

Benson, NC BRIC 2022 Application

Benefit Cost Methodology

1. Project Overview

This document identifies the data and methodology used to complete a benefit-cost analysis (BCA) for the Town of Benson, NC Driving Branch Stream Restoration Project which will protect Town facilities and assets against flooding and ensure continuation of essential services to Town of Benson residents. The avoided losses from flooding after Hurricane Matthew in 2016 were quantified for the purposes of this BCA. This project qualifies for the Alternative Cost Effectiveness Method because it addresses climate change impacts. For further description, see Section 7 of this document.

- Using a 7% discount rate, the overall project result was a calculated benefit-cost ratio of .76 with \$2,342,947 in project benefits and \$3,085,626 in costs.
- Using a 3% discount rate, the overall project result was a calculated benefit-cost ratio of 1.29 with \$4,368,129 in project benefits and \$3,396,044 in costs.

This is a phased project as the Town will conduct all drainage, survey, environmental, and related research during Phase 1. Construction drawings will be prepared and detailed engineers' estimates for construction will also be developed in Phase 1. The budgeted figures presented in the application budget are estimates and will be refined and modified based on the results of the Phase 1 findings. This BCA will be re-run using refined figures and supporting documentation will be supplied as part of the Phase 1 tasks. A Justification Letter from the Town Manager is included as part of the supporting documentation for the BCA. All BCA attachments are listed in Section 9 of this document.

2. Project Background

The proposed project comprises five related elements along a portion of Driving Branch, a perennial blueline stream, within the Town of Benson, North Carolina. This work includes floodplain and stream restoration on a section of Driving Branch, floodproofing water lines crossing Driving Branch at North Johnston Street, replacing the culvert and raising the roadway grade at the North Market crossing of Driving Branch, and replacing the culvert carrying Driving Branch under SR 1175 (North Johnston Street).

As it exists, the only access to Benson's Public Utilities Office, as well as its maintenance yard, is located beyond the end of pavement of North Market Street. Driving Branch is conveyed under the existing maintenance yard via a series of undersized 60-inch corrugated metal pipes joined to a five-foot-by-five-foot box culvert beneath the unpaved portion of North Market Street. The area along Driving Branch east of the CSX railroad to North Johnson Street has been severely impacted by storms since Hurricane Matthew in 2016. More specifically, the piped section of Driving Branch between the CSX railroad and North Market Street had multiple pipes displaced during Hurricane Matthew. This area has historically flooded and made North Market Street impassable during subsequent large storms, preventing access to town maintenance equipment.

The Town has recently constructed a new Public Works Facility on high ground along North Market Street adjacent to and northeast of the existing maintenance yard. However, the new facility must still be accessed via North Market Street and the conditions previously described make the facility inaccessible during large storm events, limiting the Town's ability to serve the public in critical times.

Downstream of this area, the North Johnson Street culvert for Driving Branch has also incurred headwall damage and erosion during storm events. The North Johnson Street culvert location also has an aerial sanitary sewer line, a subsurface water main, and overhead power lines. The piers and footers for the aerial line that were installed along the banks are now impacted by the stream erosion. Some of the poles for the power lines are on the bank of the channel and are at risk of becoming undermined by erosion. Furthermore, the stream erosion has resulted in the below grade water main becoming fully exposed in the bed of the channel. Areas upstream, west of the railroad often experience flooding during storm events as well. The Town is seeking BRIC funding to address these recurring issues by conducting stream restoration, flood mitigation, and roadway improvements, as described below.

3. Proposed Mitigation Actions

The Driving Branch Mitigation Project has been divided into five separate mitigation actions, each referred to as an 'element' in the project Scope of Work. The five mitigation actions within the project are listed below.

Element 1 – Floodplain and stream restoration, North Market Street

Element 1 includes stream restoration that will increase flood capacity along Driving Branch southeast of the railroad, protect downstream infrastructure, and reduce flooding in surrounding areas. This element includes restoring an approximately 375 linear foot section of Driving Branch by daylighting stream channel that is currently piped through a 60-inch diameter pipe. Proposed improvements will include removal of the pipe and restoration of the reach utilizing a Priority 2 approach. Priority 2 restoration will include the excavation of an appropriately sized floodplain bench along the stream reach that will provide stability to the stream system, provide much needed flood flow storage and retention, and will provide stream and riparian habitat that is currently non-existent with the current piped condition. In addition to correcting the floodplain and channel dimension, restoration will include re-aligning the stream to have an appropriate pattern and profile for its hydrologic regime. Riffles and pools will be created in the channel, which will significantly improve the sediment transport capacity, hydraulics, and in-channel habitat for Driving Branch. In-stream structures such as log vanes, log-rock riffles, and log cross vanes will be utilized to provide channel bed stability and create a diversity of aquatic habitat. After the channel has been re-graded to a natural and stable form, the banks and riparian areas will be vegetated with native species to provide long term bank stability for flood protection and riparian habitat.

In order for the stream restoration to be completed, demolition of the two existing Public Works Facility structures must be accomplished in addition to relocating the 12" water line that runs down the center of the facility driveway. The relocated water line will run south along Market Street to Hill Street (approximately 865' feet to be relocated).

Element 2 – Floodplain and stream restoration, North Johnson Street

Approximately 1,100 linear feet downstream of the area described in Element 1, Driving Branch flows through two pipes under North Johnson Street. This area encompasses Element 2 of the project. Several utilities exist within the North Johnson Street right-of-way at this crossing, including an aerial sanitary sewer line, a subsurface water main, and overhead power lines. Within the vicinity of the crossing, Driving Branch has experienced chronic channel stability issues which threaten the integrity of the existing culvert and utilities. Erosion has occurred around the headwall for the culvert, resulting in damage. Some of the poles for the power lines are on the bank of the channel and are at risk of

becoming undermined by erosion. The degradation of the channel has led to areas of the subsurface water main becoming fully exposed in the channel bed, and the piers and footers for the aerial sanitary sewer line have also become compromised.

As part of this element, stream restoration measures will be implemented to stabilize the channel within the vicinity of the culvert and utilities. The channel will be reshaped and floodplain benches will be created where possible to create a dynamic equilibrium that will protect the integrity of the nearby infrastructure, and also improve the stream and riparian habitat. The stream restoration measures proposed include bank stabilization, the design and implementation of in-stream structures such as log vanes, log-rock riffles, and log cross vanes, and the restoration of riparian vegetation. Because of the culvert and utilities, low-growing vegetation will be utilized to ensure that maintenance of the utilities is still possible.

Element 3 – Potable water line floodproofing (North Johnson Street)

The purpose of this element is to provide additional protection for the potable water line so that less damage is incurred in future flood events. At Johnson Street, 200' of 6" fusible PVC will be replaced. The section crossing the stream (approximately 40') being placed in steel casing. The length of the line crossing the stream will be installed below the stream bed (currently the line is at the bed elevation).. These measures will protect the line from being impacted as it crosses the creek. This element will also include mobilization, traffic control, and erosion control.

Element 4 – Road Improvements (North Market Street)

The approximately 700-foot section of existing North Market Street from East Holmes Street to the new Public Works Facility will be reconstructed as a two-lane, 34-foot face to face roadway with curb and gutter. The existing culvert carrying Driving Branch will be replaced and the grade of North Market Street will be raised to prevent the road from being overtopped during storm events.

The proposed roadway improvements will ensure access via North Market Street to the Town's relocated maintenance yard during flooding events. This element will include replacing the existing five-foot by five-foot culvert carrying Driving Branch under North Market Street with an appropriately sized culvert. In addition, the grade of North Market Street at the crossing will be raised to prevent the street from being overtopped and access to the maintenance yard cut off during severe storm events.

Element 5 – Road Improvements (North Johnson Street)

The existing pipes carrying Driving Branch under SR 1175 (North Johnson Street) will be replaced with an appropriately sized culvert. This work will involve removing the existing pipes and constructing the culvert. An approximately 200-foot section of North Johnson Street will be resurfaced following completion of the culvert construction. Construction will include demolition and replacement in a new location outside the stream bed of two 5' concrete piers for the aerial sewer line.

The proposed culvert replacement will reduce stream velocities and erosion at this crossing during large storm events, providing protection to the water and sewer lines upstream of the crossing.

4. Methodology

The BCA for this project was produced using FEMA's BCA Toolkit Version 6.0 and guided by the FEMA BCA

Reference Guide. Following the FEMA BCA Reference Guide and Supplement, this analysis uses a combination of observed damages from historical flood events and modeled potential future damages to understand the before and after mitigation costs and benefits of the proposed project.

The costs and benefits from these five mitigation actions make up the overall Driving Branch Mitigation Project BCR. Notes on each BCA entry are included in the software and are also cut-and-paste as Section 8 of this BCA Methodology document. The following notes will assist to understand the BCA approach taken for the five different elements. Please note that all staff salaries include an additional 30% for fringe/benefits.

- Map Marker 1: Floodplain and stream restoration, North Market Street (Element 1)
 - This element is being implemented on .86 acres of the current Public Works Facility. An average linear foot calculation was prepared by adding together the costs for ecological restoration, water line relocation and steel encasing, plus the demolition and removal of two structures.
 - Only ecological benefits are included in this Element. All damages (pre and post mitigation) are included in Element 4 (Road Improvements, North Market Street).
- Map Marker 2: Floodplain and stream restoration, North Johnson Street (Element 2)
 - Only ecological benefits are included in this Element. All damages (pre and post mitigation) are included in Element 5 (Road Improvements, North Johnson Street).
 - All non-construction costs were added to this element. Prior to adding these costs, this element had the highest benefit-cost ratio.
- Map Marker 3: Road Improvements, North Market Street (Element 4)
 - Optional Damage columns are Project Worksheets, Crusher Fines, and cleanup/facility losses. are Clean-up and Traffic Control are combined as the third column of Optional Damages.
 - The road was closed for seven days due to damages from Hurricane Matthew in 2016. During that time, the Public Works Facility was completely blocked for four days, and Town staff were unable to gain access due to flooding. In addition, the facility operated at reduced capacity for several months due to the damages.
 - The BCA includes some of the incurred costs associated with the four days of no access. During Phase 1 it is anticipated that costs associated with operating at reduced capacity will be further researched and document.
 - There is no detour associated with this element.
- Map Marker 4: Road Improvements, North Johnson Street (Element 5)
 - Costs associated with the loss of service for the wastewater line and electrical line are included as Optional Damages. The estimate for loss of service was calculated as two separate projects (one for wastewater and one for electrical). The BCA export files include information on these two separate projects. The reports generated for each of these separate projects and are included as attachments to this Methodology.
 - Clean-up and Traffic Control are combined as the third column of Optional Damages.
- Map Marker 5: Potable water line floodproofing, North Johnson Street (Element 3)
 - Costs associated with the loss of service for the water line at Johnson Street are included as damages.
 - Although the Town was billed by the County for an additional \$2,272 during this period, additional costs may be added during Phase 1 research.

5. Historic Events

Frequent flooding occurs throughout the Town during heavy precipitation events. On October 8-9, 2016, the Town was inundated with heavy rain associated with Hurricane Matthew. Areas within the Town

that were prone to flooding during less intense rain events, experienced major flooding with significant damage to residential, commercial and government facilities. Existing stormwater infrastructure throughout the Town was negatively impacted with pipe separations, sink holes and major damage to roadway crossings over streams. A post-storm assessment was conducted immediately following Hurricane Matthew and eight areas within the Town were observed to have significant damages from floodwaters. One of these was the Town of Benson Public Works Facility at North Market Street.

An existing 60-inch CMP used to convey the flow of Driving Branch underground across the Public Works Yard severely restricted the flow of the stream during Hurricane Matthew and caused flooding immediately upstream of the pipe because of the excessive headwater. The upstream flooding caused severe damage to several residential units in the adjacent Hwy 301 Mobile Home Park. During the storm event, the pipe was ultimately unearthed, and the flood waters inundated the Public Works Facility with approximately 5 feet of water. The floodwaters caused severe damages to the Public Works Facility and destroyed multiple vehicles, heavy construction equipment, and outdoor storage equipment.

6. Summary of Hydraulic Results

The Town of Benson had a Hydrologic and Hydraulic (H&H) Study Floodplain Analysis completed in 2018 that analyzed separate drainage areas based on the receiving streams for each. The results of the study were depicted in maps sub-divided into five zones. The 10-year, 25-year, and 100-year water surface elevations are depicted for each zone. The complete H&H study has been included as an attachment, but this report will also provide a summary of the findings related to the Town of Benson Public Works Facility at North Market Street.

With a predicted flow of 931 CFS for the 10-year storm event, the existing 60" CMP used to convey the flow of Driving Branch underground across the Public Works Yard is significantly undersized and will cause backwater effect upstream from the inlet of the pipe. The recommendation from the engineers was that the pipe should be replaced with a 96" pipe or the pipe section should be removed, and the stream restored to its original dimension and profile. The current potential flood elevation for even a 10-year storm event is above the ground elevation for the Public Works buildings.

7. Alternative Cost Effectiveness Method

This project qualifies for the Alternative Cost Effectiveness Method because it addresses climate change impacts.

As stated in the Future Conditions portion of this application (Qualitative Criteria #2), extreme precipitation events in North Carolina, including those accompanying hurricanes, are very likely to increase over time due to climate change induced increases in atmospheric water vapor. This is likely to lead to increases in inland/freshwater flooding. Recent storms demonstrate what will occur more frequently in the future. Benson received 11-12 inches of rainfall during Hurricane Matthew with resultant flooding blocking access to the Town maintenance yard from North Market Street for four days.

The hydrologic and hydraulic study commissioned by the Town following Hurricane Matthew found that, as currently configured, the Public Works Facility and the mobile homes nearest the stream in the HWY 301 Mobile Home Park are at risk from even the 10-year flood event, with increased risk at the level of the 25- and 100-year floods. The report recommends daylighting the stream at Market Street to help decrease the expected flood elevation in these areas.

The project utilizes engineered and nature-based solutions to increase the flood capacity of Driving Branch at North Market Street to accommodate larger and more frequent floods. North Market Street provides access to the town maintenance yard where essential equipment for response to future flooding and other emergencies is stored. In anticipation of future flooding, the project will ensure reliable access to the maintenance yard under high water conditions and protect utilities including water and sewer lines along Johnson Street to ensure continuity of water and sewer service and avoid spills.

This project is aligned with priorities identified in the Cape Fear Regional Hazard Mitigation Plan and the North Carolina Climate Risk Assessment and Resilience Plan and is specifically identified in the Hurricane Matthew Resilient Redevelopment Plan.

8. Mitigation Action Notes

- Map Marker 1: Floodplain and stream restoration, North Market Street (Element 1)
 - Project Useful Life
Based on the input from the Town on-call team (P.E. that specializes in ecological restoration), useful life of 50 years was assumed for the stream restoration components of this project. Ideally, once a stream restoration project is complete, it is considered “maintenance free” due to the fact that it is intended to function as a natural system and not a utility such as a water line or a sewer main.
 - Mitigation Project Cost
 - 375 linear feet x \$750/linear foot restoration is \$281,250 + \$82,175 water line relocation + \$10,746 demolition and removal of two structures = \$374,171/375 ft = \$997.79 per linear foot
 - \$750/linear foot for this stream restoration work is based on past experience with similar site conditions, as per the ecological restoration P.E.
 - Based on input from the ecological restoration P.E., stream restoration will include: excavation of an appropriately sized floodplain bench to provide stability to the stream system, much needed flood flow storage and retention, and stream and riparian habitat that is currently non-existent with the current piped condition; re-align the stream to have an appropriate pattern and profile for its hydrologic regime; create riffles and pools in the channel to significantly improve the sediment transport capacity, hydraulics, and in-channel habitat; in-stream structures such as log vanes, log-rock riffles, and log cross vanes to provide channel bed stability and create a diversity of aquatic habitat. After the channel has been re-graded to a natural and stable form, the banks and riparian areas will be vegetated with native species to provide long term bank stability and riparian habitat.
 - Additional costs included in the average are 1) water line relocation at \$82,175 (865' of water line relocation at \$95/linear ft) and 2) demolition/removal of two structures at \$10,746. Demolition cost includes 1) 2 equipment operators at \$29.25/hr x 8 hrs x 15 days = \$3510 + 2) 3 PW staff at \$26/hr x 8 hrs x 15 days = \$3,120 + 3) PW Superintendent at \$41.16 for 100 hours = \$4,116
 - Annual Maintenance Cost
Based on input from the ecological restoration P.E., it is not uncommon to expect minor repairs during the first 5 years after construction for a stream restoration project. Therefore, stream restoration projects are typically monitored for a period of 3-5 years to ensure that the project is progressing towards a state of dynamic equilibrium. Walk through field observation will be conducted on an annual basis for the first five years. It is anticipated that staff time for the site walk through will be \$1,000 per year (\$5,000) with repair/re-placement of vegetation at \$5,000 in years 3 and 5 (\$10,000). Walk-throughs will be conducted every-

other year for the rest of the life of the project (\$22,500). Even though it is not anticipated, \$2,500 in repair/replacement costs will be budgeted for maintenance every ten years (\$12,500). This totals \$50,000 for the life of the project with an annual average of \$1,000.

- Analysis Year
H&H Study is from 2018.
- Year Built
The intersection of Market Street at the maintenance yard was built in approximately 1962. The maintenance yard was gifted to the Town and the exact year of construction is unknown. The building is visible in aerial photography from 1962.
- Damages Before Mitigation
Only ecological benefits are included in this Element. All damages (pre and post mitigation) are included in Element 4 (Road Improvements, North Market Street).
- Damages After Mitigation
Only ecological benefits are included in this Element. All damages (pre and post mitigation) are included in Element 4 (Road Improvements, North Market Street).
- Ecosystem Total Project Area
375 linear feet long x 100 feet wide (state definition) = 37,500 sq ft = .8608 acres
- Percent Riparian
Based on ecological restoration P.E., the restored acreage will create .86 acres of riparian ecosystem where there was none prior to restoration.
- Map Marker 2: Floodplain and stream restoration, North Johnson Street (Element 2)
 - Project Useful Life
Based on ecological restoration P.E., the restored acreage will create .86 acres of riparian ecosystem where there was none prior to restoration.
 - Mitigation Project Cost
 - 250 linear feet x \$500/linear foot = \$125,000
 - \$500/linear foot for this stream restoration work is based on past experience with similar site conditions, as per the ecological restoration P.E.
 - Based on input from the ecological restoration P.E., stream restoration measures for this element will be implemented to: stabilize the channel within the vicinity of the culvert and utilities; reshape the channel; and creation of floodplain benches to create a dynamic equilibrium that will protect the integrity of the nearby infrastructure (and also improve the stream and riparian habitat). The stream restoration measures proposed include bank stabilization, the design and implementation of in-stream structures such as log vanes, log-rock riffles, and log cross vanes, and the restoration of riparian vegetation. Because of the culvert and utilities, low-growing vegetation will be utilized to ensure that maintenance of the utilities is still possible.
 - All non-construction costs for the project (from pre-award through close-out) were added to the project cost for this element (\$760,332.16).
 - Stream restoration plus all non-construction costs for all elements = \$885,332.16
 - Annual Maintenance Cost
Based on input from the ecological restoration P.E., it is not uncommon to expect minor repairs during the first 5 years after construction for a stream restoration project. Therefore, stream restoration projects are typically monitored for a period of 3-5 years to ensure that the project is progressing towards a state of dynamic equilibrium. Walk through field observation will be conducted on an annual basis for the first five years. It is anticipated that staff time for the site walk through will be \$1,000 per year (\$5,000) with repair/re-placement

of vegetation at \$3,000 in years 3 and 5 (\$6,000). Walk-throughs will be conducted every-other year for the rest of the life of the project (\$22,500). Even though it is not anticipated, \$1,500 in repair/replacement costs will be budgeted for maintenance every ten years (\$7,500). This totals \$41,000 for the life of the project with an annual average of \$820.

- Analysis Year
H&H Study is from 2018.
- Year Built
The year the road was built is assumed to be 1938, based on historical NCDOT maps. No maps dated prior to 1938 showing North Johnson Street extending across Driving Branch have been found.
- Damages Before Mitigation
Only ecological benefits are included in this Element. All damages (pre and post mitigation) are included in Element 5 (Road Improvements, North Johnson Street).
- Damages After Mitigation
Only ecological benefits are included in this Element. All damages (pre and post mitigation) are included in Element 5 (Road Improvements, North Johnson Street).
- Ecosystem Total Project Area
250 linear feet long x 100 feet wide (state definition) = 25,000 sq ft = .5739 acres
- Percent Riparian
Based on ecological restoration P.E., the restored acreage will create .57 acres of riparian ecosystem where there was none prior to restoration.
- Map Marker 3: Road Improvements, North Market Street (Element 4)
 - Project Useful Life
As per PUL Summary Table.
 - Mitigation Project Cost
Cost estimate is Town's on-call engineering firm estimate based on similar work done in the past.
 - Annual Maintenance Cost
Cost estimate is Town's on-call engineering firm estimate based on similar work done in the past. Assumption is that the road would need to be resurfaced every 10 years. Costs were calculated based on the area of pavement within the project. The costs came from a recent cost estimate that was prepared by NCDOT with an assumed increase of 3% a year.
 - Analysis Year
H&H Study is from 2018.
 - Year Built
The intersection of Market Street at the maintenance yard was built in approximately 1962. The maintenance yard was gifted to the Town and the exact year of construction is unknown. The building is visible in aerial photography from 1962.
 - Damages Before Mitigation
 - Past Public Work Director confirmed 100-year recurrence interval resulted in road closure for seven days (damages from Hurricane Matthew in 2016). He also confirmed that during that time, the public works facility was completely blocked for four days, and Town staff were unable to gain access due to flooding. In addition, the facility operated at reduced capacity for several months due to the damages.
 - PW1230 - Flood water unearthed and damaged 60 ft x 60" corrugated metal pipe in the Public Works Yard, pipe bedding and fill materials (5 ft x 5ft 60ft), 3" of gravel. Engineering, survey/design and as built, mobilization, construction, erosion control = \$45,292.

- PW1537 - Flood water and high wind caused damages to Excavator Bays 1 and 2 in the interior of the Public Works Department. In addition, two vehicles were submerged and inoperable. The total for repair of the Bays and two vehicles (1997 Johnston Street sweeper and 1998 Ford dump truck) will be \$39,654.

- Based on the Public Works Superintendent and Town Project Manager there were \$141,881 in costs associated with the damages to the Public Works Facility (staff time \$8,190 + equipment \$133,446 + contractor time \$245). Upon initial review, it appears that none of these costs were included in the PWs. During Phase 1 detailed analysis, these costs will be analyzed in detail for confirmation. Labor to relocate equipment from the lower yard at 7 people for 36 hours each at \$32.50 per hour ($\$25 \times 130\%$) = \$8,190. Equipment costs at \$133,446: replace supervisor trucks at \$23,500; generator repair at \$43,500; tow employee personal property at \$8,900; damages to equipment at \$5,000; damages to shed at \$5,675; 97 Ford F 150 at \$9,600.00; 2004 Chevy Silverado at \$5,350.00; 1993 Chevy Truck at \$4,788.00; 2000 Ram 2500 at \$6,097.00; 1997 Chevy 2500 at \$7,572.00; equipment lost at Public Works at \$13,464.00. A contractor was hired at \$10 per hour for 24.5 hours to clean-up and repair Market Street = \$245.

- Based on the Public Works Superintendent and Town Manager estimates, there was \$9,114.84 expended by Town staff outside the Public Works Department in response to Hurricane Matthew. Three staff from the Electrical Department and two staff from the Wastewater Department spent 4.5 days clearing debris, maintaining storm drain capacity, and similar clean-up. The Electrical Superintendent and Wastewater Superintendent spent 36 hours at time-and-a-half for \$3,375 ($\31.25 per hour for 36 hours at 1.5 for two people). Two electrical crew members spent 36 hours at time-and-a-half for \$2,700 ($\25 per hour for 36 hours at 1.5 for two people). Two wastewater crew members spent 36 hours at time-and-a-half for \$2,363.04 ($\21.88 per hour for 36 hours at 1.5 for two people). In addition, a bucket truck was utilized for 18 hours at \$37.60 per hour (based on insurance claim) to equal \$676.80. This work totals \$9,114.84 (\$3,375 Superintendents, \$2,700 Electric Department staff, \$2,363.04 Wastewater Department staff, \$676.80 bucket truck).

- Clean-up/Facility Loss Optional Damages are \$141,881 plus \$9,114.84 at \$150,995.84

- 250 tons of crusher fines were installed on Market Street in 2016 after Hurricane Matthew at \$6,625 ($\26.50 per ton). The cost for a Dump Truck (FEMA Cost Code 8723) was \$7,544.64 ($\78.59 per hour for six dump trucks for two days at eight hours per day) and for a bull dozer (FEMA Cost Code 8252) was \$1,527.20 ($\95.45 per hour for one bull dozer for two days at eight hours per day). Labor was four staff for two days at \$39 per hour was \$2,496. The cost for laying the crusher fines after Hurricane Matthew was \$18,192.84 (\$6,625 material, \$7,544.64 dump truck, \$1,527.20 bull dozer, and \$2,496 personnel).

- Additional crusher fines had to be installed to maintain access to the Public Works Facility on Market Street each year since 2016. From 2017 to 2021, 100 tons were installed each year. In 2022 500 tons were installed. On average the cost per year from 2017 through 2022 was \$12,332.19 ($\$7,521.50$ for five years plus \$36,385.68 for one year = $\$73,993.15/6$ years).

-- 100 tons of crusher fines were installed on Market Street in 2017 through 2021 at \$2,650 ($\26.50 per ton). The cost for a Dump Truck (FEMA Cost Code 8723) was \$2,357 ($\78.59 per hour for three dump trucks for one day at ten hours per day) and for a bull dozer (FEMA Cost Code 8252) was \$954.50 ($\95.45 per hour for one bull dozer at 10 hours per day). Labor was four staff for four days for ten hour days at \$39 per hour was \$1,560. The cost for laying the crusher fines each year from 2017 through 2021 was \$7,521.50 ($\$2,650$ material, \$2,357 dump truck, \$954.50 bull dozer, and \$1,560 personnel).

-- 500 tons of crusher fines were installed on Market Street in 2022 at \$13,250 ($\26.50 per ton). The cost for a Dump Truck (FEMA Cost Code 8723) was \$15,089.28 ($\78.59 per hour for

six dump trucks for four days at eight hours per day) and for a bull dozer (FEMA Cost Code 8252) was \$3,054.40 (\$95.45 per hour for one bull dozer for four days at eight hours per day). Labor was four staff for four days at \$39 per hour was \$4,992. The cost for laying the crusher fines after Hurricane Matthew was \$36,385.68 (\$13,250 material, \$15,089.28 dump truck, \$3,054.40 bull dozer, and \$4,992 personnel.

- Based on the Public Works Superintendent and Town Manager estimates, annual clean-up costs continue until Market Street improvements are implemented. The cost of \$8,103.84 per year is based on three staff at \$26 per hour for four hours at five times each year (\$1,560) plus a 4.5 cy excavator at \$272.66 hour (FEMA Cost Code 8284) for three eight hour days (\$6,543.84).

- Damages After Mitigation
 - Post-mitigation expected damages are estimated to be half a day of closure in the 100-year recurrence interval storm.
 - Costs for re-surfacing is included in the maintenance figure of \$18,000 per year.
- Map Marker 4: Road Improvements, North Johnson Street (Element 5)
 - Project Useful Life
 - As per PUL Summary Table.
 - Mitigation Project Cost
 - Cost estimate is Town's on-call engineering firm estimate based on similar work done in the past. An additional \$12,000 was added based on an estimate from the previous Public Works Director for replacement/relocation of two piers for the aerial sewer line.
 - Annual Maintenance Cost
 - Cost estimate is Town's on-call engineering firm estimate based on similar work done in the past. Assumption is that the road would need to be resurfaced every 10 years. Costs were calculated based on the area of pavement within the project. The costs came from a recent cost estimate that was prepared by NCDOT with an assumed increase of 3% a year.
 - Analysis Year
 - H&H Study is from 2018.
 - Year Built
 - The year the road was built is assumed to be 1938, based on historical NCDOT maps. No maps dated prior to 1938 showing North Johnson Street extending across Driving Branch have been found.
 - Number of Trips
 - Estimated Number of One-Way Traffic Detour Trips per Day is 1,100 based on NC DOT 2021 AADT web map (<https://ncdot.maps.arcgis.com/home/webmap/viewer.html?webmap=ff72d8f962bf40ac8973669fcdc63380>).
 - Time per Trip
 - Additional time is 8-minutes per one-way trip based on the detour map provided by the Town, speed limit, and number of stop lights as interpreted by the Town Project Manager. See attached map.
 - Number of Miles
 - Additional 2.3 miles per one-way trip based on the detour map provided by the Town as interpreted by the Town Project Manager. See attached map.
 - Damages Before Mitigation
 - Past Public Works Director confirmed that the 100-year recurrence interval resulted in road closure for 14 days (damages from Hurricane Matthew in 2016).

-Electrical damages were calculated as a separate BCA Project to get the dollar value of the damages and are used as Optional Damages. The sub-station down for one day at this location on Johnson Street serves 1,158 meters. The calculation for number served is based on 2.76 people per household (Johnston County average from census data <https://www.census.gov/quickfacts/fact/table/johnstoncountynorthcarolina,NC/HSD310221>). $1158 \times 2.76 = 3196$ customers served. The Value of Unit of Service (\$/person/day) that was automatically generated was \$182. $\$182 \times 3196 = \$581,672$.

-Wastewater damages were calculated as a separate BCA Project to get the dollar value of the damages and are used as Optional Damages. This line has 65 connections, as per Town records. The calculation for number served is based on 2.76 people per household (Johnston County average from census data

<https://www.census.gov/quickfacts/fact/table/johnstoncountynorthcarolina,NC/HSD310221> . $65 \times 2.76 = 179$ customers served. The Value of Unit of Service (\$/person/day) that was automatically generated was $\$179 \times 60 = \$10,740 \times 7 \text{ days} = \$75,180 + \$10,000$ in clean-up costs. Past Public Work Director confirmed 10-year recurrence interval resulted in water line service interruption for seven days (damages from Hurricane Matthew in 2016).

- The Police Department and Fire Department provided traffic control during the 14-day road closure at a cost of \$11,051.60. Two patrol officers worked 12-hour shifts for 14 days at \$8,576.96. ($\21.88 per hour for eight hours straight time $\$175.04$ plus $\$32.82$ for 4 hours of time-and-a half at $\$131.28 = \306.32 per day for 14 days for two officers). Police Chief and Fire Chief worked for 4.5 days at $\$2,474.64$ $\$34.37$ per hour for 4.5 days at eight hours per day for two Chiefs). This work totals \$11,051.60 ($\$8,576.96$ Patrol Officers and $\$2,474.64$ Chiefs).

- North Carolina Department of Transportation identified \$9,400 in cleanup costs for North Johnson Street after Hurricane Matthew.

- Cleanup and traffic control are entered as Option Damages at \$20,451.60 for the 100-year recurrence interval ($\$9,400$ NCDOT cleanup plus $\$11,051.60$ traffic control)

-Annual clean-up costs continue until Johnson Street improvements are implemented. The cost of \$8,103.84 per year is based on three staff at \$26 per hour for four hours at five times each year ($\$1,560$), a 4.5 cy excavator at \$272.66 hour (FEMA Cost Code 8284) for three days ($\$6,543.84$).

- Annual traffic control costs when Johnson Street floods is \$1,817.70. Three officers work for four hours for each of the five estimated floods per year at \$1,560 ($\26 per hour for four hours for five events for three officers). The Police Chief works 1.5 hours for each event at $\$257.77$ ($\$34.37$ per hour for 1.5 hours for five events). This work totals \$1,817.70 ($\$1,560$ officers and $\$257.77$ Chief).

- Cleanup and traffic control are entered as Option Damages at \$9,921.54 annually ($\$8,103.84$ annual clean up plus $\$1,817.70$ traffic control)

- Damages After Mitigation
 - As stated in the Town Manager's Justification Letter, post-mitigation expected damages are estimated to be half a day of loss of service in the 100-year recurrence interval storm.
 - Costs for re-surfacing is included in the maintenance figure of \$5,900 per year.
- Map Marker 5: Potable water line floodproofing, North Johnson Street (Element 3)
 - Project Useful Life
 - As per PUL Summary Table.
 - Mitigation Project Cost
 - 200' of 6" fusible PVC will be replaced. The section crossing the stream (approximately 40') being placed in steel casing. The length of the line crossing the stream will be installed below

the stream bed (currently the line is at the bed elevation). These measures will protect the line from being impacted as it crosses the creek. This element will also include mobilization, traffic control, and erosion control.

- The cost for the water line is approximately \$80,000 based on a generalized estimate from the current Public Works Superintendent and on-call engineer. The estimate is based on 200' of 6" fusible PVC plus 40' of steel casing (\$60,000) and mobilization, traffic control, and erosion control (\$20,000).

- Annual Maintenance Cost

Annual maintenance costs are estimated to be \$302 based on 1) Annual inspection will be \$2,600 (Public Works Specialist at \$26/hr x 2 hours x 50 years) + 2) anticipated repairs every ten years will be \$12,500 (\$2,500 in repairs x 5 times). These are generalized estimates from the current Public Works Superintendent.

- Analysis Year

H&H Study is from 2018.

- Year Built

The potable water line was built in 1972 based on town records.

- Number of Customers Served

This line has 400 connections, as per Town records. The calculation for number served is based on 2.76 people per household (Johnston County average from census data <https://www.census.gov/quickfacts/fact/table/johnstoncountynorthcarolina,NC/HSD310221> . $400 \times 2.76 = 1104$ customers served. The Value of Unit of Service (\$/person/day) that was automatically generated was \$116. $\$116 \times 1104 = \$128,064$.

- Damages Before Mitigation

- Past Public Work Director confirmed 100-year recurrence interval resulted in water line service interruption for seven days (damages from Hurricane Matthew in 2016).

- The Town was billed an additional \$2,272 by the County for water during this period.

- Damages After Mitigation

As stated in the Town Manager's Justification Letter, post-mitigation expected damages are estimated to be half a day of loss of service in the 100-year recurrence interval storm.

9. Attachments in support of the BCA

- BCA Methodology (this document)
- BCA zip file export
- BCA Excel export
- BCA Text export
- BCA Report – Driving Branch Mitigation Project (all five mitigation actions)
- BCA Report – Electrical Loss of Service Project
- BCA Report – Wastewater Loss of Service
- Town Manager Justification Letter
- Johnson Street Detour Map
- Project Worksheet 1230 (DR-NC-4285)
- Project Worksheet 1537 (DR-NC-4285)
- H&H Study