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1. Executive Summary

In the fall of 2021, the City of Orangeburg received a Community Development Block Grant Mitigation (CDBG-MIT) from the South Carolina Office of Resilience (SCOR) to perform a stormwater drainage study. The funding for this study was provided because of three (3) presidentially declared disasters in South Carolina: Hurricane Joaquin 2015, Hurricane Matthew 2016, and Hurricane Florence 2018. Ultimately, funding became available for flood mitigation projects in qualifying low-to-moderate income (LMI) communities.

Carolina Transportation Engineers & Associates, RK&K, and Stantec (the Study Team) were selected to develop and deliver a Stormwater Drainage Study for the City of Orangeburg. The primary purpose of this study is to identify hydraulic deficiencies and provide solutions likely to withstand future disasters. The CDBG-MIT grant promotes the prudent use of public funds by identifying resilient projects in vulnerable communities. To ensure equitable distribution of funding, grant criteria demand strict adherence to the viability of selected projects demonstrated through technical analysis and close examination of socio-economic data.

The Study Team conducted a public information meeting to gather data on drainage deficiencies from the citizens in the study area. Twenty-two (22) sites were reported. The Study Team also collected flooding data from the City of Orangeburg, SCDOT and Orangeburg Emergency Management Office to gather all the information possible on the sites identified through the Public Involvement phase. A field assessment was performed on each of the 22 sites to determine if the sites should move forward in the study process. Six (6) locations were selected to advance for full analysis and consideration for funding.

For each site, both an alternatives analysis and a benefit cost analysis were performed. The percentage of LMI households and the Social Vulnerability Index (SoVI) for each site were examined. A Benefit Cost Ratio (BCR) greater than one (1) was the most important factor in qualifying projects. This factor and other socioeconomic criteria were used to rank projects for this study and qualify them to compete for funding at the state level.

City of Orangeburg Stormwater Drainage Study

2. Introduction

(a) In the fall of 2021, the City of Orangeburg received a CDBG-MIT grant from the South Carolina Office of Resilience (SCOR) to perform a stormwater drainage study. The funding for this study was provided because of three (3) presidentially declared disasters in the state of South Carolina (Hurricane Joaquin 2015, Hurricane Matthew 2016, and Hurricane Florence 2018). These storms qualified millions of dollars of funding for flood mitigation projects in qualifying low-to-moderate income (LMI) communities.

The City of Orangeburg is the county seat of Orangeburg County. The county is the 4th largest county (by area) in South Carolina. It is labeled a persistent poverty area with some of the highest LMI census tracts located in the city of Orangeburg. According to the 2022 U.S. Census Bureau data, the population of Orangeburg is 12,482 people. The racial makeup is reported as 70.8% African American, 26.5% White, and 0.6% Hispanic. Compared to the State population percentages, South Carolina's overall population is 26.7% African American, 68.6% White, and 6.4% Hispanic, which is depicted in Table 1 below. The median household income in the city is $28,597, with 32.1% of the population living below the poverty level. The median income for the state was $58,234, while only 14.6% of South Carolinians lived in poverty.

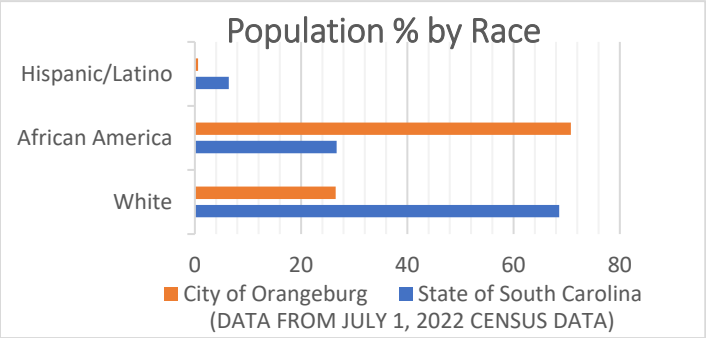

Table 1. Orangeburg County Population vs State of SC

Considering the socio-economic data and the history of Orangeburg, this city is a prototypical candidate for assistance from the Department of Housing and Urban Development (HUD). The CDBG-MIT Program provides a unique opportunity for disadvantaged communities as they are more susceptible to impact from natural disasters. The grant also places emphasis on decreasing the risk of damage due to future disasters in qualifying areas.

The City of Orangeburg lies in a transitional geographic area of the state. The study area is located at the eastern end of the Inner Coastal Plain as it transitions to the Outer Coastal Plain as noted in

Figure 1 below. The terrain in the northern portion of the city rolls and efficiently deposits runoff into numerous streams and tributaries. The highest elevations in the city are approximately 330 feet above sea level along Saint Matthews Road in northern Orangeburg. This area is urbanized and well-developed with schools and commercial areas supporting the surrounding communities.

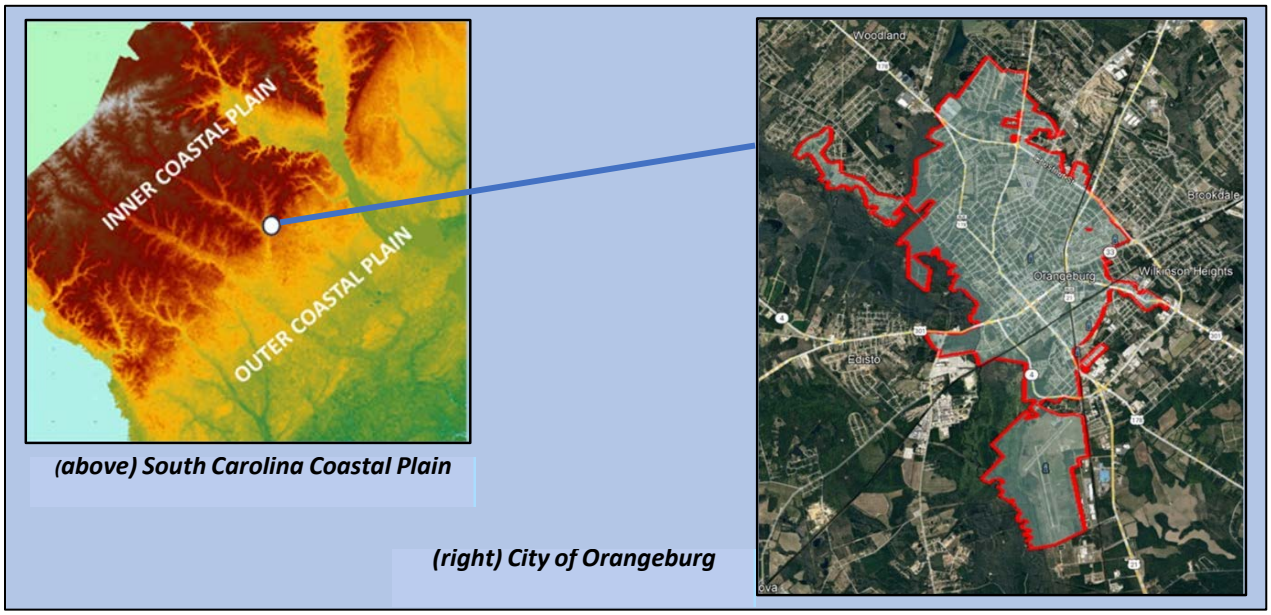

Figure 1. Coastal Plains to City of Orangeburg

At the heart of the city, US 601 Magnolia Street bisects the City of Orangeburg (north to south) and crests near the intersections of Russell Street and John C. Calhoun Boulevard with elevations between 250 -240 feet. The terrain flattens as the region transitions from the Inner Coastal to the Outer Coastal Plain. This region is characterized by a much flatter topography with significantly fewer elevation changes. The southern portion of the study area is populated with more commercial and industrial facilities. Communities consisting of smaller older homes still exist around these businesses. These mill villages housed employees of the textile and agricultural plants in the early and mid-1900s. The county fairgrounds (elevation 200 feet) and the airport are in the southern part of the city with an increased number of older, low-income communities. The flatter terrain and the transition in socioeconomic makeup combine to present a zone primed for possible drainage improvements.

(b) Historical of Flooding

Historically, the City of Orangeburg has been subject to flooding during long periods of heavy rains, but more frequent and intense bursts of storms have also produced flooding in these areas. Flooding consistently occurs in the study area's eastern, western, and southern quadrants. These zones carry runoff from the highest points in the city, located in the most northern portions of Orangeburg. The following description is depicted in Figure 2. The study area has three (3) primary discharge outlets for its runoff: North Edisto River, Cow Castle Creek, and Middle Pen Branch. The North Edisto River flows south through western Orangeburg, collecting water from the Caw Caw Swamp, Hess Branch, and Sunnyside Canal. The Edisto River is the longest free-flowing blackwater river in North America. Heavy sustained rains in the study area create flooding from the confluence of the Caw Caw Swamp south to Glover Street. This backup, in turn, causes tributaries to flood the heart of the city. The affected areas are primarily residential, impacting parks, businesses, and other public facilities.

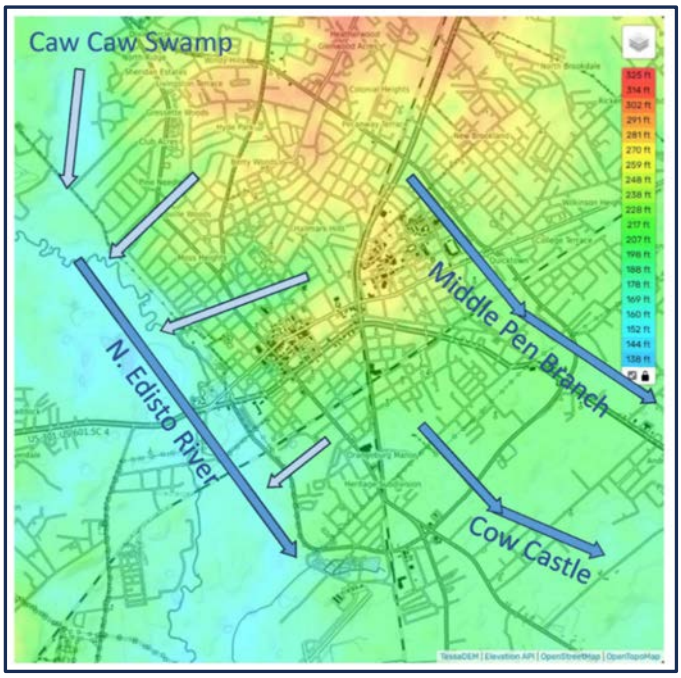

Figure 2. Major Drainage Outlets

The lower-mid section of the study area eventually drains south into Cow Castle Creek. Water from this portion of the study causes frequent flooding as the terrain is considerably flatter. Runoff south of US 301 from Broughton Street to Whitaker Parkway flows south into Cow Castle Creek. This area is notably flatter, with significantly less capacity to adequately accommodate runoff.

Finally, the eastern portion of the study area drains through Middle Pen Branch. This tributary extends from Hillcrest Golf Course south, crossing Magnolia Street, running along Chestnut Street, and parallel to Whitaker Parkway before exiting the study area in an easterly direction just north of US 301. Water joins this basin from east of Boulevard Street and south of Saint Matthews Road. Eventually, Middle Pen Branch becomes Middle Pen Swamp after leaving the boundaries of the study area.

Figure 3. Edisto Memorial Gardens flooding and normal conditions

During the Historic floods of 2015, 2016, and 2018, low-lying areas of the city were inundated by flooding. Hurricane Joaquin, in 2015, caused the most extensive damage, dumping more than 10 inches of rain to the City of Orangeburg in a 48-hour period. Other parts of the county saw more than 16 inches in the same period. The North Edisto River flooded into Edisto Gardens and Spray Park, a popular recreational area adjacent to communities along the river's banks **(Figure 3)**.

Low-lying areas at the intersection of Glover Street and Stonewall Jackson Boulevard also overtopped the roadway, impeding traffic and closing area businesses. **Figure 4** shows flooding and normal conditions. Several areas south of the city were also impacted as the river basins could not contain unprecedented runoff from the 1,000-year storms. US 21 bypass, Joe Jeffords Highway experienced water overtopping the road in several locations. This section of the bypass is just outside the southern limits of the study area. It conveys runoff from the central portion of the study area with very little elevation change. Frequent reports of flooding also occurred along sections of US 301, John C. Calhoun Boulevard.

Figure 4. Stonewall Jackson Blvd flooding and during normal conditions

A Kids in Motion Learning Center, located near the intersection of Russell and US 21 Bypass also flooded due to proximity to Middle Pen Branch (**Figure 5**). Flooding across the study area caused numerous road closures and rerouting of traffic for emergency services, restricting access to distressed communities in the central and southern part of the study area.

Figure 5. A Kids in Motion Learning Center flooding and during normal conditions

Currently, the oldest sections of the City of Orangeburg's drainage system are not able to handle the area's drainage needs beyond a 10-year storm event. A large portion of the city's drainage infrastructure was designed and installed more than 50 years ago. Inspections across the study area reveal undersized and outdated catch basins connected with terracotta pipe. When located and found in a state of disrepair, these materials require total replacement. In recent years, the intensity of storms has greatly increased requiring additional capacity for the drainage system to accommodate sudden downpours.

The location of Orangeburg also plays a factor in the deficiencies of the drainage infrastructure as sudden changes in elevation cause the system to flood low-lying areas in the southern portion of the study area. **Figure 6** shows Sunnyside Canal at Riverside Drive in normal and catastrophic flood conditions. The water level was 8 to 9 feet above normal conditions during the flood of 2015. Homes were inundated by flooding as the canal overflowed by nearly 3 feet. Though Sunnyside Canal is one (1) of the most critical drainage assets in the study area, the system does not have the capacity to accommodate runoff produced by this 1,000-year storm.

Figure 6. Sunnyside Canal during 2015 flood (left) and during normal conditions (right)

3. Review of Planning Parameters

(a) Social Vulnerability Index (SoVI) uses 16 Census variables to identify communities that are vulnerable to the effects of natural disasters. Social Vulnerability is an adverse impact on a community caused by external stresses. Natural disasters, disease outbreaks or man-made catastrophes all qualify as stress that cause an increase in an area's social vulnerability. Social Vulnerability is measured in an overall score but is comprised of several components: Socio-economic status, Household Characteristics, Racial and Ethnic Minority Status and Housing Type/Transportation. The index is measured on a scale of 0 to 1, with 1 being the highest reading of vulnerability. The data for Orangeburg County shows higher SVI readings in more densely populated areas of the county (**Figure 7**). This theme is consistent nationwide, as rural areas generally yield slightly higher values due to sparse population distribution. Variations in household makeup, race, and public resources are also major factors in determining social vulnerability.

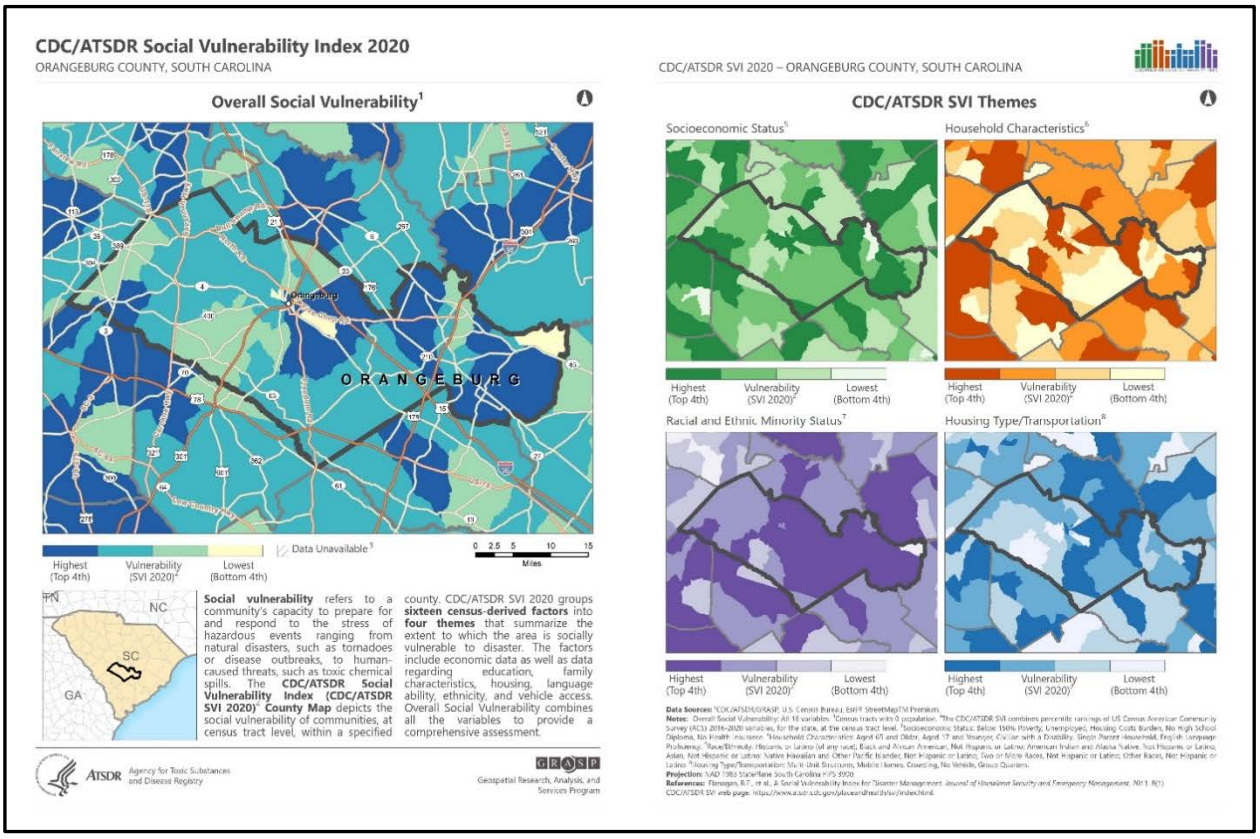

Figure 7. ASTDR Social Vulnerability for Orangeburg County

(b) Low to Moderate Income (LMI) is a variable used by HUD to characterize the income level of communities. Low income is defined as households earning less than 50% of the area median income while moderate income households have an income between 50 - 80% of the area median income. Combining these categories creates a unique opportunity to view the income distribution of an area and highlight zones that are at risk due to financial limitations. **Figure 8** illustrates the LMI areas in and around the study area. The LMI percent for the City of Orangeburg is 48.1%, with most of the city in moderate to high areas of vulnerability. It is noticeable that areas in the central and southern portions of the study area show consistently moderate to high levels of income.

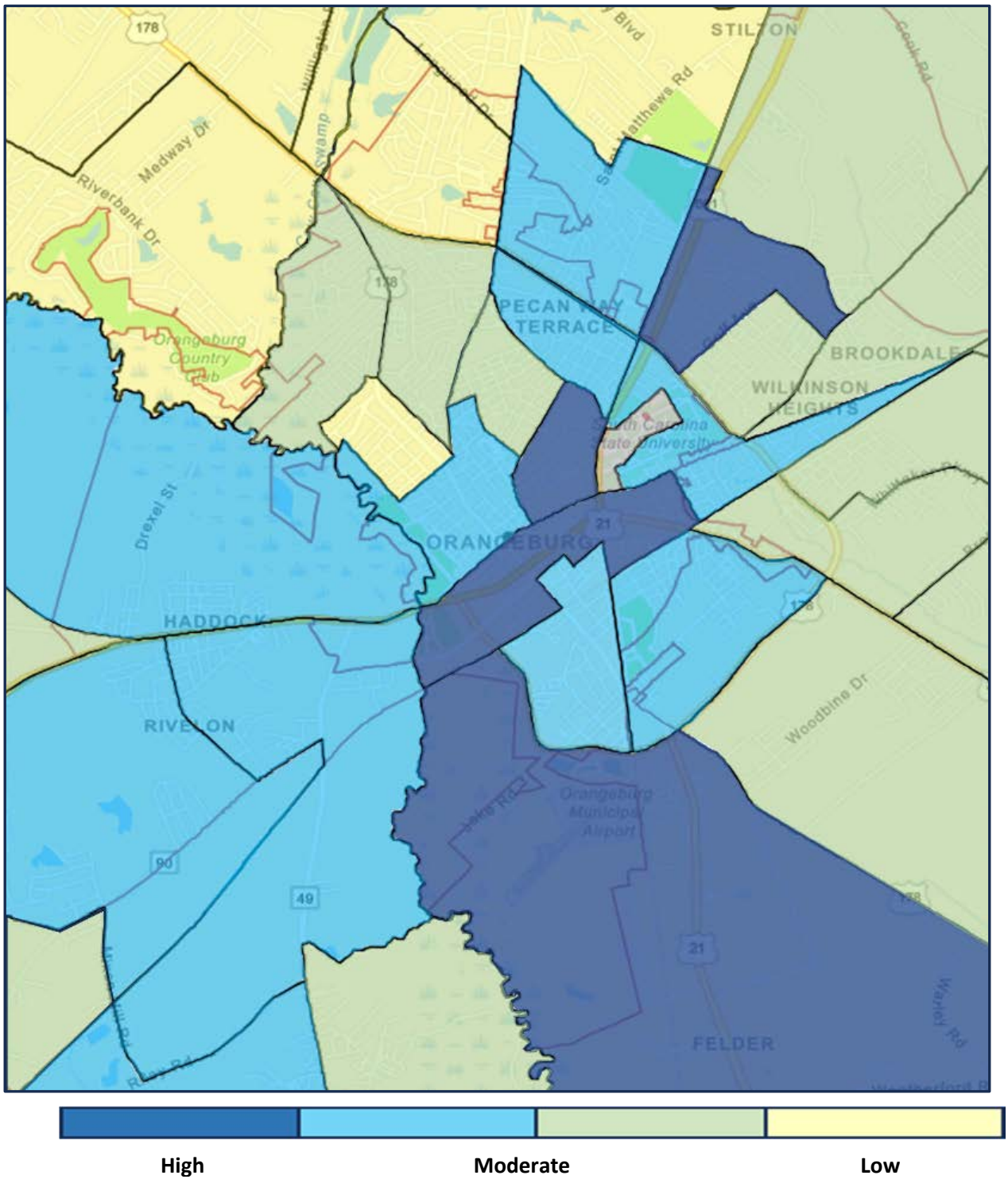

Figure 8. Ranges of Low to Moderate Income Households for Orangeburg County

(c) The **Community Development Block Grant Mitigation (CDBG-MIT) Program** is a grant program provided by U. S. Department of Housing and Urban Development (HUD). The program

targets vulnerable communities in low to moderate income areas to mitigate the risk of future natural disasters. This program awards funding to communities that can demonstrate recent impact by natural disasters. CDBG-MIT grants assist these areas to implement feasible improvements to infrastructure to mitigate risks and reduce the impact of future disasters.

Using social vulnerability and low to moderate income as factors in the ranking and selection of projects, ensures that funding will be allocated to communities with an urgent need and a qualified population. The CDBG-MIT grant also specifies a benefit cost ratio > 1. This is determined using the Federal Emergency Management Agency (FEMA) Benefit Cost Analysis (BCA) Toolkit. This tool provides a concise platform for calculating the direct benefits of a project in comparison to the estimated cost of construction. Projects are considered viable if the benefits are greater than the costs. The higher the benefit costs ratio, the more practical the project.

(d) A **ranking system** was created to fairly incorporate required criteria, considering the significance of each variable to the requirements of the grant. The projects selected for analysis were all analyzed and ranked using the following criteria: Benefit Cost Ratio (BCR), Low-to-Moderate income (LMI) percentage, Social Vulnerability Index (SoVI), and Local Significance. These parameters, as listed in Table 2, were selected to satisfy the CDBG-MIT grant requirements. Table 3 presents the points given to each BCR quartile, and Table 4 presents the points given to both the LMI and SoVI categories.

Ranking Criteria	Percent of Total	Points
Benefit Costs Ration (BCR)	40%	0 – 20
Low to Moderate Income % (LMI)	30%	0 - 15
Social Vulnerability Index (SoVI)	20%	0 - 10
Local Significance	10%	0 – 5
Total	**100%**	**50**

Table 2. Ranking Criteria and scoring for BCR, LMI% and SoVI

Benefit Cost Ratio Quartile	Points
0-25%	0
25-50%	7
50-75%	13
75-100%	20

Table 3. Points assigned to each Benefit Cost Ratio Quartile

LMI %	Points
0%-25%	0
25%-30%	1
30%- 35%	2
35%- 40%	3
40% - 45%	4
45%-50%	5
50%-55%	6
55%-60%	7
60%- 65%	8
65%-70%	9
70%-75%	10
75%-80%	11
80%-85%	12
85%-90%	13
90%-95%	14
95%-100%	15

Overall SoVI	Points
0- 0.2	1
0.2 - 0.4	3
0.4 -0.5	5
0.5 -0.6	6
0.6 - 0.7	7
0.7 - 0.8	8
0.8 - 0.9	9
0.9 - 1.0	10

Table 4. Points assigned to each range of LMI %s and Social Vulnerability Index

4. Agency Coordination

Attempting to find studies and published documentation proved challenging. Only three (3) documents were located after contacting the U.S. Army Corp of Engineers, the S.C. Department of Natural Resources, the S.C. Department of Health and Environmental Control, the S.C. Department of Parks Recreation and Tourism, and the S.C. Department of Agriculture. The Orangeburg County Conservation Commission District provided a **Watershed Management Plan for Caw Caw Swamp** published with the City of Orangeburg Department of Public Works and Friends of the Edisto. A **FEMA Flood Plain Analysis** was found for the Sunnyside Canal and used for the Study Team's analysis of Adden Street.

The Study Team also found a **Watershed Water Quality Assessment for the Edisto River Basin**. The Department of Health and Environmental Control completed the study in 2012 as a comprehensive assessment of the county's major watersheds. The assessment provided information about the Caw Caw Swamp and the North Edisto River Basin that was useful to the Study Team to identify the primary watersheds for the study area. The published information collected by the Study Team is compiled and located in the appendix of this document for reference.

Figure 9. City of Orangeburg Public Works Department cleaning Sunnyside Canal

While performing the initial assessment of the reported sites, the City of Orangeburg Department of Public Works was observed cutting trees and removing debris from the Sunnyside Canal (**Figure 9**). This paved drainage ditch is over 3,400 feet long and carries water from the heart of Orangeburg to the North Edisto River, located on the City's west side. This infrastructure is one (1) of the most important drainage assets in the study area.

With minimal published information available, the Study Team reached out to the City of Orangeburg Department of Public Works and the S.C. Department of Transportation (SCDOT) for a deeper historical understanding of the drainage issues within the study area. The Study Team hosted a meeting with both entities to discuss their experiences with flooding within the City limits. Staff from both entities were accommodating, citing areas with high incidences of flooding. Though the City did not have a mature inventory of its system, a map was shared by staff that appeared to be more than 30 years old (**Figure 10**). The map served as a handwritten inventory of the culvert pipes, catch basins, and drainage structures across the city. It provided details on the flow of streams, creeks, and tributaries across the City of Orangeburg. The Study Team suggests verifying the assets on the map and developing a digital record of the city's drainage assets. Once completed, the inventory should be updated annually. The inspection and maintenance of these physical assets should be performed

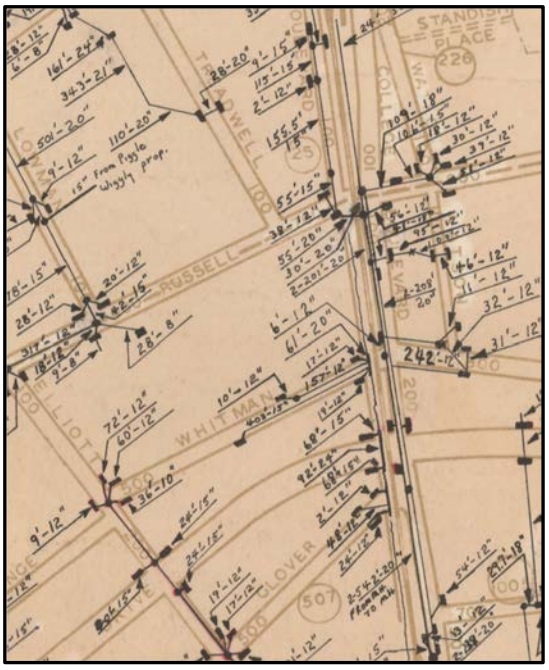

Figure 10. Inventory of Drainage Assets

periodically, allowing the city to quickly respond to drainage deficiencies, prioritize, and plan for improvements.

The City of Orangeburg Public Works and SCDOT generated work requests and completed work orders for responses to flooding and hazardous conditions dating back to 2015. The Study Team verified flooding documented by these reports with information gathered from citizens present at the public information meeting. Both entities are advised to review the use of Asset Management Systems to create inventories of their drainage assets to routinely assess conditions and proactively schedule maintenance of drainage infrastructure.

5. Comprehensive List of the Project Considered

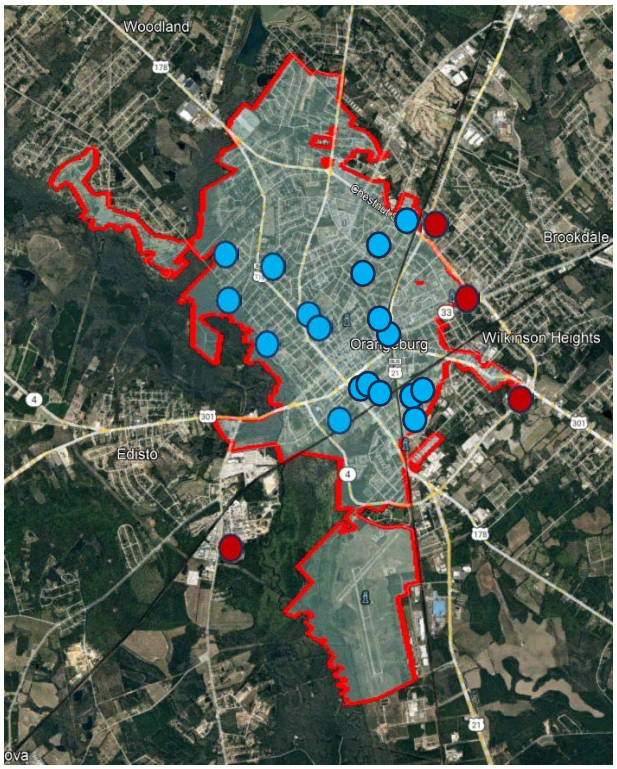

Fig 11. Location of Considered Projects

A total of 22 locations were reported during the public information meeting and comment period for this study. **Figure 11** illustrates a balanced geographic distribution of the sites across the study area. Though some of the sites were outside the study boundary, the Study Team investigated the reports and provided a list of recommendations for possible improvements.

A comprehensive list of the considered projects is included in Table 4 and illustrated on the accompanying map. Locations outside of the study area are noted in red.

Projects Considered					
1	2363 Russell St	**9**	1219 Luke St	**17**	491, 516 Bayne St
	(2376, 2369, 2371)	**10**	1313 Riverbank Dr	**18**	Boulevard @ RR Corner
2	1149 Glover St	**11**	1225 Moss St	**19**	Magnolia St
3	1137 Glover St	**12**	886 Adden St	**20**	John C. Calhoun Blvd
4	1041 Ellis Avenue	**13**	610 Adden St	**21**	County Fairgrounds
5	1710 Amelia St	**14**	902 Ellis Ave	**22**	210 Dukes St
6	139 Poplar St	**15**	358 Bayne St		(Site Out of Study Area)
8	1075 Sprinkle Ave	**16**	690 Riggs St		

Table 4. Comprehensive List of Projects Considered

a. Parameters for Selection

To ensure adherence with the required parameters of the CDBG-MIT grant, a thorough process for the initial assessment was created to perform field inspections. Locations received from public comments and the City of Orangeburg staff were compiled and investigated using the assessment form created by the Study Team. The assessment was completed in two (2) steps. **Step 1** was an objective field evaluation of the reported sites. No initial consideration was given to the planning parameters identified for the study area.

b. Definition of Screening Criteria

The locations were evaluated to document the Study Team's assessment of reported deficiencies. This provided a balanced geographic representation of problem areas that would be included in the study for future use by City Officials beyond the assistance provided by this study. The following criteria were used at each location to standardize the review process and provide a baseline for the consistent and objective evaluation of all reported sites. (Step 2 criteria are denoted in blue.)

- **Project Within Study Limits** – limits established to determine the boundaries of the study area and if projects would qualify for funding if selected. Some locations were reviewed outside the study area for inclusion in the summary of the study.
- **Maintenance Issue** – SCOR specified that CDBG-MIT funds could not be used to address maintenance issues. Sites meeting this criterion were reviewed, noted, and referred to public entities for repair.

- **Social Vulnerability Index (SoVI)** – summary of a community's susceptibility to manmade or natural disasters. Rating is provided by the Centers for Disease Control and Prevention (CDC) and calculated from the Census to determine the overall SoVI index number.
- **Low to Moderate Income** – an individual or household with an annual income between 50% and 80% of the area median income.
- **Flood Plain** – an area of land adjacent to a river subject to flooding during periods of high discharge. Sites located in flood plains generally produce lower BCR values, increased opportunities for buyouts, and lower potential for success against future disasters.
- **Property Owned by a Public Entity** – this criterion was used to gather additional information on assets (plans, date of installation, history of failure, etc.) and determine responsibility for current and future maintenance if deficiencies were identified.
- **Property Required** – an initial assessment of the need to acquire additional property for green projects, detention, or mitigation as a part of the proposed project.
- **Comments** – summary of the Study Team's initial field assessment of sites. This information was used as the primary assessment of sites by confirming the deficiencies, evaluating the need for improvements, or assigning sites to responsible entities for repair. Comments were discussed with the full team (SCOR, City Officials, and the Study Team) to determine if further investigation through the study was recommended.

After an independent review of all the sites was completed, Step 2 commenced. Planning parameters for the study area were determined for each location selected to advance in the study. Social vulnerability and Low-to-Moderate Income (LMI) percentages were added to the initial assessment before review by the full committee. These criteria would be used later in the study as factors in the ranking process to demonstrate the community's needs in specific subsections of the study area. Examination of each site's socio-economic factors was purposefully performed independent of the field analysis for two (2) reasons. First, it guaranteed that each site would receive a fair evaluation and the resulting study would represent a comprehensive evaluation of drainage issues across the study area. Secondly, it ensured the requirements of the CDBG-MIT grant were objectively included in the study's assessment, allowing the ranking system to prioritize the projects.

The CDBG-MIT grant had very specific parameters. Drainage issues resulting from a lack of maintenance were exclusively prohibited. Projects with a benefit cost ratio of less than one (1) were also ineligible to compete for funding. Many locations reviewed in this study were determined to be maintenance issues. The Study Team summarized the problems and forwarded them to the SCDOT and the City of Orangeburg as owners of most drainage assets in the study area. Most sites were located on or adjacent to SCDOT right-of-way and the City was also referred locations that required action. These sites were noted and forwarded to be addressed as maintenance or utility issues by respective owners.

City of Orangeburg — **INITIAL SITE ASSESSMENTS** — *Last Revision date* 5/18/2022

Site	LOCATION	Within City Limit	Maintenance Issue	SVI Score	LMI %	LMI Area	Flood Plain	Owned by Public Entity	Flooding Frequency	Property Required	Preliminary Estimate	COMMENTS
1	2363, 2369, 2371 Russell St	N	Y	0.3857	81.97	Y	Y	SCDOT, SC State University	heavy rain	N	_	Site is located at the convergence of a tributary and large drainage basin. Noteable amounts of debris and fallen trees currently restrict the flow of the 2 streams. Rountine maintenance of these areas would greatly reduce the incidents of flooding at this location. The team does not recommend funding a project at this location. Proper maintenance by SC State, property owners and SCDOT would keep the waterway free of debris allowing the water to flow efficiently through the box culvert on Russell St. and further down the channel. There are beavers present in the area, contributing to the problem.
2	1137 Glover St	Y	N	0.9448	63.81	Y	N	SCDOT	heavy rain	Y	$800,000.00	This site receives water from 4 directions. The majority of the water is runoff from US 301 and South St that ponds behind abandoned properties and flows through the properties at 1137 and 1149 Glover St into the roadway. Catch basins are located at the corner of Glover an Broughton but none are located on the block of Glover between Broughton and S-211. Permissions to construct yard drains required, possible purchase of abandoned property, installation of new catch basins and pipe to connect to the system on Broughton St.
3	1149 Glover St	Y	N	0.9448	63.81	Y	N	SCDOT	heavy rain	_	_	Same as above, adjacent to 1137 Glover.
4	1041 Ellis Avenue	Y	N	0.4555	43.65	N	N	partially, SCDOT	constant	Y access & construction	$1,200,000	This site has standing water that cannot drain as a result of a failed system installed by a developer. There does not appear to be any easements or an established HOA to assume responsibility for this failed system. Team proposes to construct a natural drainage basin in back on the effected properties that drains into a box on Spring St. New concrete pipe would have to be placed along Spring St to Ellis to connect to an existng system that runs for 2 blocks and down to a natural outfall. Property permissions and easements required to construct this project.
5	1410 Amelia St	Y	N	0.8321	38.1	N	N	Methodist Church, SCDOT	heavy rain	N	$50,000	The drainage problem at this location could be reapired with the installation of a berm at the edge of the pavement at the back edge of church's parking lot. Whether earthen, asphsalt or concrete the water would be redirected to run to Amelia street and into the natural outfall system.
6	139 Poplar St	N	Y	0.7531	50.95	Y	N	SCDOT	heavy rain	N	$30,000	This complaint appears to be a maintenance issue. The creek is over grown with trees and debris and would greatly benefit from clearing and scheduled, routine maintenance.
7	358 Bayne St	Y	Y	0.8321	83.9	Y	N	SCDOT	heavy rain	Y	$600,000	This site was located near the Fairgrounds. Owner states that a terracotta pipe that carries water from the drainage box in front of his house was broken. SCDOT refused to repair the pipe as it was not covered in their records by RW or an easement. Site review suggests that this water drains south through a closed system under Whaley St to an outfall on the fairgrounds.
8	1075 Sprinkle Ave	N	Y	0.6963	83.9	Y	Y	SCDOT	heavy rain	N		House is located in a low lying area suceptible to flooding. A ditch is located next to the house but does not appear to be routinely maintained. Water from US 301 could contribute to this problem as water is known to pond on John C Calhoun during heavy rains.
9	1219 Luke Street	N	N	68.57	68.57	Y	Y	private property	heavy rain	nN		Resident complained of ground water entering her septic tank. Home is located on the low end of Luke St. Runoff from Cannon Bridge Rd sheet flows down hill in an easterly direction until reaching the N. Edisto drainage basin. Property would have to graded by the owner to reroute the natural flow of surface water to resolve this issue.
10	1313 Riverbanks Dr.	Y	N	0.0583	18.54	N	Y	private property	heavy rain	Y	$750,000	This property is located directly adjacent to the N. Edisto River and a major tributary that drains the northern portion of the city. No efficient way to control flooding at this location as USACE would immediately be involved on the fix. Buyout recommended but will not produce a BCA that would advance the project.
11	1225 Moss St	Y	N	0.0583	27.75	N	N	SCDOT	heavy rain	N		The back of this 2 story property sits much lower than the roadway. Valley gutters are located on Keitt Street which directs runoff away from the high side of the property and its driveway. Property owner is advised to upgrade gutters and existing drainage system to collect runoff and discharge it at the lowest corner of the lot.
12	886 Adden St.	Y	N	0.8321	58.64	Y	Y	SCDOT	heavy rain	N	$1 million	The rear of this property is adjacent to the Sunnyside Canal but holds water in the backyard. The property retains water because the valley gutter is paved higher than the sidewalk. Water is trapped in the driveway with no positive drainage. Team recommends adding boxes and regrading the valley gutter on Adden St. to create positive drainage and additional relief points for system at the low point of the roadway to improve drainage for the entire block.
13	610 Rutledge Ave	Y	N	0.0583	18.54	N	N	private property	heavy rain	N		The house at this property sits lower than the road. The property takes on water from Rutledge and S-1621, Biltmore St. To repair this problem, the owner should grade the yard to direct water around the house to the back yard which is the lowest point of the property.
14	902 Ellis St	Y	N	0.4555	43.65	N	N	private property		N		Inspection provided no evidence of serious drainage issues. Yard was well maintained and graded to promote postive drainage for the lot. Gutters could be used to direct water away from low areas on the property.
15	491 Bayne St	Y	N	0.6963	83.9	N	N	private property, SCDOT	heavy rain	Yes, access, easement		Site had a drainage pipe under Tucker St that empties behind this house. It appears that the water overflows across the back of the properties to a catch basin on Baynes St. A ditch relieves the system across the church property on the opposite side of Bayne St to Whaley St across to a ditch.
16	690 Riggs St	Y	Y	0.9448	63.81	N	N	SCDOT	heavy rain	N	NA	***Forward Work Request to SCDOT to cut a swell to relieve flooding at the end of Riggs St near sewer manhole. Water will drain directly into the ditch adjacent to the property.***
17	516 Baynes St	Y	Y	0.6963	83.9	N	N	private property	heavy rain	N	NA	This property is a well graded residential lot. It appears to collect runoff from the roof of the metal building at the back of the property. Water could be piped from the gutters on the mill to resolve this issue.
18	Railroad Corner	Y	N	0.8321	38.1	N	N	SCDOT, City of Orangeburg	heavy rain	N	$ 1.5 million	Improving this site would require installation of new 18' RCP on Boulevard construction of new drainage boxes and sidewalk along Boulevard St. The system would need to be examined to determine the correct path of for outfall and verify capacity if tied to an existng system. Project would greatly reduce surface runoff for the areas adjacent properties. Utility and railroad coordination required.
19	Magnolia St	Y	N	0.7531	50.95	Y	N	SCDOT	intense rain	N	$2.5 Million	Flooding occurs under the railroad bridge north of the intersection of Chestnut and Magnolia St. A floodzone is located just to the south of the intersection of Magnolia and Chestnut Street. Intense storms could produce flash flooding that ponds water at this intersection and under the railroad overpass for short periods of time. Maintenance of downstream locations could assist in alleviating this problem. Possible improvements would be raising the road under the rail bridge and increasing the number and location of catch basins. Required railroad coordination would not produce an acceptable BCR for recommended improvements.
20	John C. Calhoun	Y	Y	0.9026	63.81, 83.9	Y	Y	SCDOT	very heavy rain	N	_	1. Flood zone is located from Bleakley St to Plywood St and possibly down to Sprinkle Ave, *Public Works staff states that the improvements to commercial property on US 301 across from Sprinkle has increased run off and frequency of flooding.* 2 is located at the Firestone on Middleton St. Water ponds here as water runs downs from both directions to boxes located on either side of John C Calhoun. *This system needs to be checked for capacity* . 3. flood zone is located from Stonewall Jackson to Xpress Travel Center just past Cannon Bridge Rd. *SCDOT is preparing to let a bridge replacement and intersection improvement over the N. Edisto River that should improve drainage in this area.*
21	Fairgrounds	Y	Y	0.6963	83.9	Y	N	DPU/SCDOT	very heavy rain	N	_	SCDOT states that water from the Fairgrounds goes under Magnolia St to the railroad ditches. There is a pole that DPU installed at the fairgrounds that goes through a pipe in this system. Entities should work together to repair this and re-evaluate the system.
22	210 -Dukes St	Y	Y	0.9448	57.75	Y	Y	SCDOT	heavy rain	N	_	This warehouse floods during heavy rains and has lost large amounts of inventory due to flooding. The property does not have positive drainage to the roadway drainage system. SCDOT and Public Works Staff states that a drainage pipe on ***Railroad RW*** contributes to the flooding at this location. SCDOT upgraded the drainage system on Dukes St to provide relief from flooding to previous owners of the property 20-25 years ago. Initial inspection did not show deficiencies in the existing roadway drainage system.

6. Probability of Success Against Future Disasters.

One (1) of the primary purposes of this study is to identify hydraulic deficiencies and provide solutions likely to withstand future disasters. After analyzing six (6) sites across the study area, each location presented a slight variance in probabilities of resilience. The primary factors in each assessment were the site's location, adjacent terrain, proximity to flood plains, and susceptibility to damage in future disasters. Proposed site improvements were designed to exceed SCDOT standards for 10-year events, meeting the capacity requirements for 25-year storms. In the case of a future disaster, a 500-to-1,000-year event, all the recommended designs show a minimum 50% probability of success. The largest contributing factors were the terrain and proximity to flood plains.

Table 5 ranks the study sites by probability against future disasters. The two (2) highest-ranking sites (Railroad Corner and Ellis Avenue) experience drainage issues that directly result from failed drainage systems. As a result, water ponds cause flooding during normal and moderate rainfall events. Neither site is located in a flood plain, and implementing the proposed repairs will promote positive drainage away from the sites in normal to heavy rain events. During a 500- or 1,000-year event, the chance of flooding will increase due to the event's intensity, but the proposed infrastructure would likely endure and remain functional.

The following two (2) sites (Amelia Street and Glover Street) have challenges with terrain and inadequate infrastructure. The drainage issues on Amelia Street result from excessive runoff across a paved parking lot. The large impervious area has no drop inlets or berms to channel runoff toward the closed system on Amelia Street. The result is a large amount of runoff during heavy storms that inundate two (2) homes below the church parking lot. Glover Street is located two (2) blocks south of John C. Calhoun Boulevard, which laterally bisects the city. The location of the complaint is significantly lower than John C. Calhoun Blvd. and receives runoff from the 5-lane roadway and paved commercial facilities. This water collects behind the houses on Glover Street and has no adequate inlets to enter the existing closed system.

Probability of Success After Natural Disasters

Rank	Location	Cost	Comments
1	Railroad Corner	$4,000,000	Upgrading the failing drainage system at this location will minimize flooding incidents for commercial buildings on Boulevard Street. The site sits higher than adjacent properties to the north, providing natural protection from future disasters. **(Estimated probability 70%)**
2	Ellis Avenue	$1,609,462	Repairing failed drainage systems would protect properties from long-term ponding in future flooding disasters. The site is above the flood plain and the improvements would be highly sustainable. **(Estimated probability 65%)**
3	Glover St.	$1,083,474	Piping water from behind the impacted properties and improving the drainage system on Glover will significantly reduce the probability of flooding in future events. The topography during intense storm events may cause temporary flooding, but the system will remain intact. **(Estimated probability 60%)**
4	Bayne St.	$2,462,462	Proposed improvements will accommodate flooding in heavy rains, but the terrain will continue to make this area susceptible to flooding. Recommended infrastructure improvements will not eliminate future disasters. **(Estimated probability 50%).**
5	Amelia St.	$548,231	The concern at this location is the large amount of runoff that sheet flows across a sharply graded parking lot. Water would be redirected to reduce future flooding on adjacent properties, but the rate of rainfall is the most would dictate the risk of future incidents. **(Estimated probability 50%)**
6	Adden St.	$ 936,231	Improvements will significantly reduce flooding for residential properties and roadway flooding during normal and heavy rain events. The site's proximity to the floodplain will continue to make it susceptible to flooding during future disasters, but the upgrades to the drainage system will endure future events. **(Estimated probability 50%)**

The remaining two (2) sites, Adden Street and Bayne Street are subject to flooding due to their location. Adden St. is located one (1) block northwest of Sunnyside Canal. This paved channel conveys runoff for the west side of Orangeburg into the North Edisto River. This area is in a flood plain and improvements will only mitigate the flooding. Bayne Street suffers from poor infrastructure and very flat terrain. This area, just south of the heart of downtown Orangeburg,

greatly needs improvements to its drainage infrastructure. However, it will require an extensive system to accommodate the runoff volume over the service area. It should be noted that the Orangeburg County Fairgrounds are a part of the proposed Bayne Street Improvements.

The ranking for each location's probability of success against future disasters is located in the chart below. Each has an estimated cost and specific comments about its ability to withstand future disasters.

7. Project Analysis

Overview of Analysis

The Study Team has provided a summary of the analysis for each of the six (6) project sites examined in the study. The full Drainage Report and Benefit Cost Analysis, Low to Moderate Income, Social Vulnerability, and Ranking for each project are included in the appendix of this study, documenting the team's summary and conclusions. Active links to each report are included in the analysis of each site, allowing readers to reference information throughout the report.

A location map for the 6 projects selected for analysis is illustrated in **Figure 12.** Most of the sites were in urban areas along state-maintained roadways with existing drainage infrastructure. These "grey projects" in well-developed sections of the study area did not present many opportunities for the use of green spaces or buyouts in project recommendations. However, the Study Team was able to recommend improvements that replace outdated infrastructure and upgrade systems to meet the required capacity for 25-year storms as requested by SCOR as the baseline for all design improvements.

Figure 12. Location of Six (6) Sites Analyzed

Each of the sites present an opportunity for needed improvements to Orangeburg's drainage infrastructure. Though this study has specific criteria for benefit cost ratio and socio-economic thresholds, the summary of the analysis can be used by the City of Orangeburg to plan for needed improvements to its drainage infrastructure. Of the six (6) sites investigated, all were in low to moderate-income communities. Each of these sites also produced social vulnerability indexes that were above 0.5, making the project sites strong candidates for CDBG-MIT funding. Four (4) of the sites produced benefit cost ratios greater than one. While Railroad Corner and Amelia Street did not generate benefit cost ratios qualifying them to advance and compete for funding identified by this grant, improvements are still needed for the homes and businesses around these locations even though the sites did not meet minimums qualifications to advance for funding.

The summary of the final project ranking is shown below in Table 6. The areas in dark blue denote the highest concentration of distressed communities based on the Overall Social Vulnerability Index. Likewise, the dark shades of green indicate the highest levels of low to moderate income households by census blocks. As specified by the parameters for the study, the BCR show the greatest separation in project scoring. This variable illustrates the level of benefit divided by the cost to construct. The ranking was calculated after the benefit cost analysis for each site was completed. The socio-economic factors were taken from the latest census information.

Project Ranking

				40%		*30%*		*20%*		*10%*		
Project ID	Project Name	Benefit	Cost	BCR	Score 0-20	LMI	LMI pts 0-15	SoVI	SoVI pts 0-10	Local 0-5	Total	Rank
2	1137 Glover St	$1,441,574	$1,083,474	1.33	7	**59.12**	**7**	0.9448	10	0	**24**	3
4	1041 Ellis Ave	$2,066,905	$1,609,462	1.28	7	*61.14*	*0*	0.4555	5	0	**12**	4
5	1410 Amelia St	$287,788	$548,231	0.52	0	*53.92*	*0*	0.8321	9	0	**9**	5
15	358 Bayne St	$4,776,294	$2,462,462	1.94	13	**62.4**	**11**	0.8321	9	0	**33**	1
12	886 Adden St	$8,684,598	$936,231	9.28	20	**49.8**	**3**	0.8321	9	0	**32**	2
18	Railroad Corner	***$1,500,000***	***$4,000,000***	0.38	0	*38.1*	*0*	0.6963	7	0	**7**	6

Each of the projects analyzed as a part of the study are individually summarized in the next six (6) subsections of the chapter. The full report, benefit cost analysis and summary of the socio-economic factors can be found in their entirety in the appendix of this report.

Adden Street

Figure 13 identifies the portion of Adden Street studied in this project. The existing conditions for its drainage system only accommodates a 2-to-5-year storm event. Residents report flooding during normal, everyday rain events and major downpours. The runoff from Windsor Street overtops the valley gutter along Adden Street, trapping water on residents' property. Water from Riverside Drive and properties on the north side of the neighborhood converges and ponds at the low point of Adden Street. This ponding consistently causes road closures and rerouting of traffic. Some residents are not financially able to address standing water or remove it from crawl spaces before permanent damage is caused to their homes. The standing water on private property has caused some houses in this community to be abandoned.

Figure 13. Adden St. Location

The recommended project is designed to eliminate flooding in both the 10- and 25-year storm events. The study team has developed a series of flood maps to illustrate the impact of flooding within the limits of the project. **Figure 14** compares flooding in the existing condition to the projected 25-year flood map. Currently, water would flood private property and the roadway on Adden Street. The current valley gutter system routes water to a catch basin and outfall ditch at the low point of the roadway. The undersized ditch and drainage system backs up water as it flows to Sunnyside Canal. The proposed improvements significantly upgrade the capacity of the existing system by installing new catch basins and pipes. The outlet ditch is also widened and deepened to allow runoff to reach the canal more efficiently, eliminating roadway and property flooding in the 25-year event.

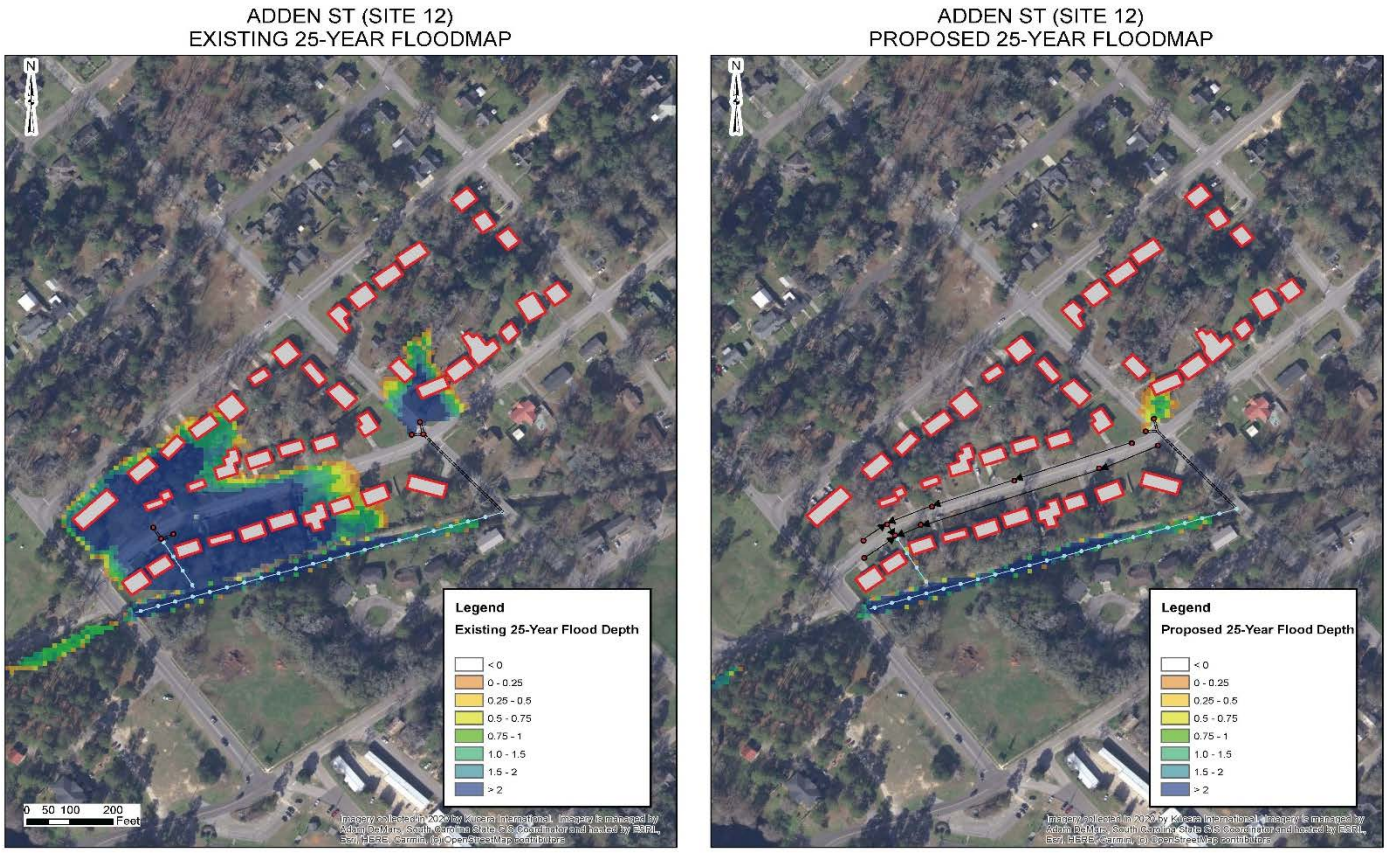

Figure 14. Adden Street – Existing and Proposed 25-Year Floodmaps

Adden Street produced the highest **benefit cost ratio** in the study with a value of 9.28. The recommended improvements impacted the 17 properties identified in Table 7 and had a benefit of $8,684,598. Due to the size project area and minimal improvements required to obtain benefit to the community, the project costs were estimated at $936,231.

Adden Street – List of Impacted Homes*					
	Property Type	Address		Property Type	Address
1	House	806 Adden St	10	House	848 Adden St
2	House	810 Adden St	11	House	860 Adden St
3	House	813 Adden St	12	House	872 Adden St
4	House	814 Adden St	13	House	886 Adden St
5	House	818 Adden St	14	House	836 Park St
6	House	824 Adden St	15	House	844 Park St
7	House	833 Adden St	16	House	852 Park St
8	House	836 Adden St	17	House	868 Park St
9	House	841 Adden St		***(No buyouts recommended)***	

Table 7. Adden Street – Impacted Homes

Adden Street is in Census Tract 114, Block Group 3 with a **LMI percentage** of 62.21%. It is located next to the Sunnyside Canal, which drains a significant portion of the City of Orangeburg into the North Edisto River. This community is the focus of a revitalization effort by Orangeburg City Council to demolish abandoned properties and assist in building new homes in this and other impoverished areas of the city. The recommended project will deliver a much-improved drainage system for the community. This will allow abandoned properties to be reconstructed with a reduced incidence of flooding and increase the community's property value.

Also located in this LMI zone are three (3) parks: Spray Park, Albergotti Park, and Edisto Memorial Gardens. The Social Vulnerability Index for this community is 0.8599, which is the second highest value found in the study. Recommended improvements will upgrade the drainage infrastructure for the community's citizens, access to the parks, and increase the value of residential properties subject to flooding. Residents currently experiencing flooding will also benefit from decreased health risks as water collecting in crawl spaces can be significantly reduced or eliminated. A schematic of the conceptual plans for Adden Street improvements is included below in **Figure 15**. Recommended improvements will install 10 new catch basins on Adden Street. The system will add over 1,400 linear feet of 18-inch concrete pipe connecting the new catch basins.

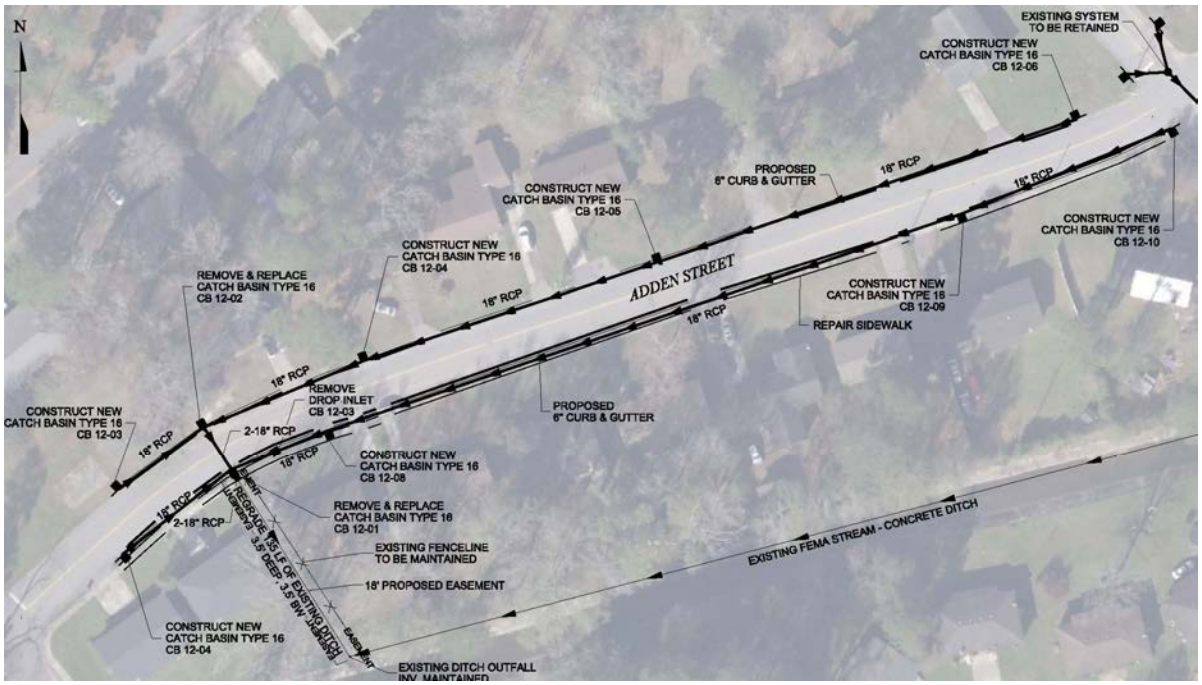

Figure 15. Adden Street – Proposed Improvements

Advancing this project presents minimal adverse **risks**. It will significantly reduce flooding on residential property, minimize runoff from overtopping the valley gutter and crossing the roadway causing traffic to be rerouted routinely. Adden Street is in a FEMA flood zone. Despite the proposed improvements, it will remain subject to flooding during future catastrophic events. The upgraded infrastructure has a 50% chance of enduring a future disaster. A summary of risks for current and future events is summarized below in Table 8.

ADDEN STREET – SITE RISKS		
Do Nothing (EXISTING CONDITION)	25 yr. Storm Event HEAVY RAINS	100 + yr. Storm Event HISTORIC FLOODS
Flooding on the entire street persists, causing property damage and possible abandoning of more properties. Road closures and detours will continue.	The project is advanced to construction; flooding is eliminated for normal rain events up to 25-year storms. Road closures will no longer be routine, saving maintenance effort and increasing public safety.	Due to their proximity to the Sunnyside Canal and the N. Edisto River, properties in this community will still be subject to flooding in 50-year storm events and beyond. The proposed project will likely not be damaged due to high rainfall events.

Table 8. Adden Street – Site Risks

The proposed construction is contained within one (1) city block, and convenient alternate routes are available for local traffic and emergency services. The recommended construction will efficiently route water to the Sunnyside Canal and upgrade the capacity of the existing system. The anticipated environmental clearances are outlined below. As noted in Table 9, the project will require an encroachment permit from SCDOT, and due to proximity to the flood zone, a Federal Emergency Management (FEMA) Conditional Letter of Map Revision (CLOMR) may also be required .

ADDEN STREET – ENVIRONMENTAL CLEARANCES			
Agency	Requirement	Duration	Comment
FHWA	NEPA Document	-	Not required
SCDOT	Encroachment Permit	3 months	Required on SCDOT RW
FEMA	CLOMR	6 months	Possible CLOMR required

Table 9. Adden Street – Environmental Clearances

Glover Street

Figure 16. Glover St. Location

Figure 16 identifies the portion of Glover Street studied in this project. **Glover Street** is centrally located in the City of Orangeburg, just two (2) blocks south of US 301, John C. Calhoun Boulevard. The existing conditions do not provide adequate drainage for a 10- or 25-year storm event. Water sheds from commercial facilities on John C. Calhoun Boulevard across South Street and ponds behind the houses facing Glover Street. The water then flows through the properties on Glover Street, routinely covering the entire roadway. Complaints of routine flooding were filed by two (2) residents on Glover Street during the public information meeting. Residents deal with standing water in their yards and the roadway during heavy downpours. Recommended improvements will upgrade the existing system by adding catch basins, manholes, and new reinforced concrete pipe.

The existing system will be upgraded and approximately 400 linear feet of new pipe will be added. Analysis shows that the proposed improvements will meet SCDOT standards, accommodating the runoff for 10- and 25-year storm events. The project will improve living conditions for residents and eliminate flooding on residential property and roadways by moving runoff efficiently through the upgraded system.

Figure 17 illustrates the severity of flooding that occurs for residents and businesses on South Street and Glover Street during a 25-year storm event. Properties are inundated with standing water, seen in the blue areas. The water escapes by flowing through properties facing Glover Street

to the South. The runoff stands in the roadway until reaching the nearest catch basin on Broughton Street.

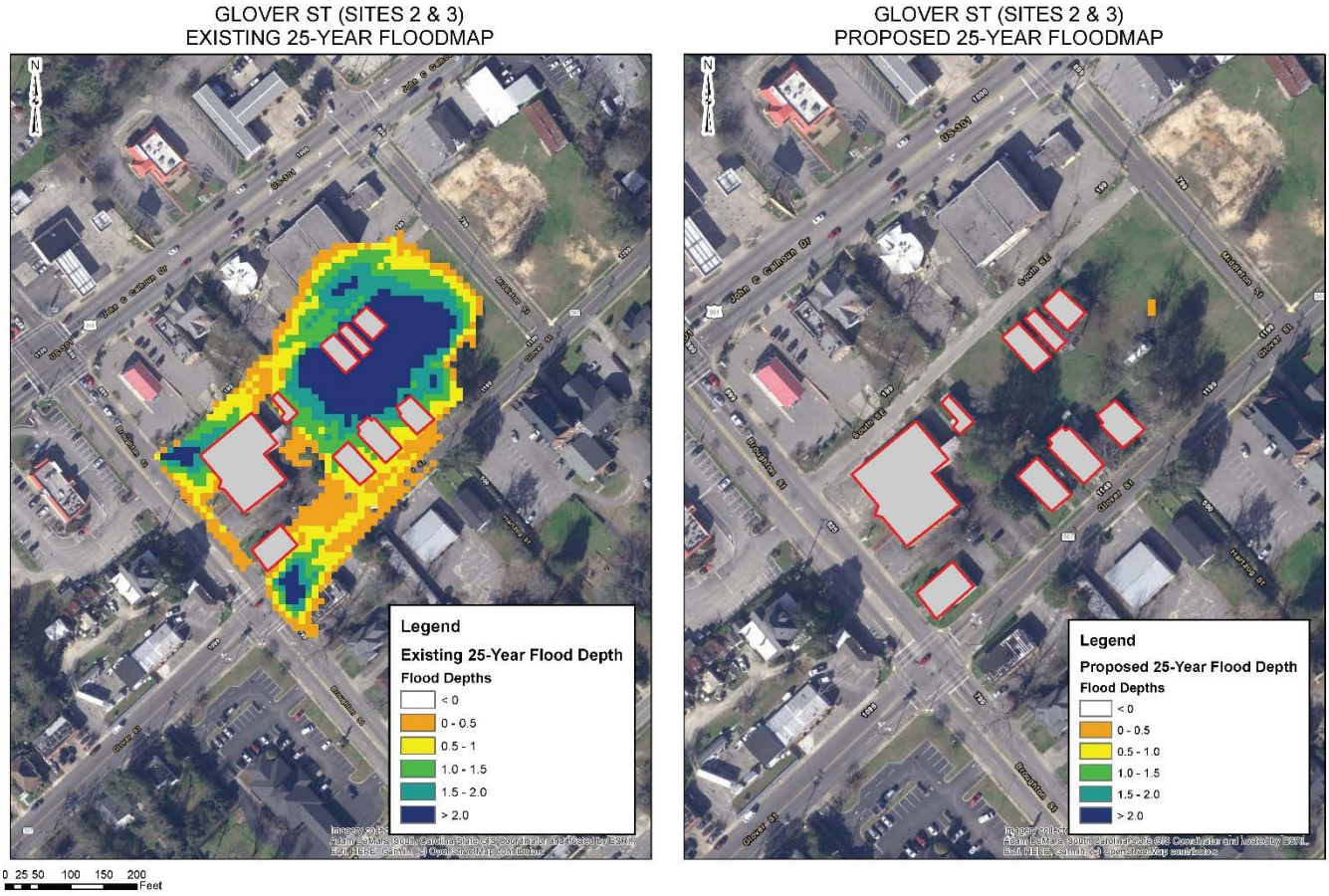

Figure 17 Glover Street – Existing and Proposed 25-Year Floodmaps

The calculated **benefit cost ratio** for the recommended improvements on Glover Street was 1.33. The analysis shows six (6) homes on Glover and South Street as beneficiaries of the project (Table 10). The total benefit calculated was $1,441,574 and the cost of the project was estimated to be $1,083,474. The ratio hovers just above the threshold of one (1) or greater because only six (6) properties were identified to show a direct benefit from the construction of the proposed project. The project also reduced roadway flooding, which increases safety for motorists.

Glover Street – List of Impacted Homes		
	Property Type	**Address**
1	House	150 South St
2	House	156 South St
3	House	136 South St
4	House	1157 Glover St
5	House	1149 Glover St
6	House	1137 Glover St
	(No buyouts recommended)	

Table 10. Glover Street – Impacted Homes

Glover Street has a **low to moderate income percentage** of 63.69%. This location also produced the study's highest **social vulnerability index** at 0.9519. This index accurately reflects the needs of this community's citizens and the distress caused by the flooding due to inadequate infrastructure. Residents on Glover Street are renting older homes that present adverse circumstances for occupants during rain events. Some residents are trapped in their homes during heavy rains due to intermittent flooding.

Figure 18a shows the layout of the recommended improvements. A total of eight (8) catch basins, two (2) manholes, and 377 linear feet of additional pipes were used to upgrade the existing system. Two (2) new catch basins and 130 linear feet of 36-inch pipe will be constructed to capture the water trapped between the properties on South and Glover Street, causing several properties to flood. This section of the system will require an easement to construct and maintain. The inlet will connect to the existing system on the north side of Glover Street, connecting to another upgraded catch basin across the roadway.

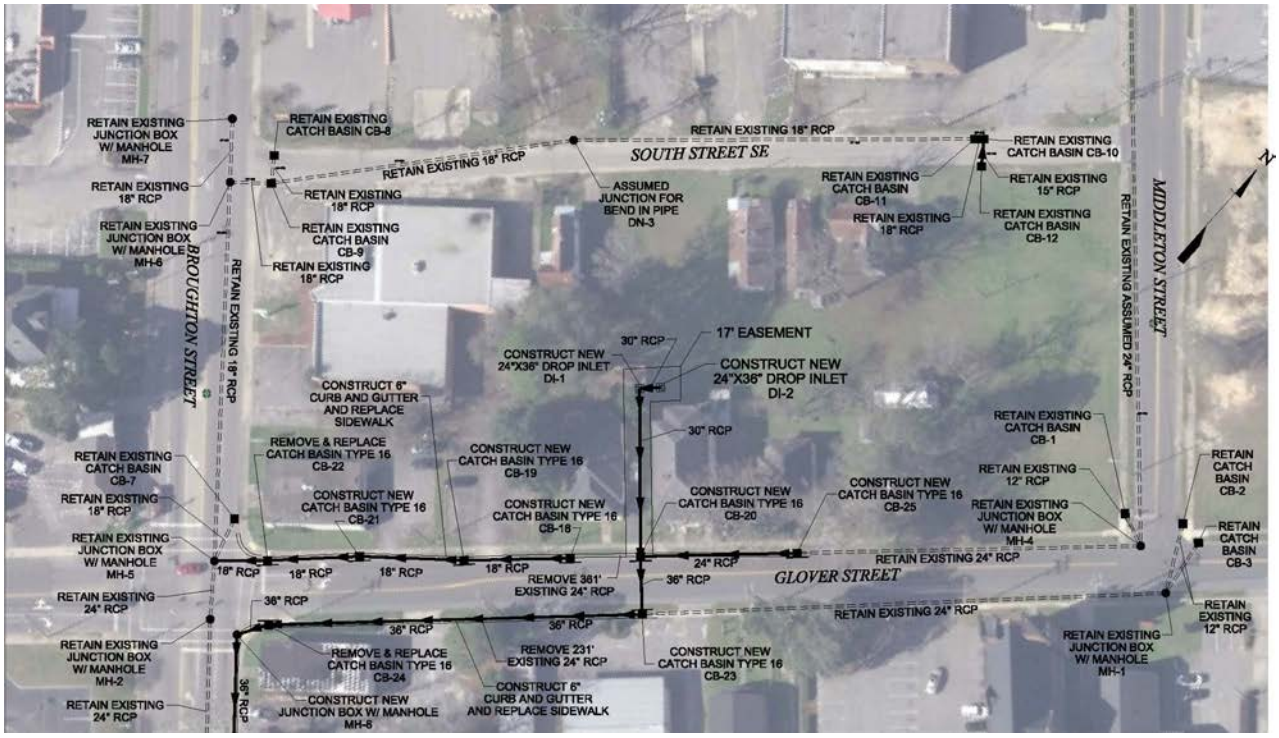

Figure 18a. Glover Street – Proposed Improvements

A new system of 36-inch pipes will be used to transport the surface water to the intersection of Boulevard Street. The 36-inch drainage line will turn 90 degrees and continue south under Boulevard Street for 200 feet, running parallel to an existing line. At this point, the system will

enter a new catch basin and upgraded junction box, connecting it to the existing system in the center of the roadway. The system continues from this point on Broughton St. until reaching a junction with a 60-inch culvert approximately 1,400 feet to the south (**Figure 18b**). The 60-inch culvert adequately accommodates the increase in volume.

This project addresses several **risks**. The direct impact of the recommended improvements is the immediate relief to residents of the community from property and roadway flooding. The flooding does not usually close the roadway, but it does present a hazard to motorists as standing water increases the risk of hydroplaning. Flooding at this location prevents the residents from safely exiting their homes. One (1) resident is disabled and cares for children. She is not able to get to her van when her yard floods without the use of her wheelchair. The social vulnerability index reflects the specific challenges of this resident, producing the highest value in the study.

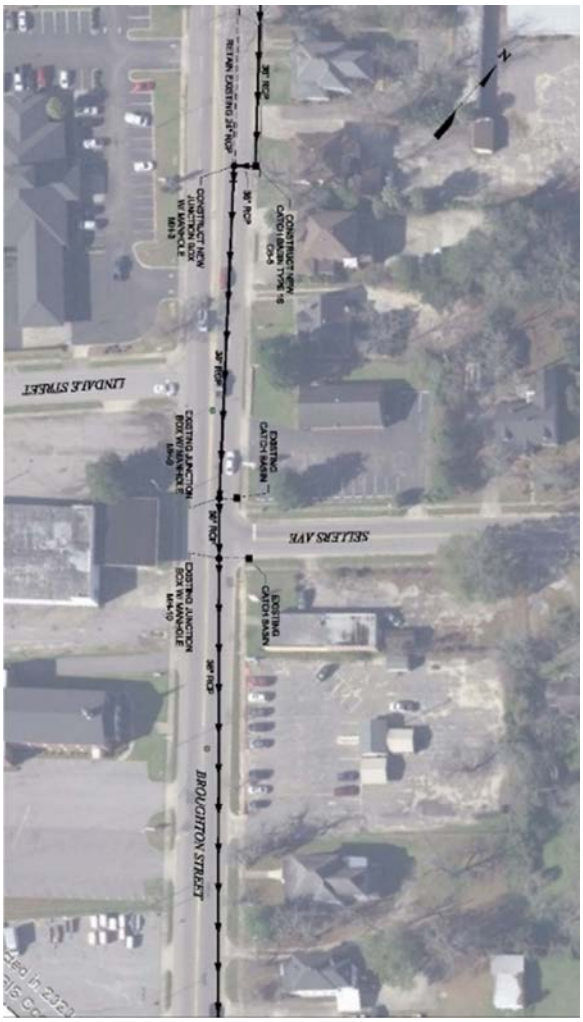

Figure 18b Glover Street – Proposed Improvements along Broughton St.

GLOVER STREET – SITE RISKS		
Do Nothing (EXISTING CONDITION)	25 yr. (HEAVY RAINS)	100 + yr. (HISTORIC FLOODS)
Flooding persists on private property and Glover Street during heavy downpours in 5-to-10-year storm events.	Proposed project is advanced to construction; flooding is eliminated for 10- to 25-year storms. Road closures will be eliminated with minimal flooding on private property.	Constructing this project will not eliminate flooding in catastrophic events. Properties and roadway will flood due to the volume of runoff and the terrain.

Table 11. Glover Street – Site Risks

Environmental clearances for this project are minimal. There are no flood zones or areas that present environmental concerns within the limits of the proposed construction. No environmental approvals from Federal Emergency Management Agency (FEMA) are required. The project is

primarily grey construction. An environmental document may not be necessary since this project focuses on upgrading an existing drainage system. Due to the impact on traffic on Boulevard and Glover Street, a public meeting is recommended. This process could take six (6) months to complete with the support of the community. The project would upgrade the current infrastructure by upsizing pipes in the existing system and draining through the natural outfall further to the south on Boulevard Street.

GLOVER STREET – ENVIRONMENTAL CLEARANCES			
Agency	Requirement	Duration	Comments
FHWA	NEPA	6 months	Upgrades and additions to the system may require public involvement
SCDOT	Encroachment Permit	3 months	

Table 12. Glover Street – Environmental Clearances

Amelia Street

Figure 19 identifies the portion of Amelia Street studied in this project. **Amelia Street** is in the central portion of Orangeburg, one (1) block north of Russell Street. The area consists of residential properties, businesses, churches, and historic homes. Existing conditions sheet flow runoff from a paved parking lot behind the historic Trinity United Methodist Church on Boulevard Street. The runoff floods two (2) buildings and a residential property. Analysis shows that the existing drainage system on Amelia Street is operating at capacity. The flooding caused by the parking lot increases exponentially with storm intensity due to the size and slope of the paved parking area, producing runoff.

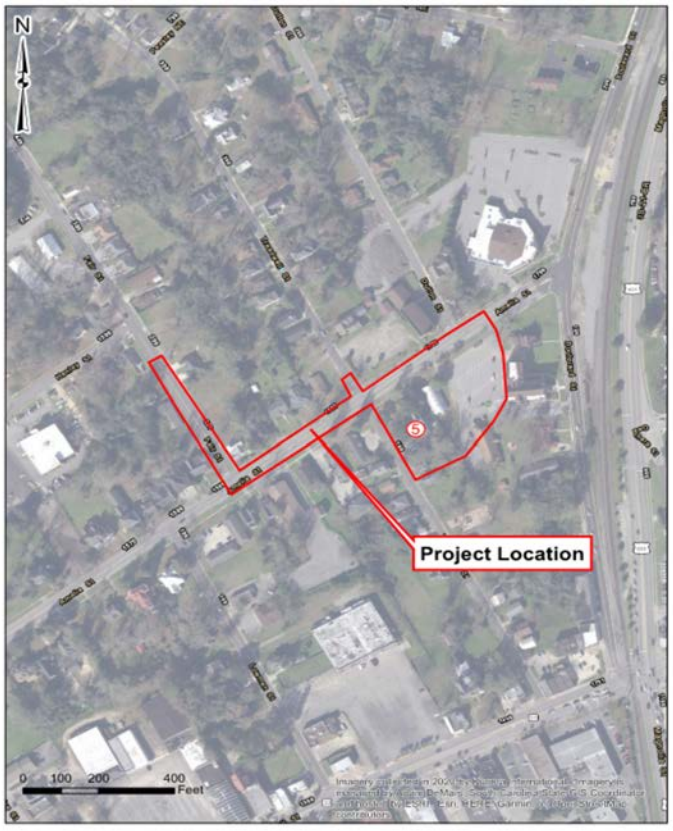

Figure 19. Amelia St. Location

In the existing condition for a 25-year storm event, the current system is undersized. Flooding occurs along Amelia Street and the adjacent residential properties. The steep grade of the parking lot behind the United Methodist Church contributes to flooding by producing a large amount of sheet-flow from this paved area. **Figure 20** illustrates the impact of the runoff produced during the 25-year storm event for both the existing and proposed conditions. The proposed changes will eliminate flooding on Amelia Street by installing additional catch basins and new pipe to increase the capacity of the system. Some pipe will also be upsized. As a result, the proposed system will eliminate flooding in the 25-year storm event.

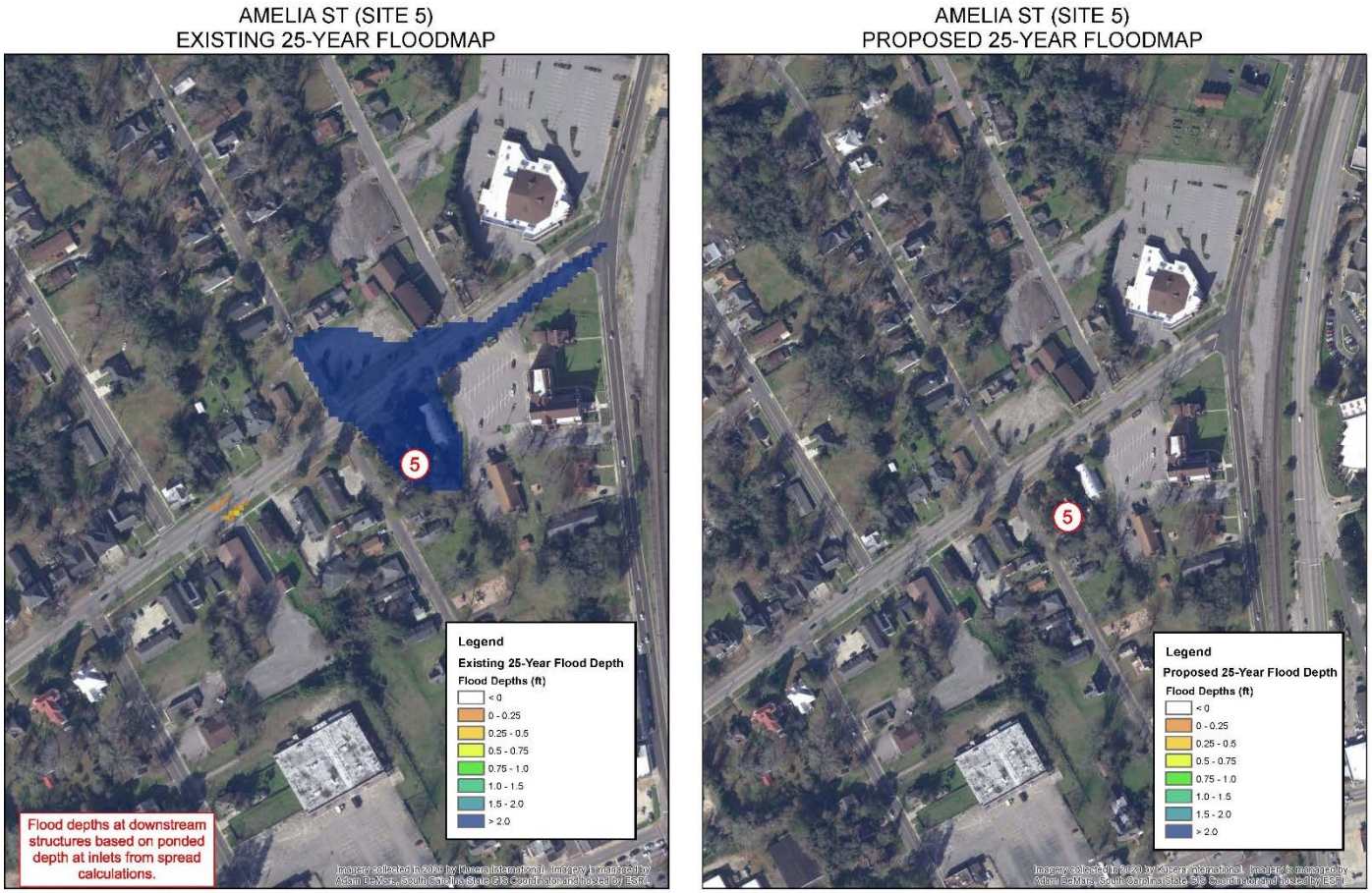

Figure 20. Amelia Street – Existing and Proposed 25-Year Floodmaps

The **low to moderate income percentage** for this location was 78.43% and the **social vulnerability index** was 0.8599. Both indicators were very high, clearly indicating the community's vulnerability to future disasters. Due to the size and small scale of this project, the City may consider a financial set aside in future budget years to assist a community partner or seek financial assistance through other sources to fund needed improvements at this location. Any improvements would bring relief to the residents and improve the infrastructure.

The proposed project reroutes surface water from the parking lot by adding nine (9) new catch basins and 665 linear feet of new pipe to the current system to accommodate a 25-year storm event. A berm ditch and drop inlet will be constructed at the base of the paved parking lot behind Trinity Methodist Church. Recommended changes will capture runoff and route it to the existing system on Amelia Street. The additional capacity of the system will be provided by new sections of upsized pipe from the inlet through the entire system, with additional catch basins enhancing the efficient flow of water through the systems.

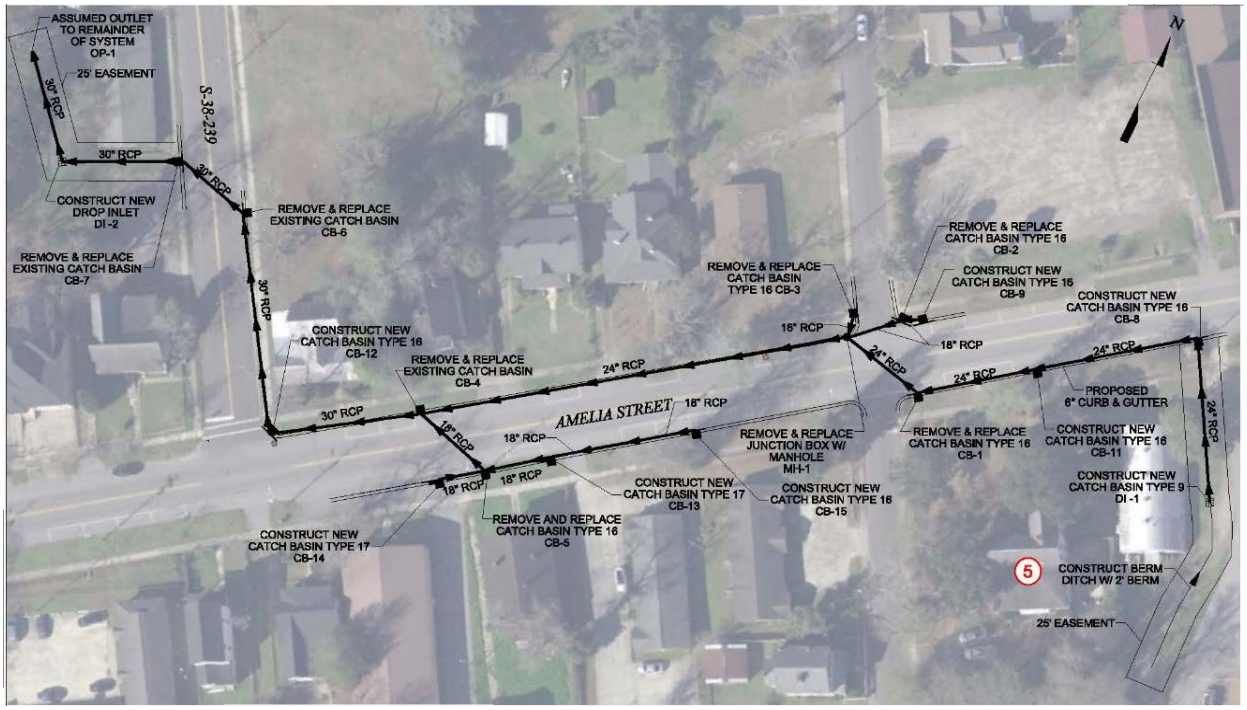

Figure21. Amelia Street – Proposed Improvements

This site was not recommended for funding at the conclusion of the study's analysis. Analysis of Amelia Street produced a **benefit cost ratio** of 0.52. The cost of the project was estimated at $548,231, while the benefit was only $287,788 due to only two (2) properties showing a direct benefit from the proposed project (Table 13). The proposed improvements for Amelia Street did not meet the CDBG-MIT threshold (BCR >1) for funding.

Amelia Street – List of Impacted Homes*		
	Property Type	**Address**
1	House	1730 Amelia St
2	House	1710 Amelia St
	No buyouts recommended	

Table 13. Amelia Street – Impacted Homes

Environmental concerns were minimal with respect to the permitting and construction of the proposed project. The site is urban with no existing environmental challenges. Inspection of the community reveals older homes located adjacent to commercial areas that are the subject of revitalization by the City of Orangeburg. If federal funds are used to fund this project, an environmental document may be required, as well as an encroachment permit from SCDOT. There are no concerns with the planning and execution of this project.

AMELIA STREET – ENVIRONMENTAL CLEARANCES			
Agency	Requirement	Duration	Comments
FHWA	NEPA	6 months	Upgrades to the system may require public involvement if funded by federal dollars.
SCDOT	Encroachment Permit	3 months	SCDOT, Orangeburg

Table 14. Amelia Street – Environmental Concerns

The **risks** associated with improvements on Amelia Street are minimal. Flooding concerns were only documented at three (3) locations. With no improvements, only these locations continue to be impacted. If constructed, the project will upgrade the existing system and eliminate flooding in the street and the parking lot in the 25-year event. A catastrophic event will cause the system to overflow.

AMELIA STREET – SITE RISKS		
Do Nothing (EXISTING CONDITION)	25 yr. (HEAVY RAINS)	100 yr. (HISTORIC FLOODS)
Flooding will continue to threaten homes and businesses behind Trinity Church.	Improvements will eliminate damage due to flooding and reduce flooding on Amelia Street because of the upgraded system.	Constructing this project will not eliminate flooding in catastrophic events. The elevation change of the parking lot will increase the chance of flooding.

Table 15. Amelia Street – Site Risks

Bayne Street

Figure 22 identifies the portion of Bayne Street studied in this project. **Bayne Street** is a two-lane state-owned road. This site is located in the southern part of the City of Orangeburg, south of the railroad and just north of the county fairgrounds. This area was developed as a mill village to support the neighboring plants and other agricultural mills located within walking distance of the community. Two (2) complaints (358 and 519 Bayne Street) were addressed at this location as they both merged into the same drainage system.

Figure 22. Bayne St. Location

The existing drainage infrastructure serving Bayne Street is undersized and outdated. Residents report numerous areas of flooding on roadways and private property. The Study Team observed terracotta pipes at several locations during initial field inspections and surveys. Flooding occurs during 10- and 25-year storm events as the existing system is not designed to accommodate runoff for these storms.

Proposed improvements will require upgrading existing and adding new pipes, constructing new catch basins, and reconstructing existing valley gutters. Easements will be required to connect the system between Bayne and Whaley Street.

Improvements to the system will meet the 10- and 25-year storm drainage requirements. As illustrated in **Figure 23**, the two (2) areas of flooding reported on Bayne Street and the County Fairgrounds will be eliminated by the construction of the proposed system. The primary areas of flooding are residential caused by failed and outdated infrastructure. These locations produce large areas of standing water and that eventually spread into the roadways serving this community. The area reported on the campus of the Fairgrounds is also of major concern as this site is used for emergency staging operations for FEMA to respond to regional disasters such as hurricanes, snowstorms, and catastrophic flooding. Orangeburg County also used the Fairgrounds to provide COVID-19 shots to residents and citizens of Calhoun County.

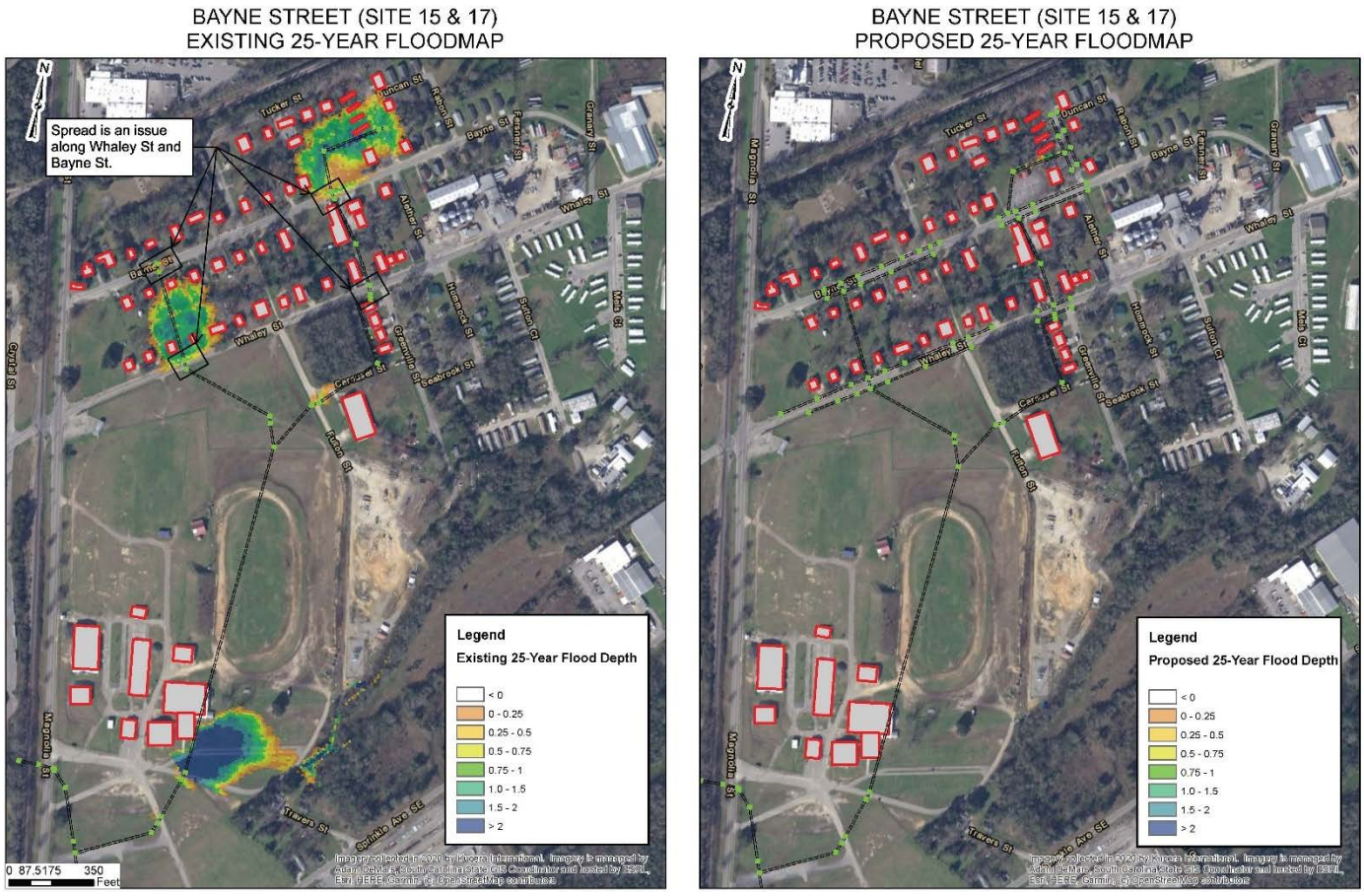

Figure 23. Bayne Street – Existing and Proposed 25-Year Floodmaps

The analysis for this site was developed in two (2) parts. The two (2) sites converge at the fairgrounds connecting to a common outlet. Site 15, in the 25-year design, adds 16 new catch basins, 1 manhole, and 1,666 linear feet of pipe. The area requires the construction of new catch basins and pipe on Fulton Street and draining into an existing outfall ditch north of Bayne Street. The ditch will connect to a new run of 36-inch pipe that ties into the new system of pipe on both sides of Bayne Street. This new section of Bayne Street will require the construction of valley gutters to collect surface water efficiently, removing it from travel lanes. The system will require a new easement, moving the water through a 36-inch pipe south to Whaley Street.

New catch basins and 18-inch pipe will also be added along with upgraded curb and gutter, allowing the 36-inch pipe to discharge into the existing ditch south of Whaley Street. This ditch may require maintenance to ensure connection to the drainage system located on the County Fairgrounds. The improvements described here are depicted in **Figure 24**.

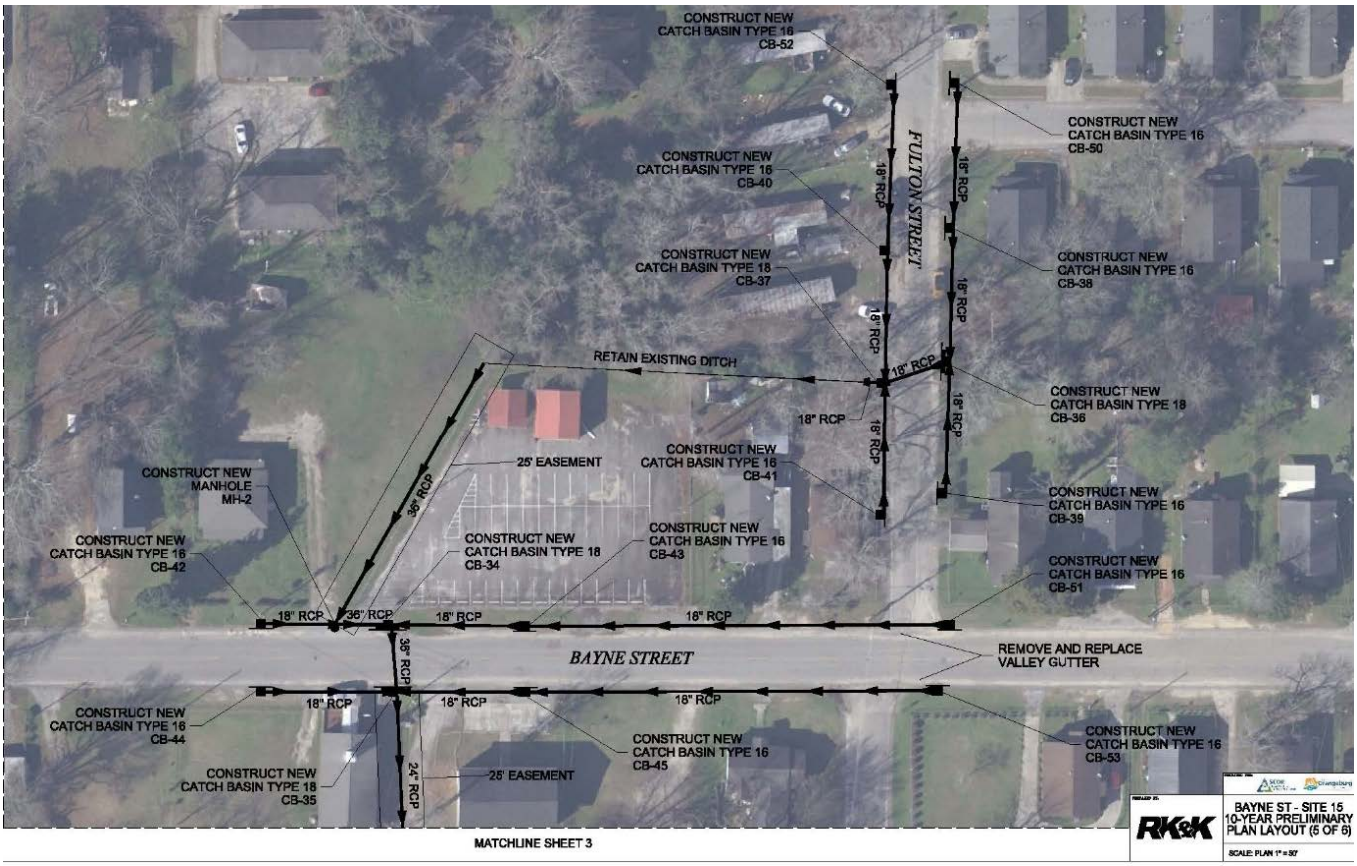

Figure 24a. Bayne Street – Proposed Improvements

Site 17, in the 25-year design, adds 2,760 linear feet of new pipe and 24 catch basins. The improvements also require upgrading the existing valley gutters on Bayne Street to route water into the new catch basins. An easement will be required to move water from Bayne south to Whaley Street. New catch basins, pipes and reconstructed curb and gutter will be required on Whaley as the water crosses under the travel way through another easement to connect to the existing system on the County Fairgrounds. Coordination with the county will be required for the construction and maintenance of the recommended upgrades.

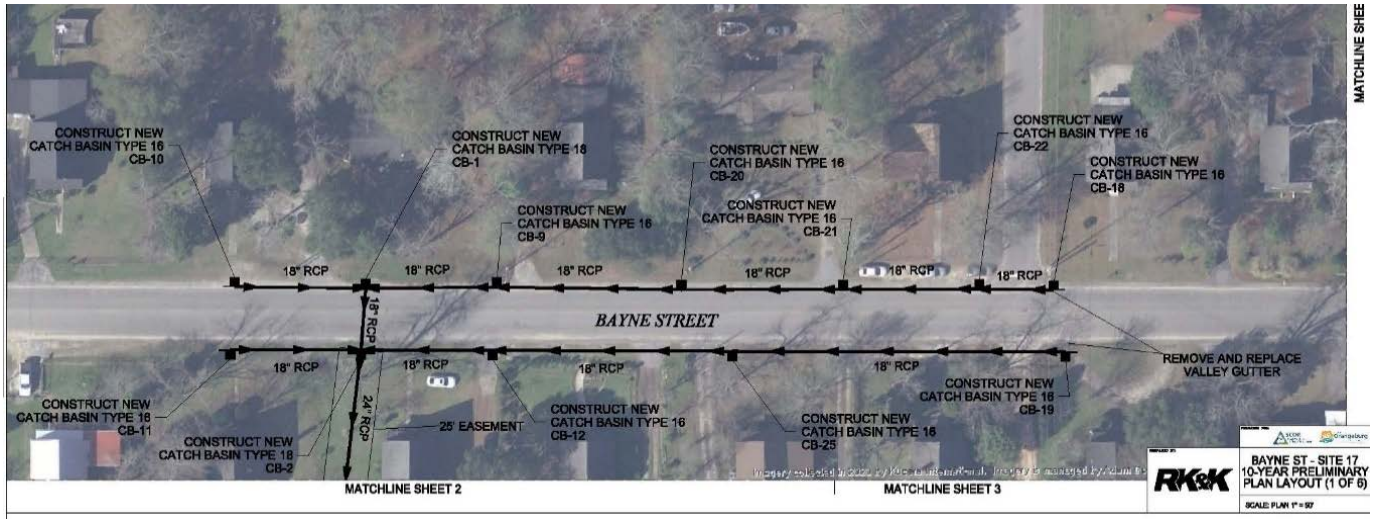

Figure 24b. Bayne Street – Proposed Improvements: Catch Basins

The benefit cost ratio for Bayne Street was calculated at 1.94. The total estimated cost for the proposed improvements was $2,462,462, while the benefits were calculated to be $4,776,294. There were 11 homes directly impacted by the recommended improvements. The upgraded drainage system will also provide relief to the County Fairgrounds.

Bayne Street – List of Impacted Properties					
	Property Type	**Address**		**Property Type**	**Address**
1	Home	491 Bayne St	7	Home	358 Bayne St
2	Home	353 Whaley St	8	Home	370 Bayne St
3	Home	445 Bayne St	9	Home	762 Alether St
4	Home	363 Whaley St	10	Home	502 Duncan St
5	Home	373 Whaley St	11	Home	505 Duncan St
6	Home	344 Whaley St		***(No buyouts recommended)***	

Table 16. Bayne Street – Impacted Homes

The **LMI %** for this site was 60.0% with an accompanying **Social Vulnerability Index** of 0.7739. This neighborhood consists of older homes and an established community of older citizens. No major infrastructure upgrades have been undertaken in this community in several decades. This is reflected in the outdated system and the condition of the outfalls serving the community.

This project will require a significant effort to complete. It will impact traffic on Bayne and Whaley Streets to establish easements for access and maintenance. Access to the fairgrounds will be required for additional upgrades to the system. Public involvement is recommended, though not required, due to the scale of the project's impact on the community's residents. No FEMA clearances are required and an encroachment permit from SCDOT will be needed prior to construction.

BAYNE STREET – ENVIRONMENTAL CLEARANCES			
Agency	Requirement	Duration	Comments
FHWA	NEPA	6 months	Required for most federally funded projects
SCDOT	Encroachment Permit	3 months	SCDOT, Orangeburg

Table 17. Bayne Street – Environmental Clearances

Recommendations for improvements at this location will impact the community due to the scale of the improvements. If no work is performed, the existing system will continue to deteriorate, causing more inconvenience to residents and the traveling public. The existing terracotta pipe is fragile and does not allow the option for repair. Instead, damaged sections must be fully replaced. Upgrading the drainage system will reduce incidents of roadway and residential flooding and increase the system's capacity. While the impact from catastrophic events is not eliminated, the new system will reduce the community's frequency and susceptibility to flooding in future disasters.

BAYNE STREET – SITE RISKS		
Do Nothing (EXISTING CONDITION)	25 yr (HEAVY RAINS)	100 yr (HISTORIC FLOODS)
Flooding will continue to impact public safety with ponding on roadways and on private property. Drainage systems will continue to fail with age.	Improvements will eliminate roadway flooding and greatly reduce the standing water on private property.	Constructing this project will not eliminate flooding in the catastrophic events. The level terrain will make the area subject to flooding in future disasters.

Table 18. Bayne Street – Site Risks

Ellis Avenue

Figure 25 identifies the portion of Ellis Avenue studied in this project. **Ellis Avenue** intersects Boulevard Street just north of downtown Orangeburg. This area is an established residential community serviced by roads that connect citizens to the major roads through the city. Residents from this area complain of water ponding behind homes on Ellis and Fairfield Street due to the failure of a drainage system installed on private property. The residents are unable to cut their grass, and the area is a nuisance. Since the problem exists on private property, there is no clear path to finding a public resource to assist in resolving the problem.

Figure 25. Ellis Ave. Location

Existing conditions on Ellis Street do not provide adequate drainage for the 10- or 25-year storm events. The current system is undersized and dated. Sections of pipe on Spring Street are separated and broken, contributing to the backup of water on the properties between Ellis and Fairfield. This area is a nuisance to property owners and the community as residents are not able to properly maintain their yards due large areas of standing water. The system crosses Ellis at Spring Street and continues for a block to Eutaw Street, where it turns eastward and connects to a crossline, and discharges south of Eutaw Street. Since flooding exists on private property there is no clear path to finding a public resource to assist in resolving the problem.

Figure 26 illustrates existing and proposed flooding for the 25-year storm event. Note the intensity of the flooding behind the properties on Ellis Avenue and Boulevard Street in the existing condition. The proposed improvements replace failing sections of drainage pipe behind homes on Fairfield Street and Ellis Avenue extending to the system on Spring Street.

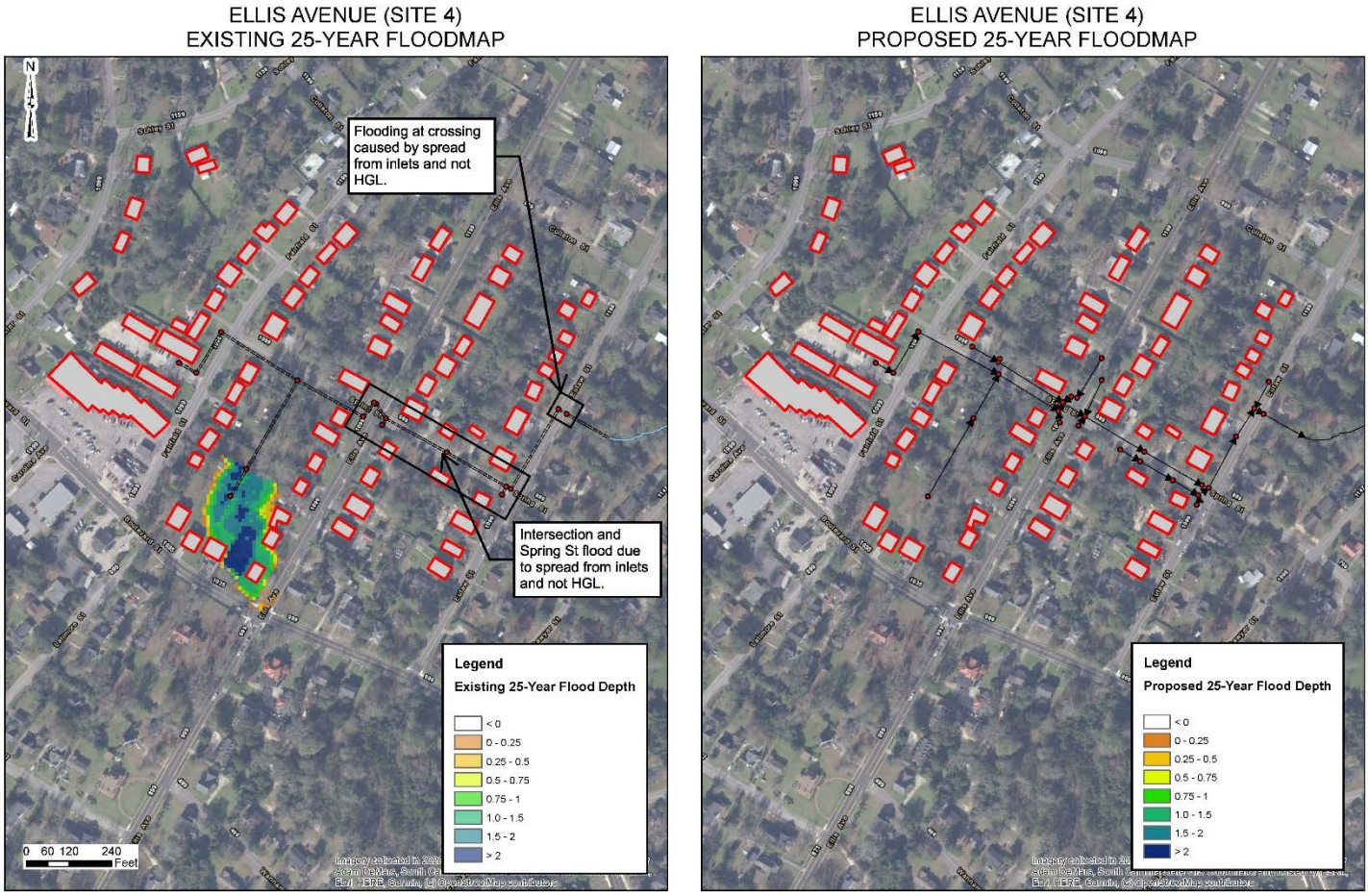

Figure 26. Ellis Aveue - Existing and Proposed 25-Year Floodmaps

The proposed improvements to this system will require 1,514 linear feet of new pipe and 19 new catch basins. Recommended upgrades depicted in **Figure 27** include replacing the failed drainage system that lies parallel to Ellis Avenue and Fairfield Street with 24-inch reinforced concrete pipe and new catch basins. This work will require an easement to remove and upgrade the failed system surrounded by privately owned property to accommodate the increase in volume to the system. Easements will also be required at the end of the project. The portion of the system on Spring and Eutaw Street will require upgrading to install the upsized pipe.

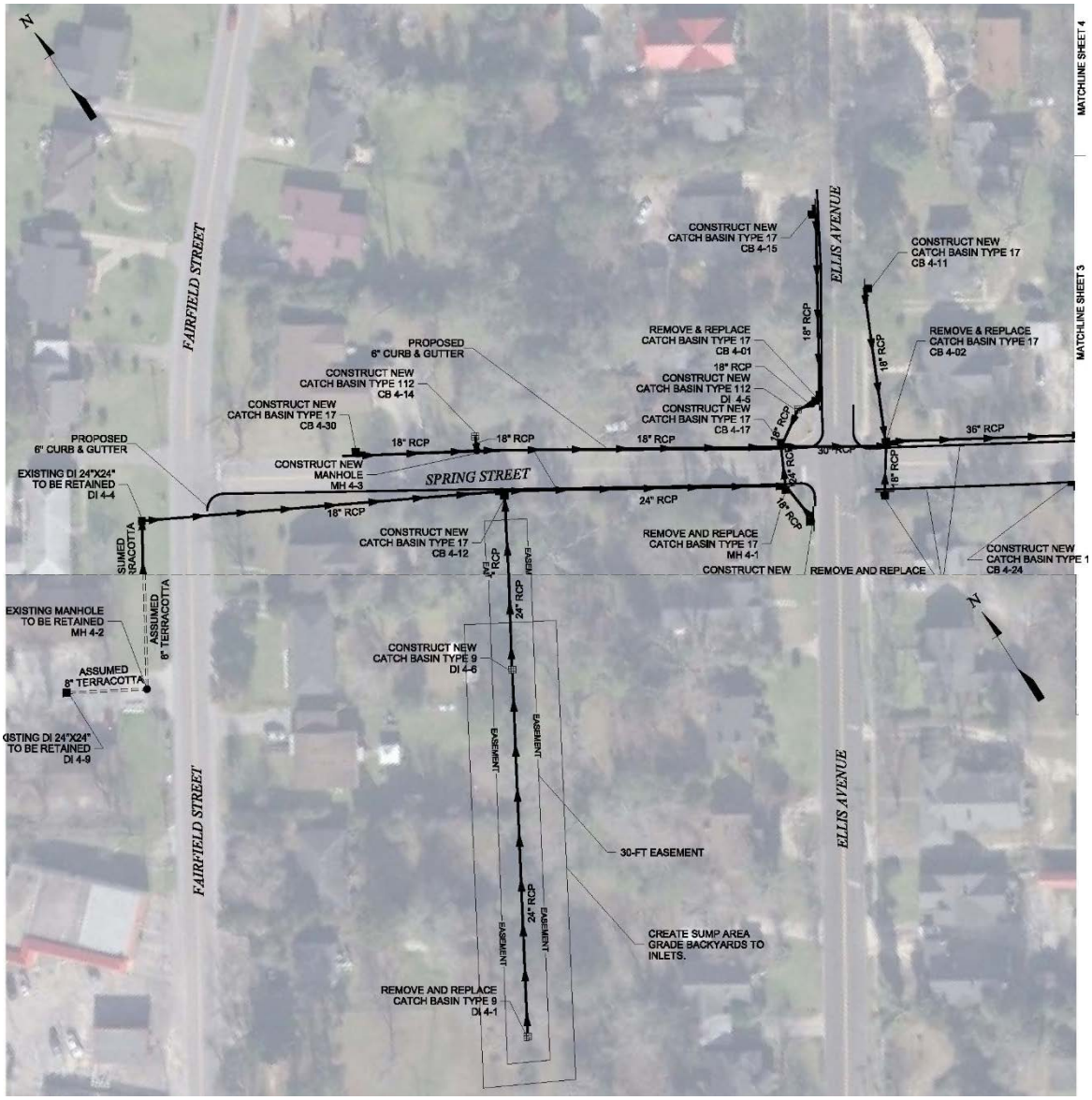

Figure 27. Ellis Avenue - Proposed Improvements

The **benefit cost ratio** for Ellis Avenue was 1.28. The cost to construct this project was estimated at $2,066,905, while the benefit was calculated to be $1,609,462. Due to the increase in pipe diameter, significant utility conflicts are anticipated with the construction of this project. This could inflate project costs and lengthen the construction schedule. Table 19 identifies the four (4) residences with a direct

Ellis Avenue - List of Impacted Properties*		
	Property Type	Address
1	House	1041 Ellis Ave
2	House	1029 Ellis Ave
3	House	1004 Ellis Ave
4	House	1024 Ellis Ave
	***No buyouts recommended**	

Table 19. Ellis Avenue – Impacted Homes

benefit from the construction of the proposed improvements. Considering the cost of the project and the number of benefitting properties, the project was not viewed as favorable to advance for funding.

Located in census zone 110, the **LMI%** of 59.17% is just above the threshold of 50%. The **social vulnerability index** for this site scored a moderate 0.5433, while the site meets the minimum thresholds for the benefit cost analysis and low to moderate income. The result of this construction would immediately improve the living conditions for residents on Ellis Avenue and Fairfield Street. If no work is done in this area, there is an increased risk of homes being abandoned if the standing water persists. This could reduce easements the tax base for the City and County and depreciate property values for the community.

This project would require several environmental clearances. If it advanced to construction, acquiring for access and future maintenance may prove challenging. The construction will require open cuts and special coordination between contractors and utility workers. There are no flood zones within the limits of the proposed project. This work will impact traffic patterns and reroute traffic for short periods of time. Public involvement may be required in advance of this project as a courtesy to residents and commuters. An SCDOT encroachment permit will also be required as the construction is an upgrade to the drainage system on a state-owned road. Construction is estimated to take 12 months.

ELLIS AVENUE – ENVIRONMENTAL CLEARANCES			
Agency	Requirement	Duration	Comments
FHWA	NEPA	6 months	Required for most federally funded projects
SCDOT	Encroachment Permit	3 months	SCDOT, Orangeburg
City or SCDOT	Easement	3 to 6 months	All property owners would have to agree to terms of the easement before construction

Table 20. Ellis Avenue – Environmental Clearances

There are moderate **risks** associated with the construction of this project (Table 21). If the existing condition persists, health risks could arise from standing water near homes. Advancing the project will require a significant amount of utility relocation to upsize the catch basins and pipes along Spring Street. Utility impacts could escalate the cost of the project and extend the construction schedule. Ellis Avenue runs east to west and connects the by-pass on the east side of Orangeburg to the Gibson Street just west of downtown. Delays to the construction schedule could force unwanted traffic in residential areas and cause accelerated deterioration of residential roads.

ELLIS AVENUE – SITE RISKS		
Do Nothing (EXISTING CONDITION)	25 yr (HEAVY RAINS)	100 yr (HISTORIC FLOODS)
Stagnant water continues to stand behind homes. The property owners may be forced to abandon that cannot be sold or inhabited.	Improvements will eliminate roadway flooding and significantly reduce standing water on private property. Easements required and extensive utility relocation.	Advancing this project will not eliminate flooding in catastrophic events. Increased capacity of the system will provide improved protection in future.

Table 21. Ellis Avenue – Site Risks

Railroad Corner r

Figure 28 identifies the portion of Railroad Corner studied in this project. **Railroad Corner** is located at the intersection of Boulevard and Russell St. This is a historic corner of Orangeburg that is subject to a revitalization effort by the City of Orangeburg with the award of a $500,000 planning grant and the recent award of a $22.7M RAISE Grant. The current drainage system on Railroad Corner is not adequate to convey stormwater for 10- and 25-yr storm events, as water ponds above the existing curb and gutter along the southern end of Boulevard Street. Water stands in the travel lane of the roadway and several locations of failed pipe and catch basins were identified during the field inspection. Water from this system connects to the

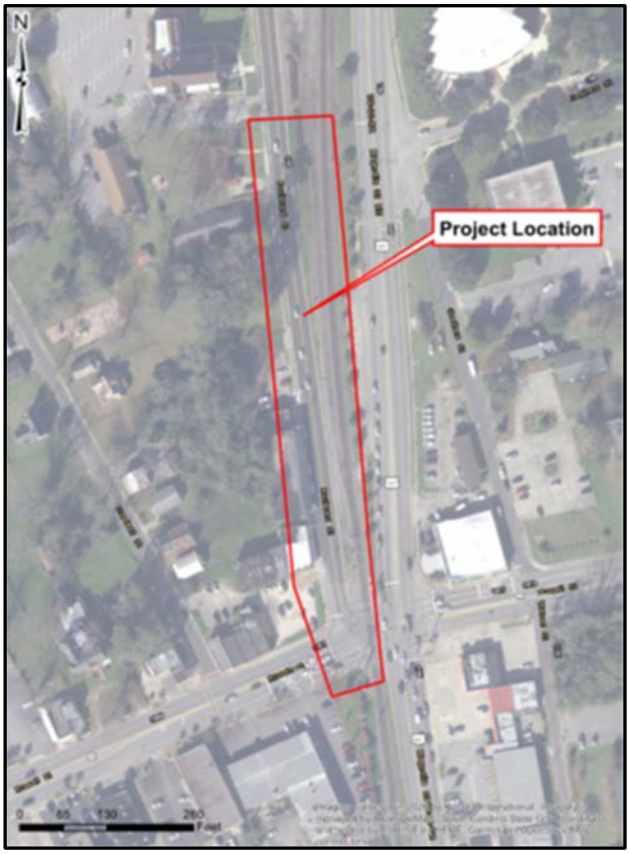

Figure 28. Railroad Corner Location

drainage system Magnolia Street under the railroad, continuing for over a half mile south before discharging on the railroad right of way.

Figure 29 provides illustrations of the existing and proposed flood conditions during a 25-year storm event. The map of the existing condition clearly highlights the areas along Boulevard Street and Russell Street that experience flooding during heavy rains. The proposed improvements eliminate flooding for the 25-year storm event. This project site is located on a crest and sheds runoff north to Treadwell Street and south down Magnolia Street. It is important to note that water also ponds opposite Railroad Corner on Magnolia Street and other locations south of Railroad Corner. Upgrading this drainage system will reduce incidents of flooding further at these locations and provide relief to adjacent sections of John C. Calhoun Boulevard.

Figure 29. Railroad Corner – Existing and Proposed 25-Year Floodmaps

The Study Team recommends replacing the existing pipe and catch basins on Boulevard Street and supplementing the location with additional drainage assets to accommodate a 10- and 25-year storm. This would require an upsized 42-inch pipe to be placed under the railroad, connecting the drainage on Boulevard and Russell Street to Magnolia Street. Due to the increase in pipe size and meeting the Railroad requirements for cover, the entire system would require upsizing for capacity. The project would extend south for nearly 2,800 feet crossing John C. Calhoun Blvd. and discharge on the railroad right of way. **Figure 30** illustrates the recommended changes and the scale of the required improvements.

Figure 30. Railroad Corner – Proposed

The **benefit cost ratio** for the site was determined to be 0.38. The benefit from the 10 impacted properties listed in Table 22 was calculated to be $1,500,000 at the time of analysis. The costs were estimated to be over $4,000,000. It is important to note the age and current condition of the properties considered for this analysis. If the city advances the revitalization of Railroad Corner, the value of these properties would be substantially greater, creating a much higher BCR. The cost of this project is considerably higher than any other project in the study due to its length and location. However, the upgraded drainage system would serve a large portion of downtown Orangeburg. The proposed improvements occur on the railroad right of way and along the busiest north-south highway in the city. Due to the age and condition of the current drainage system, flooding at Railroad Corner and on Magnolia Street during heavy downpours will continue to be

a problem for the traveling public. This project is needed to efficiently address the drainage demands of the downtown area and its pending revitalization.

List of Impacted Properties*					
	Property Type	Address		Property Type	Address
1	Commercial	141 Boulevard St	6	Commercial	111 Boulevard St
2	Commercial	155 Boulevard St	7	Commercial	1719 Russell St
3	Commercial	139 Boulevard St	8	Commercial	1710 Russell St
4	Commercial	120 Boulevard St	9	Commercial	1705 Russell St
5	Commercial	1721 Boulevard St	10	Commercial	1701 Russell St
***No buyouts recommended**					

Table 22. Railroad Corner – Impacted Properties

The **LMI%** for this area is 78.43%. Boulevard Street is located very close to the center of the City of Orangeburg. The **SoVI** was 0.8599. Both parameters are very strong indicators of the area's vulnerability to natural disasters, meeting the qualifications for the study parameters. If improvements were pursued for Railroad Corner, South Carolina State and Claflin Universities would enjoy a direct benefit from the project. Residents, citizens of the surrounding community and students who patronize businesses in downtown Orangeburg will gain improved access to businesses and unimpeded emergency services during heavy rains. Drainage improvements would also benefit any proposed revitalization projects pursued by the City of Orangeburg, beginning with Railroad Corner. Motorists traveling to Russell, Boulevard, and Magnolia Streets would benefit from safer travel ways.

The **environmental permitting**, scheduling, and utility coordination for this project will prove the most challenging. The permitting may require SHPO coordination if historic buildings are impacted as a result of the improvements. There are no live streams or environmental concerns, within the project limits, but the volume of water moving through the system will increase because of recommended improvements and pending revitalization efforts. Extensive railroad coordination will be required to cross and work parallel to their right of way. Due to prior rights of ownership for railroads, negotiating is usually very difficult and costly. Railroad Inspectors are generally required at the expense of the project. An encroachment permit from SCDOT will be required to construct the drainage upgrade on Boulevard and Magnolia. Any plans for the revitalization of Railroad Corner would have a direct impact on the recommended improvements. Any additional increases in runoff should be considered before the construction of this project. This site would

likely require a NEPA document due to the scale of the project and its impact on the surrounding community.

RAILROAD CORNER – ENVIRONMENTAL CLEARANCES			
Agency	Requirement	Duration	Comments
FHWA	NEPA	6 months	Required for most federally funded projects
SCDOT	Encroachment Permit	3 months	SCDOT, Orangeburg
Railroad Coordination	Encroachment Permit	12-18 months	Extensive coordination required
SHPO		6 months	If historic properties are impacted by proposed work

Table 23. Railroad Corner – Environmental Clearances

Risks associated with this project area are significant. The current condition of the city's drainage infrastructure will not support continued improvements in the most central and urbanized sections of Orangeburg. To be clear, the existing infrastructure requires upgrades and presents the risk of flooding during heavy downpours and prolonged rain events. Commercial expansion and revitalization projects will likely increase the runoff and put more pressure on the drainage system. Delaying these improvements could hinder the growth, economic development, and quality of life for citizens. Construction of this project would occur along a very busy 4-lane section of Magnolia St and its intersections with Russell Street and John C. Calhoun Boulevard. Safety for the traveling public would be a concern as an open cut would likely be required to install the new 42-inch reinforced concrete pipe along railroad right of way for the length of the project.

RAILROAD CORNER – SITE RISKS		
Do Nothing (EXISTING CONDITION)	25 yr (HEAVY RAINS)	100 yr (HISTORIC FLOODS)
Standing water and flooding will continue on Boulevard, Russell and Magnolia Street. It could hinder future economic development and revitalization efforts, while threatening safety.	Improvements will eliminate roadway flooding and significantly reduce standing water on commercial properties. It will also accommodate future growth.	Advancing this project will not eliminate flooding in catastrophic events. Increased capacity of the system will provide improved protection during future disasters with a small chance of the system failing.

Table 24. Railroad Corner – Site Risks