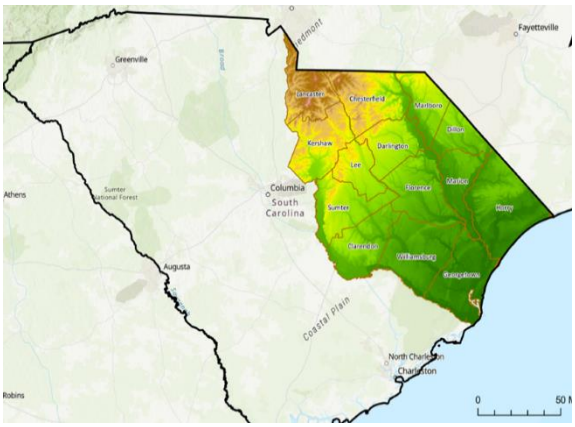
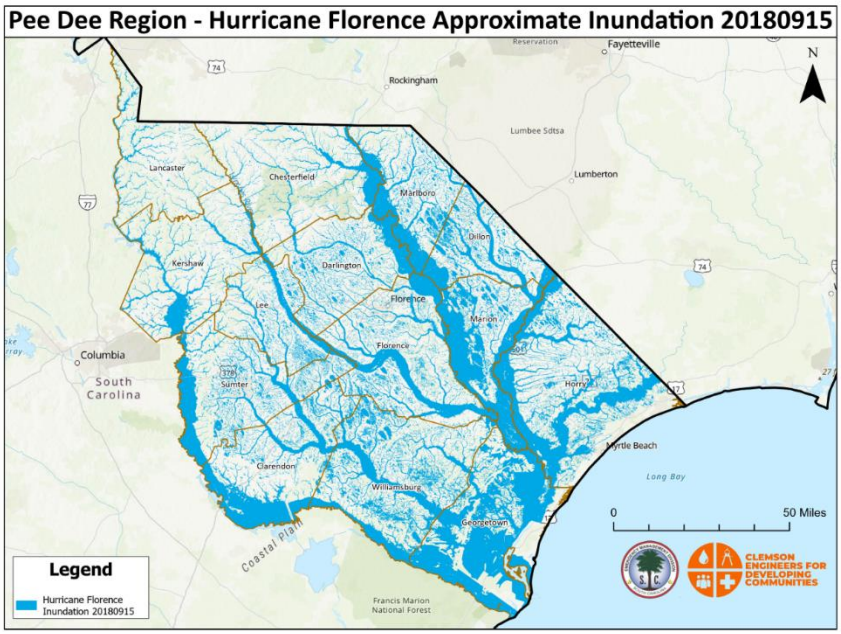
Appendix J. Critical Infrastructure and Flood Risk in the Pee Dee



Counties in the Pee Dee River Basin in South Carolina have experienced significant flood events, including damage from Hurricane Florence in fall 2018 (see section IV. F. Tropical Cyclones, in the 2023 SHMP for background). In the aftermath of Hurricane Florence, South Carolina initiated multiple activities to better understand and mitigate flood risk in the area as well as statewide. SCEMD and Clemson University collaborated to examine critical infrastructure assets at risk of flood impacts in the Pee Dee region, which resulted in this appendix. Basic aspects of risk analysis and front-end components of the Infrastructure Resilience Planning Framework (IRPF) informed the study.



The analysis in this study used open-source data to map critical infrastructure in 14 Pee Dee counties and compare those locations to 100- and 500-year floodplains as well as to a Hurricane Florence flood inundation scenario. Counties in the study: Chesterfield, Clarendon, Darlington, Dillon, Florence, Georgetown, Horry, Kershaw, Lancaster, Lee, Marlboro, Marion, Sumter, and Williamsburg. The counties are part of the Pee Dee River Basin, which includes 27 watersheds in South Carolina and another 18 in North Carolina and 5.5 million acres in the two states.

Critical infrastructure includes facilities, systems, and networks that are so vital that their incapacitation or destruction would have a debilitating effect on security and/or public health or safety. A total of 282,651 assets were considered across multiple critical infrastructure sectors. See Table 1 for infrastructure and types of assets studied. Location and elevation information was compiled to compare to flood inundation levels in the three scenarios. Failure points – locations at which operational capacity of the infrastructure would be negatively impacted or limited by floodwater – were identified or estimated.

Infrastructure Sector	Asset Type	Assets Found in Pee Dee Region
Energy	Power Generation	72
	Substations	335
Water	Wastewater Treatment Plants	46
	Public Water Supply Wells	569
Transportation	Train Stations	2
	Aviation	39
	Maritime and Inland Ports	2
	Bridges & Rail	2,373
	Highway Road Segments	158,140
	Road Segments	118,983
Communications	Broadband Towers	721
	FM Radio Stations	70
	AM Stations	37
	Television Stations	19
Healthcare	Hospitals	124
	Clinics	72
Government	Post Offices	95
	Private Schools	63
	Public Schools	336
	Town Halls	52
	Prisons & Jails	68
	Courthouses	23
	US Marshall Offices	1
	Military Bases	1
	Colleges & Universities	71
	Libraries	52
Emergency Services	Police Stations	21
	Fire Stations	250
	Emergency Operation Centers	14

Table 1. Infrastructure and asset types considered

Critical infrastructure asset location data was compiled, and locations were mapped using a geographic information system (GIS) application. Asset elevations were estimated using Google Earth and a validation methodology. Flood map layers for the three flood scenarios were added to identify infrastructure sites that would likely be inundated in each of the scenarios. Limitations include the use of federal Flood Insurance Rate Maps (FIRMs), which are not high-resolution and are not necessarily current or comprehensive since their purpose is for flood insurance determinations rather than detailed risk analysis. Also, road and bridge access elevations were not available for analysis.

Based on FIRMs, assets were flagged as high risk if they were in the 100-year flood plain. Assets were flagged as medium risk if they were in the 500-year flood plain and not the 100-year flood plain. Assets were marked as no identified risk if they were not in either flood plain. Using Hurricane Florence flood inundation data, assets were flagged as potential no impact or potential impact based on whether the asset was in the flood inundation area.

Summary of Data

Analysis for the 14 counties indicates that asset types most vulnerable to flood inundation include: inland ports (not surprising given location and function); U.S. marshal's offices; train stations; wastewater facilities; highways and roadways; AM radio stations; and courthouses. See Table 2 below for risk by asset type.

Infrastructure Type	Total Number in 100-Year Flood Plain	Total Number in 500-Year Flood Plain	Total Number in Florence Inundation Map	Number of Assets	Percent High Risk	Percent Medium Risk	Percent in Florence Inundation Map
AM Stations	7	7	14	37	18.92%	18.92%	37.84%
Aviation	0	0	4	39	0.00%	0.00%	10.26%
Broadband	26	36	111	721	3.61%	4.99%	15.40%
Medical Clinics	0	1	2	72	0.00%	1.39%	2.78%
Colleges/ Universities	1	1	6	71	1.41%	1.41%	8.45%
Courthouses	0	1	5	23	0.00%	4.35%	21.74%
Electric Substations	11	17	43	335	3.28%	5.07%	12.84%
EOCs	0	0	1	14	0.00%	0.00%	7.14%
Fire Stations	6	9	18	271	2.21%	3.32%	6.64%
FM Stations	4	4	10	70	5.71%	5.71%	14.29%
Hospitals	0	0	7	124	0.00%	0.00%	5.65%
Libraries	2	4	6	52	3.85%	7.69%	11.54%
Maritime Inland Ports	1	1	2	2	50.00%	50.00%	100.00%
Military	0	0	0	1	0.00%	0.00%	0.00%
NG Compression Stations	0	0	0	2	0.00%	0.00%	0.00%
Police Stations	3	3	9	66	4.55%	4.55%	13.64%
Post Offices	3	4	6	95	3.16%	4.21%	6.32%
Power Generation	3	3	9	72	4.17%	4.17%	12.50%
Prisons/Jails	2	5	7	68	2.94%	7.35%	10.29%
Private Schools	1	4	6	63	1.59%	6.35%	9.52%
Public Schools	3	7	24	336	0.89%	2.08%	7.14%
Public Wells	30	37	94	569	5.27%	6.50%	16.52%
Town Halls	4	4	5	52	7.69%	7.69%	9.62%
Train Stations	0	0	1	2	0.00%	0.00%	50.00%
TV Stations	1	1	1	19	5.26%	5.26%	5.26%
US Marshal	0	0	1	1	0.00%	0.00%	100.00%
Wastewater	5	9	14	46	10.87%	19.57%	30.43%
Highway Segments	13,956	15,997	35,400	158,140	8.83%	10.12%	22.39%
Road Segments	10,181	12,832	25,230	118,983	8.56%	10.78%	21.20%

Table 2. Flood risk assessment by asset type

The percent of assets at risk in a Hurricane Florence scenario were higher for each asset type than in a scenario based on 100- or 500-year flood maps.

Based on assets and flood scenarios mapped, Georgetown and Marion counties have the highest percentages of critical infrastructure subject to flood inundation in Hurricane Florence and 100-year flood scenarios. Georgetown, Horry, and Florence counties have the highest numbers of critical infrastructure in high flood risk areas.

County	Number in 100-Year Flood Plain	Number in 500-Year Flood Plain	Number in Florence Inundation Map	Number of Assets	Percent High Risk	Percent Medium Risk	Percent in Florence Inundation Map
Chesterfield	0	0	4	184	0.00%	0.00%	2.17%
Clarendon	11	12	30	204	5.39%	5.88%	14.71%
Darlington	4	4	28	229	1.75%	1.75%	12.23%
Dillon	4	5	17	129	3.10%	3.88%	13.18%
Florence	14	14	49	457	3.06%	3.06%	10.72%
Georgetown	19	32	101	195	9.74%	16.41%	51.79%
Horry	24	38	54	547	4.39%	6.95%	9.87%
Kershaw	3	5	8	187	1.60%	2.67%	4.28%
Lancaster	1	3	4	160	0.63%	1.88%	2.50%
Lee	1	2	8	88	1.14%	2.27%	9.09%
Marlboro	3	4	7	111	2.70%	3.60%	6.31%
Marion	10	13	22	126	7.94%	10.32%	17.46%
Sumter	9	13	27	295	3.05%	4.41%	9.15%
Williamsburg	4	5	34	196	2.04%	2.55%	17.35%

Table 3. Critical infrastructure in flood-prone locations by county (not including roads, bridges, or railroads)

Information from this study, including open-source data and resulting analysis, will be available to counties in the Pee Dee and state agencies and organizations with infrastructure in the region to inform mitigation and infrastructure protection planning and actions.

Recommendations for Further Study

Further analysis of the data used in this study as well as the integration of additional data sources would be beneficial to improve hazard mitigation planning in South Carolina communities. Further analysis could include the following:

1. **Localized analysis that captures the risk of critical infrastructure failure** to population centers and incorporated cities and towns.
    a. Maps produced in this analysis show high-risk infrastructure at the regional and county level. Supporting counties and/or communities to identify locations of high-

risk infrastructure can better support local hazard mitigation and infrastructure protection planning and mitigation grant application development.

b. Development of flood risk scores to rank high-risk infrastructure by highest to lowest risk to support prioritization of mitigation activities. This study used a pass/fail system to represent flood vulnerability. With more detailed and localized research, scores could be generated for priority assets using a blend of statistical confidence of failure and the cost associated with failure.

2. **Analysis of critical but high-risk transportation infrastructure** in comparison to community access and evacuation routes. High-risk transportation infrastructure, including roads and bridges, can be further researched to understand which roads are most critical based on their use by communities as well as their purpose in serving as evacuation routes in emergency situations.
3. **Identification of interdependencies of critical infrastructure** and the risks of cascading failures. This analysis did not consider the how the infrastructure studied are interconnected and the potential for cascading failures to impede recovery and exacerbate damage. Additional study by local governments or infrastructure owners/operators could consider in more detail how interdependency of infrastructure affects risk.
4. **Improvement of floodplain modeling.** As noted in this and other studies and plans, statewide, up-to-date, and high-resolution floodplain modeling data is needed for South Carolina. The most widely available floodplain maps are FIRMs, which are intended for insurance purposes rather than hazard modeling. Improving access to more accurate and representative flood models will increase risk awareness and facilitate hazard mitigation planning. Ongoing analysis of flood inundation models mapped with critical infrastructure data will improve understanding of flood risk in support of improved mitigation and comprehensive planning in the Pee Dee region and throughout the state.