



FEMA

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**Vulnerability Analysis for Alabama Hurricane Events
Final Report
April 2012**

VULNERABILITY ANALYSIS FOR ALABAMA HURRICANE EVENTS

National Hurricane Program

FINAL REPORT

Prepared for:

Federal Emergency Management Agency
National Hurricane Program



FEMA

Prepared by:

U.S. Army Corps of Engineers:
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1 PURPOSE

The purpose of the Alabama vulnerability analysis is to identify the areas, populations, and facilities in Mobile and Baldwin counties that are potentially vulnerable to hurricane-induced flooding and wind damages under a variety of hurricane scenarios. The vulnerable population residing within the evacuation zones that may be subject to storm surge was estimated as part of the Transportation Analysis. Tourists that would need to evacuate during a hurricane threat were included in the estimate. Because of their greater vulnerability to the strong winds associated with hurricanes, all mobile and manufactured home residents within the counties were also considered vulnerable regardless of their location within the study area.

Since the Alabama Emergency Management Agency (AEMA) has previously been provided the vulnerable population data in the Transportation Analysis, this Vulnerability Analysis study effort concentrates on developing information on data sets that have not been identified previously. These vulnerability data sets include power lines and substations, sewer lines and pumping stations, generator locations and gas stations. Data on these facilities and their vulnerability to the five hurricane storm surge areas were compiled in a GIS database for Mobile and Baldwin counties.

The Vulnerability Analysis identifies all institutions, medical facilities and other points of interest (i.e. critical facilities, hazardous material storage facilities, major points of interest, etc.) potentially vulnerable to hurricane hazards. The institutions selected for analysis were determined in coordination with State and local emergency management. Local tax assessor data was utilized to estimate the number of vulnerable properties (residential, commercial and industrial). GIS data were created to illustrate the location of each facility or point of interest in relation to surge-inundation areas, wave impact areas and flooding from rainfall runoff.

2 STORM SURGE INUNDATION AND MAPPING

Because of uncertainties in hurricane forecasting, storm surge mapping takes a variety of scenarios into account due to the sensitivity of surge values to the track, direction, size (radius of maximum winds) and landfall location. Within a few hours, a hurricane can change its forward speed, intensity and direction, which can create quite different flooding scenarios prior to and at landfall. The Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model is the computer model utilized by the National Oceanic and Atmospheric Administration (NOAA) and is used by the National Hurricane Center (NHC) for coastal inundation risk assessment and the operational prediction of storm surge. For Mobile and Baldwin Counties, storm surge inundation maps have been produced for each Safir-Simpson category of hurricane, based on the composite results of thousands of hurricane scenarios simulated by the SLOSH model. The maps depict the area of possible flooding from each category of hurricane.

GIS mapping of storm surge inundation was completed by the Mobile District U.S. Army Corps of Engineers (USACE) to support the Transportation, Behavioral and Vulnerability Analyses of the Hurricane Evacuation Study (HES). Figures 2-1 and 2-2 show the extent of possible surge inundation in Mobile and Baldwin counties. It should be noted that not all storms of a given category will produce a storm surge as large as these maps show, however, these maps represent the highest storm surge values calculated by the SLOSH model for a given storm category. The colored areas of the map correspond to the additional areas of possible surge inundation for a particular storm category beyond that of all lower storm categories. It should be noted that the total surge inundation for each category includes the area labeled for that category as well as all areas in lower storm categories.

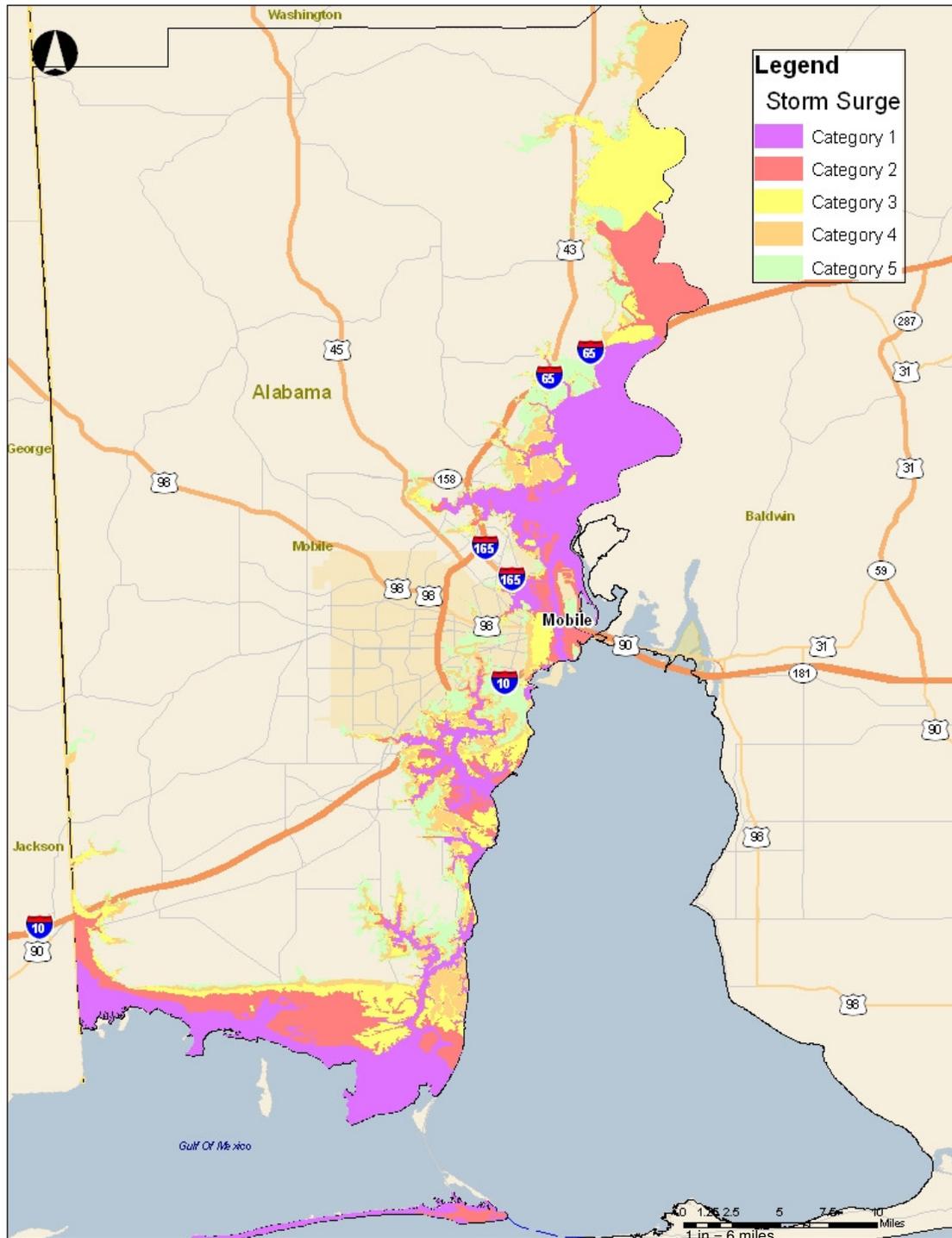


Figure 2-1: Mobile County Storm Surge Areas

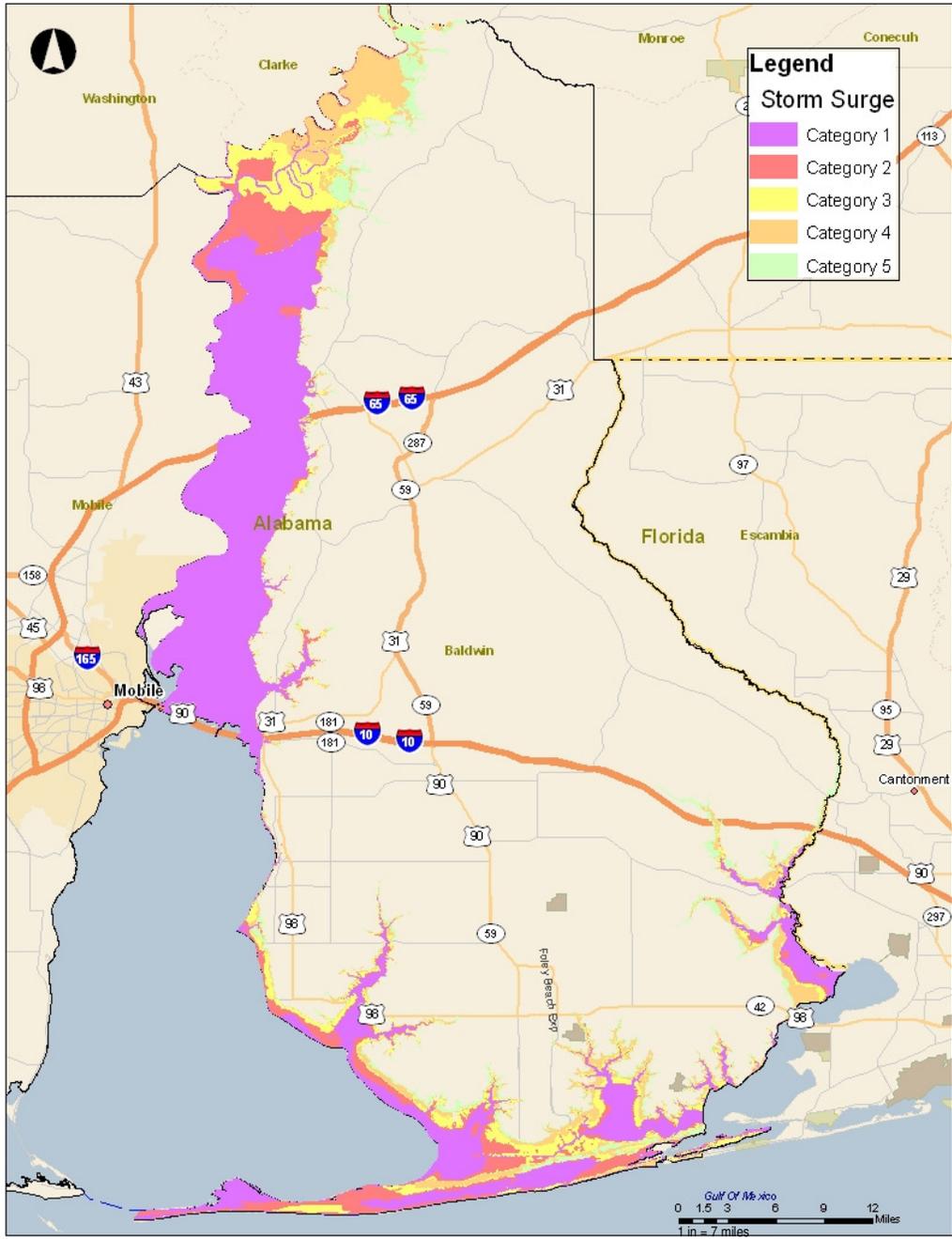


Figure 2-2: Baldwin County Storm Surge Areas

3 HURRICANE EVACUATION SCENARIOS AND ZONES

Evacuation Zones are developed to depict areas where threatened populations should be moved away from hazards caused by natural or manmade disasters. Zones are established to simplify notification to the public and foster an efficient and timely response to evacuation orders given by elected officials. Hurricane evacuation zones are the areas that need to be evacuated for a particular hurricane scenario to protect residents at risk from flooding or high winds. Evacuation zones include all areas having at risk of storm surge flooding. Evacuation zones sometimes include non-flood areas if they would potentially be cut off or surrounded by flooded areas or need to be included in the evacuation zone to allow the public to better understand the locations being asked to evacuate. When evacuation orders are given, residents and visitors in these areas are expected to move out of the respective zones to a site further inland or move to higher ground.

Evacuation scenarios are developed to simplify evacuation decision-making and public communication of evacuation orders. The evacuation zones are initially based on the areas of potential storm surge for each hurricane category, and then further refined. The development of approved evacuation zones was completed during the Transportation Analysis portion of the HES. Individual zones were developed through coordination of the Mobile District USACE with the local counties and State EMA, and were then provided for use in the Vulnerability Analysis process. Vulnerability data sets were assessed based on their location relative to these evacuation zones.

Evacuation zones in Mobile and Baldwin counties are based primarily on prominent community features (i.e., streams, rivers, major highways, etc) and correspond generally to the storm surge flooding risk. Mobile County has four evacuation zones. Evacuation Scenario 1, which consists of the evacuation of Zones 1 and 2, would be ordered in a Category 1 or Category 2 hurricane. Evacuation Scenario 2, all zones (1 through 4), would be ordered for a Category 3, 4, or 5 storm (a major hurricane).

In Baldwin County, there are five evacuation zones. In evacuation scenario 1, each zone corresponds to the category of hurricane which would warrant an evacuation of that area. Also included would be any zone below the zone corresponding to the storm category. Hence, Zone 1 would be evacuated in a Category 1 storm, Zones 1 & 2 would be evacuated for a Category 2 storm, and Zones 1 through 3 would be evacuated for at Category 3 storm. In a Category 4 or 5 storm, Zones 1 through 4 would be evacuated. In the event that elected officials in Baldwin County deem a wider evacuation order is necessary (evacuation scenario 2), Zones 1 through 5 will be evacuated for a Category 5 storm.

Tables 3-1 and 3-2 identify the evacuation scenarios that were established through coordination with the local jurisdictions in 2010. These scenarios have been developed for Mobile and Baldwin counties in Alabama. Figures 3-1 and 3-2 map the evacuation zones for each county.

Table 3-1: Mobile County Evacuation Scenarios

Evacuation Zone	Storm	Description
1	Category 1 & 2	Consists of all areas of Mobile County south of Interstate 10. This includes Dauphin Island, residents of manufactured homes, low lying areas and flood prone areas anywhere in the County.
2	Category 1 & 2	Consists of all areas of Mobile County north of Interstate 10 and east of a line formed by Interstate 65 north to U.S. Highway 43 then north to the county line.
3	Category 3, 4 & 5	Consists of all areas of Mobile County north of Interstate 10 but south of U.S. Highway 98/Moffatt Road and west of Interstate 65.
4	Category 3, 4 & 5	Consists of all areas of Mobile County north of U.S. Highway 98/Moffatt Road and west of a line formed by Interstate 65 north to U.S. Highway 43 then north to the County line.

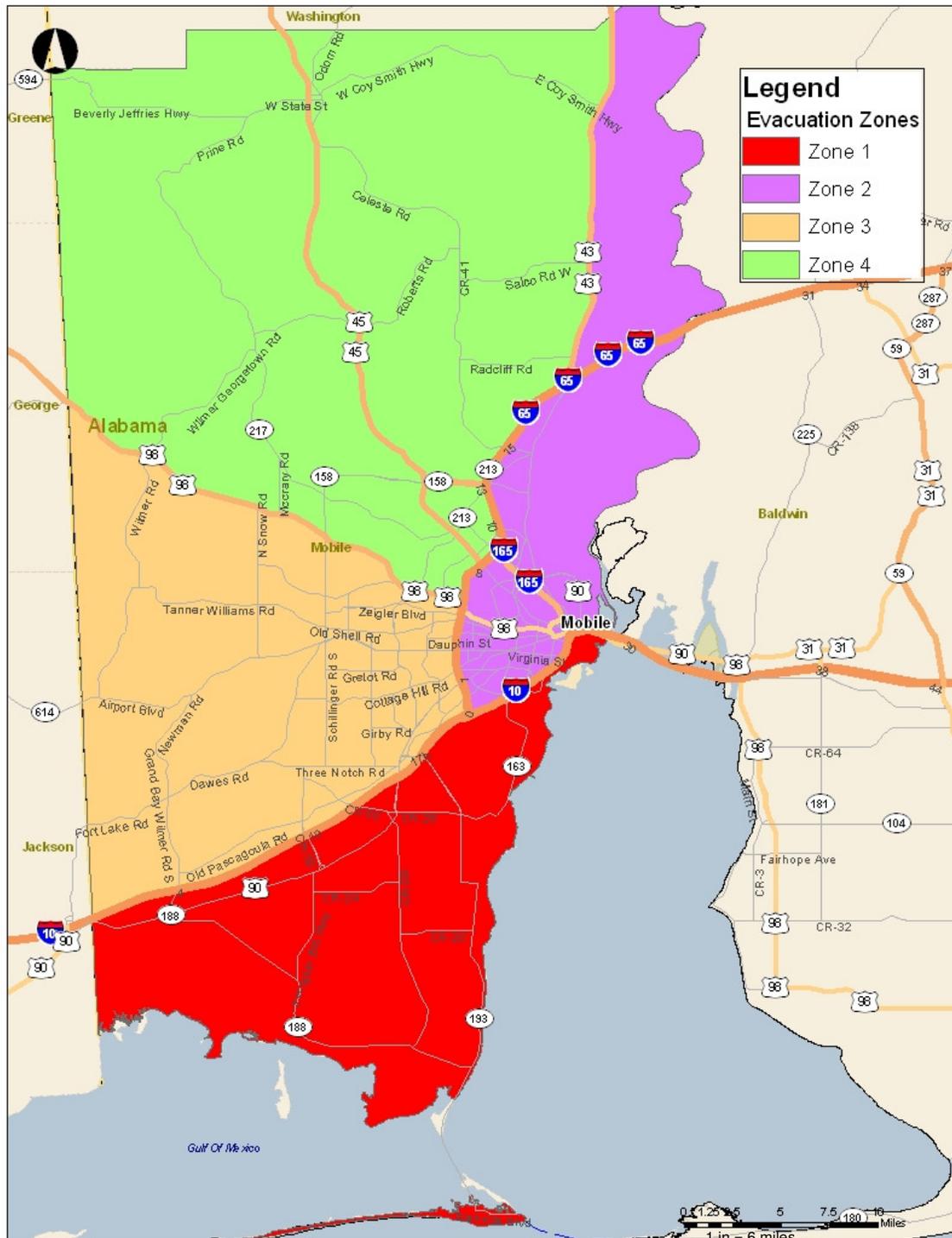


Figure 3-1: Mobile County Evacuation Zones

Table 3-2: Baldwin County Evacuation Scenarios

Evacuation Zone	Storm	Description
1	Category 1	All areas of Pleasure Island along with individuals living in manufactured homes, and those living in low lying flood prone areas countywide. (Pleasure Island consists of all areas south of the Intra-coastal Canal to include Fort Morgan, Gulf Shores, Orange Beach and Ono Island.)
2	Category 2	All areas south of State Hwy 98 and the area on the Eastern Shore that is South of Interstate 10 and West of State Hwy 98. Also all individuals living in proximity to the Fish, Styx, Blackwater and Perdido Rivers and all individuals living in manufactured homes, and those living in low lying flood prone areas countywide.
3	Category 3	All areas south of State Hwy 98 and the area on the Eastern Shore west of State Hwy 98, State Hwy. 225 and Hwy 59 North of Stockton to the Baldwin/Monroe County line. Also all individuals living in proximity to the Fish, Styx, Blackwater and Perdido Rivers and all individuals living in manufactured homes, and those living in low lying flood prone areas countywide.
4	Category 4	All areas south of Interstate 10 and the area on the Eastern Shore west of State Hwy. 225 and Hwy 59 North of Stockton to the Baldwin/Monroe County line. Also all individuals living in manufactured homes, and those living in low lying flood prone areas countywide should evacuate.
5	Category 5	Entire county should evacuate.

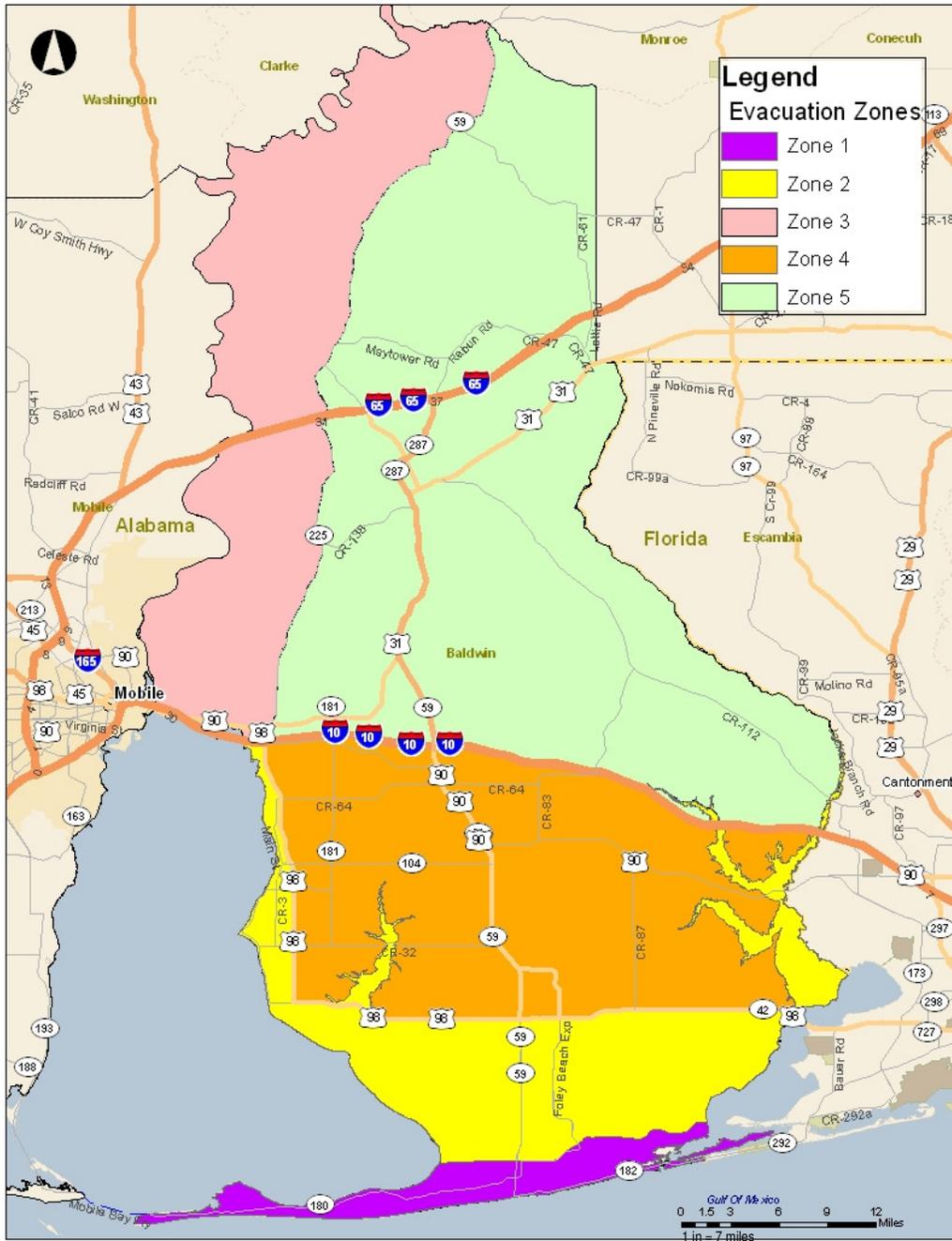


Figure 3-1: Baldwin County Evacuation Zones

4 VULNERABLE POPULATION

The identification of vulnerable populations is a critical component of any hurricane evacuation study. Vulnerable population is defined as persons residing within the evacuation zones and all those subject to storm surge and/or hurricane force winds, all mobile home residents countywide and all tourists within the county. As such, the total population of Mobile and Baldwin counties can be considered vulnerable.

Since, the vulnerable population was calculated in the Transportation Analysis portion of the Alabama HES, it will not be estimated as part of the Vulnerability Analysis. Results from the Transportation Analysis are presented in Tables 4-1 and 4-2 for Mobile and Baldwin counties, respectively. It should be noted that the Transportation Analysis estimates the population in the evacuation zones only; it does not include the population located in the storm surge inundation areas.

Table 4-1: Mobile County Vulnerable Population by Evacuation Zone

MOBILE COUNTY			
	TOTAL POPULATION	MOBILE HOME POPULATION	TOURIST POPULATION
EVAC ZONE			
1	58,028	1,772	3,088
2	154,358	2,381	7,836
3	129,820	31,092	13,556
4	63,723	8,549	5,268
TOTAL	405,929	43,794	29,748

Table 4-2: Baldwin County Vulnerable Population by Evacuation Zone

BALDWIN COUNTY			
	TOTAL POPULATION	MOBILE HOME POPULATION	TOURIST POPULATION
EVAC ZONE			
1	15,765	1,292	44,120
2	47,491	16,077	21,976
3	4,760	3,115	968
4	82,329	10,359	5,208
5	33,852	5,926	1,712
TOTAL	184,197	36,769	73,984

5 VULNERABLE STRUCTURES

Along with the vulnerable population, the number of structures within the community that are vulnerable to storm surge is imperative information for emergency managers. It is a crucial piece of knowledge to be used to support evacuation, response and recovery planning and decision making. This component of the Vulnerability Analysis has been developed to assist emergency managers in determining the number and characteristics of vulnerable properties within their communities.

Parcel data from the Mobile and Baldwin County tax assessors was utilized in a spatial analysis to classify and select the residential, commercial and industrial structures in the county that are vulnerable to the five hurricane storm surge categories. Table 5-1 shows the number and type of vulnerable structures in each surge area as well as those that are located outside of the surge areas. The values listed are cumulative and not independent by storm category. Figures 5-1 and 5-2 illustrate the distribution of residential, commercial and industrial parcels in Mobile and Baldwin counties.

Table 5-1: Vulnerable Structures by Storm Surge Area

County Surge Area	Residential Structures	Commercial Structures	Industrial Structures
MOBILE COUNTY			
CATEGORY 1	4,892	238	65
CATEGORY 1 - 2	8,194	495	109
CATEGORY 1 - 3	12,348	1,060	137
CATEGORY 1 - 4	18,304	1,593	168
CATEGORY 1 - 5	27,987	2,132	181
Non-Surge Area	102,311	4,967	79
TOTAL	130,298	7,099	260
BALDWIN COUNTY			
CATEGORY 1	7,954	408	8
CATEGORY 1 - 2	17,501	584	9
CATEGORY 1 - 3	25,313	706	9
CATEGORY 1 - 4	31,016	804	9
CATEGORY 1 - 5	35,273	856	9
Non-Surge Area	53,108	2,571	89
TOTAL	88,381	3,427	98

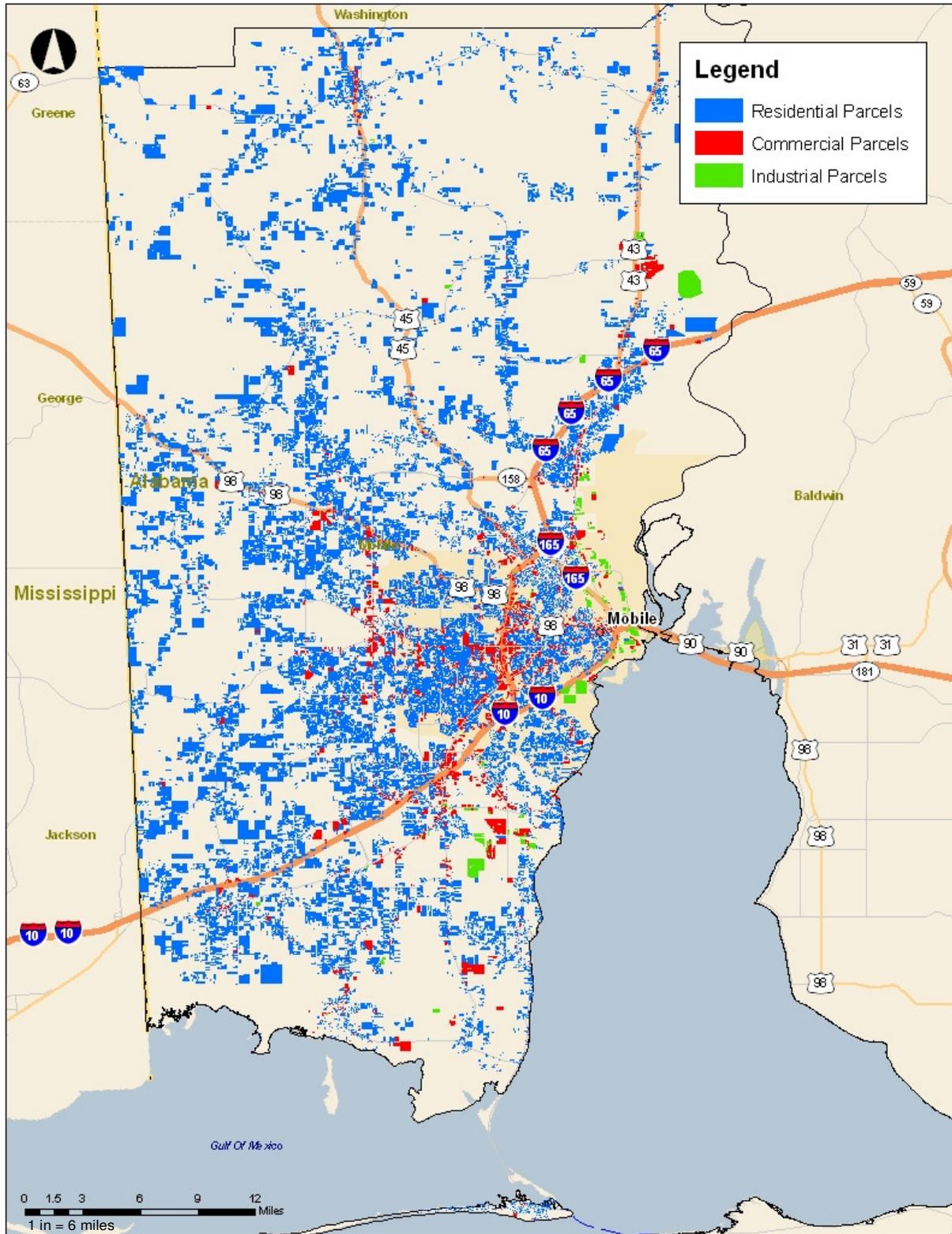


Figure 5-1: Mobile County Parcels

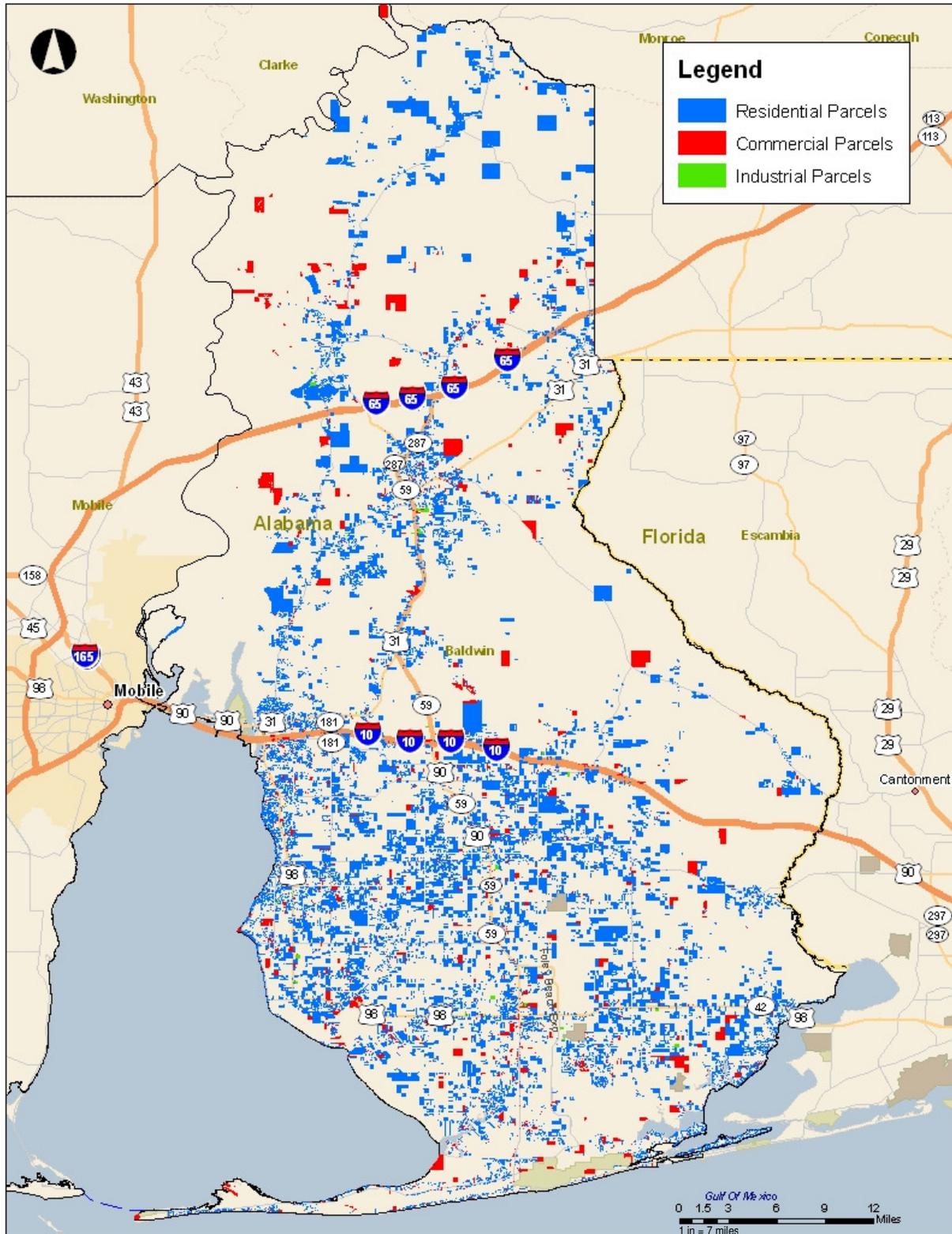


Figure 5-2: Baldwin County Parcels

RESIDENTIAL

An assessment of vulnerable structures reveals that both Mobile and Baldwin counties have a higher percentage of their residential structures outside of a surge area than within a surge area. Baldwin County has a larger percentage of residences located in surge areas (40%) compared to Mobile County (20%). A higher percentage of Baldwin County residents live in communities closer to the coast. The percent increase in vulnerable structures declines above a Category 2 storm surge area in Baldwin County. The majority of residences within a surge area are located in Category 1 and Category 2 storm surge areas, with the highest amount being in the Category 2 surge area. Conversely, in Mobile County, the percent of vulnerable structures continually increases with increasing distance from the coast, exhibiting the largest jump in residential structures from a Category 4 to a Category 5 surge area. Lower category storms are likely to have a greater impact on residential structures in Baldwin County.

COMMERCIAL

A large number of commercial structures in both counties would be affected by storm surge. Mobile County has a slightly larger percentage of commercial properties located in surge areas (30%) compared to Baldwin County (25%). The distribution of commercial properties mirrors the distribution of residential properties in both counties. In Mobile County, the number of commercial structures increases steadily above a Category 2 storm surge area. The percent increase in structures that will be vulnerable to storm surge increases with larger category storms, a positive correlation.

Baldwin County has a greater percentage of its commercial structures in the Category 1-2 surge area. Of the commercial properties that are vulnerable to storm surge in Baldwin County, the highest percent are located in a Category 1 storm surge area. Again, an inverse relationship exists between the percent of commercial structures vulnerable to storm surge and the storm surge category. Hence, there is a greater potential impact on commercial activities in Baldwin County from smaller storms than in Mobile County. The economy of Baldwin County relies heavily on the tourism industry, whose livelihood depends on the occupancy of its tourist structures and the operation of its businesses along the coast. A significant portion of commercial activity is located along the beaches of Gulf Shores and Orange Beach in Baldwin County, making these areas extremely vulnerable to storm surge and increasing their potential for serious economic losses in the aftermath of a hurricane.

INDUSTRIAL

Perhaps the largest threat to Mobile County comes from disruption of industrial activities. Mobile County has a much larger percentage of industrial properties located in surge areas (70%) compared to Baldwin County (10%). A focal point of Mobile County industry is the Port of Mobile and the waterways of Mobile Bay. Approximately 25% of all industrial properties in Mobile County are located in the Category 1 storm surge area and the percent increase in vulnerable industrial structures declines from there.

Industry in Baldwin County is primarily located inland where it is less likely to experience impacts from hurricane storm surge. Inland winds may be of greater concern to industrial properties in Baldwin County.

6 CRITICAL FACILITIES

Critical facilities are community entities that are critical to the operation of the community and need special consideration for hurricane preparedness. They may need assistance or special consideration or attention prior to evacuation or immediately after the storm has past as they have been deemed “critical” to the livelihood of the community. Critical facilities as viewed by AEMA and local emergency management include: shelters, hospitals, police stations, fire stations, local government offices and emergency operations centers that are needed for community support functions and/or emergency response activities before, during and after an emergency. Other critical facilities considered in the vulnerability analysis include schools, elderly care facilities, airports, hazardous material sites, points of distribution (PODs), and large supply outlets; each representing an asset of the community that is vital to maintaining and restoring normal operations within the County in the post-storm environment. Data for the critical facilities assessment was obtained from local emergency management and AEMA. Neither first floor elevation nor potential storm surge heights were provided with the data.

The critical facilities from the various data sources were compiled by county; any multiple facilities were eliminated and gaps in the data (address, city, state, zip, and latitude/longitude) were addressed. A spatial analysis (select by location) was performed to associate the facilities’ location with respect to surge area, evacuation zone and flood hazard area. High risk flood areas were defined as areas with a 1% annual chance of flooding (100 year floodplain) designated as Zone A on FEMA Flood Insurance Rate Maps (FIRMs). Potential wave impact was also assessed by examining the location of each facility in respect to the coastal high hazard area, identified as Zone V. Any facilities outside of the surge areas or evacuation zones were labeled as zero or NA. Yes (Y) or No (N) classifications were assigned to each critical facility based upon whether or not it was located in the 100 year floodplain or wave impact area. Once the geodatabase was complete, the list of critical facilities was sent to local emergency management for approval and modified based on the responses received.

Table 6-1 provides a summary of critical facility types in each of the five storm surge areas. The values presented are cumulative by storm category. Figures 6-1 and 6-2 show the location of some primary critical facilities, such as the emergency operations center (EOC), police and fire stations, medical facilities and shelters.

A geoPDF file for Mobile and Baldwin counties has been provided which contains the locations of all critical facilities designated by each county. The attributes of each facility include the facility name, type, address, and in which hurricane surge area and evacuation zone it is located. The location relative to the 100-year floodplain and potential for wave impacts are also included. These attributes can be queried and viewed within the geoPDF file. It should be noted that the surge area, evacuation zone, floodplain and wave impact designations were assigned based on the GIS data and/or latitude and longitude provided by the counties. Verification of street addresses or geographic coordinates was not completed as part of the assessment.

Table 6-1: Critical Facilities Summary Table

Facility Type	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5	Outside Surge Area	Within 100 Year Floodplain	Within V-Zone	TOTAL
Mobile County									
Emergency Services	3	9	15	19	27	54	2	-	81
Elderly Care Facilities	-	-	3	3	8	35	2	-	43
EOC	-	-	-	-	-	1	-	-	1
Government	7	16	36	41	52	37	27	-	89
Hazmat	11	21	24	30	48	65	21	3	113
Medical	-	-	1	2	2	7	-	-	9
Schools	-	3	10	16	28	151	2	-	179
Shelters	-	-	2	2	4	34	1	-	38
TOTAL	21	49	91	113	169	384	55	3	553
Baldwin County									
Airports	-	-	1	1	1	2	-	-	3
County Facilities	1	2	2	3	3	85	2	-	88
Elderly Care Facilities	-	-	-	-	-	21	-	-	21
EOC	-	-	-	-	-	1	-	-	1
Fire Stations	1	5	6	9	12	50	5	-	62
Hazmat	3	6	7	10	12	20	6	1	32
Medical	-	-	-	1	1	19	-	-	20
PODs	-	-	-	-	2	13	-	-	15
Police Stations	-	1	2	3	3	17	2	-	20
Schools	-	1	1	2	5	79	1	-	84
Shelters	-	-	-	-	-	23	-	-	23
Supply Outlets	-	-	1	2	2	8	1	-	10
TOTAL	5	15	20	31	41	333	17	2	374

From the summary table and maps, it is evident that the majority of critical facilities identified by Mobile and Baldwin county EMA are located outside of surge areas. A slightly higher percentage of the critical facilities identified in Mobile County are located in Category 1-5 surge areas (30%) versus those in Baldwin County (10%). In both counties, the majority of medical institutions and emergency services are situated outside of the surge area. All shelters in Baldwin County are located outside of the surge area. Four shelters were identified in Mobile County which could be susceptible to storm surge in a major hurricane event (Category 3 and above).

As noted previously in the examination of vulnerable structures, industry in Mobile County is particularly vulnerable to storm surge. Particularly concerning is the number of hazardous material sites within the county that are located in surge areas. Approximately 50% of these locations are vulnerable to storm surge. Additionally, over half (58%) of government facilities in the County (i.e., city hall, DOT, public works, county commission, transit authority, district court, among others) are vulnerable to storm surge. As a result, Mobile County should, if they have not already done so, strongly consider developing and adopting a Continuity of Operations (COOP) and a Continuity of Government (COG) plan in the event their government facilities are severely impacted by storm surge from a major hurricane event.

Communities that have these types of plans in place prior to a disaster can more quickly return their vital government operations and services to some sense of normalcy. In Baldwin County over one third (38%) of hazardous material storage locations are located within a surge area.

In addition to storm surge hazards, emergency management officials should be aware of the potential for wind damage to upper floors of multi-story buildings. Post-hurricane surveys in other areas show that extreme winds can inflict major damage to substantial structures, exposing occupants to life-threatening danger. Agencies responsible for hurricane preparedness of special needs facilities (hospitals, nursing homes, adult homes, and correctional facilities) should ensure that proper attention is given to the complex task of planning and coordinating emergency response.

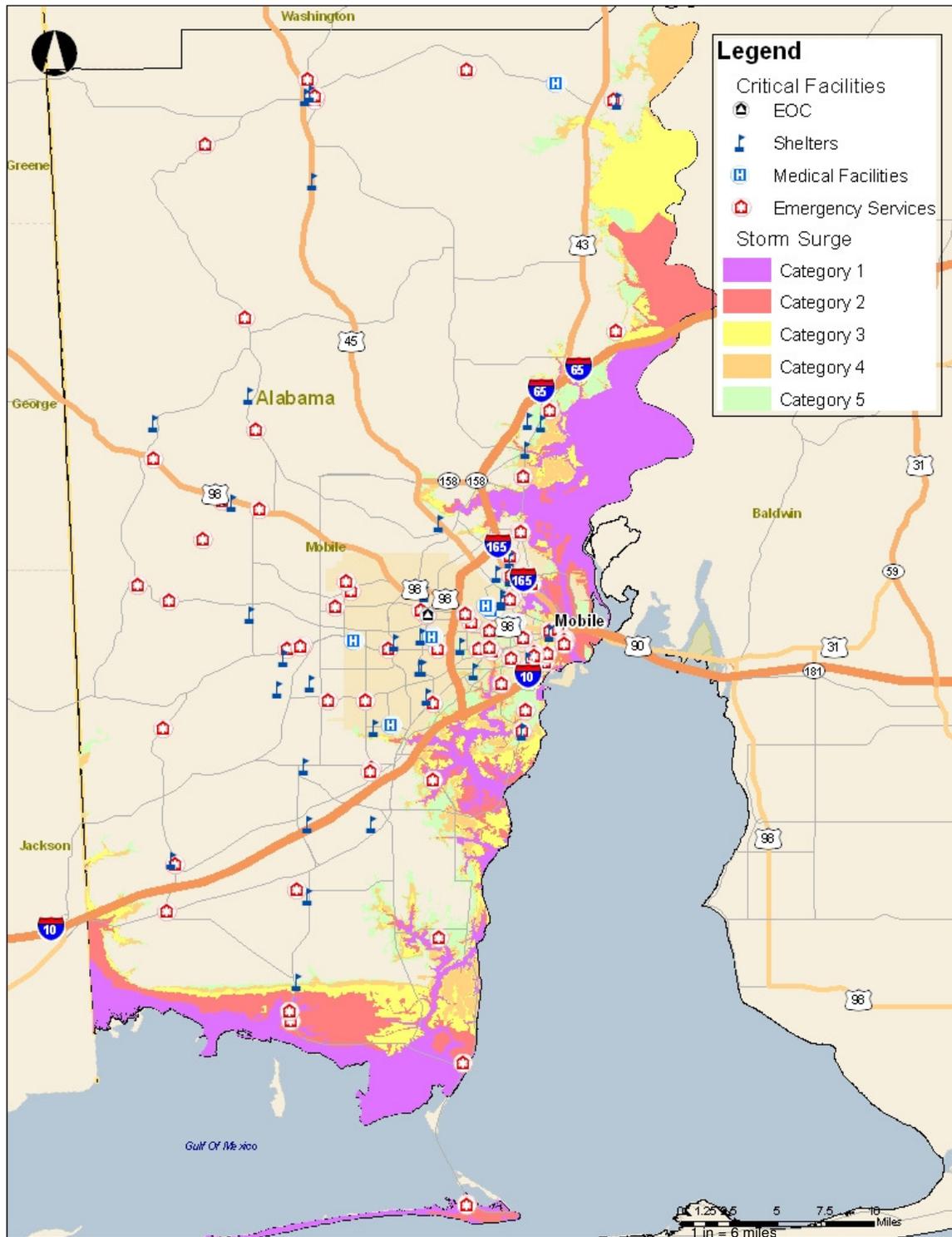


Figure 6-1: Mobile County Critical Facilities

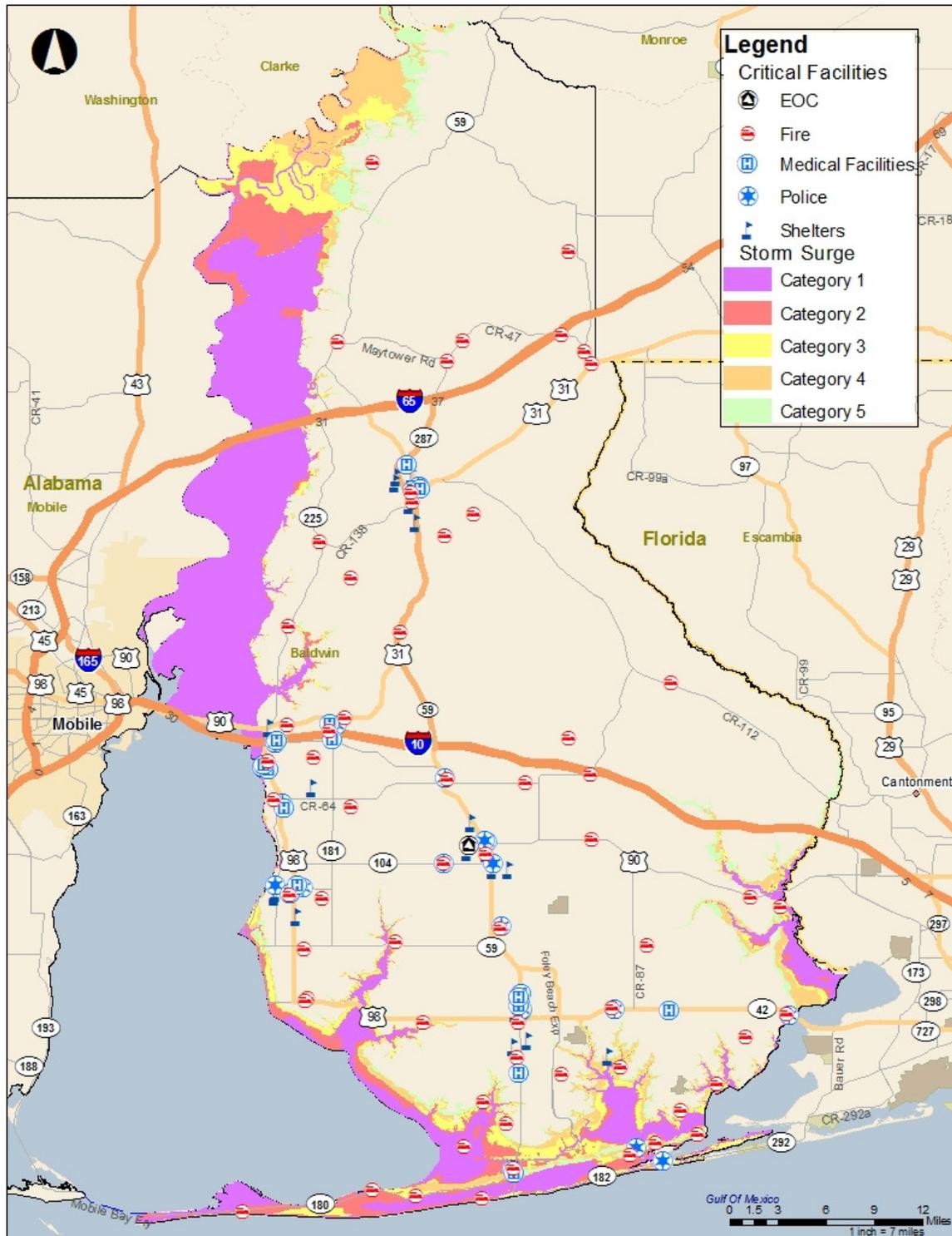


Figure 6-2: Baldwin County Critical Facilities

7 INFRASTRUCTURE

For decades, engineers and scientists have been developing techniques, strategies, and materials to help the built environment withstand the effects of hurricanes. In addition, building and zoning codes have been changed to keep critical infrastructure away from hazardous areas to minimize the risks of flood and wind damage. Despite some advances, a community will inevitably face major infrastructure damage, from compromised levees and closed ports to damaged bridges and hundreds of roadways left underwater. As such, a top priority for AEMA is the restoration of transportation and utility systems, enhancing evacuation capabilities, and facilitating economic recovery.

As part of the Vulnerability Analysis, AEMA has requested additional vulnerability data sets be developed to support this initiative. These data include power lines and substations, sewer lines and pumping stations, generator locations and gas stations. State and County emergency management offices and local utility providers were contacted to collect available GIS data. An analysis was performed to determine which facilities are within the areas of potential storm surge for each of the five hurricane categories. The location of vulnerable infrastructure relative to evacuation zones, one percent annual chance floodplain and coastal high hazard area (V-Zone) was also determined.

Infrastructure and utility systems vulnerable to storm surge were estimated based on best available data from County offices. Mobile and Baldwin Emergency Management Agencies provided contact information for various utility providers in their respective counties.

The primary sources for utility data included:

- Baldwin County Sewer
- Riviera Utilities
- Loxley Sewer
- South Alabama Utilities

Despite extensive data collection efforts, GIS data on sewer lines and pumping stations in Mobile and Baldwin counties proved difficult to obtain. Either the data did not exist in GIS format (in rural parts of the counties) or the data could not be provided by certain offices for various reasons. Documentation of the data collection process and all correspondence was provided to the study manager. Additional utility data for the beach communities of Baldwin County was obtained through coordination with Auburn University and the research that was conducted as part of the Geospatial Mapping Project of the Coastal Communities of Alabama. Available data from NAVTEQ Smart Data Compression (SDC) North America (NA) version 2009.3 was referenced when data at the local level was not available or not provided.

Table 7-1 summarizes the vulnerability of the available infrastructure and utility data sets provided in the Vulnerability Analysis. The values presented are cumulative by storm category. Figures 7-1 through 7-3 illustrate the location of these infrastructure systems in Mobile and Baldwin counties.

Table 7-1: Vulnerable Infrastructure Summary Table

Facility Type	Cat 1	Cat 2	Cat 3	Cat4	Cat 5	Outside Surge Area	Within 100 Year Floodplain	Within V-Zone	TOTAL
Mobile County									
Gas Stations	1	5	12	21	33	148	13	-	181
Generators	14	26	34	45	56	54	36	1	110
Pumping Stations*	-	-	-	-	-	9	-	-	9
Substations	3	8	21	32	41	84	17	-	125
Transmission Lines	29	36	45	52	58	59	91	4	117
TOTAL	47	75	112	150	188	354	157	5	542
Baldwin County									
Gas Stations	-	2	4	9	11	62	1	1	73
Generators	-	-	-	-	1	37	-	-	38
Pumping Stations*	8	24	39	51	58	159	16	6	217
Sewer Lines*	169	375	513	627	696	3,836	367	30	4,532
Substations	1	5	7	9	9	35	3	-	44
Transmission Lines	20	21	22	22	24	20	31	6	44
TOTAL	198	427	585	718	799	4,149	418	43	4,948

* Line items marked with an asterisk are not inclusive of all sewer systems within the County. The figures in these rows represent the data that was available at the time the Vulnerability Analysis was performed.

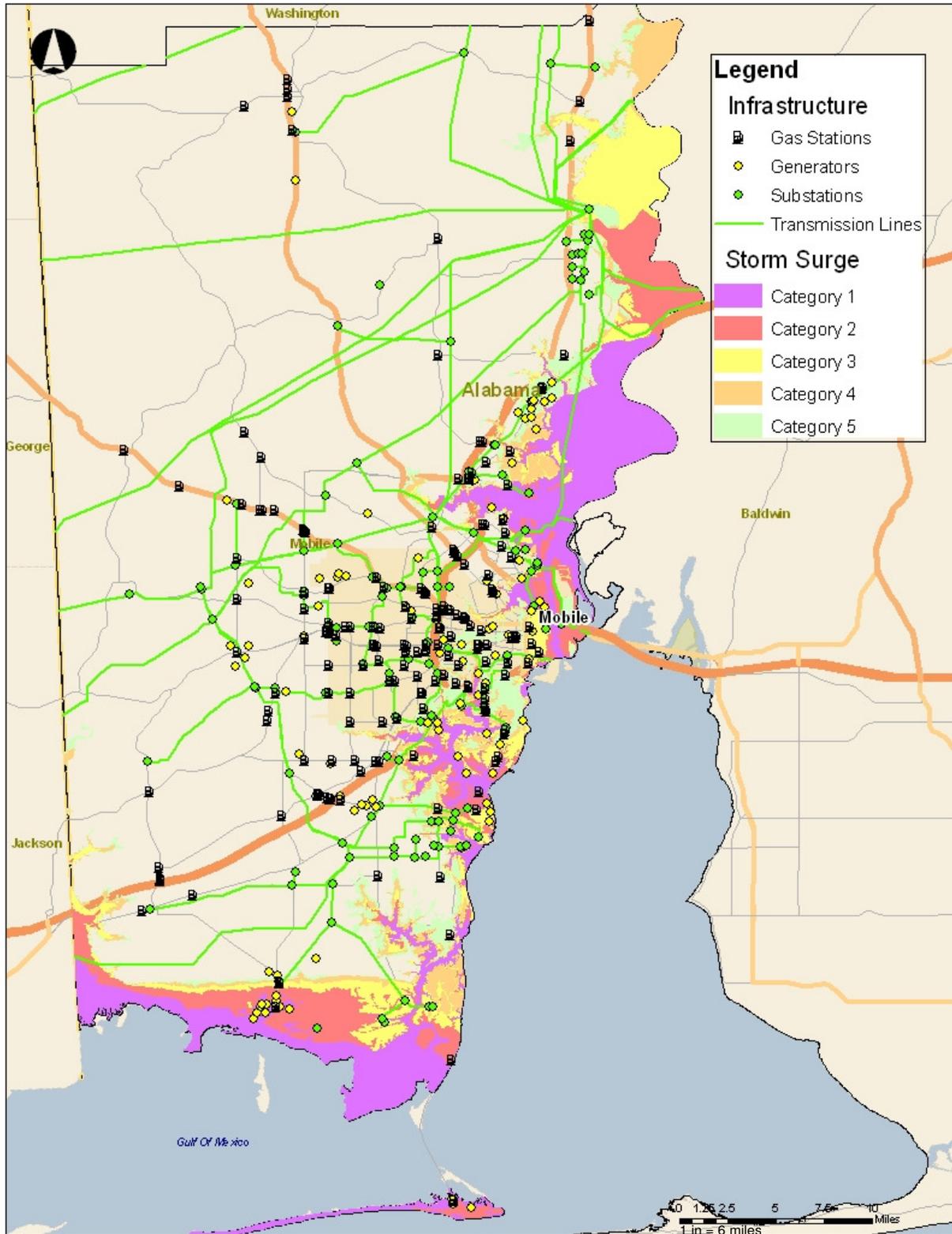


Figure 7-1: Mobile County Vulnerable Infrastructure

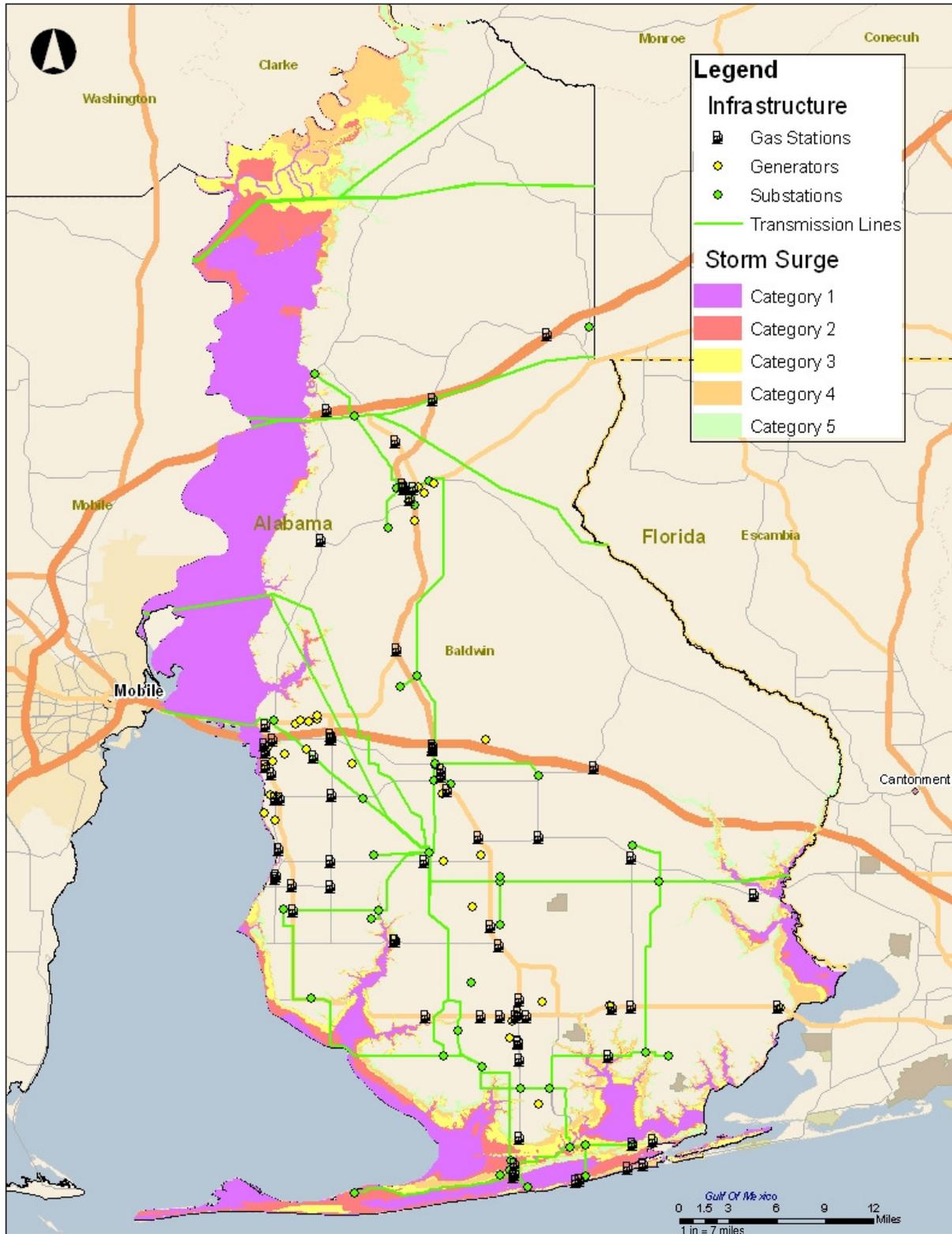


Figure 7-2: Baldwin County Vulnerable Infrastructure

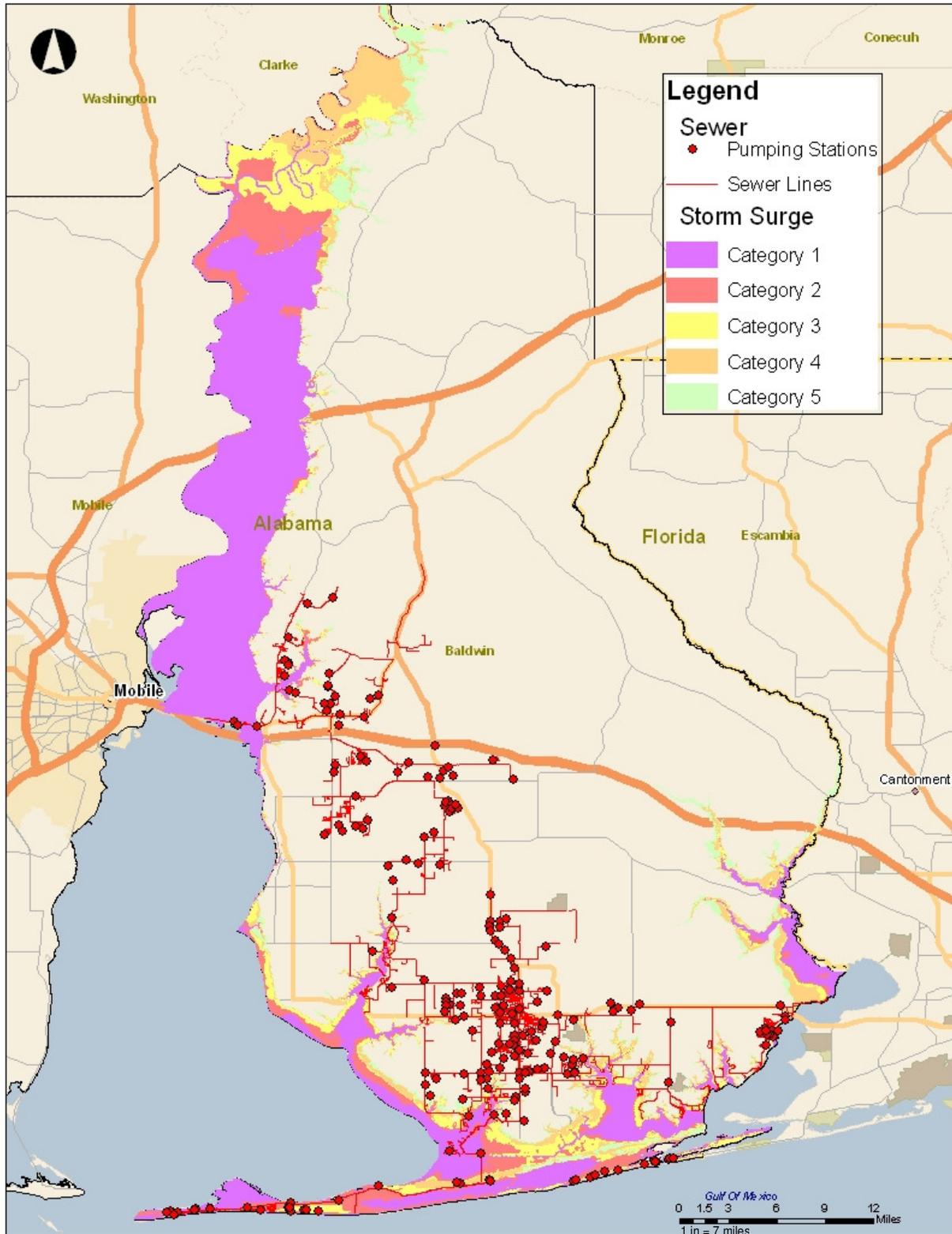


Figure 7-3: Baldwin County Sewer System

While hurricane hazards will always pose a threat to lives and property, utility and infrastructure resilience, though immensely important to community recovery, are often overlooked. The Vulnerability Analysis looks at a few of these facilities that have not traditionally been analyzed in the HES. Benefits of a resilient community infrastructure include:

- Faster recovery post-storm
- Decreased cost of recovery in a community
- Business continuity in the aftermath of an event
- Maintenance and community sustainability in the long term

Power lines in Mobile and Baldwin counties are extremely vulnerable to hurricanes. Approximately half of the transmission lines in both counties are located in storm surge areas. And hurricane force winds can result in downed trees and power lines countywide. Substations are primarily located outside of storm surge areas but of those vulnerable substations in the coastal counties, a greater percentage occurs in Mobile County (33%) than in Baldwin County (20%).

Generator locations for Mobile and Baldwin counties are maintained in AEMA's Emergency Managers Information Tracking System (EMITS). Generators in Baldwin County are located outside of storm surge areas with the exception of one location. Over half of the generators in Mobile County are located in storm surge areas, many of which could be impacted by storm surge in a minor category storm.

Standby power systems provide a good way to keep facilities safe, comfortable and functioning during a disaster and in its aftermath—provided that planning has been appropriate for the potential infrastructure damage. Hurricane Katrina proved disasters that severely impact a region's infrastructure of buildings, highways and energy supplies present the most difficult of challenges. To better cope with future disasters, emergency managers should focus on making their standby power system less vulnerable to wind, storm surge and flooding. Generators should be located indoors on upper floors or on rooftops. If outdoors, they should be mounted on an elevated platform above the highest expected water level.

The majority of gas stations in Mobile and Baldwin counties are located outside of storm surge areas. Though many are located outside of the surge area, these facilities are still vulnerable to wind damage and widespread power outages. Fuel supply agreements should be negotiated in expectation of extended outages. In areas prone to severe flooding during storms, emergency managers should consider contracting for temporary fuel tanks and additional fuel supply in anticipation of shortages. In some areas, natural gas may be a viable option for standby power.

High winds and surge from hurricanes have the potential to severely impact a wide range of public service facilities, including drinking water and sewage treatment plants. Sewer lines and pumping stations located within the storm surge areas of Mobile and Baldwin counties are particularly vulnerable to damage and could experience lengthy disruption in service after a hurricane. Damage at many infrastructure facilities are the result of either flooding or loss of electric power to pump, process and treat raw water supply and wastewater. Initially following a storm, plants may be able to operate temporarily on backup generators, so long as fuel is available. However, even after restoration of electricity, cleanup and recovery at flooded water and sewage treatment plans is likely to take considerable time. Pre-disaster preparation and conservative use post-storm are vitally important to an efficient recovery in these communities.

8 SUMMARY

The vulnerability analysis depicts the areas, populations, facilities, infrastructure, critical facilities, institutions and community areas subject to a storm's hazards. Other facets, such as utilities and infrastructure that impact a community's vulnerability to hurricane hazards are also analyzed.

As evidenced in the analysis, the vulnerability of property, critical facilities and infrastructure along Alabama's coast is not evenly distributed between cities or along transportation routes. Some regions are more susceptible to the impacts of hazards than other places based on the characteristics of development and landscape. As witnessed extensively in previous storms, when community growth is coupled with residences in high-risk surge areas, differential vulnerabilities can lead to catastrophic results. The geographic distribution of vulnerability also necessitates different mitigation, post-response, and recovery actions. Given temporal and spatial changes in vulnerability in the future, there is no one-size-fits-all approach to preparedness, response, recovery, and mitigation.

Knowing where properties, critical facilities and infrastructure are concentrated within communities and the general characteristics of their nature is an important step towards effective emergency management. The geospatial identification of important community features performed in the Vulnerability Analysis may be the most effective method to reduce the risk and improve local resilience to hurricane hazards.