

5.2 Prioritization of Risk

Section 4.2 outlined the process for identifying the priority projects. The next step is to establish an objective scoring system, which consists of a *risk factor* and a *probability factor* for each project. The risk factor should be associated with the potential consequences or losses associated with the project and other factors. The probability factor relates to how frequently or how likely the event that would put the community at risk will occur. Although weighting is not necessary, if some of the selection criteria have more priority than the others, then a weighting factor can be applied. The weighting factor can be related to the level of importance assigned to each criterion. For example, Scott and Smith (2019) assigned a weighted composite score using stakeholder input based on flood probability factor (65%) and consequence of risk factor (35%) assessments.

To establish guidelines for assigning a risk factor associated with potential consequences of failure, it is suggested to create categories for properties and infrastructure, as follows:

1. **Tier 1. Critical facility protection (water, sewer, public safety, hospitals, schools, power).** These essential service facilities are required to respond to emergencies and protect public health, safety, and welfare. Areas that include these facilities should be rated the highest.
2. **Tier 2. Essential services (groceries, pharmacies, roadways).** These facilities are needed to sustain people – food, medications, and mobility access. These receive the second highest priority. Most are located along major roadways that act as access routes. Most roads are state or county owned.
3. **Tier 3. Economic centers.** These facilities are rated high to protect jobs so the community can keep the local economy flowing while minimizing disruption to daily life.
4. **Tier 4. At risk communities.** The highest rated residential communities involve at risk populations who have limited ability, financially or otherwise, to escape the impacts of flooding. These may include high density developments, so flooding will impact a larger number of people that may have health, food, age, and other limitations to adaptation to flood conditions.
5. **Tier 5. Other urban/suburban property.** Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development).
6. **Tier 6. Agriculture/public property/vacant/undeveloped.** These types of properties have less flooding impacts on populations.

Table 1 outlines the Florida Department of Revenue (DOR) codes from the property appraiser's office and assigns an associated priority. Based on these priorities, the relative risk priority of

DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is most vulnerable and 6 is the least vulnerable, according to the tier scaling described previously.

Table 1. Department of Revenue (DOR) land use codes

| DOR (use code) | Description | Priority | Delineator |
|---------------------------|---|-----------------|--------------------|
| 000 | Vacant Residential | 6 | |
| 001 | Single Family Residential | Depends | Value, Age, Income |
| 002 | Mobile Homes | 4 | |
| 003 | Multi-Family >9 units | 4 | |
| 004 | Residential Condo | Depends | Value, Age, Income |
| 007 | Misc. Residential | 5 | |
| 008 | Multi-Family <10 | 4 | |
| 009 | Residential Common Area | 6 | |
| 010 | Vacant Commercial | 6 | |
| 011 | One-Story Stores | 3 | |
| 012 | Mixed Use Store | 4 | |
| 013 | Department Store | 3 | |
| 014 | Supermarket | 2 | |
| 015 | Regional Shopping Center | 3 | |
| 016 | Community Shopping Center | 3 | |
| 017 | Office Non-Professional | 3 | |
| 018 | Service Multi-Story | 3 | |
| 019 | Professional Services Building | 3 | |
| 020 | Terminals | 3 | |
| 021 | Restaurant | 3 | |
| 022 | Drive-in | 5 | |
| 023 | Financial | 2 | |
| 026 | Laundry | 3 | |
| 027 | Service Station | 3 | |
| 028 | Mobile Home Sales, Parking Lot, Mobile Home Parks | 5 | |
| 031 | Drive-in Theater | 5 | |
| 032 | Auditoriums/Indoor Theaters | 5 | |
| 033 | Bar | 5 | |
| 034 | Skating Rinks, Poolhalls, Bowling Alleys | 5 | |
| 035 | Tourist Attractions | 5 | |
| 038 | Golf Course | 6 | |
| 039 | Hotel | 3 | |
| 040 | Vacant Industrial | 6 | |

| DOR (use code) | Description | Priority | Delineator |
|---------------------------|--------------------------------|-----------------|---|
| 041 | Light Manufacturing | 4 | |
| 048 | Warehouse Distribution | 5 | |
| 049 | Open Storage | 6 | |
| 052 | Cropland | 6 | |
| 063 | Grazing Land | 6 | |
| 066 | Orchard | 6 | |
| 067 | Poultry | 6 | |
| 069 | Ornamentals | 6 | |
| 070 | Vacant without Features | 6 | |
| 071 | Church | 5 | |
| 072 | Private School | 3 | |
| 073 | Private Hospital | 2 | |
| 074 | Home for the Aged | 4 | |
| 075 | Orphanage | 4 | |
| 076 | Cemetery | 6 | |
| 077 | Club, Hall | 5 | |
| 078 | Convalescent Homes | 4 | |
| 080 | Vacant Government | 6 | |
| 082 | Military, Forest, Parks | 6 | |
| 083 | Public School | 2 | |
| 084 | Public College | 2 | |
| 086 | County | Depends | Utilities, Arterial =1 |
| 087 | State | Depends | Arterial = 1 |
| 088 | Federal | 6 | |
| 089 | Municipal | 1 | |
| 091 | Utility | Depends | Water/Wastewater Treatment Plants, Public Safety = 1 |
| 094 | Right of Way | Depends | Florida Department of Transportation (FDOT), Arterial = 1 |
| 095 | Submerged, lakes | 6 | |
| 096 | Sewage Disposal | 1 | |
| 099 | Other Non-Agricultural Acreage | 6 | |

The results of this analysis for the Broward County scenario (flood risk map shown in Figure 1 and critical facilities in Figure 2), Hollywood (Figure 3), and Clewiston (Figure 4) demonstrate how this protocol assists with infrastructure prioritization. In both cases, higher priority can be

given to those critical facilities that also flood, whereas flooded areas with lower priority would be adjusted accordingly. Ultimately the goal would be to protect critical infrastructure first and spend limited public funds on the lower priorities last. In addition, areas that do not flood can be removed from further consideration.

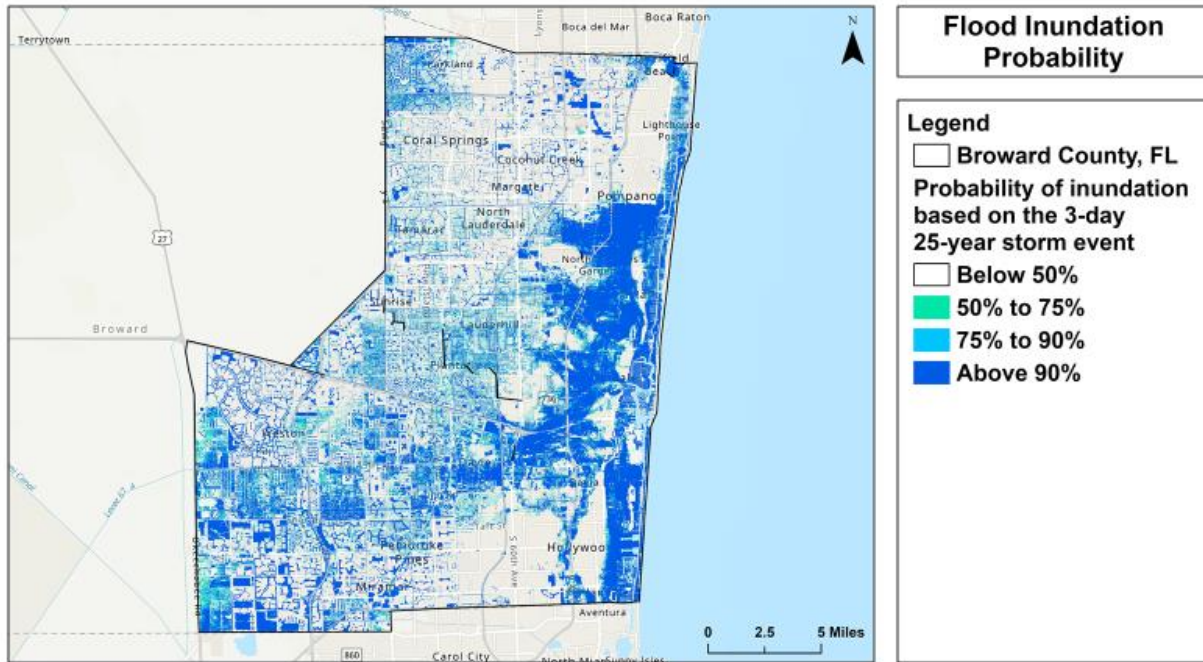


Figure 1. Broward County, FL flood risk map

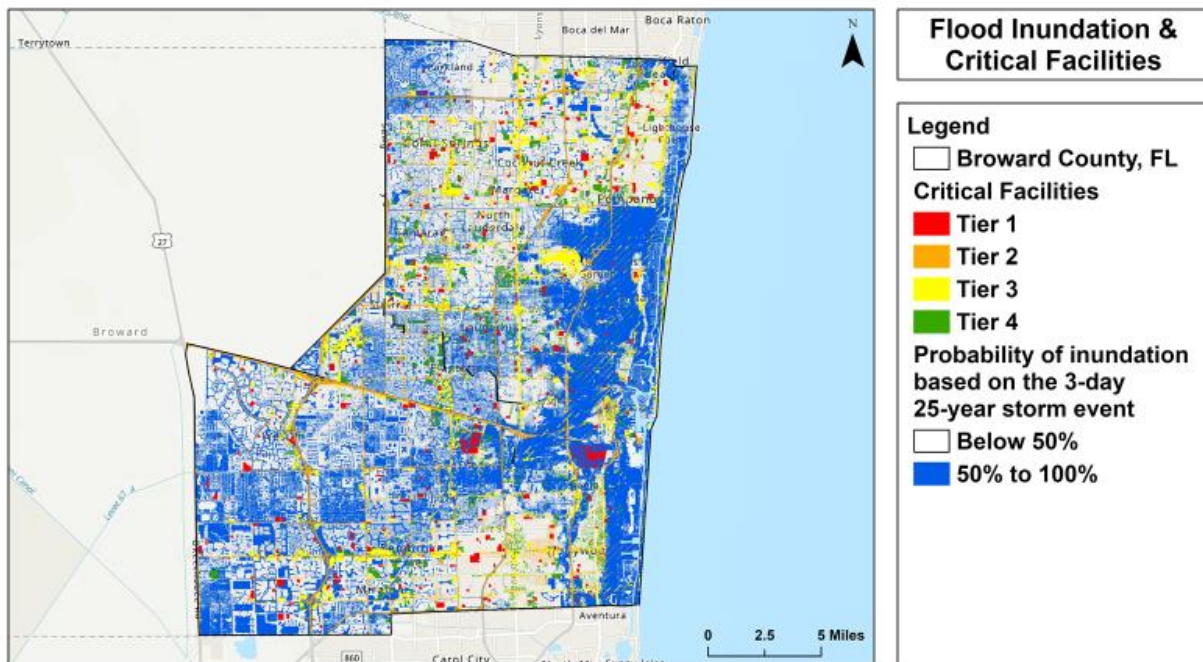


Figure 2. Broward County, FL flood risk and critical infrastructure

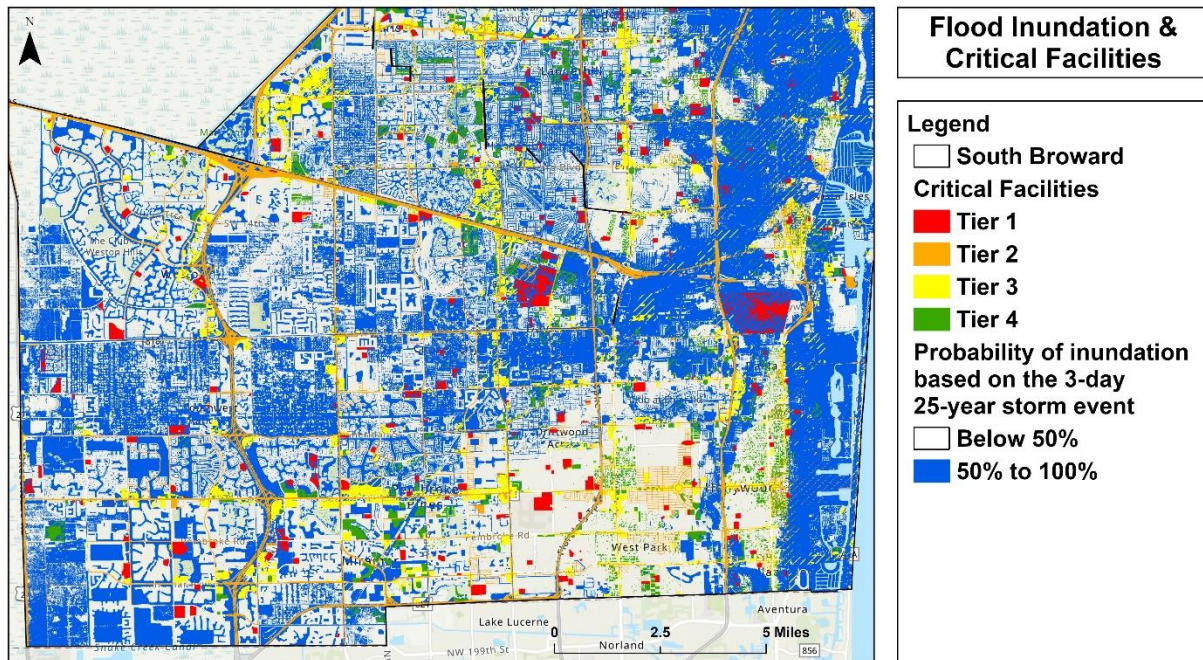


Figure 3. Hollywood, FL flood risk and critical infrastructure

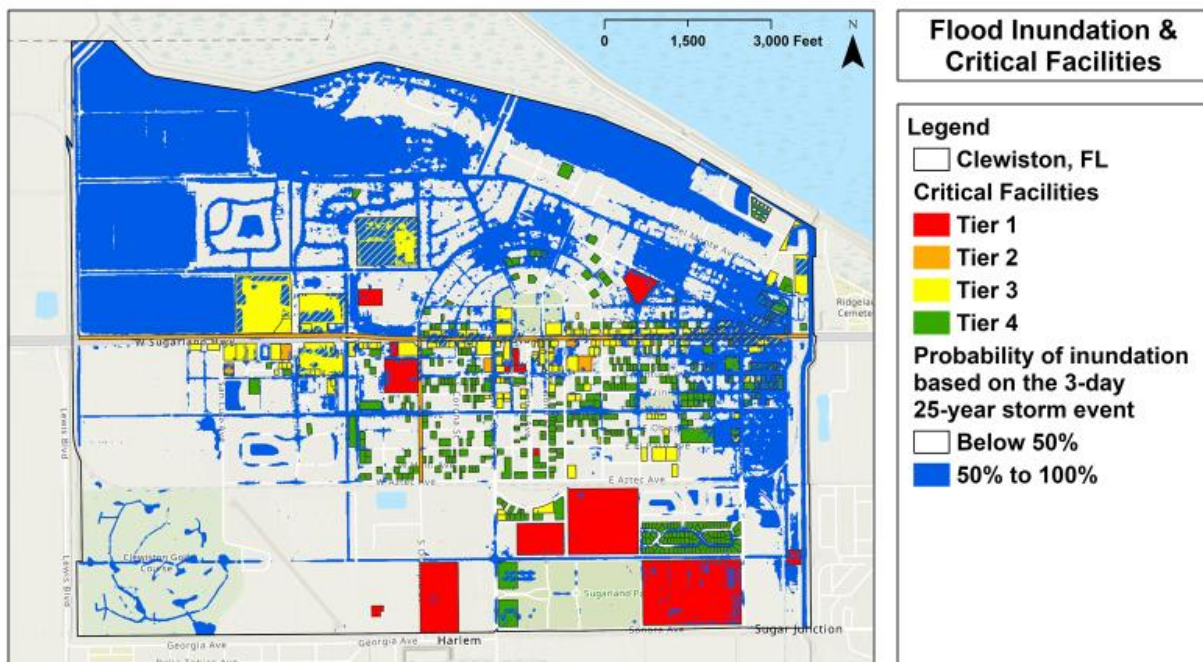


Figure 4. Clewiston, FL flood risk and critical infrastructure

To evaluate flood vulnerability at the subwatershed scale at the parcel (or local) level, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding)

based on output from the screening tool for a specified design storm. Next, attributes of that raster based on “*VALUE = 1*” query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the *SUM* of flooded values (1) within each critical parcel. The output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m²). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): “0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!”. Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the “percent-flooded” columns are calculated as follows:

- $PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100$
- $PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100$

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. An example of this analysis for the Ninemile Canal subwatershed in Clewiston, FL is shown in Table 2.

Table 2. Excerpt of the high risk critical facilities that are in DOR code priority tiers #1-4 and experience 10-percent or more flooded area during a 3-day, 25-year and 1-day, 100-year storm event for the City of Clewiston, FL

| Parcel ID | Legal Description | Priority Tier | DOR (code) | DOR Use Code Description | Facility | Total Area (acres) | Percent-Flooded (3d 25y) | Percent-Flooded (1d 100y) |
|--|--------------------------------|----------------------|-------------------|---------------------------------------|--|---------------------------|---------------------------------|----------------------------------|
| 3 34 43 15 A00 0001.0500 | CLEWISTON BEG 1134.75 FT S OF | 1 | 086 | Other counties | Floodgate | 1.496 | 40.8% | 43.2% |
| 3 34 43 01 010 0123-001.0 | CLEWISTON BLK 123 | 1 | 083 | Public schools | Clewiston Adult School and Clewiston Intermediate School | 4.754 | 19.6% | 39.3% |
| 3 34 43 01 010 0345-001.0 | CLEWISTON BLKS 343-344 + BLK 3 | 1 | 085 | Public hospitals | Hendry Regional Medical Center | 9.126 | 16.1% | 25.2% |
| 3 34 43 15 A00 0001.0300 | CLEWISTON BEG 2252.5 FT E + 10 | 1 | 083 | Public schools | Clewiston High School | 47.263 | 11.5% | 18.7% |
| 3 34 43 16 A00 0005.0100 | CLEWISTON BEG INTERSECTION OF | 2 | 023 | Financial institutions | Everglades Federal Credit Union | 0.950 | 50.2% | 61.4% |
| Roadway: 7000011, OLYMPIA STREET (Begin Post = 0, End Post = 0.485) | | 2 | N/A | Urban: minor arterial | Olympia Street | 3.847 | 30.6% | 54.8% |
| Roadway: 7030000, US-27/SR-80/SUGARLAND HWY (Begin Post = 2.147, End Post = 4.711) | | 2 | N/A | Urban: principal arterial - other | Sugarland Hwy | 19.760 | 39.2% | 49.4% |
| 3 34 43 01 010 0362-007.0 | CLEWISTON BLK 362 LOTS 13 TO 2 | 2 | 023 | Financial institutions | First Bank | 0.505 | 26.0% | 33.0% |
| 3 34 43 01 010 0155-001.0 | CLEWISTON BLK 155 | 3 | 027 | Automotive repair, service, and sales | Kelly Tractor Co. | 0.577 | 100.0% | 100.0% |
| 3 34 43 01 010 0152-001.0 | CLEWISTON BLK 152 LOTS 1 TO 3 | 4 | 012 | Mixed use, i.e., store and office | Martinez Tire | 0.215 | 100.0% | 100.0% |

Using the information provided in the sorted table, the prioritization at the parcel level can be included in the analysis. Having identified the vulnerable properties at the parcel and broader watershed levels and conducted screening modeling to determine the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

$$\text{Consequence of risk factor} = 7 - \text{DOR Code Priority Tier}$$

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, as follows:

| Percent of Parcel Flooded | Flood Risk Factor |
|---------------------------|-------------------|
| 90-100% | 6 |
| 80-89% | 5 |
| 70-79% | 4 |
| 60-69% | 3 |
| 50-59% | 2 |
| <50% | 1 |

Now we assign 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

$$\text{Flood Risk Factor} \times 25\% + \text{Consequence of Risk Factor} \times 75\% = \text{Composite Score}$$

Example:

$$1 \times 25\% + 6 \times 75\% = 4.75$$

These scores are reported in Table 3.

Table 3. Excerpt of the high-risk critical facilities that are in DOR code priority tiers #1-4 and experience 10-percent or more flooded area during a 1-day, 100-year storm event for the City of Clewiston, FL

| Parcel ID | Legal Description () | Priority Tier | DOR (code) | DOR Use Code Description (Description) | Facility (Parusedesc) | Total Area (acres) | Percent-Flooded (1d 100y) | Flood Probability Factor (25%) | Consequence of Risk Factor (75%) | Composite Score |
|--|--------------------------------|---------------|------------|--|--|--------------------|---------------------------|--------------------------------|----------------------------------|-----------------|
| 3 34 43 15 A00 0001.0500 | CLEWISTON BEG 1134.75 FT S OF | 1 | 086 | Other counties | Floodgate | 1.496 | 43.2 % | 1 | 6 | 4.75 |
| 3 34 43 01 010 0123-001.0 | CLEWISTON BLK 123 | 1 | 083 | Public schools | Clewiston Adult School and Clewiston Intermediate School | 4.754 | 39.3 % | 1 | 6 | 4.75 |
| 3 34 43 01 010 0345-001.0 | CLEWISTON BLKS 343-344 + BLK 3 | 1 | 085 | Public hospitals | Hendry Regional Medical Center | 9.126 | 25.2 % | 1 | 6 | 4.75 |
| 3 34 43 15 A00 0001.0300 | CLEWISTON BEG 2252.5 FT E + 10 | 1 | 083 | Public schools | Clewiston High School | 47.263 | 18.7 % | 1 | 6 | 4.75 |
| 3 34 43 16 A00 0005.0100 | CLEWISTON BEG INTERSECTION OF | 2 | 023 | Financial institutions | Everglades Federal Credit Union | 0.950 | 61.4 % | 3 | 5 | 4.50 |
| 3 34 43 01 010 0155-001.0 | CLEWISTON BLK 155 | 3 | 027 | Automotive repair, service, and sales | Kelly Tractor Co. | 0.577 | 100.0 % | 6 | 4 | 4.50 |
| Roadway: 7000011, OLYMPIA STREET (Begin Post = 0, End Post = 0.485) | | 2 | N/A | Urban: minor arterial | Olympia Street | 3.847 | 54.8 % | 2 | 5 | 4.25 |
| Roadway: 7030000, US-27/SR-80/SUGARLAND HWY (Begin Post = 2.147, End Post = 4.711) | | 2 | N/A | Urban: principal arterial - other | Sugarland Hwy | 19.760 | 49.4 % | 1 | 5 | 4.00 |
| 3 34 43 01 010 0362-007.0 | CLEWISTON BLK 362 LOTS 13 TO 2 | 2 | 023 | Financial institutions | First Bank | 0.505 | 33.0 % | 1 | 5 | 4.00 |
| 3 34 43 01 010 0152-001.0 | CLEWISTON BLK 152 LOTS 1 TO 3 | 4 | 012 | Mixed use, i.e., store and office | Martinez Tire | 0.215 | 100.0 % | 6 | 3 | 3.75 |

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first. Figure 5 shows the application of this methodology to Clewiston, FL.

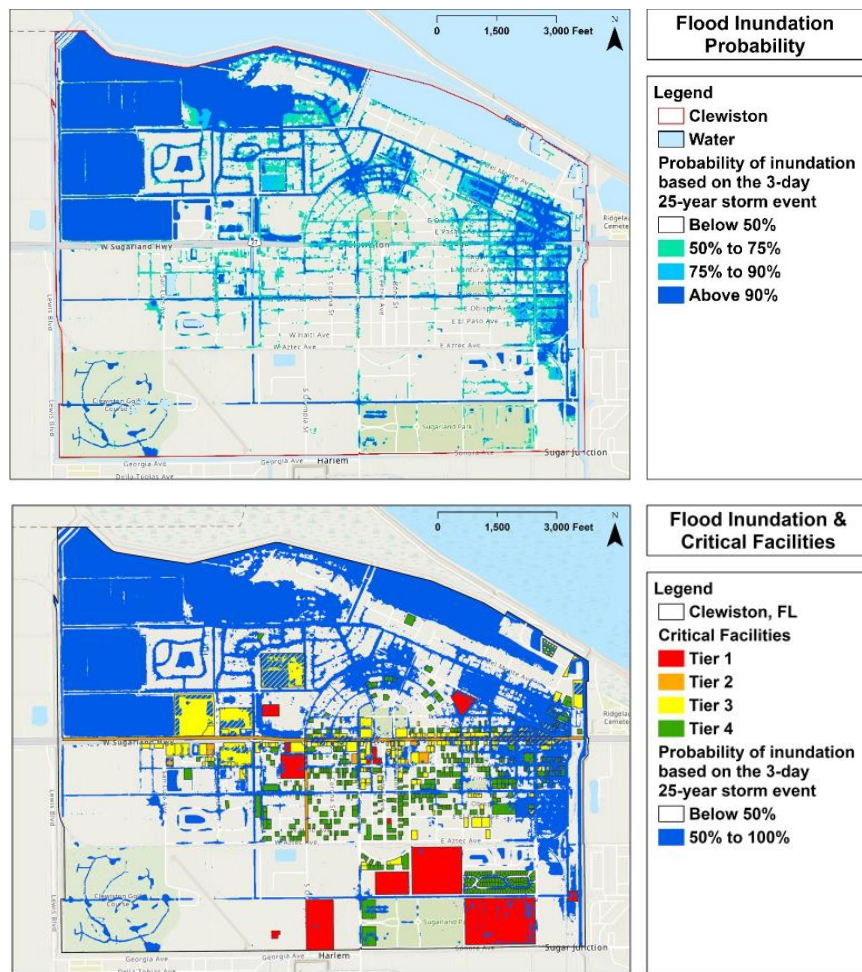


Figure 5. Clewiston flood risk (left) and critical infrastructure map (right)

After this analysis, if the conclusion of the stakeholder group is that none of the identified vulnerable areas meet the minimum threshold score, then none of the parcels will be added to the prioritized project list. If, however, some of them do meet the requirements established by the stakeholder group, then each parcel that does will qualify to be placed on the prioritized project list for capital improvement (see Section 6.4.3). Having identified the needs and critical land uses, coordination between the financial and operating policies of a utility system allows managers to properly allocate costs to those benefiting from the service, develop pricing strategies that can be clearly explained to the public, and prevent challenges to allocation methodologies. Operations, capital programs, and long-term variability of the utility system operation require financial and facility planning. Multi-year economic forecasts and financial plans are standard tools in business and are worthy of consideration by watershed and flood protection agencies. Drilling down into the community of Clewiston, FL, the eastern portion of the City is identified by the screening tool as flood-prone (refer to Figure 4).