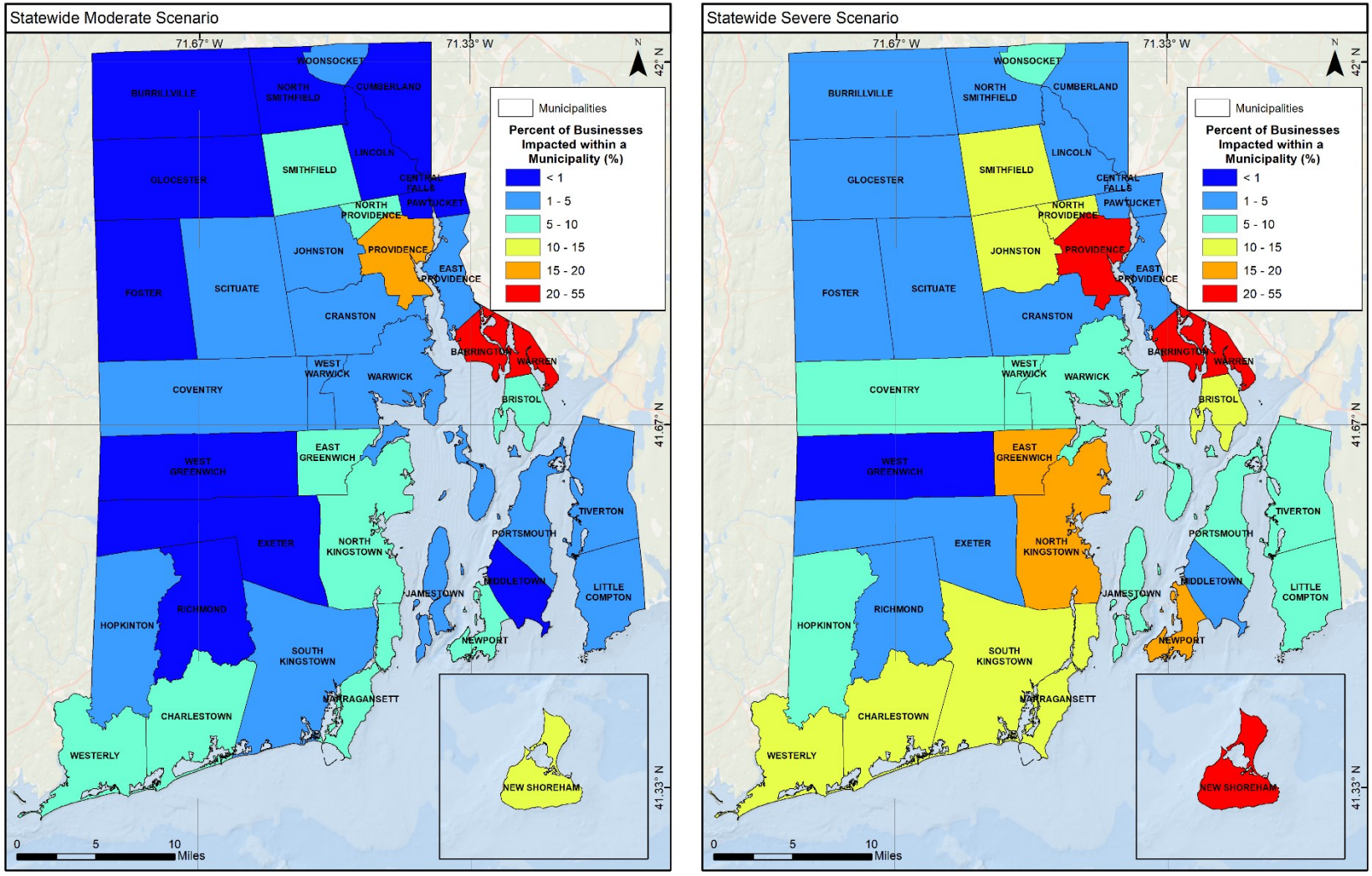


Figure 4-10: Percent of municipality's businesses impacted statewide from the moderate (left) and severe(right) combined (coastal and inland) scenarios.

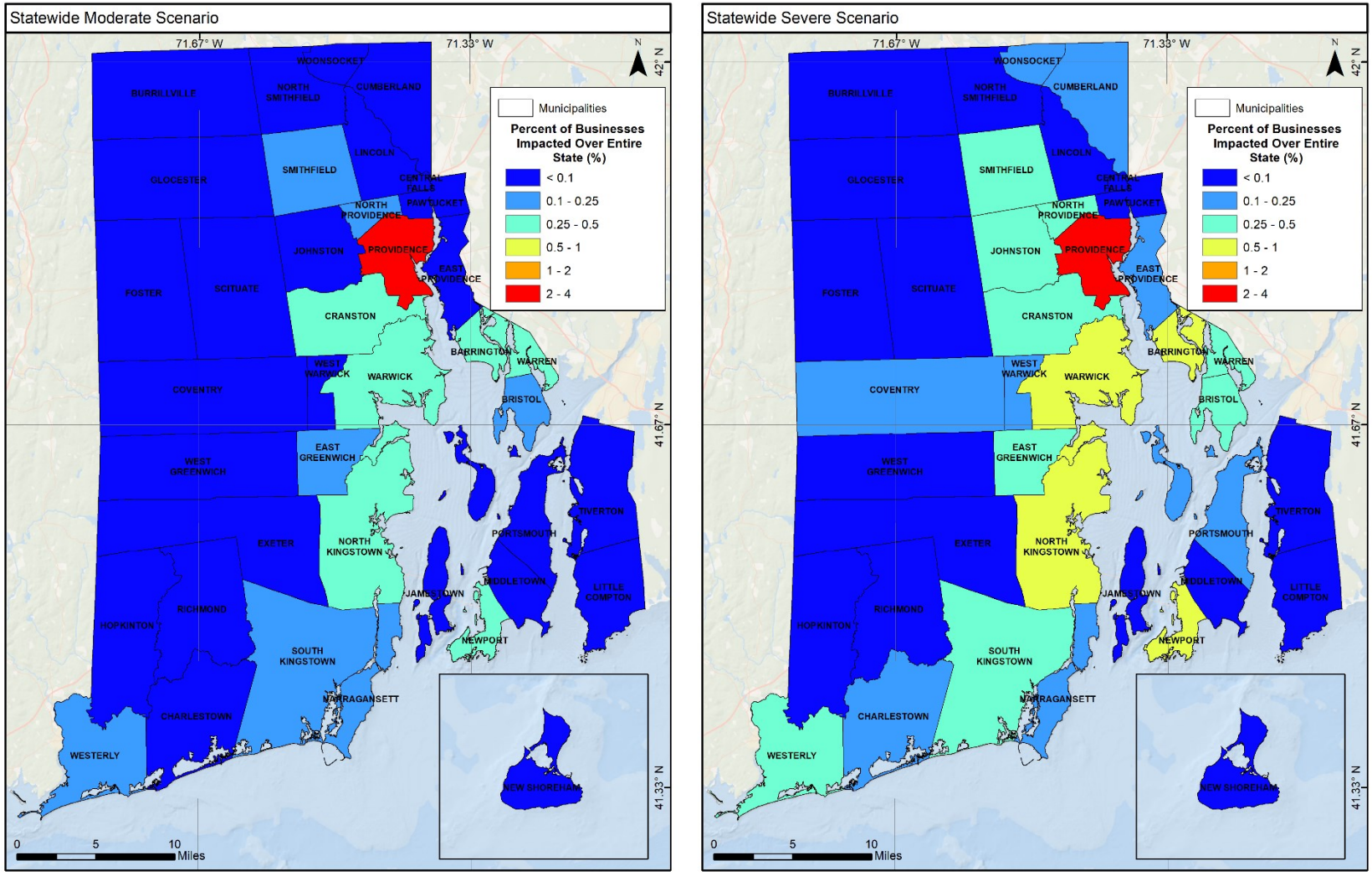


Figure 4-11: Percent of state's businesses impacted statewide from the moderate (left) and severe (right) combined (inland and coastal) scenarios.

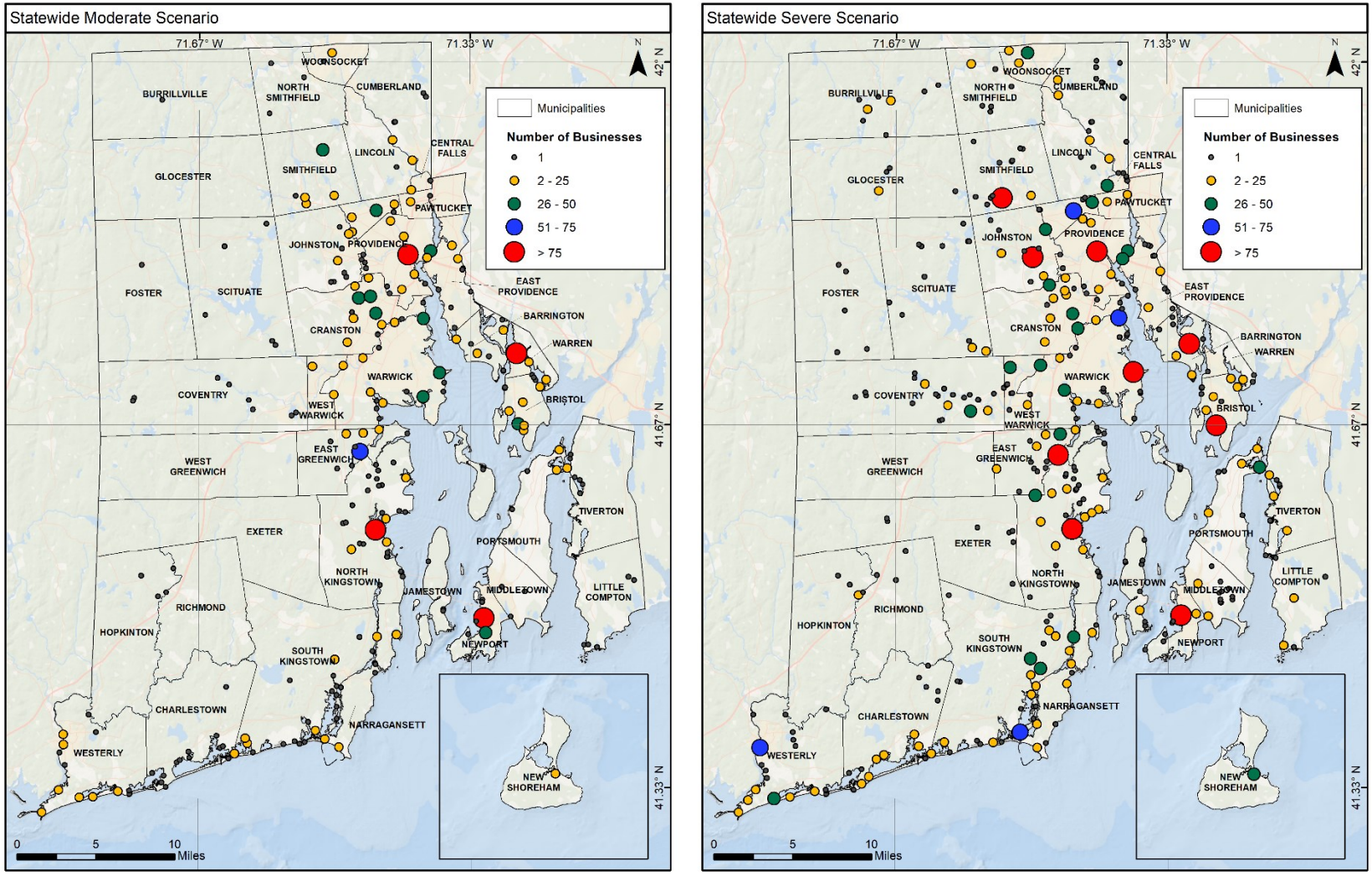


Figure 4-12: Cluster maps of businesses impacted statewide from the moderate (left) and severe (right) combined (inland and coastal) scenarios.

5 Vulnerability Assessment - Pilot Areas Selected

Following completion of the exposure analysis, four pilot areas were selected for the vulnerability assessment. In addition to having a high number of businesses potentially impacted, additional criteria were used in the decision-making process. Other criteria considered were location (inland, coastal, ocean, bay, urban, rural), willingness of the municipality to participate, demographic, history of storm damages, and history of receiving federal funding following disasters. After examining all criteria, the following regions were selected; (1) Warren and Bristol (all impacts), (2) the Woonasquatucket River corridor (including areas of Providence, Johnson, and Smithfield; riverine impacts only), (3) Newport and Middletown (all impacts), and (4) Southern Shore of Rhode Island, including Westerly, Charlestown, and South Kingstown (coastal impacts only). Figure 5-1 captures these pilot areas. The Pawtuxet River corridor (including riverine impacts in Warwick and Cranston) was selected as an alternative pilot area in the event that an adequate number of willing businesses cannot be found in the other four areas for the vulnerability assessment.

Warren and Bristol were selected as one location because of the high impacts shown by the exposure analysis. The communities are located on the bay with predominantly coastal impacts. Warren was chosen above neighboring Barrington because it is not as economically prosperous and would likely benefit more from the increased exposure to the project. The Woonasquatucket River area offered many businesses that experience inland flooding. This region spans from Olneyville to Smithfield, encompassing a diverse inland rural area with an urban region. Newport and Middletown were selected due to the high number of impacted businesses and the large economic impact on the entire state if this area was damaged by an extreme weather event. Newport is already experiencing rising tides, and the small businesses there will be able to provide lessons learned that will benefit other businesses statewide. The Southern Shore area was selected because of high impacts from coastal storms and the history of federal aid following disasters due to the extensive impacts. This region differs from the other coastal regions because it is ocean-facing, as opposed to the other communities bordering Narragansett Bay. The Steering Committee determined that these four sites each offer different opportunities for potential business resonance.

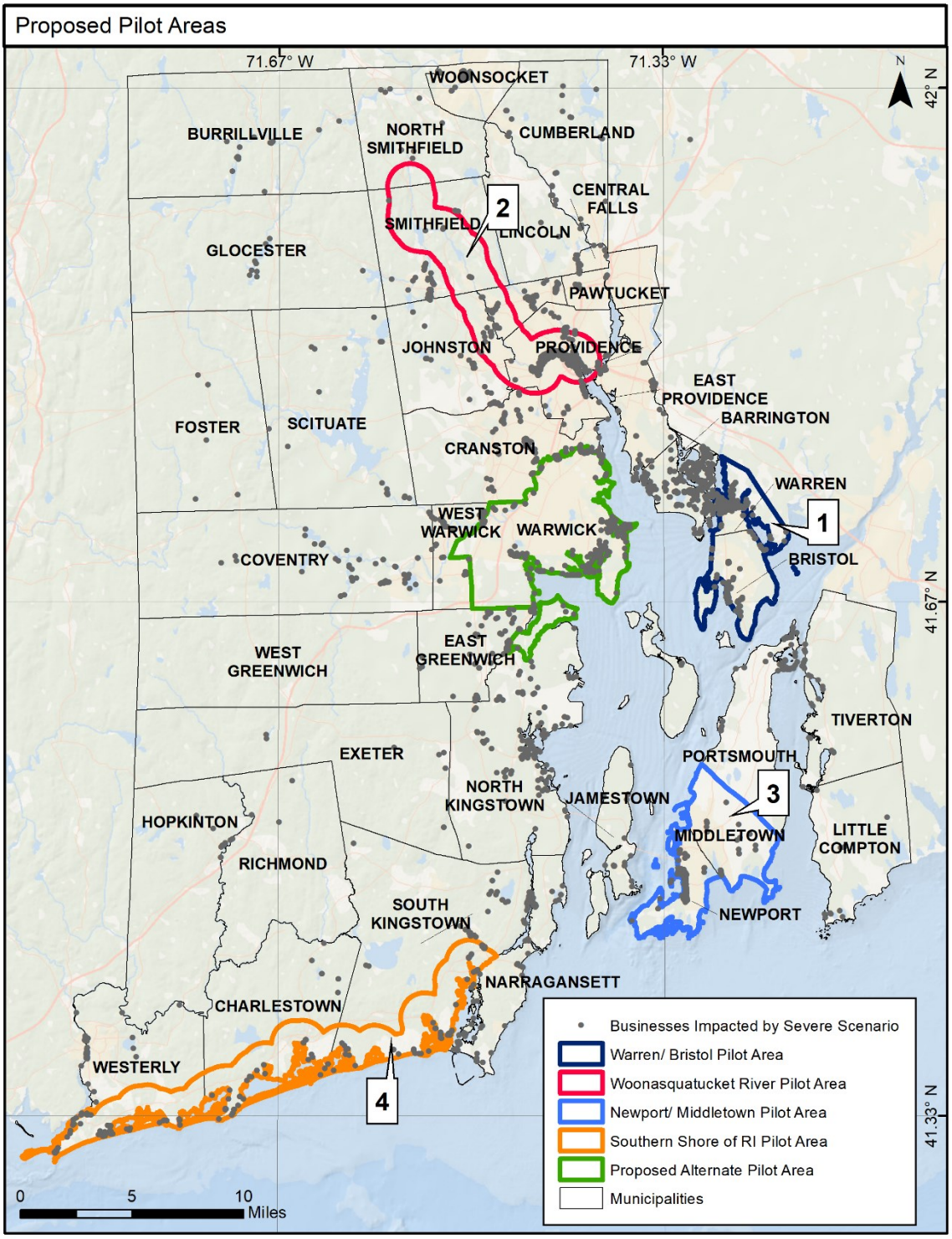


Figure 5-1: Pilot areas selected for the vulnerability assessment based on results from the exposure analysis.

6 References

Cialone, M., et al, 2015. North Atlantic Coast Comprehensive Study (NACCS) Coastal Storm Model Simulations: Waves and Water Levels, US Army Corp of Engineers, Engineering Research and Development Center, January 2015. http://www.nad.usace.army.mil/CompStudy.aspx.

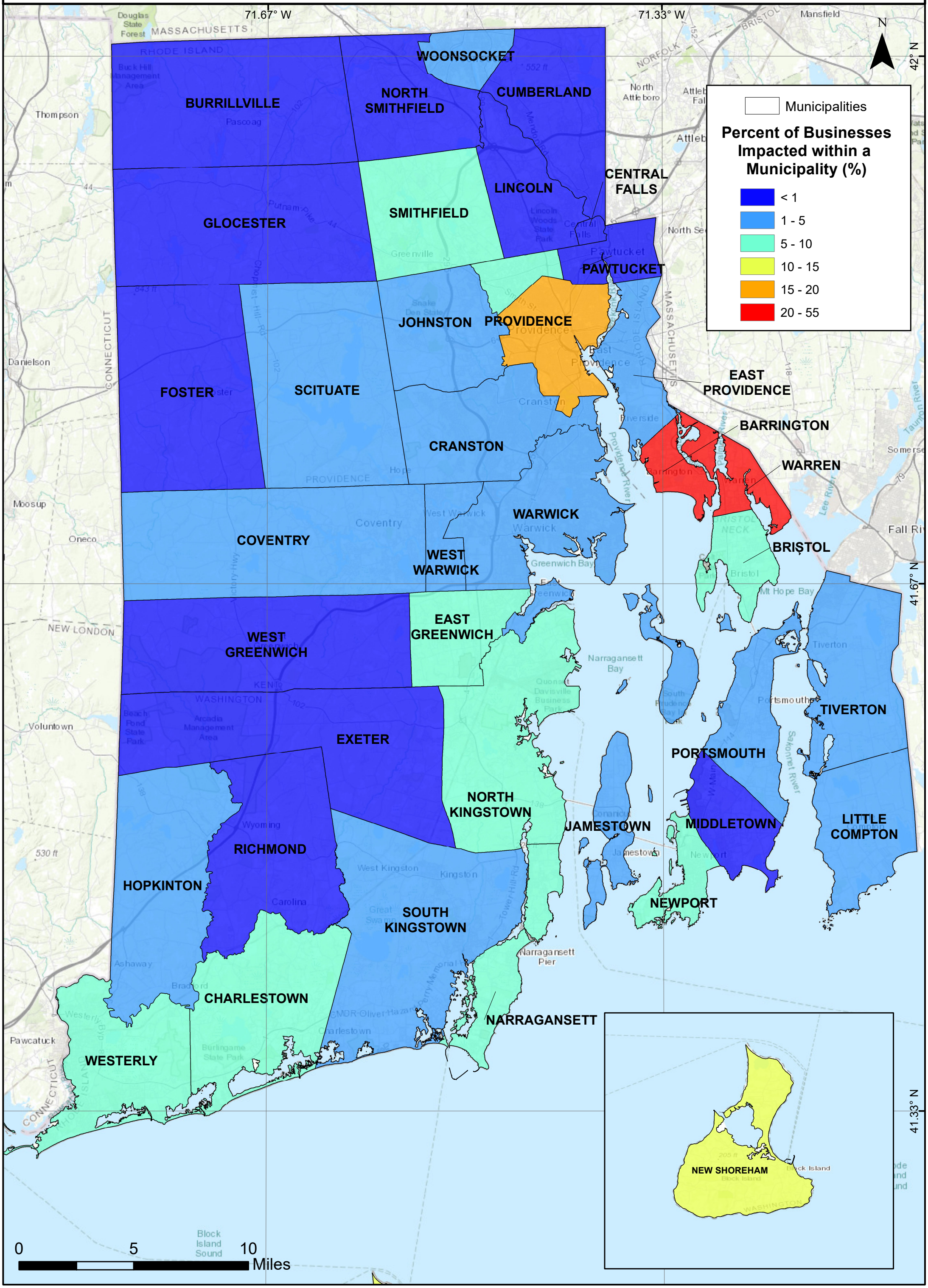
RIDEM, 2017. Implications of Climate Change for RI Wastewater Collection & Treatment Infrastructure. Report 226968.00. Prepared by Woodard & Curran and RPS ASA. March 2017.

Spaulding, M.L. and T. Isaji, 2014. Simplified flood inundation maps, with sea level rise, for RI, Ocean Engineering, University of Rhode Island, Narragansett, RI.

Appendix A – Final Map Products

The following maps are prepared in a larger format and show the exposure analysis results for the combined inland and coastal flooding scenarios.

Statewide Moderate Scenario



Statewide Moderate Scenario

71.67° W

71.33° W

42° N

41.67° N

41.33° N

N

BURRILLVILLE

WOONSOCKET

NORTH SMITHFIELD

CUMBERLAND

CENTRAL FALLS

LINCOLN

SMITHFIELD

GLOCESTER

PAWTUCKET

JOHNSTON

PROVIDENCE

EAST PROVIDENCE

FOSTER

SCITUATE

CRANSTON

BARRINGTON

WARREN

WARWICK

COVENTRY

WEST WARWICK

BRISTOL

EAST GREENWICH

WEST GREENWICH

TIVERTON

EXETER

PORTSMOUTH

NORTH KINGSTOWN

JAMESTOWN

MIDDLETOWN

LITTLE COMPTON

NEWPORT

RICHMOND

HOPKINTON

SOUTH KINGSTOWN

CHARLESTOWN

NARRAGANSETT

WESTERLY

NEW SHOREHAM

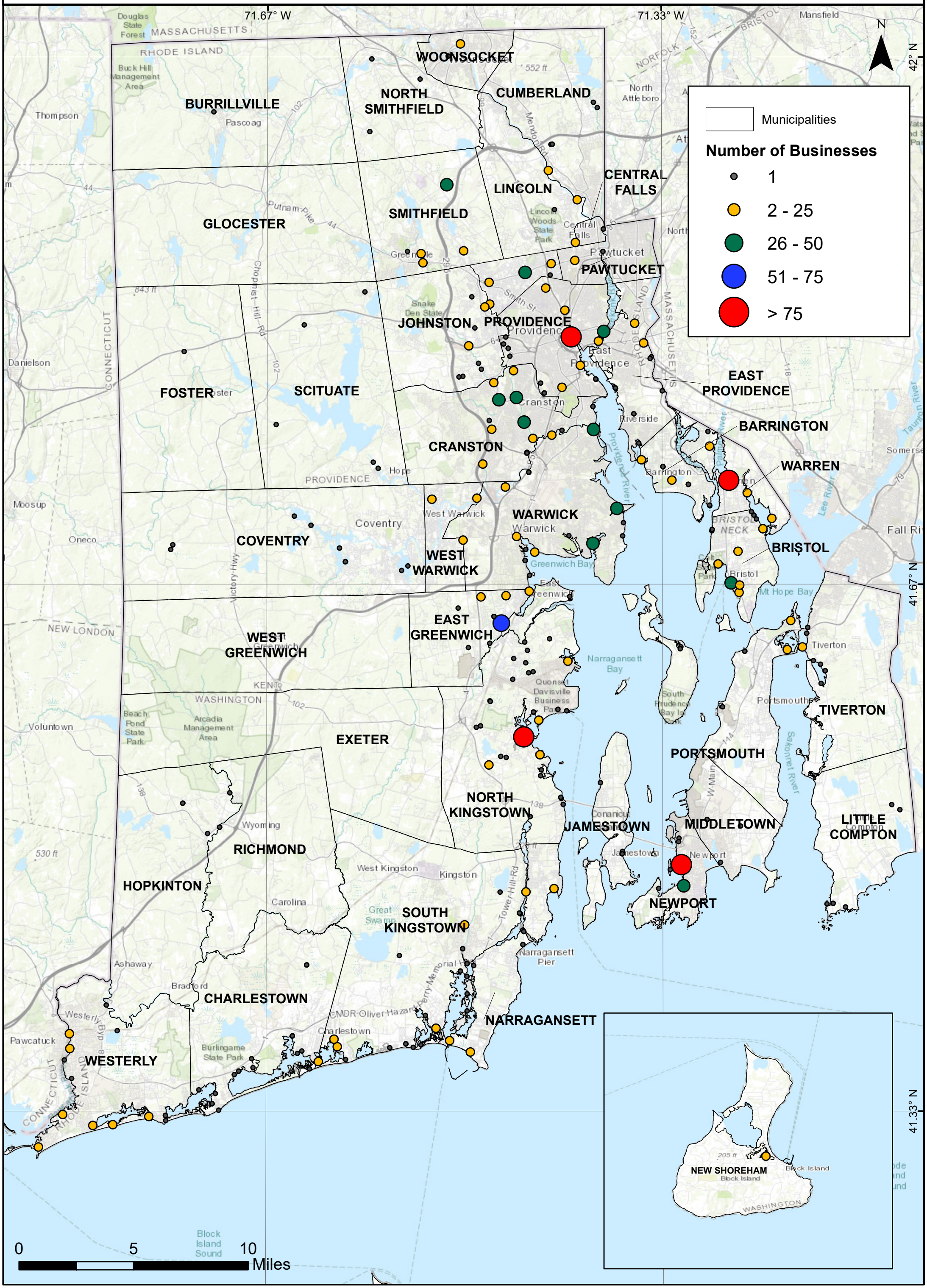
Municipalities

Percent of Businesses Impacted Over Entire State (%)

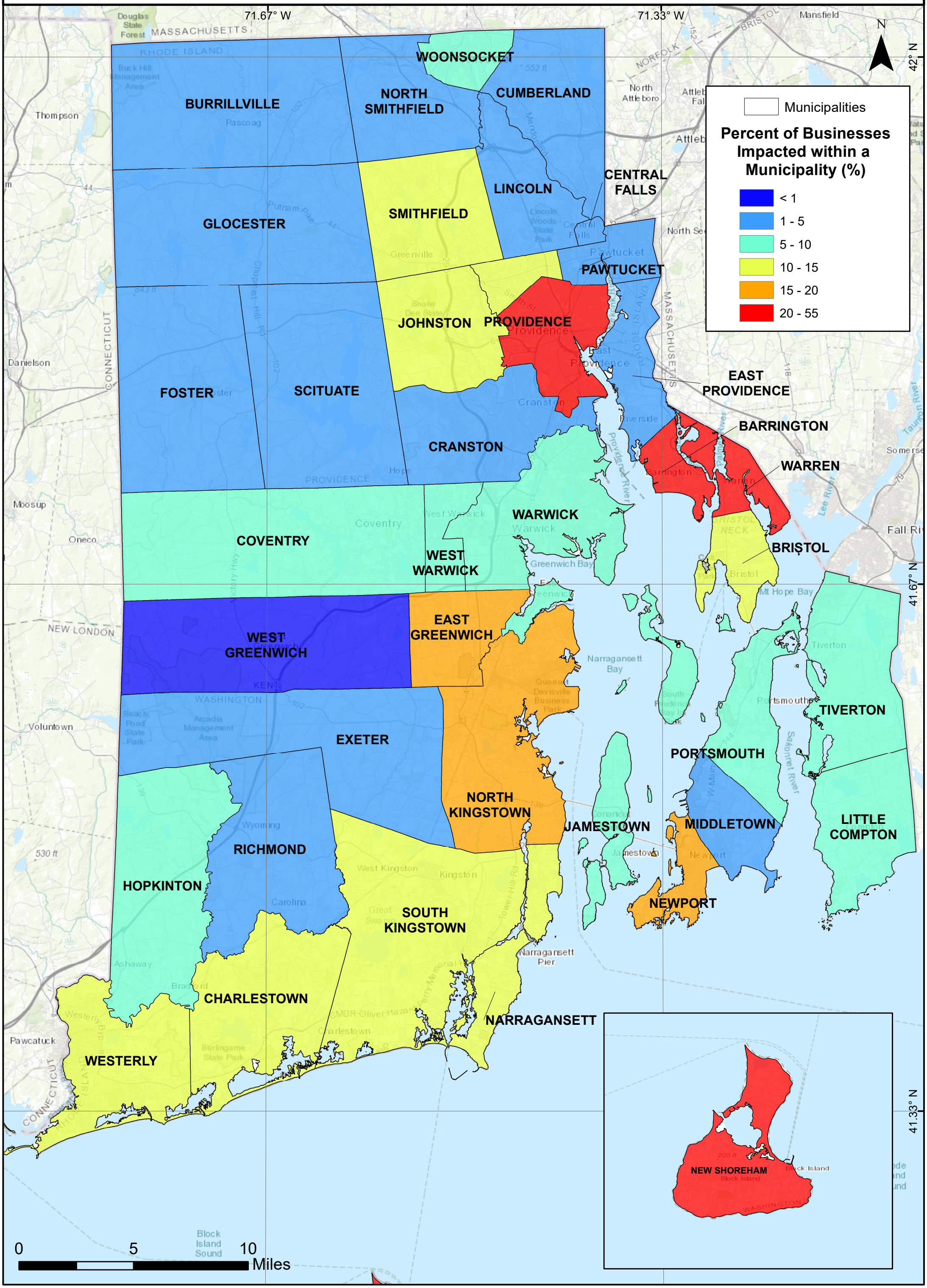
- < 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 4

0 5 10 Miles

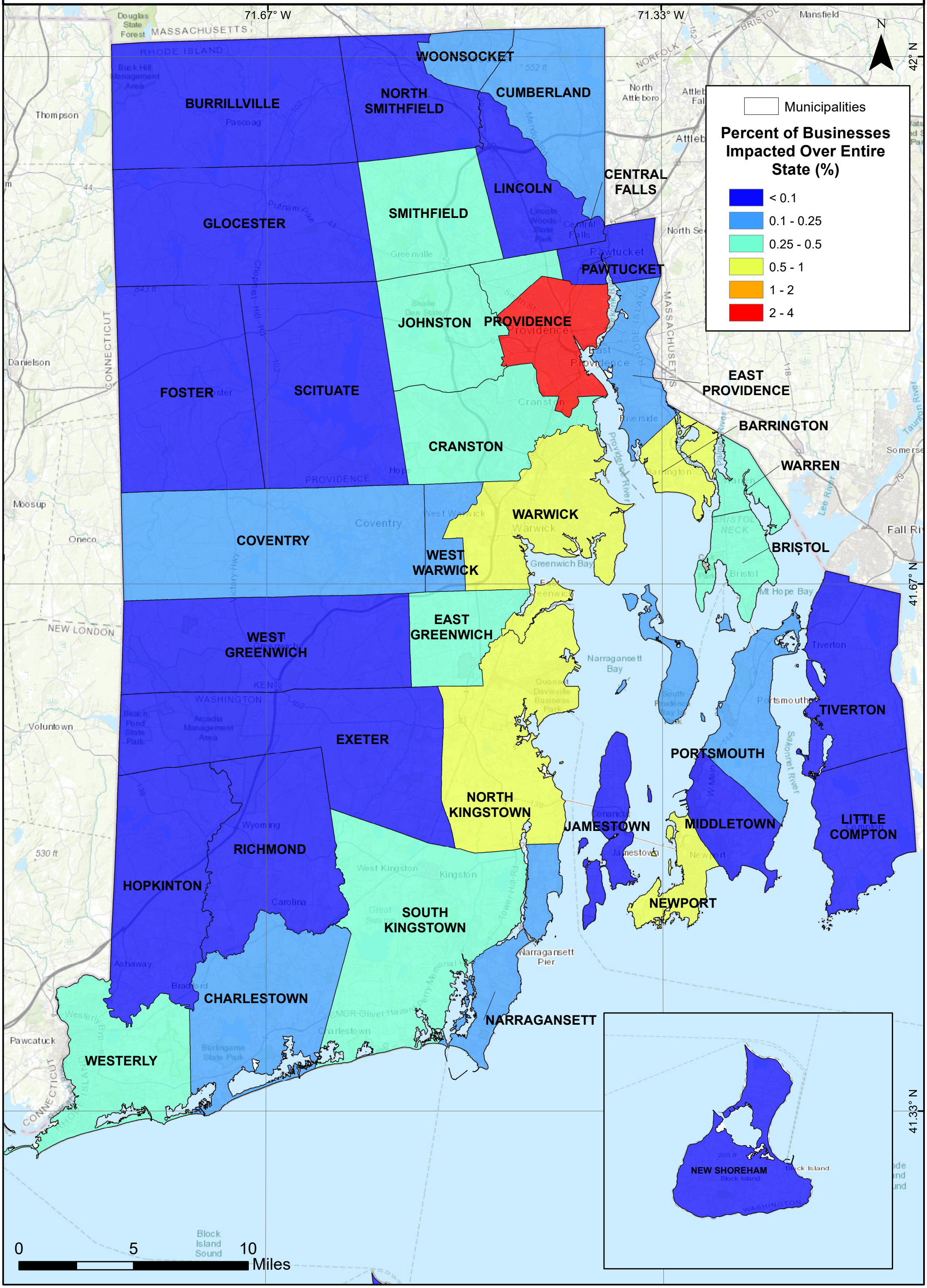
Statewide Moderate Scenario



Statewide Severe Scenario



Statewide Severe Scenario



Statewide Severe Scenario