Appendix A: Application Form for Grant Requests for All Categories

Virginia Department of Conservation and Recreation
Virginia Community Flood Preparedness Fund Grant Program

Name of Local Government: City of Chesapeake

Category of Grant Being Applied for (check one):

____**Capacity Building/Planning**

✓ **Project**

_____**Study**

NFIP/DCR Community Identification Number (CID) 510034

If a state or federally recognized Indian tribe, Name of tribe _____

Name of Authorized Official: Crystal Bloom, PE, LEED GA

Signature of Authorized Official: _____

Mailing Address (1): City of Chesapeake – Department of Public Works

Mailing Address (2): 306 Cedar Road

City: Chesapeake **State:** VA **Zip:** 23322

Telephone Number: (757) 382-6101 **Cell Phone Number:** ( )

Email Address: cbloom@cityofchesapeake.net

Contact Person (If different from authorized official): Deva K. Borah, Ph.D., P.E., F.ASCE

Mailing Address (1): City of Chesapeake – Department of Public Works

Mailing Address (2): 306 Cedar Road

City: Chesapeake **State:** VA **Zip:** 23322

Telephone Number: (757) 382-6101 **Cell Phone Number:** ( )

Email Address: dborah@cityofchesapeake.net

Is the proposal in this application intended to benefit a low-income geographic area as defined in the Part 1 Definitions? Yes ____ No ✓

Categories (select applicable project):

Project Grants (Check All that Apply)

- ☐ Acquisition of property (or interests therein) and/or structures for purposes of allowing floodwater inundation, strategic retreat of existing land uses from areas vulnerable to flooding; the conservation or enhancement of natural flood resilience resources; or acquisition of structures, provided the acquired property will be protected in perpetuity from further development.
- ☐ Wetland restoration.
- ☐ Floodplain restoration.
- ☐ Construction of swales and settling ponds.
- ☐ Living shorelines and vegetated buffers.
- ✓ Structural floodwalls, levees, berms, flood gates, structural conveyances.
- ✓ Storm water system upgrades.
- ☐ Medium and large scale Low Impact Development (LID) in urban areas.
- ☐ Permanent conservation of undeveloped lands identified as having flood resilience value by *ConserveVirginia* Floodplain and Flooding Resilience layer or a similar data driven analytic tool.
- ☐ Dam restoration or removal.
- ☐ Stream bank restoration or stabilization.
- ☐ Restoration of floodplains to natural and beneficial function.
- ☐ Developing flood warning and response systems, which may include gauge installation, to notify residents of potential emergency flooding events.

Study Grants (Check All that Apply)

- ☐ Studies to aid in updating floodplain ordinances to maintain compliance with the NFIP or to incorporate higher standards that may reduce the risk of flood damage. This must include establishing processes for implementing the ordinance, including but not limited to, permitting, record retention, violations, and variances. This may include revising a floodplain ordinance when the community is getting new Flood Insurance Rate Maps (FIRMs), updating a floodplain ordinance to include floodplain setbacks or freeboard, or correcting issues identified in a Corrective Action Plan.
- ☐ Revising other land use ordinances to incorporate flood protection and mitigation goals, standards and practices.
- ☐ Conducting hydrologic and hydraulic studies of floodplains. Applicants who create new maps must apply for a Letter of Map Revision or a Physical Map Revision through the Federal Emergency Management Agency (FEMA). For example, a local government might conduct a hydrologic and hydraulic study for an area that had not been studied because the watershed is less than one square mile. Modeling the floodplain in an area that has numerous letters of map change that suggest the current map might not be fully accurate or doing a detailed flood study for an A Zone is another example.
- ☐ Studies and Data Collection of Statewide and Regional Significance.
- ☐ Revisions to existing resilience plans and modifications to existing comprehensive and hazard.
- ☐ Other relevant flood prevention and protection project or study.

Capacity Building and Planning Grants

- ☐ Floodplain Staff Capacity.
- ☐ Resilience Plan Development
  - ☐ Revisions to existing resilience plans and modifications to existing comprehensive and hazard mitigation plans.
  - ☐ Resource assessments, planning, strategies and development.
    - o Policy management and/or development.
    - o Stakeholder engagement and strategies.

Location of Project (Include Maps): Greenbrier business corridor, Indian River City Watershed, Eastern Branch Elizabeth River, James River Basin

NFIP Community Identification Number (CID#):(See appendix F 510034

Is Project Located in an NFIP Participating Community? ✓ Yes ☐ No

Is Project Located in a Special Flood Hazard Area? □ Yes ✓ No

Flood Zone(s) (If Applicable): majority X (Shaded) and Zone X (0.2% chance) at towards outfall along length of improvements

Flood Insurance Rate Map Number(s) (If Applicable): 5100340016D, 5100340017D, 5100340018D, 5100340025D. 5100340026D, 5100340027D

Total Cost of Project: $1,975,398

Total Amount Requested $1,185,238

Appendix B: Scoring Criteria for Flood Prevention and Protection Projects

Virginia Department of Conservation and Recreation
Virginia Community Flood Preparedness Fund Grant Program

Applicant Name:	**City of Chesapeake**	
Eligibility Information		
Criterion	**Description**	**Check One**
1. Is the applicant a local government (including counties, cities, towns, municipal corporations, authorities, districts, commissions, or political subdivisions created by the General Assembly or pursuant to the Constitution or laws of the Commonwealth, or any combination of these)?		
Yes	Eligible for consideration	✓
No	Not eligible for consideration	
2. Does the local government have an approved resilience plan and has provided a copy or link to the plan with this application?		
Yes	Eligible for consideration under all categories	**Submitted for approval**
No	Eligible for consideration for studies, capacity building, and planning only	
3. If the applicant is <u>not a town, city, or county</u>, are letters of support from all affected local governments included in this application?		
Yes	Eligible for consideration	
No	Not eligible for consideration	
4. Has this or any portion of this project been included in any application or program previously funded by the Department?		
Yes	Not eligible for consideration	
No	Eligible for consideration	✓
5. Has the applicant provided evidence of an ability to provide the required matching funds?		
Yes	Eligible for consideration	✓
No	Not eligible for consideration	
N/A	Match not required	

Project Eligible for Consideration		✓ Yes ☐ No
Applicant Name:	**City of Chesapeake**	
Scoring Information		
Criterion	**Point Value**	**Points Awarded**
6. Eligible Projects (Select all that apply)		
Projects may have components of both 1.a. and 1.b. below; however, only one category may be chosen. The category chosen must be the primary project in the application.		
1.a. Acquisition of property consistent with an overall comprehensive local or regional plan for purposes of allowing inundation, retreat, or acquisition of structures.	**50**	
☐ Wetland restoration, floodplain restoration ☐ Living shorelines and vegetated buffers. ☐ Permanent conservation of undeveloped lands identified as having flood resilience value by *ConserveVirginia* Floodplain and Flooding Resilience layer or a similar data driven analytic tool ☐ Dam removal ☐ Stream bank restoration or stabilization. ☐ Restoration of floodplains to natural and beneficial function. ☐ Developing flood warning and response systems, which may include gauge installation, to notify residents of potential emergency flooding events.	**45**	
1.b. any other nature-based approach	**40**	
All hybrid approaches whose end result is a nature-based solution	**35**	35
All other projects	**25**	
7. Is the project area socially vulnerable? (Based on ADAPT VA's Social Vulnerability Index Score.)		
Very High Social Vulnerability (More than 1.5)	**15**	
High Social Vulnerability (1.0 to 1.5)	**12**	
Moderate Social Vulnerability (0.0 to 1.0)	**8**	X ¼ = 2
Low Social Vulnerability (-1.0 to 0.0)	**0**	X ¾ = 0
Very Low Social Vulnerability (Less than -1.0)	**0**	

8. Is the proposed project part of an effort to join or remedy the community's probation or suspension from the NFIP?		
Yes	**10**	
No	**0**	0
9. Is the proposed project in a low-income geographic area as defined in this manual?		
Yes	**10**	
No	**0**	0
10. Projects eligible for funding may also reduce nutrient and sediment pollution to local waters and the Chesapeake Bay and assist the Commonwealth in achieving local and/or Chesapeake Bay TMDLs. Does the proposed project include implementation of one or more best management practices with a nitrogen, phosphorus, or sediment reduction efficiency established by the Virginia Department of Environmental Quality or the Chesapeake Bay Program Partnership in support of the Chesapeake Bay TMDL Phase III Watershed Implementation Plan?		
Yes	**5**	
No	**0**	0
11. Does this project provide "community scale" benefits?		
Yes	**20**	20
No	**0**	
Total Points		**57**

Appendix D: Checklist All Categories

Community Flood Preparedness Fund Grant Program

Scope of Work Narrative	
Supporting Documentation	**Included**
Detailed map of the project area(s) (Projects/Studies)	✓ Yes □ No □ N/A
FIRMette of the project area(s) (Projects/Studies)	✓ Yes □ No □ N/A
Historic flood damage data and/or images (Projects/Studies)	✓ Yes □ No □ N/A
A link to or a copy of the current floodplain ordinance	✓ Yes □ No □ N/A
Non-Fund financed maintenance and management plan for project extending a minimum of 5 years from project close	✓ Yes □ No □ N/A
A link to or a copy of the current hazard mitigation plan	✓ Yes □ No □ N/A
A link to or a copy of the current comprehensive plan	✓ Yes □ No □ N/A
Social vulnerability index score(s) for the project area from ADAPT VA's Virginia Vulnerability Viewer	✓ Yes □ No □ N/A
If applicant is not a town, city, or county, letters of support from affected communities	□ Yes □ No ✓ N/A
Completed Scoring Criteria Sheet in Appendix B, C, or D	✓ Yes □ No □ N/A
Budget Narrative	
Supporting Documentation	**Included**
Authorization to request funding from the Fund from governing body or chief executive of the local government	✓ Yes □ No □ N/A
Signed pledge agreement from each contributing organization	□ Yes □ No ✓ N/A

A. Scope of Work Narrative – Projects

All applications must include a Scope of Work Narrative that clearly describes the proposed project or study, including supporting documentation as necessary. It may be helpful to review the checklist in Appendix C to ensure that the application includes all the required elements. The Scope of Work narrative for all applications should address the following elements.

1. ***Project Information***: Describe in detail the area to be studied or protected including the following. *Note that information should be provided on the local government(s) in which the project is taking place, even if that local government it is not the grant applicant*. Projects undertaken by municipal corporations, authorities, districts, commissions, or political subdivisions created by the General Assembly or pursuant to the Constitution or laws of the Commonwealth, or any combination of these, must be consistent with resilience plans and efforts in the local government where the project takes place. Letters of support from affected local governments must be included with the application.

This application is for the project known as Greenbrier Outfall Resiliency Improvements Phase I & II. This project was included in the Chesapeake Preliminary Resilience Plan submitted for approval concurrent with this application. The City of Chesapeake has engaged a consultant, GKY & Associated, to study this area and identify improvements to alleviate flooding during extreme storm events. GKY performed hydrologic and hydraulic analysis and developed the Greenbrier Resiliency Plan in late 2020. The Plan has been included as *Attachment 1*.

Attachment 1 **provides a detailed description of the project, background, site, analysis, and recommended improvements. Detailed map of the project area including drainage area and area to be protected by this project can be found in the Figures section starting on page 34 of this document.**

- Population
  - Provide population data for the local government in which the project is taking place, including identification of any low-income geographic area and the estimated number of residents that will be impacted by this project.

Population data for Chesapeake – 249,422 as of 2020 Census

Identification of any low-income geographic area that will be impacted by the project: none

The estimate number of residents impacted by the project: 10,620

- Historic flooding data and hydrologic studies projecting flood frequency
  - Provide information on the flood risk of the project area, including whether the project is in a mapped floodplain, what flood zone it is in, and when it was last mapped. If the property or area around it has been flooded before, share information on the dates of past flood events and the amount of damage sustained.

Flood risk of the project area: The majority of the drainage area is in flood zone X (Shaded) with the most downstream portion in Flood Zone X (0.2% chance) where the two (2) improvements will be made. The area was last mapped in 2014. See *Attachment 2* for the FIRMette of the project area.

Information on the dates of past flood events and the amount of damage sustained: The GKY study used flooding data from Hurricane Matthew in October 2016 for calibration. That documentation is provided on pages 20 & 21 of *Attachment 1*.

Other flooding data has been packaged and provided as *Attachment 3*. These include a map of known flooding locations where high water signs have been installed as well as records of work orders that have been generated based on flooding complaints.

- The ability of the local government to provide its share of the cost
  - This must include an estimate of the total project cost, a description of the source of the funds being used, evidence of the local government's ability to pay for the project in full or quarterly prior to reimbursement, and a signed pledge agreement from each contributing organization.

Estimate of total project cost: $1,975,398

Source of the funds being used: Capital Improvement Budget funds encumbered to CIB 29-230

Evidence of Ability to Pay: See Budget Narrative and referenced Attachments

Signed Pledge Agreement: N/A

- The administration of local floodplain management regulations
  - The Department will determine if the community is in good standing with the NFIP. If applicable, provide the Department with a link to the current floodplain ordinance, or attach a PDF or Word document of the ordinance.

Link to a copy of the current floodplain ordinance:

ADOPTED+Floodplain+Ordinance--7-16-2013.pdf (cityofchesapeake.net)

- Other necessary information to establish project or study priority
  - Repetitive Loss and/or Severe Repetitive Loss Properties
    - Do not provide the addresses for these properties, but include an exact number of repetitive loss and/or severe repetitive loss structures within the project area. Work with the local floodplain administrator or emergency manager to find this information. If they do not have a list of repetitive loss/severe repetitive loss structures, the Department can assist them in accessing these lists.

Exact number of repetitive loss /severe repetitive loss structures within the project area: 0

  - Residential and/or Commercial Structures
    - Describe the residential and commercial structures impacted by this project, including how they contribute to the community such as historic, economic, or social value. Provide an exact number of residential structures and commercial structures in the project area.

Description of the Area: The majority of the area impacted by the project is commercial in nature. It is one of the City's major business corridors. However, there are some residential properties within the drainage area as well.

Exact number of residential structures and commercial structures within the project area: There are 3,848 residential structures and 700 commercial structures in the project area. There are also 32 government buildings.

- Critical Facilities
  - If there are critical facilities within the project area, describe each facility. Critical facilities are those that provide services and functions essential to the community, including hospitals, fire stations, police stations, storage facilities for critical records, power plants, and wastewater treatment plants, among others.

There are 7 critical facility in the project area:

1. **Station – 5th Precinct - Greenbrier, police station**
2. **Childrens Health Systems Inc, medical**
3. **Southeastern Virginia Training Center, special needs**
4. **Public Works Operations Center**
5. **Davita Ches Dialysis Center, medical**
6. **Indian River High School, shelter**
7. **Station 14, fire station**

2. ***Need for Assistance*:** Identify and describe any relevant issues or problems that will be addressed by the project.

   - Explain the local government's financial and staff resources. How many relevant staff members (floodplain administrators, planners, emergency managers, building officials, engineers) does the local government have? To what relevant software does the local government have access? What are the local government's capabilities?

The majority of City infrastructure improvements are funded through the Capital Improvement Budget. The approved FY22 CIB is available at: Adopted+CIP+Document+FY+22-26+update.pdf (cityofchesapeake.net)

Number of relevant staff members:

- **1 Floodplain Administrator**
- **1 additional Certified Floodplain Manager**
- **7 Stormwater Engineers**
- **1 Plan Review & Codes Administrator**
- **1 Permit Services Administrator**
- **1 Principal Planner**
- **2 Senior Planners**
- **1 Deputy Coordinator of Emergency Management**

Relevant Software: Accela for plan review, numerous stormwater modeling programs (SWMM, Autodesk Hydraflow, Autodesk Storm & Sewer Analysis, Bentley Civil Storm, Culvert Master, etc.), Microsoft Office Suite, ArcGIS

Capabilities: The City has several teams within Public Works to manage the study, design and construction work performed by consultants and contractors. One of the teams also takes on in-house design for small projects that can be accomplished using on-call contractors. There is a team that focuses solely on managing construction and includes engineers as well as inspectors.

- The Department will prioritize low-income geographic areas for funding. Low-income geographic area means any locality or geographic area within a locality that may cross municipal or county boundaries, that has a median household income that is not greater than 80 percent of the local median household income, or any area in the Commonwealth designated as a qualified opportunity zone by the U.S. Secretary of the Treasury via his delegation of authority to the Internal Revenue Service.

This project DOES NOT impact low-income geographic areas.

- The Department will consider the project area's social vulnerability index score when reviewing grant applications. The Social Vulnerability Index, available through ADAPT Virginia's Virginia Vulnerability Viewer, will be used for this review.
- This index is based on census tract data; the index score for the census tract that contains the project area should be used. If the project area falls within multiple census tracts, please provide the scores for all census tracts. The average score for the project area will be used for scoring the application.
    - For more information on social vulnerability, please see ADAPT Virginia's fact sheet.

This map has been provided as *Attachment 4.* The project area spans several census tracts, three (3) of which have a low social vulnerability score while one (1) scores as medium.

2. ***Alternatives*:** If the project proposed does not employ a nature-based or hybrid solution and the total project cost is greater than $3 million, describe at least one alternative that could reasonably address the issue identified. Please also consider the No Action Option as a third alternative as part of the analysis. Explain these alternatives and the reason the proposed project was selected.

Not applicable since the total project cost is less than $3M dollars.

3. ***Goals and Objectives:*** Identify and describe the goals and objectives of the project. Include a description of the expected results of the completed project and explain the expected benefits of the project. This may include financial benefits, increased awareness, decreased risk, etc.

Lower Indian River High School lake weir and upsize existing poor-condition box culvert under S. Military Hwy to lower upstream hydraulic grade line and provide additional flood storage in Greenbrier business corridor.

Goal 1. Reduce the frequency and severity of flooding impacts to the project area during extreme storm events. A combination of these improvements along with an additional future phase provide protection equivalent to a 1000-yr storm event. Details of the analysis can be found in *Attachment 1.*

- **Objective 1.1 Increase water storage by lowering the weir at Indian River High School.**
- **Objective 1.2 Increase water storage capacity by upsizing the existing box culvert under S. Military Highway.**

The expected results and benefits of the project are in line with the project goals to decrease flooding risk. Additional benefits include decreased financial burden and loss associated with flooding as well as increased circulation in the business district leading to reduced loss of business.

4. ***Approach, Milestones, and Deliverables*:** Outline a plan of action laying out the scope and detail of how the proposed work will be accomplished with a timeline identifying expected completion dates. Determine milestones for the project that will be used to track progress. Explain what deliverables can be expected at each milestone, and what the final project deliverables will be. Identify other potential project partners.
    - If assistance is sought for a project that will be carried out in concert with a federal agency, provide evidence of an agreement with the federal agency endorsing the project.

The design has not yet started for this project.

Once the grant has been awarded, the City will engage one of their on-call consultants to develop a scope of work to design the project. The following is the anticipated schedule including milestones – used to track progress – and dates through construction of the project.

Milestone	Period Of Performance	Delivery After Grant Award
Design Consultant NTP	**3 months**	**3 months**
Development of Construction Docs	**15 months**	**18 months**
Environmental Permitting	**N/A**	**Concurrent with design**
Advertise for Bid	**2 Months**	**20 months**
Construction NTP	**4 months**	**24 months**
Construction Completion	**9 months**	**33 months**

5. ***Relationship to Other Projects*:** Where applicable, briefly describe the relationship between this project and other past, current, or future resilience projects. If the applicant has received or applied for any other grants or loans, please identify those projects, and, if applicable, describe any problems that arose with meeting the obligations of the grant and how the obligations of this project will be met.

This project has been identified in the City of Chesapeake Preliminary Resilience Plan that was submitted concurrent with this application. There is another phase of this project planned. It has also been included in the City Resilience Plan but the work for Phases I & II will be done prior to the future Phase III project. This project is not currently under consideration for any other grants or loans.

6. ***Maintenance Plan:*** For ongoing projects or projects that will require future maintenance, such as infrastructure, flood warning and response systems, signs, websites, or flood risk applications, a maintenance and management plan for the projects must be provided demonstrating how they will be maintained after the lifespan of this grant for a minimum of five years. Ongoing operation and maintenance will be the financial responsibility of the grantee and will not be eligible for monies from the Fund.

Annual inspection and maintenance for this project shall be performed by City staff as is required by the City of Chesapeake Phase I MS4 permit. The City follows standard operating & maintenance procedures established internally and by state organizations including DEQ and VDOT for O&M of stormwater infrastructure. See *Attachment 5* for the following documents:

- **Drainage Infrastructure Management (Storm Pipe/Cave-In/Ditch) - see attached PW Regulation 755.**
- **Stormwater Operation Plan (BMP) - see attached PW Regulation 756, which references the PFM that refers to the DEQ BMP Design Specifications.**
- **Weir structures - see excerpt for the Principal Spillway from DEQ BMP Design Specs**
- **Box Culvert - see excerpt from VDOT Maintenance Best Practices .**

The total project cost as identified in the application is for design and construction only. Funding for maintenance is non-fund financed.

7. ***Criteria:*** Describe how the project meets each of the applicable scoring criteria contained in Appendix B, and provide the required documentation where necessary. Documentation can be incorporated into the Scope of Work Narrative or included as attachments to the application. Appendix B must be completed and submitted with the application.

   For local governments that are not towns, cities, or counties, the documentation provided for the criteria below should be based on the local government or local governments in which the project is located and/or directly impacts.

   1. Is the applicant a local government (including counties, cities, towns, municipal corporations, authorities, districts, commissions, or political subdivisions created by

the General Assembly or pursuant to the Constitution or laws of the Commonwealth, or any combination of these or a recognized state or federal Indian tribe?

The applicant, the City of Chesapeake, is a local government.

2. Does the local government have an approved resilience plan meeting the criteria as established by this grant manual? Has it been attached or a link provided?

The applicant received grant funding in a previous CFPF grant round to develop a Resilience Plan. The Preliminary Resilience Plan developed under that scope of Word has been submitted for approval along with this project grant application and has been included as *Attachment 6.*

3. For local governments that are not towns, cities, or counties, have letters of support been provided from affected local governments?

N/A.

4. Has the applicant provided evidence of an ability to provide the required match funds?

Yes, see Budget Narrative and referenced Attachments.

5. Has the applicant demonstrated to the extent possible, the positive impacts of the project or study on prevention of flooding?

Yes, see Scope of Work Narrative A.3. Goals and Objectives and reference Attachments.

Additional Supporting Documentation

- A link to or a copy of the current hazard mitigation plan

  Hampton Roads Hazard Mitigation Plan | Emergency Management | Departments | Departments | Emergency Management | Departments | Departments | Hampton Roads Planning District Commission (hrpdcva.gov)
- A link to or a copy of the current comprehensive plan

  Comprehensive Plan 2035 (cityofchesapeake.net)

- Completed Scoring Criteria Sheet

  The Completed Appendix B: Scoring Criteria for Flood Prevention and Protection Projects follows the Appendix A: Application Form.

B. Budget Narrative- Required for All Grant Categories

Each application must include a detailed Budget Narrative explaining all proposed expenditures. A budget narrative is applicable to requests from any category of grants in this manual. The following items must be included in the Budget Narrative:

● *Estimated total project cost*: **$1,975,398**

This amount represents the estimated total project cost including engineering ($355,702) and construction ($1,619,696). See pages 50 and 51 of *Attachment 1* for a detailed breakdown of the estimated total project cost. A 20% increase was applied to these values to account for present day costs as well as observed increases in the construction industry.

● *Amount of funds requested from the Fund*: **$1,185,238**

This is the total amount of any grant assistance sought from the Fund. It represents 60% of the estimated total project cost.

Estimated Funding Request Breakdown
- **Salaries, 0**
- **Fringe Benefits, 0**
- **Travel, 0**
- **Equipment, 0**
- **Supplies, 0**
- **Construction, $971,818**
- **Contracts, $213,420**
- **Other Direct Costs, 0**

● *Amount of cash funds available*: **$790,160**

The source of these funds is CIB 29-230.

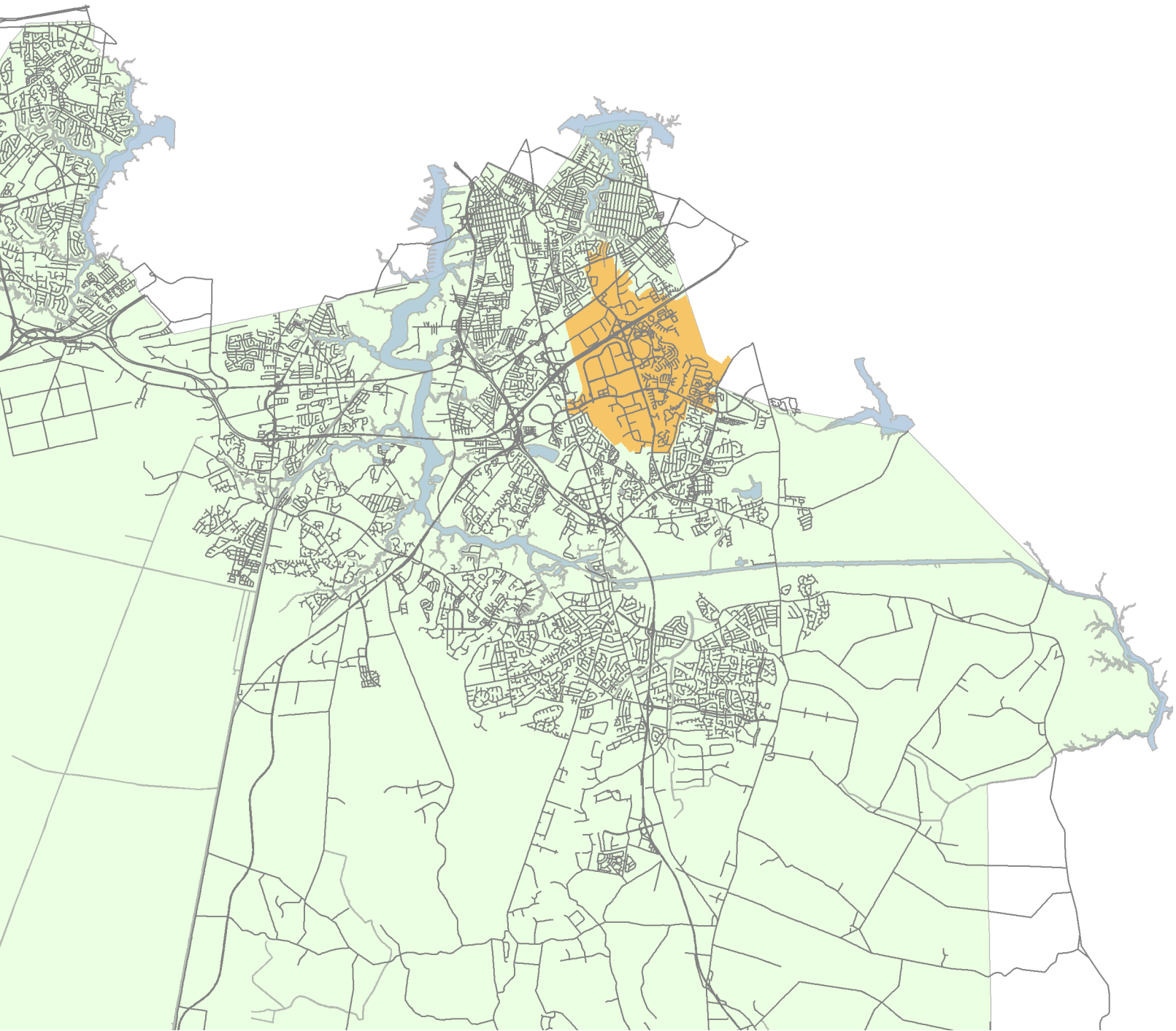
See *Attachment 7* for a letter indicating the availability of and ability to obtain funding for the local match including a description of the fund allowable expenditures and funding plan as well as a financial statement indicating sufficient funds to cover the match requirement for this grant application.

● *Authorization to request for funding: Local governments seeking funding shall also attach signed documentation authorizing the request for funding.* (**Supporting Documentation**.)

See *Attachment 7* for a letter authorizing a request for funding through the program.

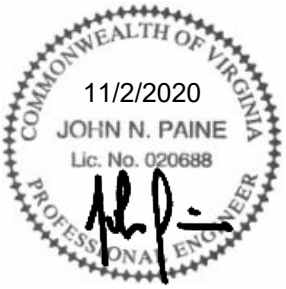
GREENBRIER RESILIENCY PLAN

November 2020



GREENBRIER RESILIENCY PLAN

November 2020



Prepared For:

Chesapeake VIRGINIA

City of Chesapeake
Department of Public Works
306 Cedar Road
Chesapeake, VA 23322

Prepared By:

GKY

GKY & Associates, Inc.
117 Herman Melville Avenue
Newport News, VA 23606

GKY No. 2017-018 TO#12

Digital Document Note: Printing these types of reports can add well over $1,000 to the delivery cost and creates the need for additional handling and filing. To avoid wasteful spending and maximize efficient use, this report is formatted for delivery as a digital document. Fonts and details are preserved for tight zooming. Users may find it convenient to make a second digital copy of this report (with a different filename) and read each on separate monitors. For example, the left monitor can display figures and tables while reading text on the right monitor.

Table of Contents

Please note that page numbers are matched to the pdf file. The cover is page 1, title page is 2, table of contents is 3, and so on.

Acronyms & Definitions

The following acronyms apply to this document and ancillary material:

BRIC	Building Resilient Infrastructure and Communities (a FEMA grant program)
CIP	Capital Improvement Program
City	unless specifically stated otherwise, the City of Chesapeake, Virginia
CLOMR	Conditional Letter of Map Revision
CWA	Clean Water Act
CRS	Community Rating System
DCR	Virginia Department of Conservation and Recreation
DEM	Digital Elevation Model
DEQ	Virginia Department of Environmental Quality
DSFPPAF	Dam Safety, Flood Prevention and Protection Assistance Fund (administered by DCR)
EPA	U.S. Environmental Protection Agency
ESA	Engdangered Species Act
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FHWA	U.S. Federal Highway Administration
FMA	Flood Mitigation Assitance (a FEMA grant program)
GKY	GKY & Associates, Inc. (see www.gky.com)
JPA	Joint Permit Application
LOMR	Letter of Map Revision
MDP	Master Drainage Plan
MDPU	Master Drainage Plan Update
MS4	Municipal Separate Storm Sewer System
MTD	Manufactured Treatment Devices
NAVD88	North American Vertical Datum of 1988
NEPA	National Environmental Policy Act
NFIP	National Flood Insurance Program
NGVD29	National Geodetic Vertical Datum of 1929
NHPA	National Historical Preservation Act of 1966
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
PCSWMM	an enhanced graphical user interface to the SWMM engine produced and marketed by Computational Hydraulics International. PCSWMM runs the EPA SWMM engine and provides a wide assortment of add-on utilities and tools.
PDF	Portable Document Format—the Adobe Acrobat file format used for this (and many other) electronic documents
ROG	Rain-on-Grid
SLAF	Stormwater Local Assistance Fund (administered by DEQ)
SWCB	Virginia State Water Control Board
SWMM	Storm Water Management Model, originally developed (and currently authorized) by EPA.
TMDL	Total Maximum Daily Load
VDOT	Virginia Department of Transportation
VERTCON	datum conversion tool produced by NOAA (https://www.ngs.noaa.gov/cgi-bin/VERTCON/vert_con.prl)
VMRC	Virginia Marine Resoucres Comission
VPDES	Virginia Pollutant Discharge Elimination System
VRA	Virginia Resources Authority
VRRM	Virginia Runoff Reduction Method, administered by DEQ
VSMP	Virginia Stormwater Management Program
WOTUS	Waters of the United States

The following rainfall event definitions apply to this document:

D6 Six inches of effective rainfall applied to the watershed in the shape of a 24-hour, NOAA Type C hyetograph. This event is analogous to a 100-year storm event.

D9 Nine inches of effective rainfall applied to the watershed in the shape of a 24-hour, NOAA Type C hyetograph. This event is analogous to a 1,000-year storm event.

D12 Twelve inches of effective rainfall applied to the watershed in the shape of a 24-hour, NOAA Type C hyetograph. This event is analogous to an event that is much more severe than a 1,000-year storm event.

Matthew Effective rainfall constructed from rain gage data collected at City Hall on October 8 and 9, 2016.

GREENBRIER RESILIENCY PLAN

November 2020

1. Executive Summary

Engineers from the City of Chesapeake, Department of Public Works, and GKY & Associates, Inc. have completed a Resiliency Plan for the Greenbrier Drainage Area, within the Indian River Creek Watershed.

The need for this plan was demonstrated during Hurricane Matthew[1]. Although the existing drainage system functions reasonably well during heavy rainfall events, key roadway intersections experience prolonged flooding during extraordinary storms. Eden Way North, Executive Boulevard, Greenbrier Parkway, Volvo Parkway, and other streets became impassible during Matthew, and the floodwaters were slow to recede.

The goal of this study is to identify potential projects to lower flood elevations and reduce the duration of flooding during an extreme storm event. The engineering approach is different from routine master drainage plans and stormwater management designs because the scale of the problem is so much larger. This study evaluated rainfall events having average recurrence intervals on the order of 100 to well over 1,000 years.[2]

GKY engineers created computer models of existing watershed conditions and incorporated potential projects to evaluate their resilience potential. The models were built using recent 3D LiDAR-derived terrain data, so flood depths and overland flows are much more reliably computed than using simpler methods.

Aerial photographs were taken during Hurricane Matthew at 7:00 a.m. on October 9, 2016 showing flooding on the ground at that time. Rainfall was reliably recorded at Chesapeake City Hall, 3½ miles from the center of the drainage area. GKY used the rainfall record and aerial photographs to calibrate the computer model, which was then used to configure and evaluate the benefits of potential flood improvement projects.

The modeling highlights the challenges of making cost-effective improvements to reduce flood levels and durations in an urbanized watershed. The results are useful not only for showing what would work, but also for avoiding projects that would not provide any appreciable benefits.

After analyzing existing problems in this watershed, the engineering team has identified three potential improvement projects (indicated with green shading in Figure 9) that can alleviate future flooding, including:

1. **Indian River High School Lake Weir:** Lower the existing weir at Indian River High School Lake from a crest elevation of 8.1 to 6.1 feet—which will lower hydraulic grade lines and provide additional flood storage;
2. **South Military Highway Culvert Replacement:** Replace the existing 6'Hx10'W box culvert under South Military Highway with a double 8'x8' box culvert, which will lower hydraulic grade lines; and
3. **I-64 Additional Culvert:** Add a 60" circular culvert under I-64, just to the east of the existing triple 9'x9' box culvert—which will lower the permanent pool elevations of upstream impoundments to create 350 acre-feet or so of new flood storage.

These three potential projects are documented below and in the report figures that follow. The projects may be implemented with some assurance that the impacts on the watershed have been adequately considered.

[1] Hurricane Matthew dropped over 11 inches of rain on October 8 and 9, 2016.
[2] Drainage and stormwater management designs typically accommodate storms that have an average recurrence interval of 10 to 100 years.

Some of the conceptual designs may need to be modified—as wetlands regulations, development sequencing, flooding issues, soil properties, risk tolerance, and economic considerations come into play.

Virginia has undertaken several initiatives in recent years to improve flood resiliency and incorporated them into a comprehensive 2020 guidance document entitled *Virginia Coastal Resilience Master Planning Framework*[3]. The projects identified in this Greenbrier Resiliency Plan should fit nicely within the goals and objectives laid out in the State's framework and should qualify for grant funding to some degree.

Appendix A provides conceptual cost opinions for all three projects, and potential grant opportunities are noted in Section 9 and Table 4. Project costs can be refined when preliminary engineering plans are prepared. The cost of the most expensive project, the I-64 Additional Culvert, is dependent upon two factors that are currently unknown. First, the additional culvert is priced for installation by microtunneling, which works better in poor soil conditions and is less likely to cause subsidence problems under I-64 than a jack-and-bore installation. If geotechnical engineering can demonstrate that jack-and-bore construction would be acceptable to the City and VDOT, the cost of the project could be reduced by as much as $1,000,000. Secondly, the modeling conducted for this study shows that one 60" circular culvert would significantly improve the resilience of the Greenbrier system, but the City may choose to use a larger culvert, or add a second new barrel, to reduce the risk of blockages and to shorten the drawdown time in the upstream drainage system. Section 8, below, describes the potential benefit of increased discharge capacity under I-64.

There are many combinations of drainage improvements that can be evaluated in any watershed. While a substantial effort has been applied to develop this study, it is by no means exhaustive. The intent of this undertaking was not only to develop sound alternatives for resilience improvements but also to leave the underlying data files and computer models so that they can be used in the future.

The maximum computed water surface elevations for existing and future conditions at key locations are presented in Table 2 and shown for the D9 design storm in Figures 10 through 12. Table 2 quantifies the reduced flood elevations that can be achieved through construction of the three improvement projects for three specific design scenarios (i.e., the D6, D8, D12 storms, described in Section 4, below).

FEMA flood insurance studies and rate maps are the definitive sources of floodplain limits and elevations in all cases. The models developed for this plan are specific design scenarios—THESE RESULTS ARE NOT TO BE CONSTRUED AS INDICATIVE OF EXPECTED WATER SURFACE ELEVATIONS FOR THE PURPOSES OF FLOODPLAIN MANAGEMENT AND/OR INSURANCE REQUIREMENTS. The models developed for this plan could be adapted for use in the National Flood Insurance Program and submitted to FEMA for approval, but until they are vetted and approved through that process, the published flood insurance studies and rate maps remain fully in effect.

2. Background

The purpose of this study is to identify specific potential improvement projects that could be constructed to improve flood resilience. The Greenbrier Drainage Area was selected because the drainage and stormwater management systems generally work well for storms up to approximately the 100-year level, but extraordinary storms, such as Hurricane Matthew, flood roadway intersections that can take many hours to become passible.

URS Corporation prepared a master drainage plan update for the Indian River Watershed (which includes the Greenbrier Drainage Area) in 2011. The underlying modeling was completed using 1D SWMM methodology and focused on design rainfall events having average recurrence intervals from 10 to 100 years. City crews performed field surveying to support the 2011 update, documenting major culvert crossing geometry and invert elevations. GKY has used the modeling and surveying data from that effort to build the models for the

[3] See https://www.governor.virginia.gov/media/governorvirginiagov/governor-of-virginia/pdf/Virginia-Coastal-Resilience-Master-Planning-Framework-October-2020.pdf.

current study. Although the focus of this 2020 study is on extreme storm events, and the technical modeling approach is very different, the results of the two studies are consistent. In context, both studies show that increasing the conveyance of the Greenbrier backbone drainage system by increasing culvert capacity at strategic locations will lower future flood levels. The 2020 study further shows that lowering the permanent pool elevations of the Greenbrier impoundments will provide substantial volumes of new, useful flood storage that will improve the resiliency of the watershed for extreme storm events.

The City is actively engaged in the NFIP and CRS programs and complies with laws and regulatory initiatives, such as the Chesapeake Bay Act, the Chesapeake Bay TMDL, the Virginia Stormwater Management Act, the Virginia Erosion and Sediment Control Law, and the Virginia Stormwater Management Program. These and other regulatory programs require considerable non-structural approaches to reduce flooding—such as requiring runoff reduction for development and redevelopment, setting minimum standards for structure locations and elevations, and educating citizens and soliciting their input and participation in programs to reduce the generation of stormwater runoff and minimize exposure to flooding.

These initiatives are invaluable and extremely cost-effective, particularly concerning future development. However, where older infrastructure meets sea level rise and climate change, structural improvements are a vital part of the City's overall approach to flood mitigation. This study focuses on identifying specific potential improvement projects and opportunities.

Significant climate change has occurred since the drainage systems in this watershed were originally constructed. Sea level rise and higher annual rainfall volumes, coupled with increases in impervious cover (that lead to increased runoff), have contributed to increases in the magnitude and frequency of flooding over the past 60 years. These issues were not well understood in the past and were not fully addressed in drainage design and stormwater management planning. Modern engineering tools, a better understanding of climate processes, and higher design standards—all of which the City now employs—were not available when many of the Greenbrier drainage systems were designed and built. As a result, some of the pipe and channel systems are undersized for current conditions.

3. Technical Approach

GKY used the U.S. Army Corps of Engineers HEC-RAS software to perform the ROG modeling. This software is free to the public and can be readily downloaded and used by City engineers without paying any fees. The software is available to download from https://www.hec.usace.army.mil/software/hec-ras/download.aspx, and manuals and reference documents—including 2D references—are at https://www.hec.usace.army.mil/software/hec-ras/documentation.aspx.

Construction of the models required careful terrain processing and data entry of approximately 50 significant culvert crossings. Secondary underground drainage system components were not included in the modeling. This type of ROG approach offers appreciable advantages over 1D SWMM modeling because surface flooding and flow routing are computed using a 3D surface model. The substantial assumptions required in 1D SWMM modeling when hydraulic grade lines rise above the ground are eliminated in ROG modeling. Likewise, flows are computed over the entire terrain, not merely along assumed 1D flow paths.

2013 Digital Elevation Model (DEM) data served by the Virginia Geographic Information Network (VGIN) division of the Virginia Information Technologies Agency was used to create a 3D surface model of the subject watershed. GKY refined this surface model to incorporate grading changes that have occurred since the 2013 data was flown and that could affect flood mapping—such as the Dollar Tree development between Volvo Parkway and Eden Way North. Figures 1 and 4 depict the modified terrain.

GKY constructed finite element mesh components on the modified terrain and input major culverts (plotted as maroon lines in Figure 5) along the backbone drainage system. Existing culvert geometry was taken from the 2011 MDPU SWMM model. Different modeling scenarios had different culvert configurations; the

configuration shown in Figure 5 includes a new culvert crossing under I-64 just to the east of the triple 9'x9' box culverts.

It is neither cost-effective nor prudent to model underground drainage pipes for this type of analysis—because flows in smaller drainage pipes are insignificant when the system is overwhelmed or completely submerged by extremely heavy rainfall. Likewise, FEMA does not typically model smaller pipe systems in producing flood insurance rate maps.

HEC-RAS does not, as of fall 2020, address infiltration and other losses from rainfall. Instead, the rainfall applied in the model is the 'effective' rainfall—i.e., that portion of rainfall that is not lost to infiltration, evaporation, transpiration, and abstractions. The approach used to develop effective rainfall for these models is described in the following section.

For this analysis, the rain-on-grid models will use 6-, 9-, and 12-inches of effective rainfall in the form of a NOAA 24-hour, Type C hyetograph. GKY also used rainfall and anecdotal water depth information for Hurricane Matthew to check the ROG, existing condition model, as described in the following section.

Methodology, data sources, and approaches used in this modeling include:

- NRCS Type C design storm hyetographs;
- Hurricane Matthew rainfall (provided by the City) and anecdotal information on flooding locations and levels (most helpfully in the form of aerial photographs taken at 7:00 a.m., October 9, 2016)
- FHWA culvert methodology for all culverts included in the models;
- Full momentum equation solutions for overland flow routing on the 2D mesh surfaces;
- A three-second computational time step;
- "No-Rain" models to generate restart (*.rst) files with initial water surface elevations in the drainage system at the start of each simulation;
- Simulation times up to 144 hours (to evaluate drawdowns of the impoundments);
- GIS data served through ArcGIS online and the City's Open GIS Data Portal; and
- HEC-RAS Version 5.07 software.

4. Effective Rainfall

Most drainage and stormwater management studies and designs employ some estimate of average recurrence interval as the basis for calculations. For example, engineers use a rainfall depth deemed statistically to have an average recurrence interval of 10- or 100-years to compute flood elevations and flows. Many assumptions and intermediate calculations are involved, but the resulting product is said to be a 10- or 100-year design. The expectation is that these designs can accommodate storm events that will be exceeded, on average, only once every 10 or 100 years.

The Rational Formula, developed over 130 years ago, is still the most widely used and trusted method to compute design flows in drainage pipes. It's longevity and popularity derive from its simplicity and the fact that designs built using the Rational Formula seem to have worked well. A simple 'C' coefficient converts the applied rainfall into surface runoff. Hydrologic processes in the watershed—such as infiltration, abstractions, evapotranspiration, and interception—are lumped into the C coefficient.

As engineering capabilities progressed, new formulas and methods were developed to compute surface runoff from applied rainfall. Soil equations, overland flow and culvert hydraulics, and design rainfall hyetographs were developed to increasing levels of complexity—all requiring additional levels of input data. The onset of computer modeling tools and geographic information systems made it possible to carry the computations and methods to deeper levels. As the complexity grew, so did the assumptions in the computational processes.

However, with climate change and increased impervious cover from development activities, what has worked in the past does not necessarily work well today. Assigning average recurrence intervals to designs can give citizens and policy makers a false sense of security and create a great deal of confusion with the public—who mistakenly assume that they will almost never be affected by such events. When heavy rainfalls happen, municipal engineers and officials must deal with unmet public expectations.

HEC-RAS does not currently compute losses from rainfall. The rainfall applied in the model is the 'effective' rainfall—i.e., that portion of rainfall that is not lost to infiltration, abstractions, evapotranspiration, and interception. What is simplified in terms of hydrology is more than made up for in surface hydraulics capabilities. Soils can be modeled for infiltration effects using other software, but soil modeling involves assumptions about physical soil properties and antecedent conditions that are difficult to justify in highly developed areas like Greenbrier where the native soils have been covered and compacted with imported topsoil.

GKY recommends basing resiliency modeling on design storm events that are specified as *inches of effective rainfall*, without specifying the return period. For example, 6-, 9-, and 12-inch, 24-hour NOAA Type C effective rainfall design storms can be used for resiliency analyses and the results reported without return periods. GKY uses this approach with other clients who are working on resiliency modeling.

To give some perspective, Hurricane Matthew produced 11.96 inches of rainfall over 27.5 hours (recorded at City Hall and plotted in Figure 3). A 6-inch effective rainfall would be on the order of a 100-year event, a 9-inch effective rainfall would be on the order of a 1,000-year event, and a 12-inch effective rainfall would have an average recurrence interval well in excess of 1,000 years. However, GKY believes it is best not attempt to link effective rainfall depths to average recurrence intervals.

For this analysis, the ROG models used 6-, 9-, and 12-inches of effective rainfall in the form of a NOAA 24-hour, Type C hyetograph. Anecdotal flood depth information for Hurricane Matthew provided by the City, as listed in Table 1, was used to check the validity of the ROG existing condition model. This validity check involved adjusting the recorded rainfall and HEC-RAS modeling parameters until a good match was achieved between the model results and anecdotal data. Figures 6, 7, and 8 show very close agreement between the aerial photographs (taken at 7:00 a.m. on October 9, 2016) and the ROG model results. Trial-and-error modeling showed that a conversion factor of 81% (i.e., assuming that 81% of the recorded rainfall contributed to runoff) produced the best match.

5. Vertical Datum

The **National Vertical Datum of 1988 (NAVD88)** was used throughout this study. All elevations used in the modeling and improvement alternatives are referenced to the NAVD88 datum.

6. Modeling Configurations (Scenarios)

GKY created three groups of HEC-RAS modeling scenarios for this analysis:

- Hurricane Matthew,
- Unimproved (Existing Conditions for D6, D9, and D12 rainfalls), and
- Improved (Proposed Conditions for D6, D9, and D12 rainfalls).

Due to differing geometry files, each scenario required a "no-rain" model run to set initial heads and flows in the Greenbrier drainage system. The results of the no-rain runs were used as initial conditions in the subsequent modeling.

As described elsewhere in this report, scores of runs were made during the resiliency analysis. HEC-RAS automatically assigns file extensions, and after multiple runs the file extensions can become somewhat random looking. Given the complexity of relationships between the different files, and that many of them occur in more than one scenario, best practice is to track the filenames carefully and not rename them. Starting over

to create a clean slate of file names is not practical because the run times involved are so long—and because files occur in multiple scenarios, HEC-RAS will not name them consistently anyway. You may or may not, for example, end up with a run that has file extensions g06, p06, u06, etc. because geometry, terrain, roughness, unsteady flow, and restart files are often shared between scenarios.

Table 2 lists the computed high water elevations for the three design storm events (D6, D9, and D12) for the unimproved and improved scenarios. Table 5 documents the HEC-RAS files used in each scenario with the modeler's log notes.

When Hurricane Matthew occurred in October 2016, two of the three culvert barrels under Greenbrier Parkway were blocked with sediment and debris—a condition reflected in the Hurricane Matthew run geometry[4]. These barrels were subsequently cleaned by the City and were modeled as clean and unobstructed for both design scenarios (unimproved and improved).

7. Modeling Results

Whereas 1D SWMM models typically run in a few minutes, ROG models take several hours. Depending on the length of the simulation and the computational capability of the computer used, run times for this project ranged from 3 to 22 hours. Run times must be considered carefully when investigating alternative scenarios.

The models and data files prepared for this study are very large. Each scenario has a combination of underlying linked data files, and scenarios share common files. The total storage capacity required for all the archived HEC-RAS runs exceeds 14 GB.

Stable modeling runs were obtained for all modeling scenarios. Continuity errors were low and Courant-condition and high-velocity checks consistently indicated numerically stable results. GKY engineers used HEC-RAS' RAS Mapper module to review the results, checking the hydraulic routing for potential stability problems or any type of flow anomaly.

After scores of trial-and-error model runs, two engineering conclusions can be supported using the profile plots in Figures 10 through 12. First, most of the existing culvert crossings have small head losses, even for very large storms. The head losses are small because the velocities through the backbone drainage system are low—typically less than 3 feet per second. The drainage profiles are very flat and the major culvert crossings occur in series, so they "hold back" the flows. Culvert improvements at these locations are unnecessary because the existing barrel capacity is sufficient to avoid causing a significant rise in the hydraulic grade line.

Secondly, as indicated in Table 6 and Figure 10, the culvert invert at I-64 sets the permanent pool elevation for 130.5 acres of upstream impoundments. If a new low-flow culvert could be installed under I-64, the permanent pool elevations in these lakes and canals would be lowered accordingly. The trial-and-error model runs demonstrated that this single improvement would generate the greatest resilience benefits, due to the additional flood storage that would be created. That additional volume is significant and would make a difference.

The ROG models produced for this study have exceptional capabilities for computing flood elevations and flows through culverts, but they are not like other urban drainage models that include flows in smaller pipes. However, profiles can be generated precisely, as plotted in Figures 10 through 12. The real benefit of these profiles is the graphical depiction of the effects of each scenario. GKY engineers focused on culvert crossings where the profiles show the largest head loss. Improving culvert crossings by adding conveyance capacity (in the form of additional culvert barrels or replacing the old barrels with a larger cross section) is unnecessary

[4] Collins Engineers, Inc. prepared an inspection report, dated December 15, 2016, of selected structures in the Greenbrier Drainage system. GKY used information from this report to prepare the Hurricane Matthew scenario.

where the existing culverts have relatively minor head losses. In this respect, the City can avoid wasting money on costly resilience projects that would produce little hydraulic improvement.

As with all models of this size and complexity, a great amount of detailed input data is required. Because it is not feasible to collect all the required data in the field, it becomes necessary to make educated guesses about inverts and pipe and channel dimensions and geometries in some locations. GKY used data from the City's 2011 Indian River MDPU, which had surveying data for many of the significant culvert crossings. Where future designs and studies will be based on these models, engineers are strongly encouraged to field-verify all items that may critically impact their designs.

The maximum computed water surface elevations at the reference nodes (shown in Figure 1) are listed in Table 2, with the peak 100-year design storm elevations computed using the SWMM model in the 2011 Indian River MDPU. The table lists D6, D9, and D12 peak water surface elevations for improved and unimproved conditions.

The improved-condition modeling results presented in this report assume that the drainage and stormwater systems will be well maintained. If debris builds up to block drainage structures, or channels fill with silt, flooding will likely be more severe than computed and represented in this report. Debris can be a significant problem in natural channel outfall systems and should be monitored carefully to ensure that these systems function properly. Likewise, dense vegetation growth can significantly worsen local flooding. Channels that are relatively free from vegetation problems in the winter months can have significantly less conveyance capacity in the summer months. Depending on the type of plant growth, the change in conditions can be dramatic.

Table 5 documents the HEC-RAS scenario files and run log for this project.

8. Potential Improvement Projects

GKY and the City have identified the following potential improvement projects, indicated by the green polygons in Figure 9, to reduce street and parcel flooding in the Greenbrier Drainage Area:

1. **Indian River High School Lake Weir:** Lower the existing weir at Indian River High School Lake from a crest elevation of 8.1 to 6.1 feet;
2. **South Military Highway Culvert Replacement:** Replace the existing 6'Hx10'W box culvert under South Military Highway with a double 8'x8' box culvert at new invert elevations 6.20 (upstream) to 6.00 (downstream); and
3. **I-64 Additional Culvert:** Add a 60" circular culvert under I-64, just to the east of the existing triple 9'x9' box culvert, from invert 6.39 (upstream) to 5.0 (downstream).

Table 3 contains a brief synopsis of each project with comments and construction and implementation issues. Appendix A contains the cost opinions in 2020 dollars.

The existing South Military Highway culvert is nearing the end of its useful life and has been identified as a hydraulic bottleneck in previous studies, including the 2011 Indian River Master Drainage Plan Update. The unimproved scenario profile in Figure 10 clearly indicates this location is a chokepoint.

The modeling results demonstrate that a new 60" circular culvert under I-64 will produce the resiliency improvements sought by the City. These three improvement projects can drop peak flood elevations versus existing conditions by more than 1.5 feet in upstream areas (Table 2) and reduce the time that roadways and intersections are flooded and impassable by more than 33 hours (Figure 14). These results are obtainable because more than 350 acre-feet of usable flood storage can be created by lowering the permanent pool elevations of the Greenbrier impoundments. A 60" diameter was used in the modeling because it is the upper

limit, according to VDOT, for jack-and-bore construction.[5] This HEC-RAS modeling indicates that six days after the peak of the D9 design storm event, the water surface elevation just upstream from I-64 would be 8.96 feet. Table 6 computes the drawdown from 8.96 to 7.42 feet at an additional five days, albeit along a flat, asymptotic curve. As water surface elevations drop, the controlling inverts shift from location to location. Figure 10 shows existing culverts with dark gray shading. 7.42 feet—at the north Greenbrier Mall entrance—would be the new controlling invert for most the Greenbrier impoundment system when the proposed new barrel is added under I-64.

The 60" culvert provides the resilience required by this project. However, if the culvert were to become blocked before the upstream impoundments drop to their new permanent pool elevations, the 350 acre-feet of new flood storage could be compromised. Adding a second, parallel culvert would provide redundancy for maintenance purposes, and would reduce the drawdown time computed in Table 6 (as would using a larger diameter culvert). However, the likelihood of encountering back-to-back D9 or higher storm events is very small, and the key would be for City maintenance crews to ensure that impoundment levels are reasonably low during the dry-weather days before a forecast major storm event. If upstream impoundment levels are elevated and the new culvert is not flowing, maintenance should be performed promptly. The construction of a parallel culvert is a matter of redundancy and risk reduction. The desired results can be achieved with a single, 60" barrel.

GKY and City engineers considered many alternatives to reduce the elevation and duration of flooding in the Greenbrier Drainage Area. Some were discussed and removed from consideration for anticipated feasibility issues (such as re-routing and diverting runoff to adjacent watersheds), some were investigated in more detail but not modeled (such as using portable pumps to lower lake levels ahead of forecast storms), and many were modeled to investigate their effectiveness. The list of alternatives identified in this report is not exhaustive, however, they do constitute potential projects that offer reasonable potential to meet resilience objectives. Lots of potential projects were dropped from further consideration because the simply would not produce enough improvement to warrant their likely expense.

Pumping lake levels ahead of forecast storms is one example of a non-modeled alternative that was ruled out from further consideration. The City currently uses trailer pumps to draw impoundment water levels down ahead of forecast major storm events in the Forest Lake and Elmwood Landing drainage systems. GKY investigated options to pump the Greenbrier impoundments using a Godwin Dri-Prime CD225M Pump (the same pump used elsewhere by the City). The Greenbrier Lake and canal system has a 130.54 acres of surface area upstream from I-64 with permanent pool elevations set by the I-64 culvert invert. The Godwin pump has a maximum capacity of 3,240 gpm. Assuming the average delivery in the field would be around 2,500 gpm, it would take 8 pumps to achieve a 72-hour drawdown of 2 feet. A manifold system would have to be constructed for the force mains, which would significantly affect the pump curves. Fuel consumption for 8 pumps for 72 hours would be almost 3,400 gallons. A 24- or 30-inch force main (or equivalent), a parking area for pumping operations, and debris-resistant inlet and outlet structures would have to be constructed. The cost to build the force main and intake station(s) could be nearly as great, if not greater, than the cost of a culvert crossing improvement—particularly if the $330,000 or so cost to purchase the pumps, hoses, and supporting equipment is added. Figure 13 shows the drawdown rates and pump specifications involved in this approximation.

Other improvement project concepts that GKY discarded included:

- Installing a new culvert under I-64 from Greenbrier Lake using a new outfall northeast of Montauk Lane—which would be much more expensive than the 60" culvert described above; and

[5] VDOT generally consider two types of construction for the installation of a new culvert under an existing highway: jack-and-bore or microtunneling. If soils are suitable (having suitable water table, strength, and cohesive properties) jack and-bore installation may be allowed. However, microtunneling is more accurate, produces less problems with roadway subsidence, and works far better in poor soil and high water table conditions.

- Enlarging the culverts under Eden Way North just east of the intersection with Greenbrier Parkway—which would lower upstream water levels by approximately 0.3 feet but would cost over $1,000,000 and would not be needed given the other three recommended improvements.

9. Grant Opportunities

The potential projects identified in this study could improve flood protection by reducing the elevation and duration of street and parcel flooding in the Greenbrier Drainage Area. Some enhancements could be made to provide water quality benefits, as described in Section 11, below. However, the conceptual configurations and cost opinions in this study are focused to provide flood protection and resilience benefits. Adding water quality enhancements would increase costs but may be worthwhile to obtain grant funding.

Under normal circumstances, these projects could qualify for grant funding, like those listed in Table 4. However, at the time this write-up is being prepared[6], an unusual degree of uncertainty surrounds grant funding for public works projects in Virginia. The Covid-19 pandemic has led to high rates of unemployment and business closings, and tax revenues have been directly impacted. The Virginia State Legislature was called into special session to deal with a $2.7 billion projected budget shortfall. Line items in the State's budget that were previously approved have been held up, deleted, or otherwise scrutinized. For example, DEQ pulled its intended, annual solicitation for SLAF grant applications. Likewise, the federal government is struggling with unprecedented deficits during the final stages of presidential, senatorial, and congressional elections. At the federal level, pandemic relief thus far has focused on business and individual payouts—not on public works projects.

Two new grant opportunities merit careful monitoring. First, FEMA's BRIC grants (https://www.fema.gov/bric) incentivize state agencies and local governments to undertake hazard mitigation projects to reduce risks from disasters and natural hazards. BRIC replaces FEMA's Pre-Disaster Mitigation program and is aggressively funded by a 6% set-aside tied to federal post-disaster grants. The BRIC program has the potential to fund large-scale resilience projects, such as those identified in this Greenbrier Resilience Plan. On August 7, 2020, VDEM announced that it was opening the application period for FY2020 BRIC and FMA grants, both of which are nationally competitive[7]. In FY2019, FEMA identified $34 million in projects for further review in Virginia. Award announcements were expected to begin in the fall of 2020. Information on FY2020 BRIC and FMA grants can be reviewed at https://www.fema.gov/sites/default/files/2020-09/fema_nofo-overview-webinar_presentation_August_2020.pdf. Nationally, $500 million and $160 million have been budgeted for FY2020.

Secondly, the Commonwealth of Virginia recently continued the Virginia Shoreline Resiliency Fund as the Virginia Community Flood Preparedness Fund[8], to be administered by VRA and DCR. The fund is intended to mitigate future flood damage, with priority given to projects that implement community-scale mitigation activities or use nature-based solutions. Details remain to be worked out, but this fund is expected to have $40 to $50 Million annually for grants and loans focused on flood resilience projects. Funding will be generated from Virginia's Regional Greenhouse Gas Initiative carbon auctions, with 45% of those proceeds going to CFPF. The enabling legislation requires that 25% of the CFPF awards be used to help low-income communities—which could make the Greenbrier improvement projects less competitive because the drainage area is mostly commercial and not low-income.

It will take the City some time to vet these potential flood resilience projects in sufficient detail to schedule them for construction—most likely as capital improvement projects. Design and permitting issues must be worked through, and projects involving VDOT or private property impacts require additional coordination. The

[6] Fall, 2020.

[7] The application period for BRIC and FMA grants was set to close on November 10, 2020. Generally, these grants are expected to cycle in the late summer or fall.

[8] See https://lis.virginia.gov/cgi-bin/legp604.exe?201+sum+SB320 for legislative summary information.

combination of design, permitting, budgeting, right-of-way acquisition, utility conflict resolution, public involvement, matching requirement approval by City Council, and other processes may take several years. When the City decides to fully commit to building a project, grants should be considered. Some grants can be used for design and planning work, in which cases the City may consider offsetting those expenses with grants. Sometimes, once local governments anticipate that a project is going forward, and that grants can be applied for, the application deadlines may help move these processes along. Given the size and complexity of the potential projects identified in this study, and the pandemic budget impacts, it may be that currently-authorized-and-available grants will not be available for use. Nevertheless, certain opportunities can be monitored so that, at the right time, the City can submit grant applications.

A well-developed benefit-cost analysis will be crucial for grant applications. Because Virginia has a mandated emphasis on social justice criteria in grant awards, these Greenbrier grant applications will compete against proposals for projects that will undoubtedly be more attractive from a social justice perspective. Greenbrier is a thriving commercial district with housing pockets that would be unlikely to qualify for social justice points. Doing a good job with benefit-cost analyses should make the Greenbrier projects more competitive and time and effort must be allotted accordingly.

Table 4 identifies the types of grant funding opportunities that may be applicable to the projects identified in this study. These sources include both federal and state grant funds, and most have some history as recurring offerings (or are new vehicles for retired opportunities). The funding source programs focus on flood mitigation and prevention, flood resilience, water quality improvement, and creating innovative flood solutions.

Other agencies were evaluated for applicable source funding and the list in Table 4 is not exhaustive. Some agencies reviewed do not provide grants to support the specific flood improvement and water quality projects identified in this report, and grant opportunities expected to pay less than $100,000 were generally omitted—because the cost of pursuing and complying with the terms of small grants is typically too high for the benefits received.

10. Potential Permitting Issues

Permitting for these projects should be straightforward. For culvert crossing and structural improvements, the permitting requirements should be the same as for similar projects undertaken by the City in recent years. Permitting processes typically involve JPAs; agency coordination through a pre-application meeting; field delineation and regulatory confirmation of jurisdictional wetlands, streams, and WOTUS; interaction with VMRC, DEQ, and the Corps of Engineers; preparation of Erosion and Sediment Control and Storm Water Pollution Prevention Plans to apply for a VSMP permit; and payment of applicable fees.

If federal funds are involved—for example if federal grant money is used for a project—additional permitting requirements would be applicable, potentially involving cultural resources surveys, heightened NHPA and ESA investigations, and enhanced environmental investigations (such as those required under NEPA).

The City often uses in-house staff to obtain permits for these types of projects, with outside support for surveying of wetland markers and preparation of exhibits. City staff has developed a good rapport with regulators and is fully capable of handling the permit applications for these projects.

Depending on the project scale, lowering permanent pool elevations of the impoundments could be accomplished using a general or nationwide permit. Regional Permit 16-RP-05[9] authorizes all aspects of pond construction, such as mechanized land clearing, dam construction, placement of water control structures and spillways, and flooding. The impacted area of WOTUS includes the wetlands, streams, and other waters of the United States that are permanently (and/or temporarily) filled, flooded, cleared, ***or drained*** as a result of the regulated activity. 16-RP-05 is restricted to projects that will not cause the loss of greater than one-half

[9] 16-RP-05 expires on June 9, 2022, which may affect how and when the City pursues these projects. Re-authorization of this permit may or may not occur.

acre of non-tidal waters, including the loss of no more than 1,000 linear feet of stream bed. The District Engineer (of the Norfolk District Corps of Engineers) may grant waivers to the 1,000-foot limit if the proposed activity will result in no more than minimal adverse direct and indirect effects. The potential projects identified in this Greenbrier Resiliency Plan report are unlikely to create a significant reduction of non-tidal waters—subject to regulatory interpretation and agreement. Permitting under 16-RP-05 would significantly shorten the regulatory approval process compared to options involving any type of general permit.

If projects involve mitigation to offset wetland impacts, five years of monitoring will be required, including spraying for invasive species—which should be considered when developing budgets. However, depending on the amount and type of planting, these projects could increase wetland coverage in the watershed.

Generally, regulators react favorably to these types of projects, particularly where environmental benefits result—such as from benching and planting new wetland cover. Increased public safety, through flood reduction, will provide a basis for the purpose and need justifications. Involving regulators early in the planning and engineering processes leads to better regulatory outcomes.

Work at the Indian River High School Lake may best be approached as a BMP retrofit rather than for other uses, such as recreation or habitat creation. This lake has been in the City's BMP inventory since the 1980s, and modifications should not be approached as entirely new construction.

Much of the impoundment shoreline in the Greenbrier Drainage Area is located along roadways and in commercial districts. Where residences abut the impoundments, the City may offer shoreline enhancements, such as the creation of benches and plant treatments to avoid the appearance of bare soil at the water's edge. Rational citizens should be supportive of these projects, given the additional flood protection benefits they will receive. Eventually, flood insurance premiums should be lower as a result of these projects.

The City's Flood Insurance Rate Maps (effective 12/16/2014) do not have mapped flood zones in the Greenbrier Drainage Area south of I-64. Between I-64 and the outfall from Indian River High School Lake to the north, the main drainageway is mapped as Zone X[10]. Between the outfall from Indian River High School Lake and Indian River the floodplain is mapped as Zone AE[11]. There is no regulatory floodway in any of these areas. However, strictly speaking and according to NFIP requirements, whenever a proposed project will cause a vertical or horizontal shift in the floodplain, a CLOMR application to FEMA is required. CLOMR and LOMR processes can be expensive and take many months to complete. The City's floodplain administrator will have to decide whether a CLOMR application should be filed. If so, the implementation schedule and budget for each project should be adjusted accordingly.

11. Water Quality Credit Potential

The potential improvement projects identified in this study could enhance flooding resiliency in the Greenbrier watershed—by lowering permanent pool elevations in the backbone system of lakes and canals, and increasing the conveyance capacity of the culvert crossings at hydraulic choke points (such as the South Military Highway culvert). Because the projects involve replacing or modifying existing culverts and control structures—rather than creating new impoundments—they will not directly generate water quality benefits themselves. However, there are opportunities to generate water quality benefits.

Lowering the weir crest, and permanent pool, at Indian River High School Lake (from 8.2 to 6.2 feet) creates an opportunity to retrofit the lake to meet DEQ's design criteria for a Level 1 or Level 2 wet pond—which would provide substantial nutrient reduction credits towards the City's required Chesapeake Bay TMDL reductions. The area draining to the lake is approximately 3,800 acres with an imperviousness of approximately 48 percent. DEQ's VRRM spreadsheet indicates the treatment volume required to convert the

[10] Zone X is sometimes casually referred to as the 500-year floodplain. It includes the 0.2% annual chance event, areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile.
[11] Zone AE is commonly called the "100-year floodplain." It includes a base flood elevation for the 1% annual chance flood.

lake to a Level 1 pond is 174 acre-feet. Using hydrographic survey information provided by the City, the lake volume at elevation 6.2 is approximately 209 acre-feet. The lake would require the construction of a sediment forebay with a volume of approximately 26 acre-feet at the south end, and the creation of aquatic benches. City staff indicated in prior discussions that cutting trees on the edge of the lake and excavating out from the normal pool to create benches was not an option. Dredge material from the forebay creation could be used along the lake edge to create aquatic benches, but without lowering the elevation of the lake, some type of containment wall—possibly made using sheet piles, gabions, or placed riprap—would likely be required to contain the fill and create the benches, adding significant cost to the retrofit. Lowering the lake would expose the bottom around the edge of the lake that could be excavated or graded and planted to create an aquatic bench.

Preliminary calculations show that as a Level 1 wet pond, Indian River High School Lake would provide nitrogen and phosphorus reductions in excess of 5,600 and 1,800 pounds respectively, and almost 900,000 pounds of sediment using DEQ's established removal efficiencies of 20%, 45%, and 60% for nitrogen, phosphorus and total suspended solids. However, it is unlikely that the City would be allowed to take full credit for the nutrient reductions as if the retrofitted lake were a new BMP, despite it not being reported to DEQ as an existing stormwater BMP. Based on the experience of other localities that have retrofitted large water bodies for nutrient reduction credit, DEQ will require the existing lake efficiencies to be computed, and the City would be allowed to take credit for the difference between the reductions provided as a Level 1 wet pond, and the calculated reductions in its existing state. Using the methodology outlined in DEQ's Chesapeake Bay TMDL Action Plan Guidance Memorandum No. 15-2005 dated May 18, 2015, a case could be made for a 40-percent reduction in nutrient removal efficiencies for the existing pond due to the age of the lake, and missing water quality features such as a sediment forebay and aquatic benches. Even with the reduced credits allowed by DEQ, a Level 1 retrofit of the lake would provide enough nitrogen and phosphorus credits to meet half of the City's Chesapeake Bay TMDL reductions required during its second VSWMP permit cycle.

If the City considers retrofitting this lake, it should first meet with DEQ to discuss the project and the nutrient reductions the City expects to receive from the project. While DEQ's guidance document is straightforward concerning the nutrient credits allowed through BMP retrofits, given the size of the upstream watershed and the significant nutrient credits the City could claim, getting DEQ's blessing on the project will be a very important first step.

There are dozens of large impoundments linked to the backbone drainage system in this watershed. As indicated in Figure 10, the culvert crossing under I-64 is sufficiently elevated to establish minimum permanent pool elevations above 9.63 feet in the upstream lakes and canals. If a new culvert crossing can be built under I-64 at lower invert elevations, the permanent pool elevations would be lowered in the upstream impoundments. This lowering would provide increased flood storage capacity that could significantly reduce flood impacts from extreme events.

Where permanent pool elevations are lowered, there can be opportunities to establish aquatic benching and potentially generate water quality credits. However, the degree to which credits could be generated would depend upon detailed subaqueous surveys and soils testing and engineering yet to be performed. Given the potential impact of retrofitting Indian River High School Lake to a Level I wet pond and the potential straightforward nature of that project, constructing benches elsewhere in the watershed would be more expensive and problematic. Still, as planning moves forward for resilience projects, such potential can be considered.

Given the relatively steep side slopes of the lakes, canals, and roadway embankments along the backbone system, it may not be feasible to create aquatic benches in locations with narrow rights-of-way. The opportunity for water quality credits is therefore limited by the side slopes of the lakes. Aquatic benching along the perimeters would be difficult without major excavation along the banks or placing sheet pile walls and backfilling behind them, and because the lakes tend to be narrow, creating sediment forebays could restrict flood flows and have negative impacts upstream. For example, creating a sediment forebay in the Indian

River High School Lake may require the construction of a weir between 500 and 700 feet long that could pass large flows with minimal impacts upstream.

The lowering of the I-64 culvert crossing could also impact wetland BMPs within VDOT's right-of-way. Because the City and VDOT have interconnected MS4 service areas, they are encouraged to collaborate on water quality BMPs and can share the costs and nutrient credits from water quality BMP projects.

12. Caveats

The modeling produced for this study is built on limited data and was prepared for a specific purpose (to identify potential flood reduction improvements for a resiliency plan). Some input data was estimated using engineering judgment for modeling purposes. These models should not be used for other engineering or planning purposes without first verifying any data that may affect the outcome.

The HEC-RAS software used for this study is not an urban drainage model. While it can compute—very handily—flows in channels, ditches, creeks, and rivers, it does not perform pipe network calculations. GKY has adapted it for urban modeling by constructing culverts (using FHWA methodology) to link low spots in the terrain, but HEC-RAS cannot process flows through pipe *networks*. It is, however, extremely good at computing 2D overland flow on a 3D terrain—something 1D models like SWMM cannot do at all. While it is possible to perform combined 1D/2D modeling, that work is quite involved and expensive. HEC-RAS produced very good results for this study, but engineers must appreciate certain limits to interpret them correctly.

- Flood depths and water surface elevations in locations that **are** hydraulically connected to the outfall—such as the backbone system of canal-sized ditches and impoundments along Greenbrier Parkway and Eden Way North—should be interpreted just as with 1D models. They have been computed using robust engineering equations based on the input data.
- Flood depths and water surface elevations in locations that **are not** hydraulically connected to the outfall—such as low spots in roadway gutter lines or along unmodeled, upstream drainage systems—are the result of ponding (or puddling) after the rainfall has been applied and overland flow equations have been solved. These results could be expected if the drainage pipes were blocked. For extreme events, such as the design storms modeled for resiliency planning in this study, the smaller pipe systems do not have a significant effect on the outcome. Incorporating them would require switching to a combined 1D/2D model at considerable added expense.

The goal of this type of study is not to relieve all flooding, but rather to identify potential improvements that can be feasibly constructed. Areas such as wetlands, woodlands, deep ravines, large open spaces, ball fields and parks, and along elevated railroad or highway embankments often do not require improvements unless there is a specific reason to construct them. Neighborhood and commercial parcel drainage and stormwater systems are neither required nor designed to accommodate flooding from extreme events such as the 50-year storm.

Grant funding opportunities are in constant flux and should be monitored continually—particularly those that have significant funding potential. CIP projects typically take years to progress from conception to construction, and lead times for grant applications should be accommodated in the project schedule.

The backbone drainage system, as modeled for this study, assumes a well-maintained system. Debris, sediment, pipe collapses, and other maintenance issues can cause very real flooding that must be addressed. In this respect, this study highlights capacity issues rather than maintenance issues (which are best resolved from inspection or citizen reports). There is good reason to create the models in this manner. If poor maintenance conditions are modeled, the capacity problems could easily be masked to the extent that public funds could be spent unnecessarily.

GKY is providing the models completed for this study to the City in the hope that future engineering efforts will build upon this effort. The responsibility for appropriate use of these models rests with the engineers who

modify and adapt the data for specific uses. HEC-RAS ROG models are not like 1D SWMM models, because smaller drainage pipes are generally omitted in 2D resiliency models. Anyone adapting these models must be aware of the limitations and assumptions and make changes appropriately.

Where improvements identified in this study occur in series, such projects must be constructed in the correct sequence. Generally, downstream improvements must be made before upstream improvements are constructed to prevent flooding that could result if conveyance is improved upstream before increased flows can be accommodated in the downstream system.

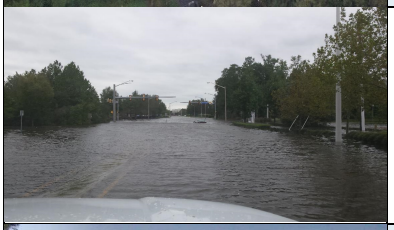
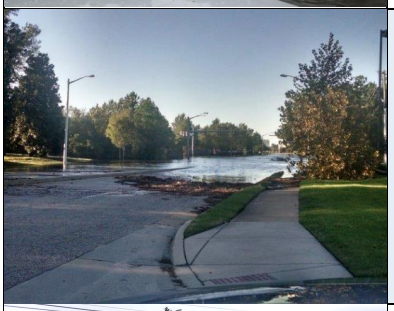
The potential improvements identified in this study will need further investigation before they can be carried forward as feasible projects. While (seemingly) reasonable assumptions have been used to estimate the expense of each project, there is significant budget uncertainty due to the degree and complexity of the required construction. There can be substantial utility conflicts to resolve, and the data required to develop accurate improvement plans and cost estimates is not yet available.

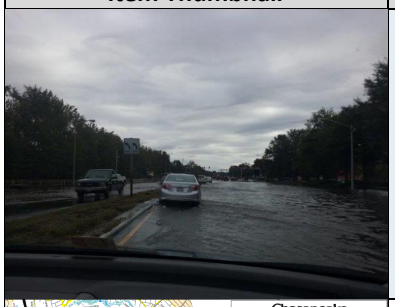
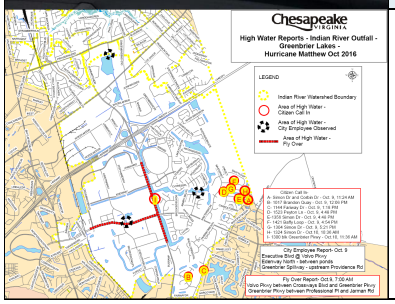
FEMA flood insurance studies and rate maps are the definitive sources of floodplain limits and elevations in all cases. The models developed for this plan are specific design scenarios—THESE RESULTS ARE NOT TO BE CONSTRUED AS INDICATIVE OF EXPECTED WATER SURFACE ELEVATIONS FOR THE PURPOSES OF FLOODPLAIN MANAGEMENT AND/OR INSURANCE REQUIREMENTS. The models developed for this plan could be adapted for use in the National Flood Insurance Program and submitted to FEMA for approval, but until they are vetted and approved through that process, the published flood insurance studies and rate maps remain fully in effect.

13. Contact Information

Liz Scheessele, PE, CFM, ENV SP and Crystal Bloom, PE, LEED GA (757.382.6393) managed this project for the City, and Jake Lewis, PE, Chad Brittle, EIT, and Olive Morrill provided engineering support. Sean Bradberry, ENV SP served as the project engineer, and John Paine, PE, PH, CFM (757.346.4422) served as the project manager for GKY.

Table 1. Hurricane Matthew Calibration Data

Item Thumbnail	Description	Use In Calibration	Source Filename (as provided by City)	Comments
	Greenbrier Parkway. 07:00 on 10/9/2016.	Edge of water at 07:00 on 10/9/2016 should match edge of water in the calibrated model.	Oct 9 2016 7AM.jpg	Note one-space difference in file name vs. "Oct 9 2016 7 AM.jpg" (although this is a completely different photo).
	Eden Way North and Stephanie Way Intersection. 07:00 on 10/9/2016.	Edge of water at 07:00 on 10/9/2016 should match edge of water in the calibrated model.	Oct 9 2016 7 AM.jpg	This is probably the second-most useful piece of calibration data.
	Volvo Parkway. Approximately 07:00 on 10/9/2016.	Edge of water at 07:00 on 10/9/2016 should match edge of water in the calibrated model.	IMG_4390.JPG	Exact time is uncertain.
	Executive Boulevard looking north across Eden Way North. No timestamp on photo.	Using flooded car at intersection as a reference, should have approximately two feet of flooding in this intersection (at the gutter line).	eden way and executive Oct 9 2016 7AM.docx	Eden Way North is crowned, and flooded car is at the gutter line.
	Executive Boulevard looking north over Eden Way North Intersection. No timestamp on photo.	Maximum water surface elevation should be greater than or equal to edge of water in the photo.	Chesapeake and Flood Control Measures Next Steps 11-30-16.pptx	This photo is redundant and not as useful as the photo of the same intersection, above. It appears to have been taken after the above photo.
	Downstream of South Military Highway, looking upstream (south). No timestamp on photo.	Maximum water surface elevation should be greater than or equal to edge of water in the photo.	Outfall upstream Military.docx	Velocity appears to be moderate.

Item Thumbnail	Description	Use In Calibration	Source Filename (as provided by City)	Comments
	Greenbrier Parkway looking south towards Volvo Parkway. No timestamp on photo.	Maximum water surface elevation should be greater than or equal to edge of water in the photo.	Chesapeake and Flood Control Measures Next Steps 11-30-16.pptx	It is difficult to pinpoint the location of this photo, but it appears to be in front of the Wells Fargo branch on Greenbrier Parkway.
	High-Water Reports.	Calibrated model should show maximum water surface elevations reaching these locations.	greenbrier resiliency hurricane matthew map.pdf	No elevations listed.

NOTES

1) This table is a summary of data provided by the City. GKY used this data to calibrate the Hurricane Matthew HEC-RAS model.

2) The City provided other data, such as maps with point locations of flooding, that do not contain specific information that can be used for model calibration.

3) The information listed above was helpful in producing a calibrated model that matches reported conditions on the ground.

4) See source files for full-size items.

Table 2. Maximum Computed Water Surface Elevations from Design Storms

		MAXIMUM COMPUTED WATER SURFACE ELEVATIONS (NAVD88)										
		2011 SWMM Model[*2]	Unimproved Condition			Improved Condition			Difference[*3]	Difference (Improved - Unimproved)		
Column Number:		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]
Reference Node[*1]	Location	100-Year Existing[*4] (ft)	D6 (ft)	D9 (ft)	D12 (ft)	D6 (ft)	D9 (ft)	D12 (ft)	$D6_{unimproved}$ minus $SWMM_{100}$ [2] - [1] (ft)	D6 [5] - [2] (ft)	D9 [6] - [3] (ft)	D12 [7] - [4] (ft)
Backbone Drainageway												
121	Upstream of Yupo Ct	15.38	13.64	16.40	18.29	11.95	14.77	17.02	-1.74	-1.69	-1.63	-1.27
129	Upstream of Executive Blvd	15.38	13.64	16.40	18.41	11.96	14.77	17.26	-1.74	-1.68	-1.63	-1.15
145	Upstream of Greenbrier Pkwy	15.37	13.64	16.40	18.42	11.95	14.77	17.28	-1.73	-1.69	-1.63	-1.14
159	Upstream of Volvo Pkwy	15.33	13.63	16.39	18.41	11.95	14.76	17.28	-1.70	-1.68	-1.63	-1.13
323	Upstream of Eden Way N	15.31	13.62	16.37	18.39	11.95	14.74	17.25	-1.69	-1.67	-1.63	-1.14
324	Upstream of Greenbrier Mall Access (S)	14.96	13.32	15.65	17.93	11.79	14.04	16.21	-1.64	-1.53	-1.61	-1.72
336	Upstream of Greenbrier Mall Access (N)	14.90	13.17	15.31	17.43	11.63	13.70	15.85	-1.73	-1.54	-1.61	-1.58
357	Upstream of I-64 Eastbound Ramp	14.85	12.99	14.99	17.03	11.42	13.36	15.39	-1.86	-1.57	-1.63	-1.64
373	Upstream of Greenbrier Pkwy NB Loop	14.82	12.92	14.88	16.85	11.32	13.23	15.21	-1.90	-1.60	-1.65	-1.64
375	Upstream of I-64	14.79	12.73	14.70	16.64	11.06	13.00	14.93	-2.06	-1.67	-1.70	-1.71
377	Upstream of I-64 Westbound Loop	14.76	12.49	14.56	16.55	10.71	12.83	14.79	-2.27	-1.78	-1.73	-1.76
379	Upstream of Greenbrier Pkwy NB Ramp	14.74	12.37	14.44	16.35	10.47	12.65	14.56	-2.37	-1.90	-1.79	-1.79
412	Downstream of Greenbrier Pkwy NB Ramp	14.72	12.26	14.34	16.19	10.38	12.51	14.38	-2.46	-1.88	-1.83	-1.81
422	Upstream of Woodlake Dr	14.72	12.25	14.32	16.18	10.36	12.47	14.35	-2.47	-1.89	-1.85	-1.83
430	Downstream of Woodlake Dr	14.68	12.19	14.20	15.99	10.28	12.30	14.02	-2.49	-1.91	-1.90	-1.97
460	Upstream of S Military Hwy	14.52	12.13	14.12	15.93	10.16	12.11	13.80	-2.39	-1.97	-2.01	-2.13
464	Downstream of S Military Hwy[*5]	13.58	9.46	10.35	11.43	8.74	10.28	12.06	-4.12	-0.72	-0.07	0.63
468	Indian River High School Lake	11.99	9.22	9.97	11.01	8.21	9.72	11.63	-2.77	-1.01	-0.25	0.62
471	Upstream of Providence Rd[*6]	5.96	5.41	6.03	6.44	5.29	6.08	6.63	-0.55	-0.12	0.05	0.19
480	Indian River Outfall[*6]	4.42	1.86	2.38	2.80	1.69	2.28	2.76	-2.56	-0.17	-0.10	-0.04
Impoundments Loop Behind Greenbrier Mall												
180	West of Shepherds Gate	15.34	13.70	16.62	18.62	12.00	14.98	17.69	-1.64	-1.70	-1.64	-0.93
241	Upstream of Eden Way N	15.34	13.70	16.62	18.62	12.00	14.98	17.69	-1.64	-1.70	-1.64	-0.93
244	South of Cypress Pl	15.31	13.62	16.37	18.39	11.95	14.75	17.25	-1.69	-1.67	-1.62	-1.14
Impoundments Loop Behind Joe's Crab Shack												
341	North of Crossways Blvd	17.59	13.25	15.51	17.93	11.73	14.20	16.79	-4.34	-1.52	-1.31	-1.14
346	West of Greenbrier Pkwy	15.76	13.24	15.45	17.78	11.72	14.10	16.62	-2.52	-1.52	-1.35	-1.16
Impoundments Along Eden Way N												
266	West of Crossways Blvd	16.46	13.91	16.59	18.46	12.30	15.03	17.70	-2.55	-1.61	-1.56	-0.76
311	West of Stephanie Way	16.56	13.89	16.56	18.46	12.29	15.01	17.68	-2.67	-1.60	-1.55	-0.78
322	West of Greenbrier Pkwy	16.53	13.88	16.53	18.47	12.26	14.98	17.67	-2.65	-1.62	-1.55	-0.80
Other Locations												
197	Inside Simon Dr Loop	18.16	14.58	19.58	20.02	13.56	17.26	19.95	-3.58	-1.02	-2.32	-0.07

Listed in downstream order

		MAXIMUM COMPUTED WATER SURFACE ELEVATIONS (NAVD88)										
		2011 SWMM Model[*2]	Unimproved Condition			Improved Condition			Difference[*3]	Difference (Improved - Unimproved)		
	Column Number:	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]
Reference Node[*1]	Location	100-Year Existing[*4] (ft)	D6 (ft)	D9 (ft)	D12 (ft)	D6 (ft)	D9 (ft)	D12 (ft)	$D6_{unimproved}$ minus $SWMM_{100}$ [2] - [1] (ft)	D6 [5] - [2] (ft)	D9 [6] - [3] (ft)	D12 [7] - [4] (ft)
360	East of Bostwyck Pl	17.78	17.44	18.31	19.98	17.44	18.30	19.96	-0.34	0.00	-0.01	-0.02
385	West of Woodlake Cir	15.64	13.36	14.98	16.37	13.17	14.84	16.23	-2.28	-0.19	-0.14	-0.14

NOTES

1) See Figure 1 for reference node locations.

2) This watershed has undergone changes in its drainage infrastructure since the 2011 SWMM models were created.

3) Methodology differences between HEC-RAS Rain-on-Grid and SWMM modeling are described in the report text, and are significant. Comparisons are for information purposes only.

4) The 100-yr existing condition 2011 SWMM model produced 5.2 inches of runoff, and indicated widespread surface flooding.

5) The channel downstream from S Military Highway is steep and wider than the existing roadway culvert; HEC-RAS computes the 2D flow spread that is otherwise ignored in 1D SWMM.

6) The 2011 SWMM models used a constant downstream tailwater elevation as a boundary condition. The HEC-RAS runs use a friction slope boundary (because event durations were as long as 6 days and elevations below Providence Road do not affect the results upstream from the Indian River High School Lake outfall.

Table 3. Potential Improvement Projects

Potential Improvement	Comments	Implementation and Feasibility Notes
1. Indian River High School Lake Weir (Lower the existing Indian River High School weir crest approximately 2 feet from elevation 8.1 to 6.1)	Lowering the weir approximately 2 feet reduces the lake volume by approximately 50 Acre-feet which could be used for flood storage. Lowering the weir would make the creation of aquatic benches easier if the lake were to be retrofitted to meet DEQ's design criteria for a Level 1 wet pond, and does not reduce the total volume below the required treatment volume for a Level 1 wet pond. Modeling assumes the weir crest is lowered to 6.1 with the six existing 48" culvert pipes in place.	The exact construction of the existing spillway structure is unknown, but it appears to be an approximately 50-foot long, 1-foot wide concrete weir between concrete wingwalls at either end. The top of weir elevation is 8.1 and is located approximately 6 to 8 feet upstream from a headwall with six 48" culvert pipes. There is an approximate 2-foot drop from the top of the weir to a concrete apron sloping down to the culvert openings. Culvert inverts range from 4.24 to 5.55. Some dredging of the lake will be needed upstream of the weir where the lake has silted in. Dredging from a barge shouldn't be necessary as the dredging could be performed from land with a long-reach excavator or crane.
2. South Military Highway Culvert Replacement (Replace the existing 6'Hx10'W box culvert under South Military Highway with a double 8'x8' box culvert at new invert elevations 6.20 to 6.00)	The existing culvert is nearing the end of its service life. The existing upstream and downstream culvert invert elevations are 7.08 and 6.13, respectively. The replacement culvert was modeled with invert elevations of 6.20 upstream and 6.00 downstream. Inverts were lowered to minimize conflicts with utilities above the culvert.	The downstream channel was widened recently as recommended in the 2011 Indian River MDPU. The downstream channel is approximately 22 to 27 feet wide between bulkheads which should accommodate a culvert with an outside-to-outside width of approximately 18 feet. Wingwalls may not be needed at the downstream end due to the existing bulkheads along the channel. Traffic control will be a major issue due to the high volume on South Military Highway.
3. I-64 Additional Culvert (Add a 60" circular culvert under I-64, just to the east of the existing triple 9'x9' box culvert, from invert 6.39 to 5.0)	The existing triple 9'x9' box culvert under I-64 was installed 2.2 feet higher than upstream culvert inverts (see Figure 10). This 'perched' culvert crossing creates approximately 350 acre-feet of dead storage in the upstream impoundments. Installing a lower culvert will draw down permanent pool levels and create approximately 350 acre-feet of new, usable flood storage.	VDOT owns the intersection right-of-way, and will have to approve the construction of the new culvert crossing. If jack-and-bore installation can be used instead of microtunneling, the project cost could be significantly reduced. The City will have to coordinate with parcel owners regarding the lowering of permanent pool levels, but rational citizens should appreciate the flood risk reduction resulting from this project. Most of the impoundment shorelines are in a commercial district and along roadways.

NOTES

1) Invert elevations in this table and report refer to the NAVD88 vertical datum.

2) Conceptual design and construction cost opinions are documented in Appendix A.

Table 4. Grant Opportunities

Information updated as of **10/30/2020**

Funding Agency *Grant Name*	Description	Prior Grant Cycle FY	Availability	Minimum Amount	Maximum Amount	Match Percentage	Type FR = Flood Resilience WQ = Water Quality	Eligibility SE= Social Economic TW = Target Waterheds	Eligibility Other	Restrictions	Potential Burdens	Expected Application Timeline	Contact (Webpage)	Comments
Federal Emergency Management Agency *Building Resilient Infrastructure and Communities (BRIC)*	Federal funds are made available to states, local communities, tribes and territories for pre-disaster mitigation activities.	N/A	Open. Closes 11/10/2020	Not listed	$500 million (entire program)	75% federal, 25% non-federal cost share	FR	Neither	Research supported proactive investments in community resilience.	Must have a current FEMA-approved Hazard Mitigation Plan. Period of Performance start date: date of recipients federal award - End date: 36 months from start date for all other sub applications.	Must use the new FEMA Grants Outcome (FEMA GO) system.	Annually	https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities	BRIC is funded by a 6% set-aside from Federal post-disaster grant funding. Pre-Award Selection Notice: 06/2021.
Virginia Department of Conservation and Recreation *Virginia Community Flood Preparedness Fund*	New fund intended to mitigate future flood damage, with priority given to projects that implement community-scale mitigation activities or use nature-based solutions.	N/A	2021	TBD	~$50 million (entire program)	TBD	FR	SE	TBD	TBD	TBD	Annually	https://www.pewtrusts.org/en/about/news-room/opinion/2020/07/07/virginias-new-flood-preparedness-program-is-a-statewide-win	This is a new fund with revenue coming from Virginia's RGGI carbon auctions. The State is preparing to administer this program, but has not yet worked out details.
National Fish and Wildlife Foundation *National Coastal Resilience Fund*	The National Coastal Resilience Fund invests in conservation projects that restore or expand natural features such as coastal marshes and wetlands, dune and beach systems, oyster and coral reefs forests, coastal rivers and floodplains, and barrier islands that minimize the impacts of storms and other naturally occurring events on nearby communities.	2020	Closed. Next grant slate will open in Spring 2021	Funding levels are described in the RFP; not less than $125,000	Funding levels are described in the RFP; no maximum award size.	Required 1:1 non-federal match	FR	Neither	Based on Community Capacity Building and Planning focus area.	This fund is investing to restore and strengthen natural systems so they can protect coastal communities from the impacts of storms, floods, and other natural hazards and enable them to recover more quickly, and enhance habitats for fish and wildlife.	Projects are expected to be completed within 24 months of the start of the grant.	Annually	https://www.nfwf.org/programs/national-coastal-resilience-fund?activeTab=tab-2	Four focus areas: Community Capacity Building and Planning, Project Site Assessment and Preliminary Design, Project Final Design and Permitting, and Restoration and Monitoring.
Virginia Department of Conservation and Recreation *Dam Safety, Flood Prevention and Protection Assistance Fund*	The fund was established to provide grants to public and private dam owners whose dams are under state regulation and also to help local governments improve methods for flood prevention and protection.	2020	Open	Determined based on amounts requested from eligible projects, application scores and available funds.	Determined based on amounts requested from eligible projects, application scores and available funds. Depending on State budgeting, the award amounts can be small.	50%	FR	SE	Flood prevention and protection.	If applicant conducts hydrologic and hydraulic studies of floodplains and create new maps, they must apply for a letter of Map Revision or a Physical Map Revision through FEMA. Grant scores can be weighted based on prior awards, as Chesapeake received in 2019.	Grant funds will be disbursed on a reimbursement basis and only after the completion of the approved project.	11/1/2020 through 2/26/2021	https://www.dcr.virginia.gov/dam-safety-and-floodplains/dsfpm-grants	Fund is managed by the Virginia Resources Authority on behalf of the Virginia Department of Conservation and Recreation. Grants are awarded through a competitive application process. Awards are approved by the Virginia Soil and Water Conservation Board. Director of DCR will determine the type and amounts of funding available prior to each funding period and will specify the categories that will be considered for grant assistance.
Federal Emergency Management Agency *Flood Mitigation Assistance Grant (FMA)*	The intent of FMA is to take action to reduce the risk of future flooding to structures that are insured through the National Flood Insurance Program (NFIP).	2020	Open. VDEM closes 1/29/2020 for FEMA's deadline of 1/29/2021.	Not listed	$160 million (entire program)	75% federal, 25% non-federal cost share	FR	Neither	This grant is for structures that are insured through NFIP and are at risk for repetitive flood damage.	Must have a current FEMA-approved Hazard Mitigation Plan. Project must be identified in the mitigation strategy; structural projects must be cost effective and comply with program regulations in the Hazard Mitigation Assistance Guidance.	Cost effective structural projects must be demonstrated through a benefit cost analysis (BCA).	Application start 09/30/2020 - application submission deadline 01/29/2021	https://www.vaemergency.gov/job/flood-mitigation-assistance-grant/	FEMA Hazard Mitigation Assistance has 5 grant programs, including Hazard Mitigation Grant Program; Flood Mitigation Assistance Program and Building Resilient Infrastructure & Communities (BRIC). Virginia is preparing to administer these grants (as of 10/30/2020).
Federal Emergency Management Agency *Hazard Mitigation Grant Program (HMGP)*	The intent of HMGP is to provide funding for state, local, tribal and territorial governments so they can rebuild in a way that reduces or mitigates disaster losses.	2020	Depends on disaster declaration	Up to 15% of the first $2 billion	Up to 20% for amounts not to exceed $35.333 billion (entire program)	75% federal, 25% non-federal cost share	FR	Neither	This grant provides funding after a presidentially declared disaster.	Grant recipients have 36 months or three years from the close of the application period to complete the project.	Submit a letter of intent to FEMA within 30 days after a disaster declaration.	Depends on disaster declaration	https://www.fema.gov/grants/mitigation/hazard-mitigation	Funding is based on the estimated total cost of disaster assistance.
RISE Resilience Innovation (Non-profit organization) *Flood Management Resilience Challenge*	Funds are for areas in need of innovative solutions identified by entities operating in Hampton Roads.	2020	Closed	Not listed	250000	Non-equity funding	FR, WQ	TW	Must focus on a Hampton Roads need while demonstrating the ability to scale to other communities.	Must be either small businesses or non-profit entities.	Particularly interested in innovative solutions for cost-effective management of ground, storm, or tidal water.	TBD	https://riseresilience.org/current-challenges/	RIF awards come in two forms: 1) loans (revenue based or 0 interest fixed payment) and 2) reimbursement grants.
Virginia Department of Environmental Quality *Stormwater Local Assistance Fund (SLAF)*	Provides matching grants to help localities install efficient and effective pollution-control measures.	2019	On hold pending review of Commonwealth debt capacity.	50000	Disbursements shall be held at 95% of the total grant amount to ensure satisfactory completion of the project.	Grant will be awarded and the grantee may begin requesting monthly reimbursement for 50% of eligible costs incurred.	WQ	TW	Reduce non-point source pollution from stormwater runoff.	Must complete the program requirements, advertise for construction bids and develop and receive approval of a final grant budget based on as-bid construction and contractual engineering costs.	Several submittal packages must be reviewed and approved by DEQ CWFAP staff.	Annually	https://www.deq.virginia.gov/Programs/Water/CleanWaterFinancingAssistance/StormwaterLoan.aspx	SLAF projects are awarded primarily on the basis of cost efficiency and pollutant removal benefit.

Information updated as of **10/30/2020**

Funding Agency *Grant Name*	Description	Prior Grant Cycle FY	Availability	Minimum Amount	Maximum Amount	Match Percentage	Type FR = Flood Resilience WQ = Water Quality	Eligibility SE= Social Economic TW = Target Waterheds	Eligibility Other	Restrictions	Potential Burdens	Expected Application Timeline	Contact (Webpage)	Comments
United State Environmental Protection Agency *Multipurpose Grants to States and Tribes*	Funds are intended to be used at state and tribal discretion, for high-priority activities to complement activities funded under established environmental statutes.	2020	Closed	25000	Minimum grant amount plus supplemental amount based on FY2019 funding.	None	WQ	Neither	Eligible recipients are generally state agencies that carry out federally funded environmental programs.	Funds may be used to support several activities associated with categorical grant programs such as water pollution control, nonpoint source management, pollution prevention, Wetlands development - which are eligible for inclusion in a Performance Partnership Grant.	May accept funds through an existing PPG, by establishing a new PPG, or through a standalone grant. Steps may be required to decide which grant vehicle is most appropriate.	Summer 2021?	https://www.epa.gov/grants/specific-epa-grant-programs	Grant funding is authorized by the Further Consolidated Appropriations Act, 2020 (P.L. 116-94); Recipients have flexibility to direct funds to priority areas.
Grant Opportunities Reviewed But Not Applicable														
Natural Resources Conservation Service/United States Department of Agriculture *Agricultural Management Assistance, Conservation Stewardship Program, Environmental Quality Incentives Program, Water Bank Program*	Grant funding specifically for agricultural producers or grant funding only available in certain states.													
Virginia Department of Forestry *Economic Development, Fire Prevention and Urban and Community Forestry Grants*	Grant funding specifically for agriculture and forestry development projects, potential threats from wildfires or fire-related assistance, and specific forestry projects.													
Virginia Department of Conservation and Recreation *Virginial Land Conservation Foundation/Land and Water Conservation Fund State and Local Assistance Program*	Grant funding specifically for the acquisition and development of public outdoor recreation areas.													
Virginia Department of Environmental Quality *Stormwater Loan Program*	Provides a long term source of low interest financing for constructing facilities or structures or implementing best management practices that reduce stormwater runoff.													

NOTES

1) Grant opportunities are in constant flux. These grant sources should be monitored and updated as the Greenbrier Resiliency Plan projects move forward.

2) Small grants, having anticipated awards less than $100,000, are not detailed here (unless they have potential for increased funding) because application and administration costs tend to be high compared to the value of the grant.

3) The large grant amounts listed are for the total program, not individual projects (because individual project funding is not specifically limited).

Table 5. HEC-RAS Scenario Files and Run Log

November 2020

Saved In: P:\2017_018_Chesapeake_EngSmallProjects\TO_12_Greenbrier_ResiliencyPlan\Models\HEC-RAS\GB

HEC-RAS Project File: **Greenbrier_Resilien.PRJ**

			Plan Files Summary						FILENAMES										
Date	Plan Name	Plan Description	Plan	Geometry	Unsteady Flow	Run By	Rainfall	Changes Tried	Geometry File	Terrain File	Roughness File	Plan File	Unsteady Flow File	Restart File	Hydrograph Output Interval (mins)	Detailed Output Interval (mins)	Mapping Output Interval (mins)	Time Step (Sec)	Run Time (hh:mm)
Hurricane Matthew																			
8/14/2020	Plan 16	Run to get starting water surface elevations	**p12**	**g10**	**u10**	SMB	No Rainfall		Geometry_4	GB_Terrain_6	GB_Mannings_N	Greenbrier_Resilien.p12	NoRain_Plan_16 (Greenbrier_Resilen.u10)	Greenbrier_Resilien.p12.01JAN2020 2400.rst	240	240	120	5	1:00
8/15/2020	Hurricane Matthew	Calibrated Matthew Run	**p02**	**g01**	**u11**	JNP	Matthew 81%	Using new geometry incorporating Greenbrier mall drainage and drainage from Simon Drive lake at eastern side of watershed. Blocking 3.8 of 4-foot diameter of two culverts under Greenbrier Pkwy (per 2016 Collins report).	Geometry_5_Blocked Culverts (Greenbrier_Resilien.g01)	GB_Terrain_6	GB_Mannings_N	Greenbrier_Resilien.p02	Matthew81 (Greenbrier_Resilien.u11)	Greenbrier_Resilien.p12.01JAN2020 2400.rst	5	5	5	3	8:51
Unimproved Scenarios (Existing Conditions)																			
8/25/2020	Plan_18_No_Rain_Geom_7	No Rain to create restart file.	**p08**	**g04**	**u12**	SMB	No Rain		Geom_7_Imp_A	GB_Terrain_6	GB_Mannings_N (Manning n override added to geometry file)	Greenbrier_Resilien.p08	NoRain_Plan_18 (Greenbrier_Resilien.u12)	None	240	240	120	5	1:03
8/26/2020	D9_Rain_Event	D9 rainfall. Existing geometry.	**p03**	**g08**	**u13**	SMB	D9	Refined 2D mesh north of S. Military.	Geometry_7_Existing	GB_Terrain_6	GB_Mannings_N (Manning n override added to geometry file)	Greenbrier_Resilien.p03	D9_Rainfall_Geometry_7 (Greenbrier_Resilien.u13)	Greenbrier_Resilien.p08.01JAN2020 2400.rst	5	5	5	3	3:33
9/20/2020	72_Hour_D9_Rain_Event	Same scenario as D9_Rain_Event (p.03) except it is a 72 hour run.	**p18**	**g08**	**u21**	SMB	D9		Geometry_7_Existing	GB_Terrain_6	GB_Mannings_N (Manning n override added to geometry file)	Greenbrier_Resilien.p18	72_Hour_D9_Rainfall_Geometry_7 (Greenbrier_Resilien.u21)	Greenbrier_Resilien.p08.01JAN2020 2400.rst	15	15	15	3	9:08
10/21/2020	D12_Rain_Event_Unimproved	62 rainfall. Existing geometry.	**p05**	**g08**	**u01**	SMB	D6		Geometry_7_Existing	GB_Terrain_6	GB_Mannings_N (Manning n override added to geometry file)	Greenbrier_Resilien.p05	D6_Rainfall_Unimproved	Greenbrier_Resilien.p08.01JAN2020 2400.rst	5	5	5	3	3:09
10/21/2020	D12_Rain_Event_Unimproved	D12 rainfall. Existing geometry.	**p06**	**g08**	**u02**	SMB	D12		Geometry_7_Existing	GB_Terrain_6	GB_Mannings_N (Manning n override added to geometry file)	Greenbrier_Resilien.p06	D12_Rainfall_Unimproved	Greenbrier_Resilien.p08.01JAN2020 2400.rst	5	5	5	3	3:12

HEC-RAS Project File: **Greenbrier_Resilien.PRJ**

			Plan Files Summary						FILENAMES										
Date	Plan Name	Plan Description	Plan	Geometry	Unsteady Flow	Run By	Rainfall	Changes Tried	Geometry File	Terrain File	Roughness File	Plan File	Unsteady Flow File	Restart File	Hydrograph Output Interval (mins)	Detailed Output Interval (mins)	Mapping Output Interval (mins)	Time Step (Sec)	Run Time (hh:mm)
Improved Scenarios (Proposed Conditions)																			
10/12/2020	Plan_22_No_Rain_Geom_9_Imp_B	No rain. Starting WSEL = 7.5 for restart file for Geometry 9B	**p20**	**g12**	**u23**	SMB	D9		Geom_9_Imp_B	I64Culv_JackBore_Terrain	GB_Mannings_N (Manning n override added to geometry file)	Greenbrier_Resilien.p20	NoRain_Plan_22_Scenario_9B (Greenbrier_Resilien.u23)	None	120	240	240	5	1:23
10/13/2020	144_Hour_Run_D9_Rain_Event_Geom_9_Imp_B	D9 rainfall event. (9 inches of applied rainfall, existing conditions.) No improvement at Eden Way. 6Hx10W box culvert at S. Military Hwy Replaced with double 8x8 box. Upstream invert lowered from 7.08 to 6.2. Geometry adjusted by adding a break line down the channel north of S. Military Highway. Mesh refined north of S. Mil HWY. IRHS lake weir lowered from 8.1 to 6.1. S. Mil culvert losses changed to .2 entrance, .3 exit. 60" culvert under I-64 added just east of existing triple 9x9. 72 hour run.	**p19**	**g12**	**u22**	SMB	D9	60" culvert added under I-64 near existing triple 9x9 box culvert.	Geom_9_Imp_B	I64Culv_JackBore_Terrain	GB_Mannings_N (Manning n override added to geometry file)	Greenbrier_Resilien.p19	144_Hour_D9_Rainfall_Geometry_9B (Greenbrier_Resilien.u22)	Greenbrier_Resilien.p20.02JAN2020 0600.rst	5	5	5	3	20:57
10/21/2020	24_Hour_D6_Rain_Event_Geom_9_Imp_B	Improved conditions. Same as p19. D6 rainfall used.	**p01**	**g12**	**u08**	SMB	D6	60" culvert added under I-64 near existing triple 9x9 box culvert.	Geom_9_Imp_B	I64Culv_JackBore_Terrain	GB_Mannings_N (Manning n override added to geometry file)	Greenbrier_Resilien.p01	24_Hour_D6_Rainfall_Geometry_9B (Greenbrier_Resilien.u08)	Greenbrier_Resilien.p20.02JAN2020 0600.rst	5	5	5	3	3:11
10/21/2020	24_Hour_D12_Rain_Event_Geom_9_Imp_B	Improved conditions. Same as p19. D6 rainfall used.	**p04**	**g12**	**u14**	SMB	D12	60" culvert added under I-64 near existing triple 9x9 box culvert.	Geom_9_Imp_B	I64Culv_JackBore_Terrain	GB_Mannings_N (Manning n override added to geometry file)	Greenbrier_Resilien.p01	24_Hour_D12_Rainfall_Geometry_9B (Greenbrier_Resilien.u14)	Greenbrier_Resilien.p20.02JAN2020 0600.rst	5	5	5	3	2:54

NOTES

1) Many other runs were made during the course of this project. This table summarizes those runs that are described in the report.
2) These HEC-RAS file sizes are very large, totaling over 10.8 GB.
3) HEC-RAS automatically assigns the plan file summary (file extensions) for each run, and maps extension numbers to multiple scenarios as applicable. Likewise, it shortens and abbreviates descriptions. Modelers are cautioned not to rename these files.
4) Model run times vary significantly between computers.

Table 6. Impoundment System Extended Drawdown

Start Time (hrs)	144		
Time Increment (hrs)	1		
Starting Surface Area (ac)	130.54	(does not include lake system along Joe's Crab Shack because there is a controlling structure there.)	
Starting Surface Elevation (ft)	8.96	(at end of HEC-RAS simulation)	
Drawdown Limit Elevation (ft)	7.42	(invert elevation at Greenbrier Mall entrance)	
Assumed Bottom Area (ac)	124.01	(bathymetric survey required to determine this number; we are estimating a 5% reduction from the top surface area.)	
Initial Conic Values			
A_{top} =	5,686,322	ft2	D_{top} = 2690.73
A_{bot} =	5,402,006	ft2	D_{bot} = 2622.60
h_0 =	1.54	ft	
z =	22.12	hor/vert	(side slope of equivalent cone; this is not the 'bank' side slope, it accounts for unsurveyed sediment)

Culvert Headwater Curve Coefficients

$= C5x^5 + C4x^4 + C3x^3 + C2x^2 + C1x$

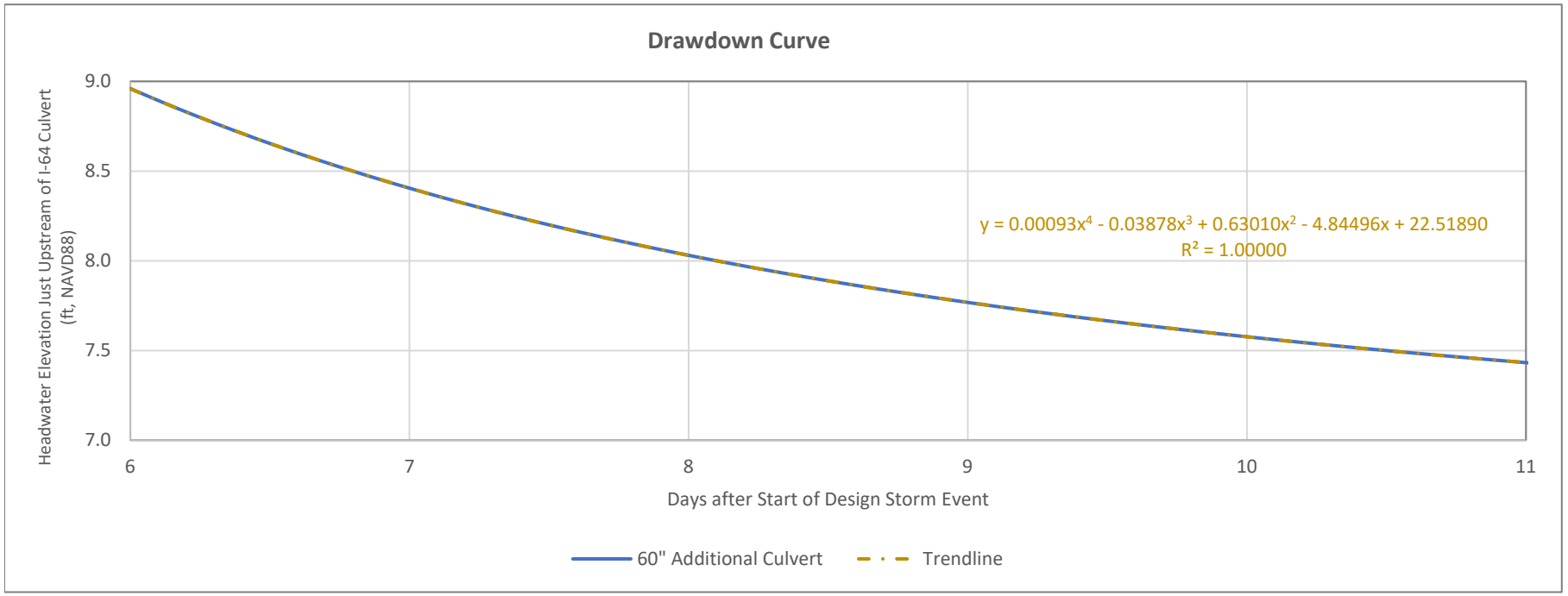
C5	0.0378020
C4	-1.3785580
C3	18.861380
C2	-111.982910
C1	242.085527

Eqn. 1

$$z = \frac{1}{2\Delta h}(D_{Top} - D_{Bot}) \Rightarrow \frac{(D_{Top} - D_{Bot})}{2z} - \Delta h = 0$$

Eqn. 2

$$V = \frac{\pi \Delta h}{12}(D_{Bot}^2 + D_{Bot}D_{Top} + D_{Top}^2) \Rightarrow \frac{12V}{\pi (D_{Bot}^2 + D_{Bot}D_{Top} + D_{Top}^2)} - \Delta h = 0$$



							Use Excel Solver add-in to solve 2 equations for 2 unknowns (Δh & D_{Bot})				
Time (hrs after start of design storm)	Time (Days)	Headwater Elevation @ Beginning of Time Increment (ft)	Volume in Relevant Portion of Impoundment System (ft3)	Culvert Discharge (cfs)	Volume Discharged During Time Increment (ft3)	D_{Top} (ft2)	Δh (ft)	D_{Bot} (ft2)	Eqn 1	Eqn 2	Headwater Elevation @ End of Time Increment (ft)
144	6.00	8.960	8,537,077	44.36	159,692	2,690.73	0.0281	2,689.5	0.00	0.00	8.932
145	6.04	8.932	8,377,386	43.53	156,696	2,689.49	0.0276	2,688.3	0.00	0.00	8.904
146	6.08	8.904	8,220,690	42.71	153,770	2,688.27	0.0271	2,687.1	0.00	0.00	8.877
147	6.13	8.877	8,066,920	41.92	150,912	2,687.07	0.0266	2,685.9	0.00	0.00	8.851
148	6.17	8.851	7,916,008	41.14	148,119	2,685.89	0.0262	2,684.7	0.00	0.00	8.824
149	6.21	8.824	7,767,888	40.39	145,391	2,684.74	0.0257	2,683.6	0.00	0.00	8.799
150	6.25	8.799	7,622,497	39.65	142,725	2,683.60	0.0252	2,682.5	0.00	0.00	8.773
151	6.29	8.773	7,479,772	38.92	140,120	2,682.48	0.0248	2,681.4	0.00	0.00	8.749
152	6.33	8.749	7,339,652	38.21	137,574	2,681.39	0.0244	2,680.3	0.00	0.00	8.724
153	6.38	8.724	7,202,078	37.52	135,085	2,680.31	0.0240	2,679.2	0.00	0.00	8.700
154	6.42	8.700	7,066,993	36.85	132,653	2,679.25	0.0235	2,678.2	0.00	0.00	8.677
155	6.46	8.677	6,934,340	36.19	130,275	2,678.21	0.0231	2,677.2	0.00	0.00	8.654
156	6.50	8.654	6,804,064	35.54	127,951	2,677.18	0.0227	2,676.2	0.00	0.00	8.631
157	6.54	8.631	6,676,113	34.91	125,679	2,676.18	0.0224	2,675.2	0.00	0.00	8.609
158	6.58	8.609	6,550,435	34.29	123,457	2,675.19	0.0220	2,674.2	0.00	0.00	8.587
159	6.63	8.587	6,426,978	33.69	121,284	2,674.22	0.0216	2,673.3	0.00	0.00	8.565
160	6.67	8.565	6,305,694	33.10	119,160	2,673.26	0.0212	2,672.3	0.00	0.00	8.544
161	6.71	8.544	6,186,535	32.52	117,082	2,672.32	0.0209	2,671.4	0.00	0.00	8.523
162	6.75	8.523	6,069,453	31.96	115,050	2,671.40	0.0205	2,670.5	0.00	0.00	8.502
163	6.79	8.502	5,954,403	31.41	113,063	2,670.49	0.0202	2,669.6	0.00	0.00	8.482
164	6.83	8.482	5,841,340	30.87	111,119	2,669.60	0.0199	2,668.7	0.00	0.00	8.462
165	6.88	8.462	5,730,222	30.34	109,217	2,668.72	0.0195	2,667.9	0.00	0.00	8.443
166	6.92	8.443	5,621,005	29.82	107,357	2,667.85	0.0192	2,667.0	0.00	0.00	8.424
167	6.96	8.424	5,513,648	29.32	105,537	2,667.00	0.0189	2,666.2	0.00	0.00	8.405
168	7.00	8.405	5,408,111	28.82	103,756	2,666.17	0.0186	2,665.3	0.00	0.00	8.386
169	7.04	8.386	5,304,355	28.34	102,014	2,665.34	0.0183	2,664.5	0.00	0.00	8.368
170	7.08	8.368	5,202,341	27.86	100,309	2,664.53	0.0180	2,663.7	0.00	0.00	8.350
171	7.13	8.350	5,102,032	27.40	98,640	2,663.74	0.0177	2,663.0	0.00	0.00	8.332
172	7.17	8.332	5,003,392	26.95	97,008	2,662.96	0.0174	2,662.2	0.00	0.00	8.315
173	7.21	8.315	4,906,384	26.50	95,409	2,662.18	0.0171	2,661.4	0.00	0.00	8.298
174	7.25	8.298	4,810,975	26.07	93,845	2,661.43	0.0169	2,660.7	0.00	0.00	8.281
175	7.29	8.281	4,717,129	25.64	92,314	2,660.68	0.0166	2,659.9	0.00	0.00	8.264
176	7.33	8.264	4,624,815	25.23	90,815	2,659.94	0.0163	2,659.2	0.00	0.00	8.248
177	7.38	8.248	4,534,000	24.82	89,348	2,659.22	0.0161	2,658.5	0.00	0.00	8.232

							Use Excel Solver add-in to solve 2 equations for 2 unknowns (Δh & D_{Bot})				
Time (hrs after start of design storm)	Time (Days)	Headwater Elevation @ Beginning of Time Increment (ft)	Volume in Relevant Portion of Impoundment System (ft3)	Culvert Discharge (cfs)	Volume Discharged During Time Increment (ft3)	D_{Top} (ft2)	Δh (ft)	D_{Bot} (ft2)	Eqn 1	Eqn 2	Headwater Elevation @ End of Time Increment (ft)
178	7.42	8.232	4,444,653	24.42	87,911	2,658.51	0.0158	2,657.8	0.00	0.00	8.216
179	7.46	8.216	4,356,742	24.03	86,504	2,657.81	0.0156	2,657.1	0.00	0.00	8.200
180	7.50	8.200	4,270,238	23.65	85,126	2,657.12	0.0154	2,656.4	0.00	0.00	8.185
181	7.54	8.185	4,185,111	23.27	83,777	2,656.44	0.0151	2,655.8	0.00	0.00	8.170
182	7.58	8.170	4,101,334	22.90	82,456	2,655.77	0.0149	2,655.1	0.00	0.00	8.155
183	7.63	8.155	4,018,878	22.55	81,162	2,655.11	0.0147	2,654.5	0.00	0.00	8.140
184	7.67	8.140	3,937,715	22.19	79,895	2,654.46	0.0144	2,653.8	0.00	0.00	8.126
185	7.71	8.126	3,857,821	21.85	78,653	2,653.82	0.0142	2,653.2	0.00	0.00	8.111
186	7.75	8.111	3,779,167	21.51	77,437	2,653.20	0.0140	2,652.6	0.00	0.00	8.097
187	7.79	8.097	3,701,730	21.18	76,246	2,652.58	0.0138	2,652.0	0.00	0.00	8.084
188	7.83	8.084	3,625,484	20.86	75,078	2,651.96	0.0136	2,651.4	0.00	0.00	8.070
189	7.88	8.070	3,550,406	20.54	73,934	2,651.36	0.0134	2,650.8	0.00	0.00	8.057
190	7.92	8.057	3,476,472	20.23	72,813	2,650.77	0.0132	2,650.2	0.00	0.00	8.043
191	7.96	8.043	3,403,659	19.92	71,715	2,650.19	0.0130	2,649.6	0.00	0.00	8.030
192	8.00	8.030	3,331,944	19.62	70,638	2,649.61	0.0128	2,649.0	0.00	0.00	8.018
193	8.04	8.018	3,261,306	19.33	69,583	2,649.04	0.0126	2,648.5	0.00	0.00	8.005
194	8.08	8.005	3,191,723	19.04	68,549	2,648.49	0.0124	2,647.9	0.00	0.00	7.993
195	8.13	7.993	3,123,174	18.76	67,535	2,647.94	0.0123	2,647.4	0.00	0.00	7.980
196	8.17	7.980	3,055,639	18.48	66,541	2,647.39	0.0121	2,646.9	0.00	0.00	7.968
197	8.21	7.968	2,989,098	18.21	65,566	2,646.86	0.0119	2,646.3	0.00	0.00	7.956
198	8.25	7.956	2,923,532	17.95	64,611	2,646.33	0.0117	2,645.8	0.00	0.00	7.945
199	8.29	7.945	2,858,922	17.69	63,674	2,645.81	0.0116	2,645.3	0.00	0.00	7.933
200	8.33	7.933	2,795,248	17.43	62,755	2,645.30	0.0114	2,644.8	0.00	0.00	7.922
201	8.38	7.922	2,732,493	17.18	61,854	2,644.79	0.0113	2,644.3	0.00	0.00	7.910
202	8.42	7.910	2,670,639	16.94	60,970	2,644.30	0.0111	2,643.8	0.00	0.00	7.899
203	8.46	7.899	2,609,669	16.70	60,103	2,643.80	0.0110	2,643.3	0.00	0.00	7.888
204	8.50	7.888	2,549,566	16.46	59,253	2,643.32	0.0108	2,642.8	0.00	0.00	7.877
205	8.54	7.877	2,490,313	16.23	58,419	2,642.84	0.0107	2,642.4	0.00	0.00	7.867
206	8.58	7.867	2,431,894	16.00	57,600	2,642.37	0.0105	2,641.9	0.00	0.00	7.856
207	8.63	7.856	2,374,294	15.78	56,797	2,641.91	0.0104	2,641.4	0.00	0.00	7.846
208	8.67	7.846	2,317,497	15.56	56,009	2,641.45	0.0102	2,641.0	0.00	0.00	7.836
209	8.71	7.836	2,261,487	15.34	55,236	2,640.99	0.0101	2,640.5	0.00	0.00	7.826
210	8.75	7.826	2,206,251	15.13	54,477	2,640.55	0.0099	2,640.1	0.00	0.00	7.816
211	8.79	7.816	2,151,773	14.93	53,733	2,640.11	0.0098	2,639.7	0.00	0.00	7.806

							Use Excel Solver add-in to solve 2 equations for 2 unknowns (Δh & D_{Bot})				
Time (hrs after start of design storm)	Time (Days)	Headwater Elevation @ Beginning of Time Increment (ft)	Volume in Relevant Portion of Impoundment System (ft3)	Culvert Discharge (cfs)	Volume Discharged During Time Increment (ft3)	D_{Top} (ft2)	Δh (ft)	D_{Bot} (ft2)	Eqn 1	Eqn 2	Headwater Elevation @ End of Time Increment (ft)
212	8.83	7.806	2,098,041	14.72	53,002	2,639.67	0.0097	2,639.2	0.00	0.00	7.796
213	8.88	7.796	2,045,039	14.52	52,284	2,639.25	0.0096	2,638.8	0.00	0.00	7.787
214	8.92	7.787	1,992,754	14.33	51,580	2,638.82	0.0094	2,638.4	0.00	0.00	7.777
215	8.96	7.777	1,941,174	14.14	50,889	2,638.41	0.0093	2,638.0	0.00	0.00	7.768
216	9.00	7.768	1,890,286	13.95	50,210	2,637.99	0.0092	2,637.6	0.00	0.00	7.759
217	9.04	7.759	1,840,076	13.76	49,543	2,637.59	0.0091	2,637.2	0.00	0.00	7.750
218	9.08	7.750	1,790,533	13.58	48,889	2,637.19	0.0090	2,636.8	0.00	0.00	7.741
219	9.13	7.741	1,741,644	13.40	48,246	2,636.79	0.0088	2,636.4	0.00	0.00	7.732
220	9.17	7.732	1,693,398	13.23	47,615	2,636.40	0.0087	2,636.0	0.00	0.00	7.723
221	9.21	7.723	1,645,783	13.05	46,995	2,636.01	0.0086	2,635.6	0.00	0.00	7.714
222	9.25	7.714	1,598,788	12.88	46,386	2,635.63	0.0085	2,635.3	0.00	0.00	7.706
223	9.29	7.706	1,552,403	12.72	45,788	2,635.26	0.0084	2,634.9	0.00	0.00	7.698
224	9.33	7.698	1,506,615	12.56	45,200	2,634.88	0.0083	2,634.5	0.00	0.00	7.689
225	9.38	7.689	1,461,415	12.40	44,623	2,634.52	0.0082	2,634.2	0.00	0.00	7.681
226	9.42	7.681	1,416,792	12.24	44,055	2,634.16	0.0081	2,633.8	0.00	0.00	7.673
227	9.46	7.673	1,372,737	12.08	43,498	2,633.80	0.0080	2,633.4	0.00	0.00	7.665
228	9.50	7.665	1,329,239	11.93	42,950	2,633.44	0.0079	2,633.1	0.00	0.00	7.657
229	9.54	7.657	1,286,289	11.78	42,412	2,633.10	0.0078	2,632.8	0.00	0.00	7.649
230	9.58	7.649	1,243,877	11.63	41,883	2,632.75	0.0077	2,632.4	0.00	0.00	7.642
231	9.63	7.642	1,201,994	11.49	41,363	2,632.41	0.0076	2,632.1	0.00	0.00	7.634
232	9.67	7.634	1,160,631	11.35	40,852	2,632.07	0.0075	2,631.7	0.00	0.00	7.627
233	9.71	7.627	1,119,778	11.21	40,350	2,631.74	0.0074	2,631.4	0.00	0.00	7.619
234	9.75	7.619	1,079,429	11.07	39,856	2,631.41	0.0073	2,631.1	0.00	0.00	7.612
235	9.79	7.612	1,039,573	10.94	39,370	2,631.09	0.0072	2,630.8	0.00	0.00	7.605
236	9.83	7.605	1,000,202	10.80	38,893	2,630.77	0.0072	2,630.5	0.00	0.00	7.597
237	9.88	7.597	961,310	10.67	38,424	2,630.45	0.0071	2,630.1	0.00	0.00	7.590
238	9.92	7.590	922,886	10.55	37,962	2,630.14	0.0070	2,629.8	0.00	0.00	7.583
239	9.96	7.583	884,924	10.42	37,508	2,629.83	0.0069	2,629.5	0.00	0.00	7.576
240	10.00	7.576	847,416	10.29	37,062	2,629.53	0.0068	2,629.2	0.00	0.00	7.570
241	10.04	7.570	810,354	10.17	36,623	2,629.22	0.0067	2,628.9	0.00	0.00	7.563
242	10.08	7.563	773,732	10.05	36,191	2,628.92	0.0067	2,628.6	0.00	0.00	7.556
243	10.13	7.556	737,541	9.93	35,766	2,628.63	0.0066	2,628.3	0.00	0.00	7.550
244	10.17	7.550	701,775	9.82	35,348	2,628.34	0.0065	2,628.0	0.00	0.00	7.543
245	10.21	7.543	666,427	9.70	34,937	2,628.05	0.0064	2,627.8	0.00	0.00	7.537

							Use Excel Solver add-in to solve 2 equations for 2 unknowns (Δh & D_{Bot})				
Time (hrs after start of design storm)	Time (Days)	Headwater Elevation @ Beginning of Time Increment (ft)	Volume in Relevant Portion of Impoundment System (ft3)	Culvert Discharge (cfs)	Volume Discharged During Time Increment (ft3)	D_{Top} (ft2)	Δh (ft)	D_{Bot} (ft2)	Eqn 1	Eqn 2	Headwater Elevation @ End of Time Increment (ft)
246	10.25	7.537	631,490	9.59	34,532	2,627.76	0.0064	2,627.5	0.00	0.00	7.530
247	10.29	7.530	596,958	9.48	34,134	2,627.48	0.0063	2,627.2	0.00	0.00	7.524
248	10.33	7.524	562,823	9.37	33,743	2,627.20	0.0062	2,626.9	0.00	0.00	7.518
249	10.38	7.518	529,080	9.27	33,357	2,626.93	0.0062	2,626.7	0.00	0.00	7.512
250	10.42	7.512	495,723	9.16	32,978	2,626.66	0.0061	2,626.4	0.00	0.00	7.506
251	10.46	7.506	462,745	9.06	32,605	2,626.39	0.0060	2,626.1	0.00	0.00	7.500
252	10.50	7.500	430,140	8.95	32,237	2,626.12	0.0060	2,625.9	0.00	0.00	7.494
253	10.54	7.494	397,903	8.85	31,876	2,625.86	0.0059	2,625.6	0.00	0.00	7.488
254	10.58	7.488	366,027	8.76	31,520	2,625.60	0.0058	2,625.3	0.00	0.00	7.482
255	10.63	7.482	334,508	8.66	31,169	2,625.34	0.0058	2,625.1	0.00	0.00	7.476
256	10.67	7.476	303,338	8.56	30,824	2,625.09	0.0057	2,624.8	0.00	0.00	7.470
257	10.71	7.470	272,514	8.47	30,485	2,624.83	0.0056	2,624.6	0.00	0.00	7.465
258	10.75	7.465	242,029	8.38	30,150	2,624.58	0.0056	2,624.3	0.00	0.00	7.459
259	10.79	7.459	211,879	8.28	29,821	2,624.34	0.0055	2,624.1	0.00	0.00	7.454
260	10.83	7.454	182,059	8.19	29,496	2,624.09	0.0055	2,623.9	0.00	0.00	7.448
261	10.88	7.448	152,562	8.10	29,177	2,623.85	0.0054	2,623.6	0.00	0.00	7.443
262	10.92	7.443	123,385	8.02	28,863	2,623.61	0.0053	2,623.4	0.00	0.00	7.437
263	10.96	7.437	94,522	7.93	28,553	2,623.38	0.0053	2,623.1	0.00	0.00	7.432
264	11.00	7.432	65,970	7.85	28,248	2,623.14	0.0052	2,622.9	0.00	0.00	7.427
265	11.04	7.427	37,722	7.76	27,947	2,622.91	0.0052	2,622.7	0.00	0.00	7.422
266	11.08	7.422	9,775	7.68	27,651	2,622.68	0.0051	2,622.5	0.00	0.00	7.417
										7.42 = Drawdown Limit	

Figure 1. Greenbrier Drainage Area with Reference Nodes

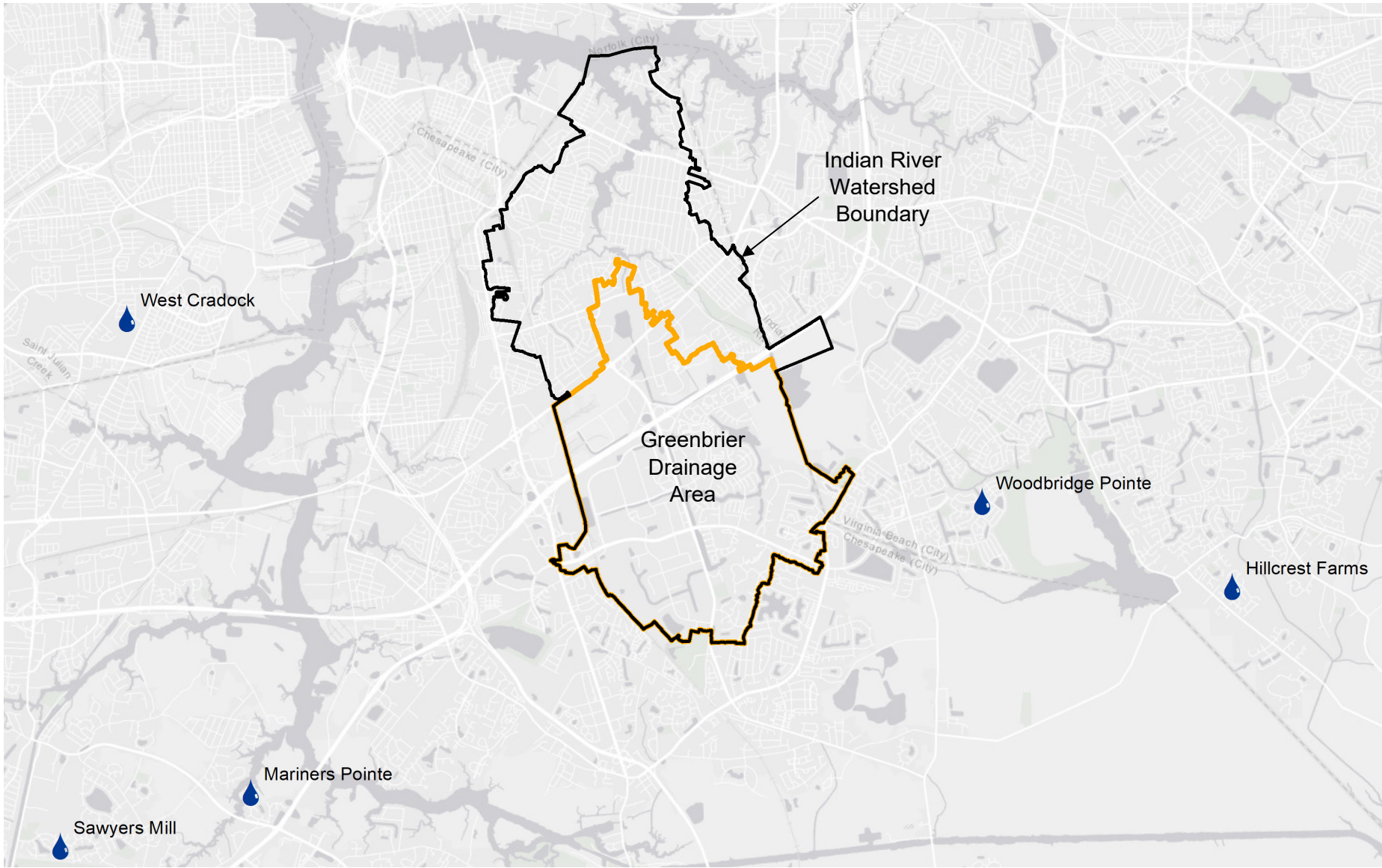
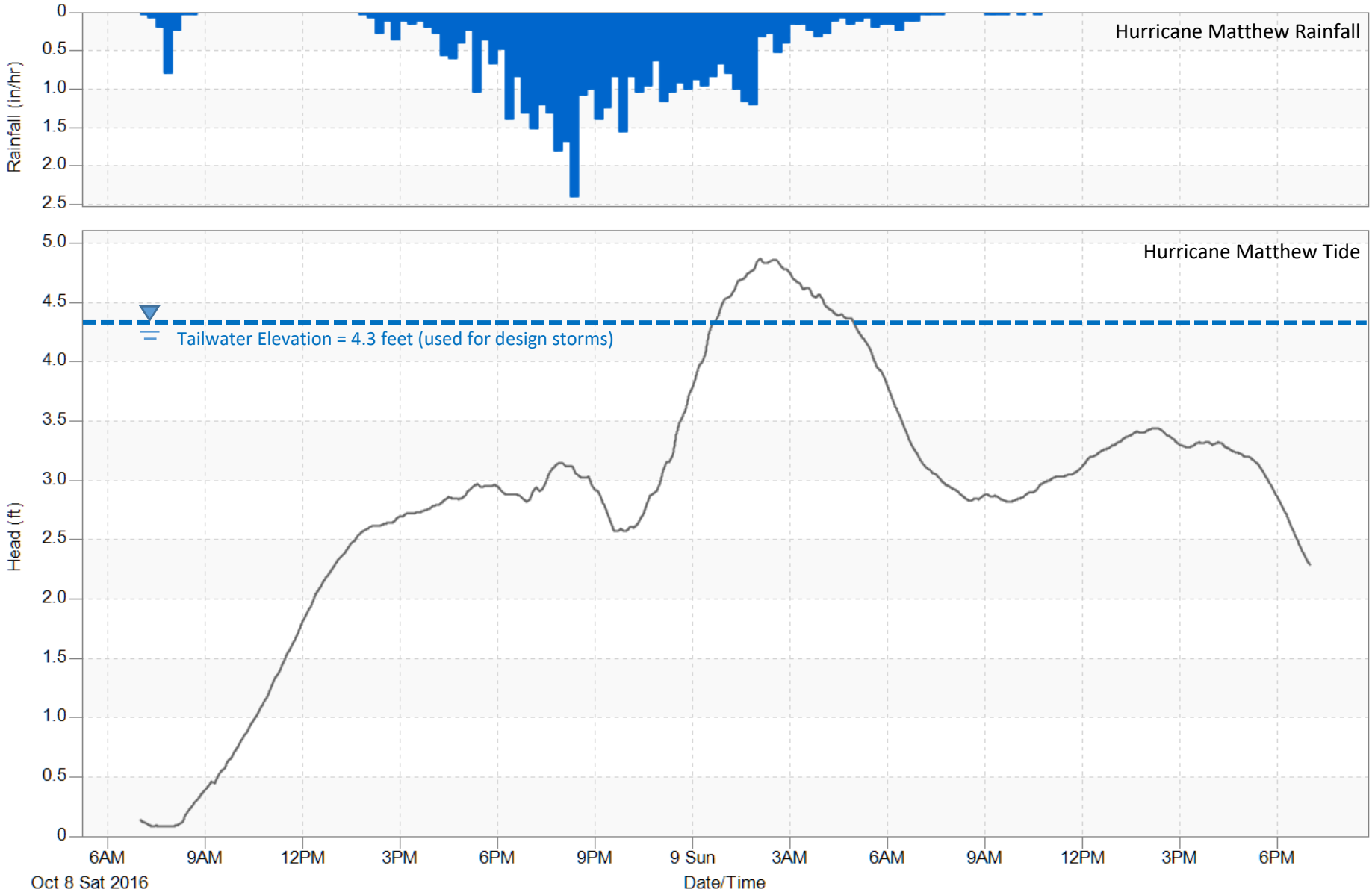


Figure 2. Hurricane Matthew Precipitation Sources



Rainfall was recorded at City Hall.
Tide was recorded at Money Point, shown for general reference.
Vertical Datum = NAVD88

Figure 3. Hurricane Matthew Rainfall and Tide

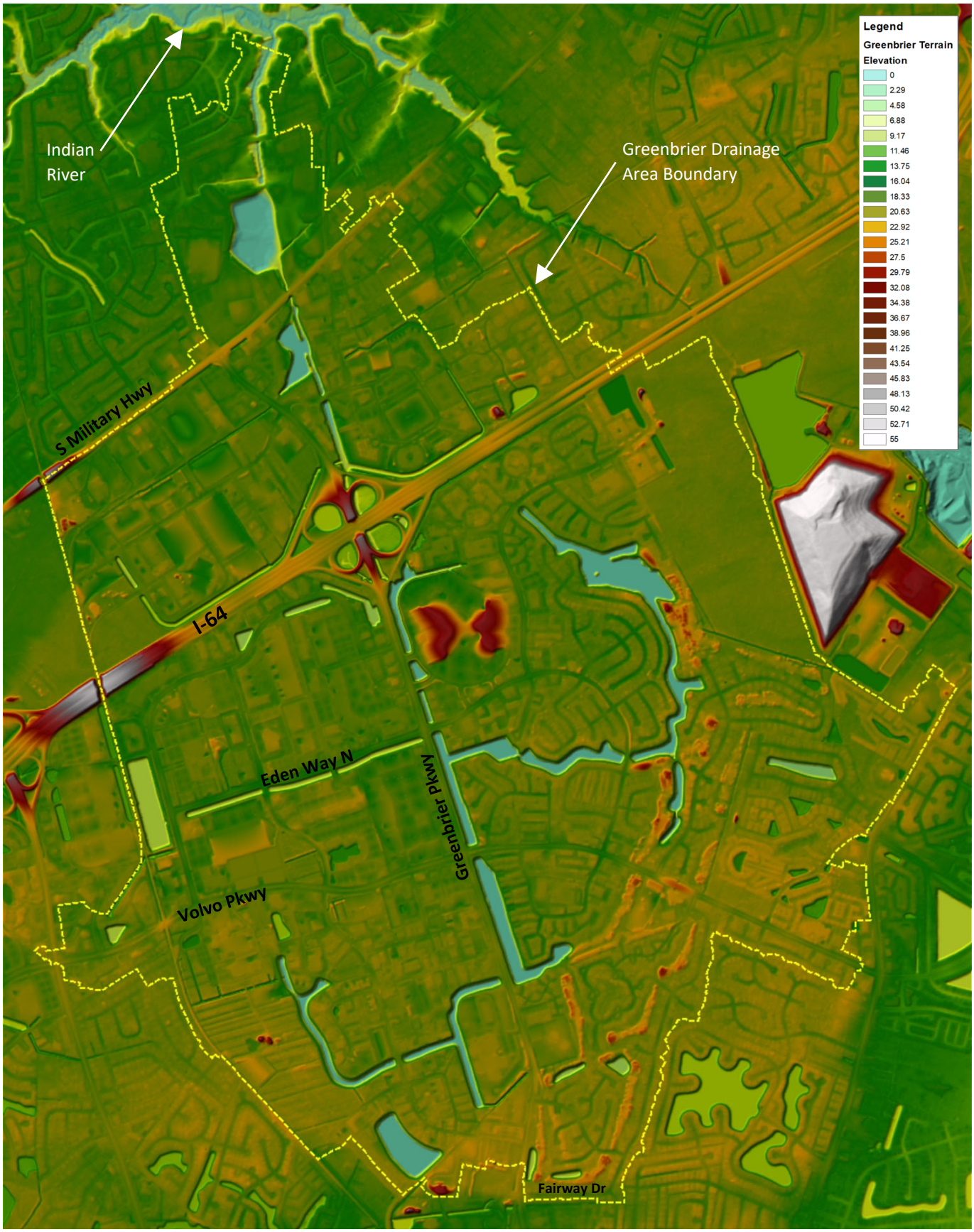
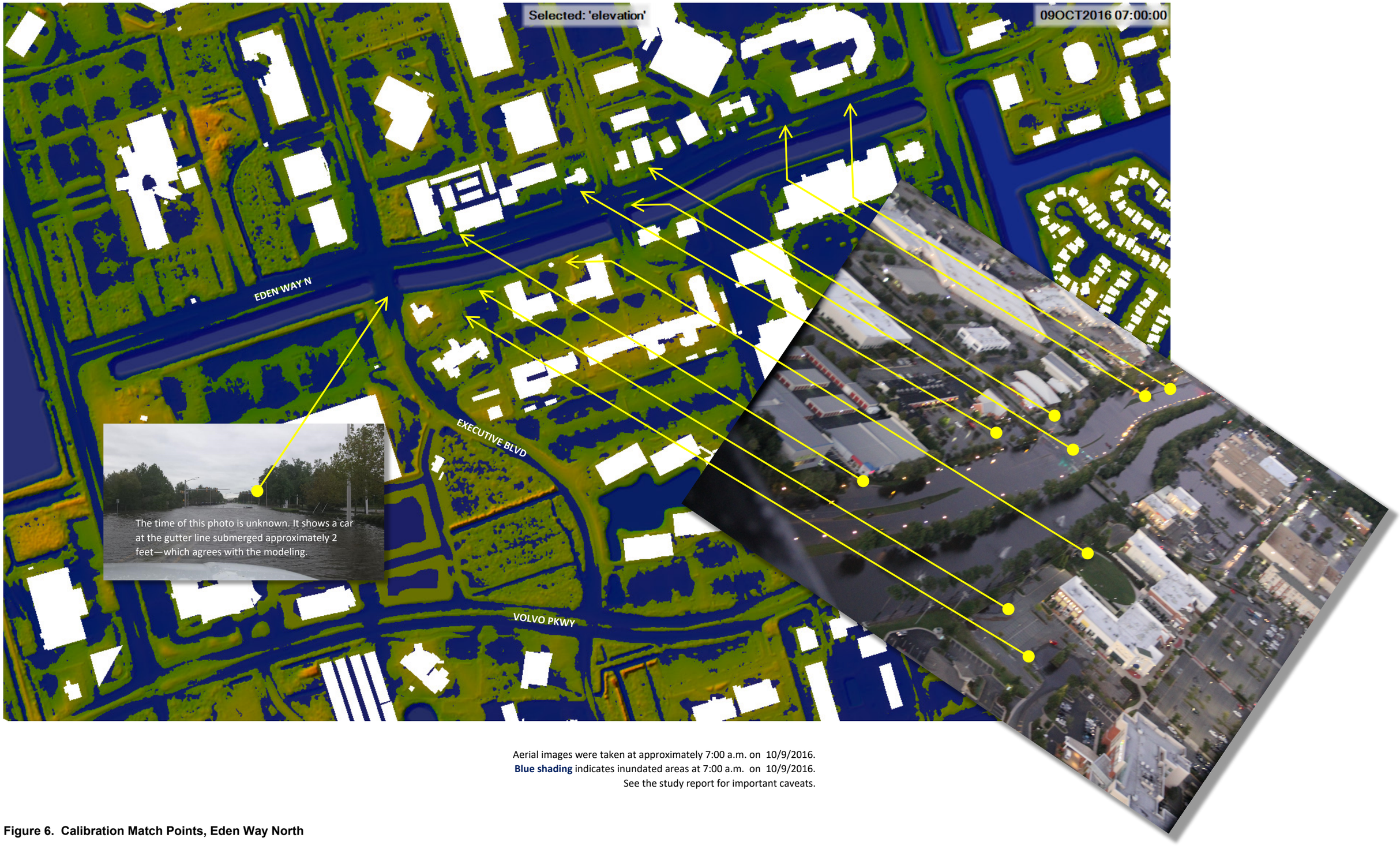


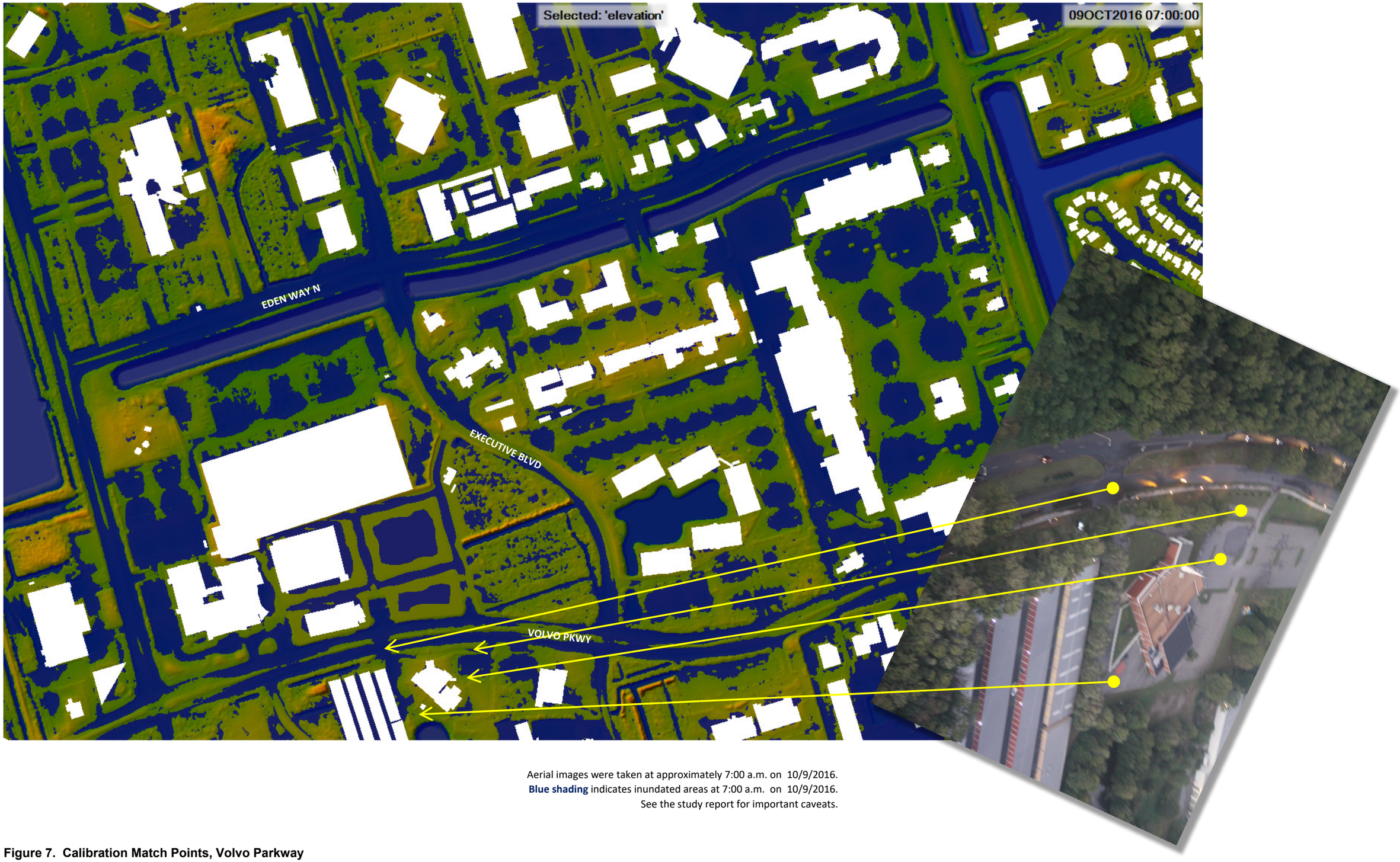
Figure 4. Rain-on-Grid Model Construction, Terrain

Figure 5. Rain-on-Grid Model Construction, 2D Mesh Geometry



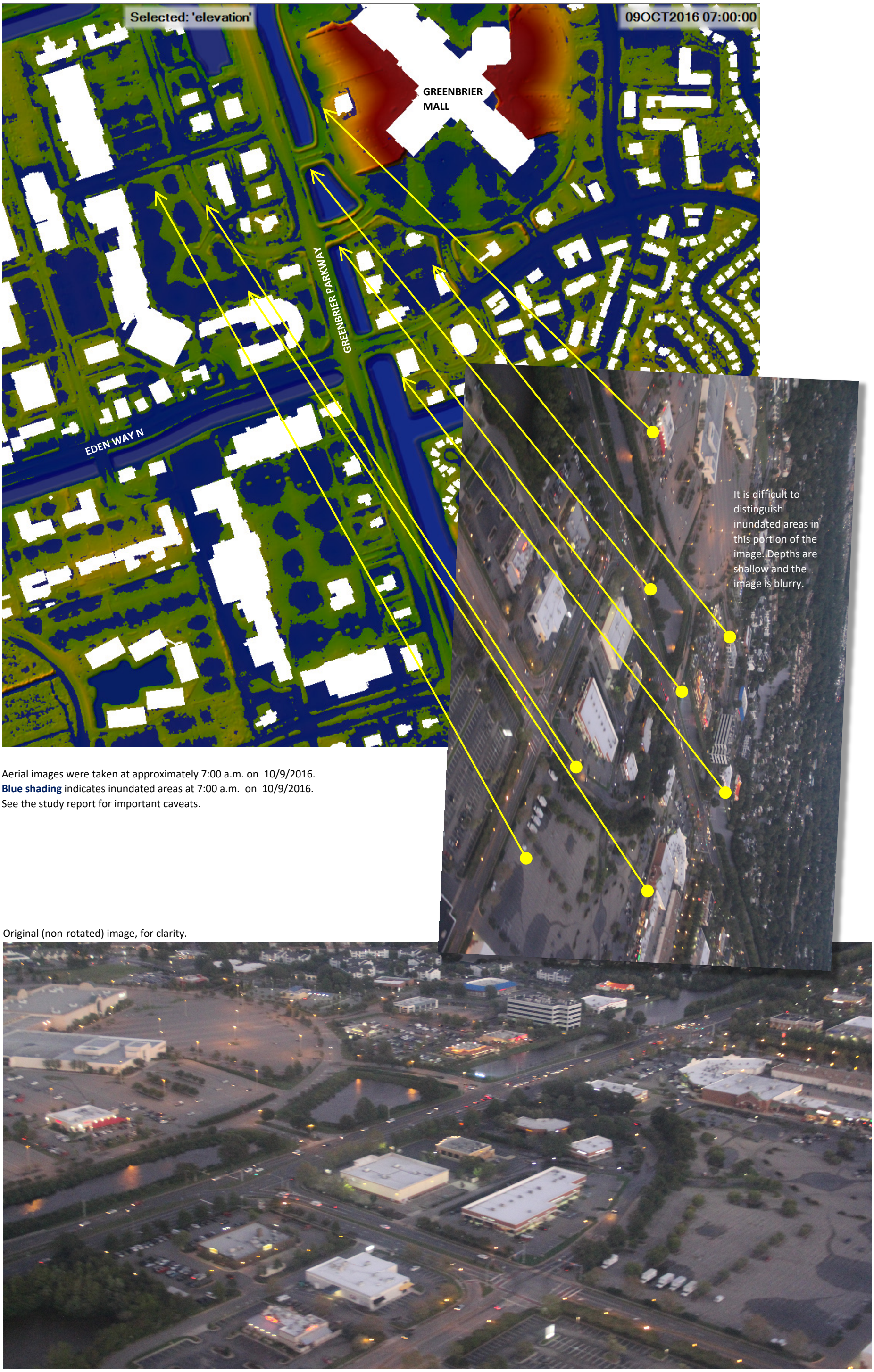
Aerial images were taken at approximately 7:00 a.m. on 10/9/2016.
Blue shading indicates inundated areas at 7:00 a.m. on 10/9/2016.
See the study report for important caveats.

Figure 6. Calibration Match Points, Eden Way North



Aerial images were taken at approximately 7:00 a.m. on 10/9/2016.
Blue shading indicates inundated areas at 7:00 a.m. on 10/9/2016.
See the study report for important caveats.

Figure 7. Calibration Match Points, Volvo Parkway



Aerial images were taken at approximately 7:00 a.m. on 10/9/2016.
Blue shading indicates inundated areas at 7:00 a.m. on 10/9/2016.
See the study report for important caveats.

Original (non-rotated) image, for clarity.

Figure 8. Calibration Match Points, Greenbrier Parkway

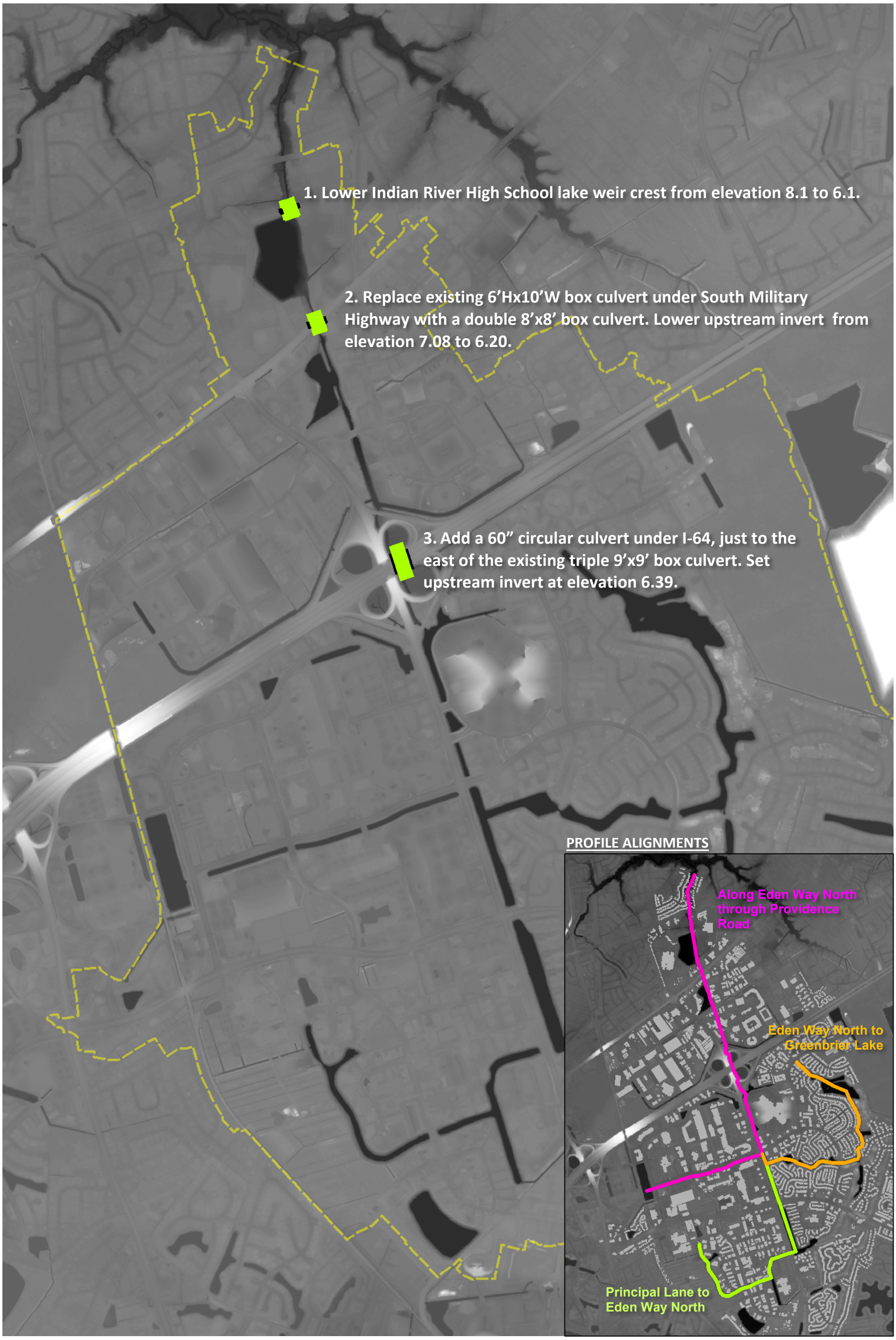
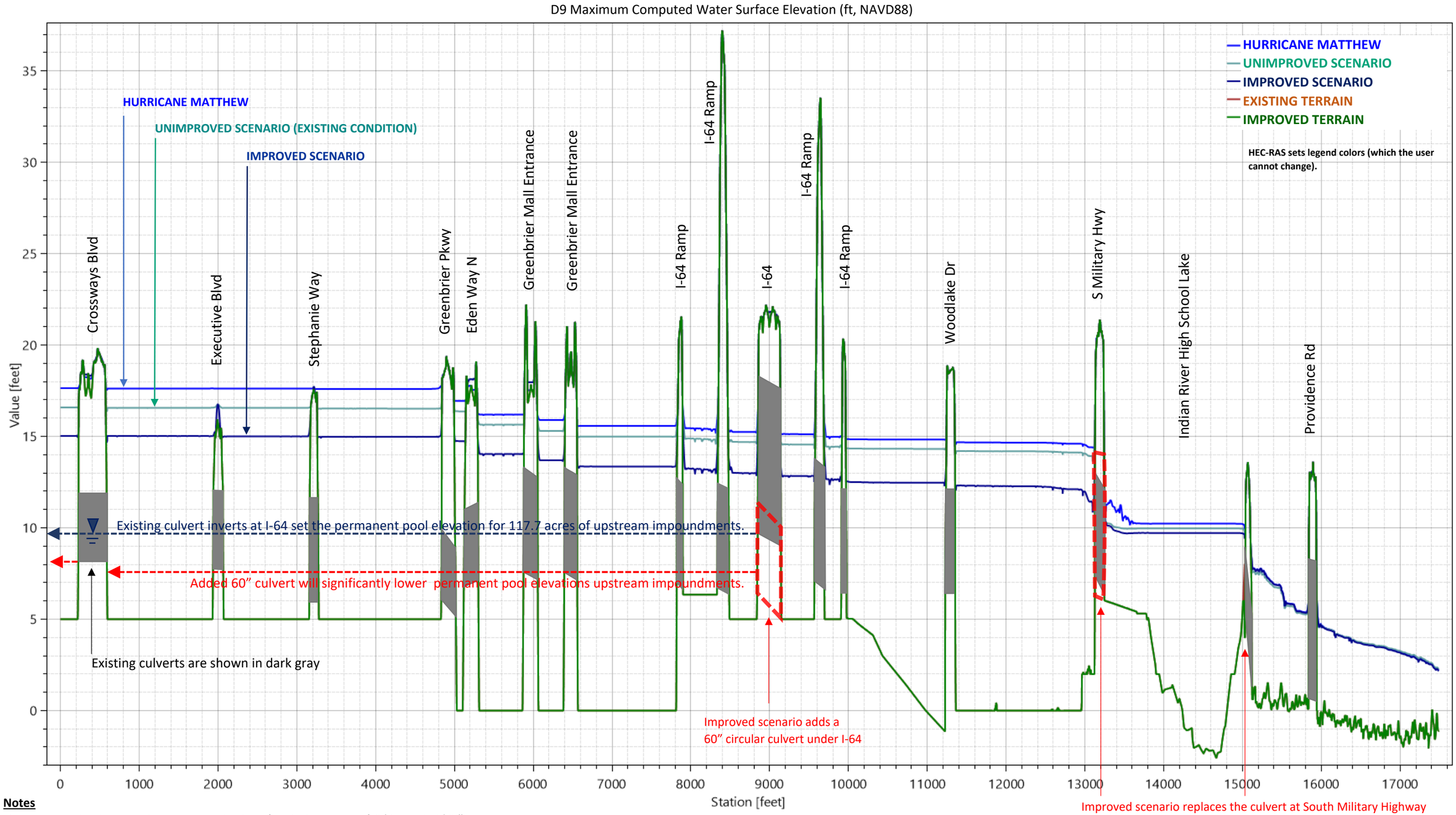


Figure 9. Potential Improvement Projects



Notes

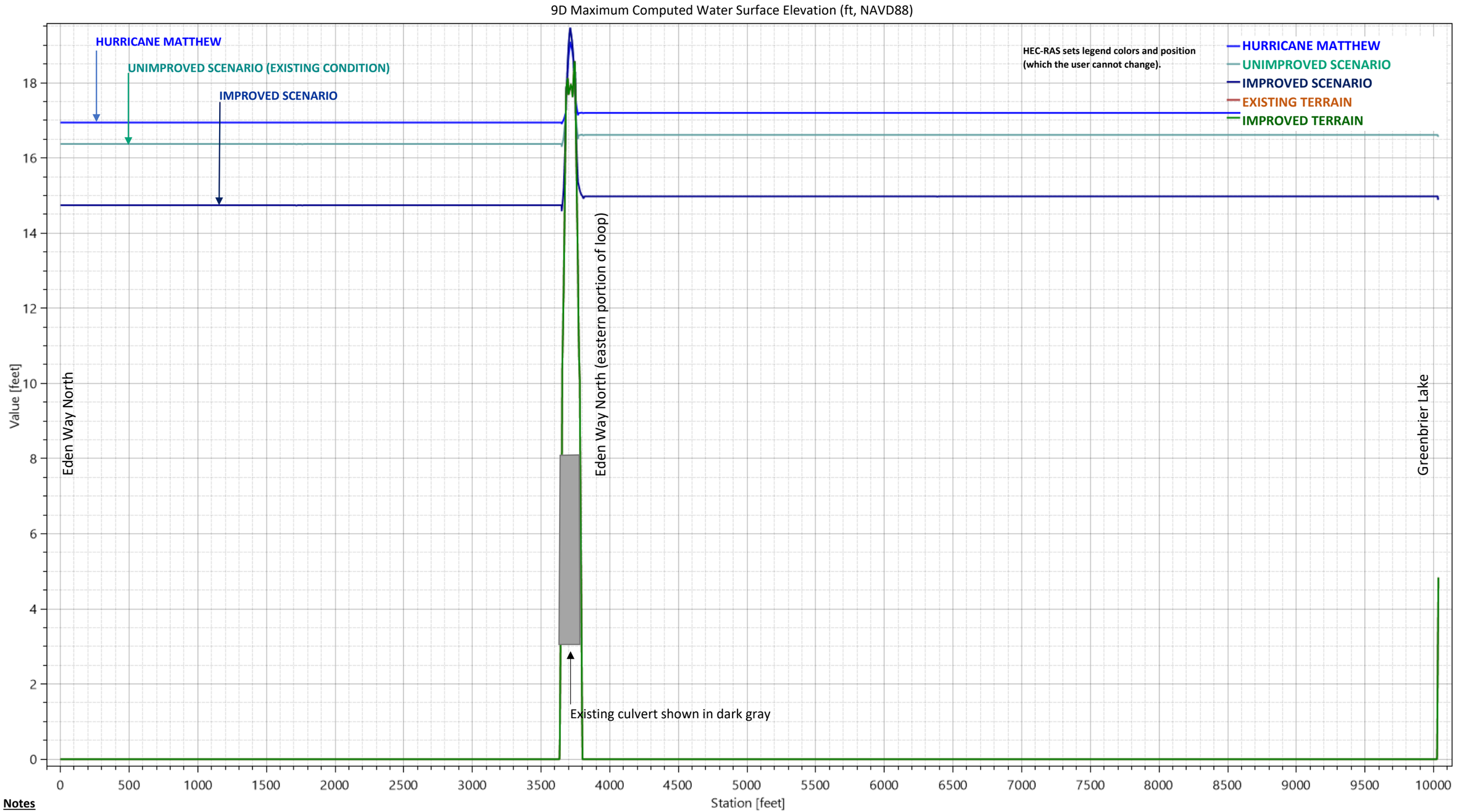
The unimproved and improved scenarios use 9 inches of applied, excess rainfall (designated '**D9**').
The unimproved and improved scenarios have the blockages removed from the pipes under Eden Way N.
All culverts are assumed to be clean in the unimproved and improved scenarios.
The existing and improved terrains are coincident lines along this profile, except for the lowering of the weir at Indian River High School lake.

Figure 10. Maximum Hydraulic Grade Lines, Along Eden Way North through Providence Road

Notes

The unimproved and improved scenarios use 9 inches of applied, excess rainfall (designated '**D9**').
The unimproved and improved scenarios have the blockages removed from the pipes under Eden Way N.
All culverts are assumed to be clean in the unimproved and improved scenarios.
The existing and improved terrains are coincident lines along this profile.

Figure 11. Maximum Hydraulic Grade Lines, Principal Lane to Eden Way North



Notes

The unimproved and improved scenarios use 9 inches of applied, excess rainfall (designated '**D9**').
The unimproved and improved scenarios have the blockages removed from the pipes under Eden Way N.
All culverts are assumed to be clean in the unimproved and improved scenarios.
The existing and improved terrains are coincident lines along this profile.

Figure 12. Maximum Hydraulic Grade Lines, Eden Way North to Greenbrier Lake

Godwin Dri-Prime CD225M Pump

Assume average output would be 2,500 gpm = 5.6 cfs

Engine option 1

John Deere 4045TF285 (T3 Flex), 99 HP @ 2200 rpm

Impeller diameter 11.4"

Pump speed 2200 rpm

Suction Lift Table

Total Suction Head (feet)	Total Delivery Head (feet)				
	42	70	101	121	137
	Output (USGPM)				
10	3148	2906	2325	-	-
15	2906	2543	2058	1695	-
20	1695	1695	1695	1453	-
25	1211	1211	1211	969	387

Fuel capacity: 100 US Gal

Max Fuel consumption @ 2200 rpm: 5.8 US Gal/hr

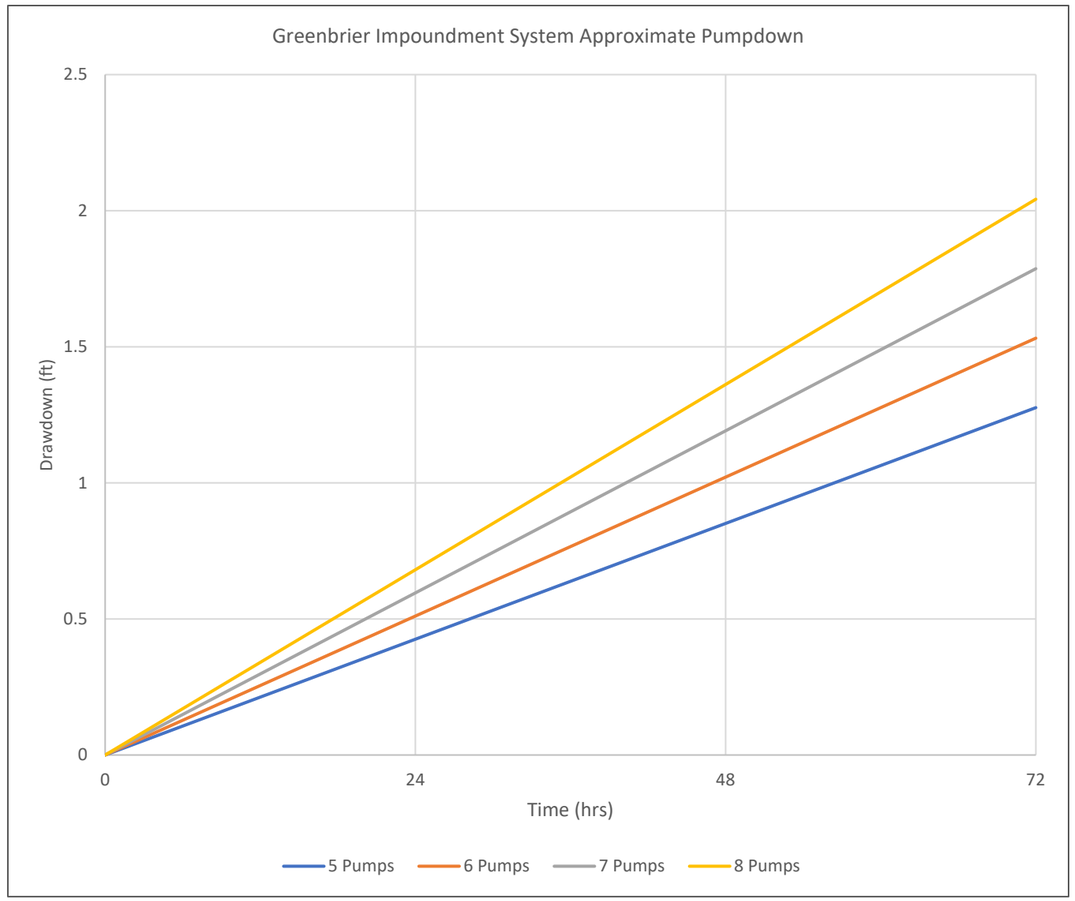
Max Fuel consumption @ 1800 rpm: 5.0 US Gal/hr

Weight (Dry): 4,440 lbs

Weight (Wet): 5,160 lbs

Dim.: (L) 155" x (W) 76" x (H) 93"

Performance data provided in tables is based on water tests at sea level and 20°C ambient. All information is approximate and for general guidance only. Please contact the factory or office for further details.



Notes

These pumps would require a manifold force main system, the details of which would significantly affect the pump performance curves. These are approximate calculations, only for feasibility consideration purposes.

Greenbrier Impoundment System
Approximate Pumpdown Times

Lake System Surface Area (ac): 130.54
Lake System Surface Area (ft2): 5,686,322

Assumed Single Pump Average Capacity (cfs): 5.6

Number of Pumps	Time (hrs)	Pumped Volume (ft3)	Lake System Drawdown (ft)
1	24	483,840	0.09
2	24	967,680	0.17
3	24	1,451,520	0.26
4	24	1,935,360	0.34
5	24	2,419,200	0.43
6	24	2,903,040	0.51
7	24	3,386,880	0.60
8	24	3,870,720	0.68
9	24	4,354,560	0.77
10	24	4,838,400	0.85
1	48	967,680	0.17
2	48	1,935,360	0.34
3	48	2,903,040	0.51
4	48	3,870,720	0.68
5	48	4,838,400	0.85
6	48	5,806,080	1.02
7	48	6,773,760	1.19
8	48	7,741,440	1.36
9	48	8,709,120	1.53
10	48	9,676,800	1.70
1	72	1,451,520	0.26
2	72	2,903,040	0.51
3	72	4,354,560	0.77
4	72	5,806,080	1.02
5	72	7,257,600	1.28
6	72	8,709,120	1.53
7	72	10,160,640	1.79
8	72	11,612,160	2.04
9	72	13,063,680	2.30
10	72	14,515,200	2.55

Figure 13. Greenbrier Impoundment System Pumpdown Options

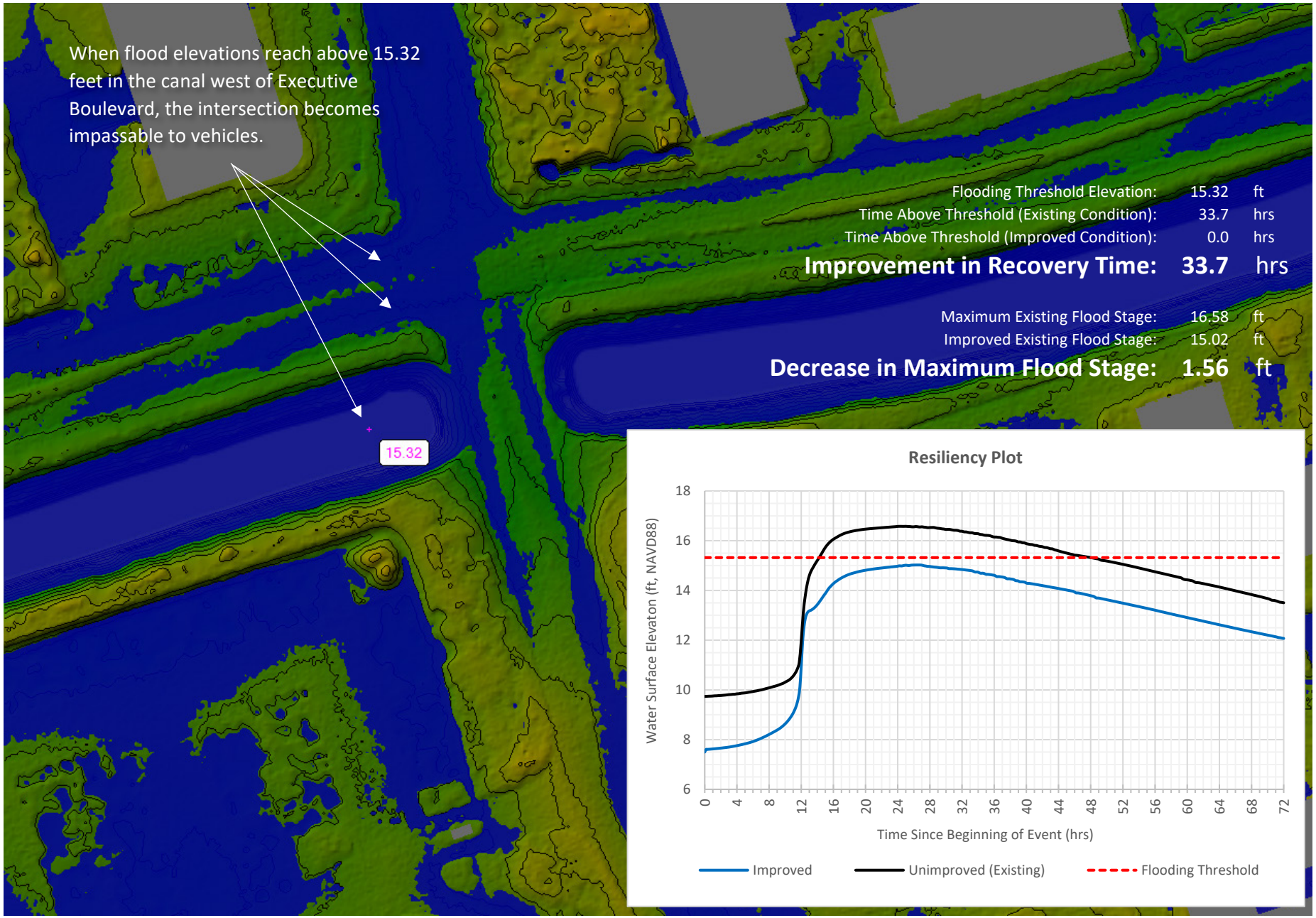


Figure 14. Resilience Improvements, Eden Way and Executive Boulevard (D9 Event)

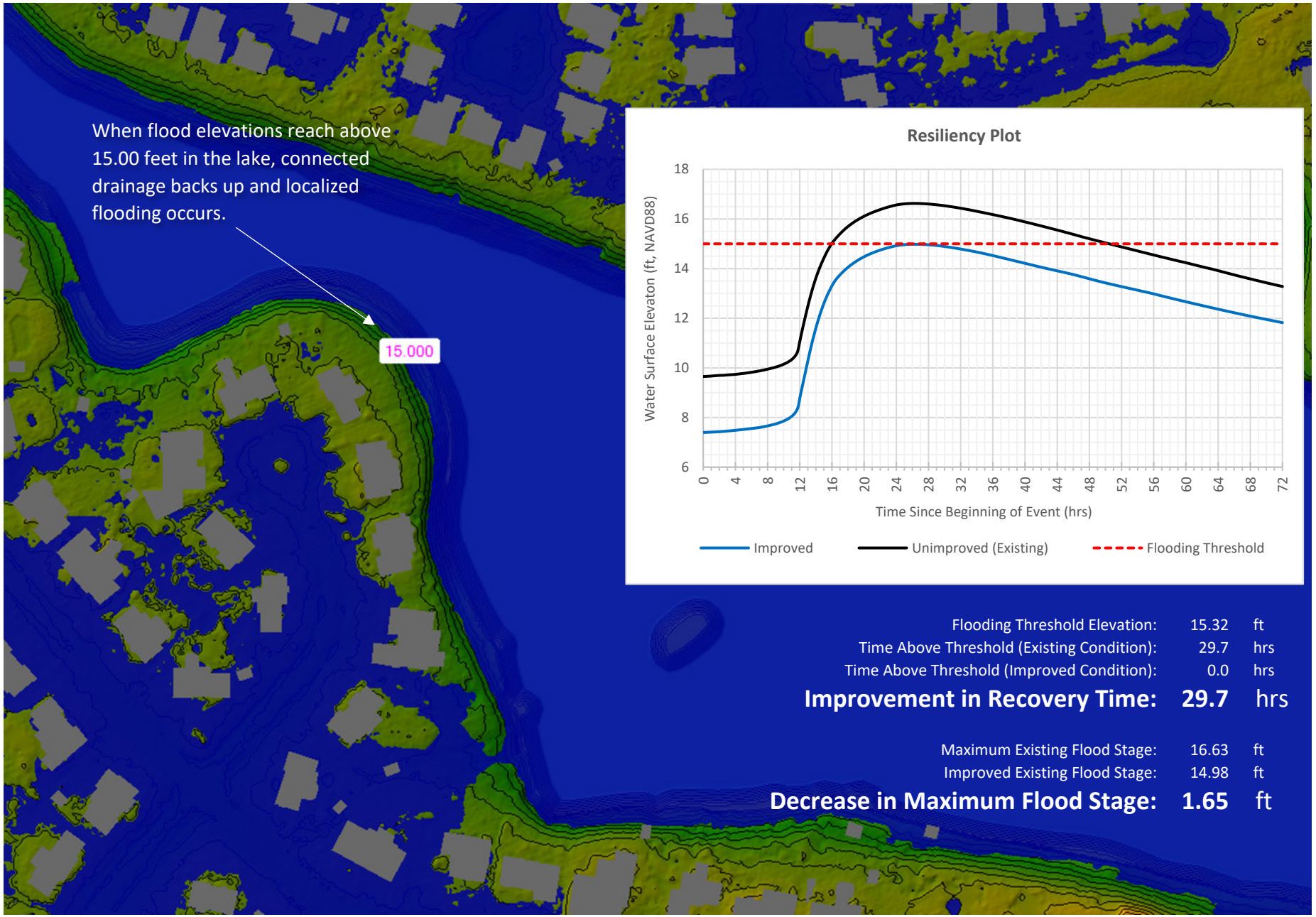


Figure 15. Resilience Improvements, Greenbrier Lake (D9 Event)

APPENDIX A

Cost Opinions

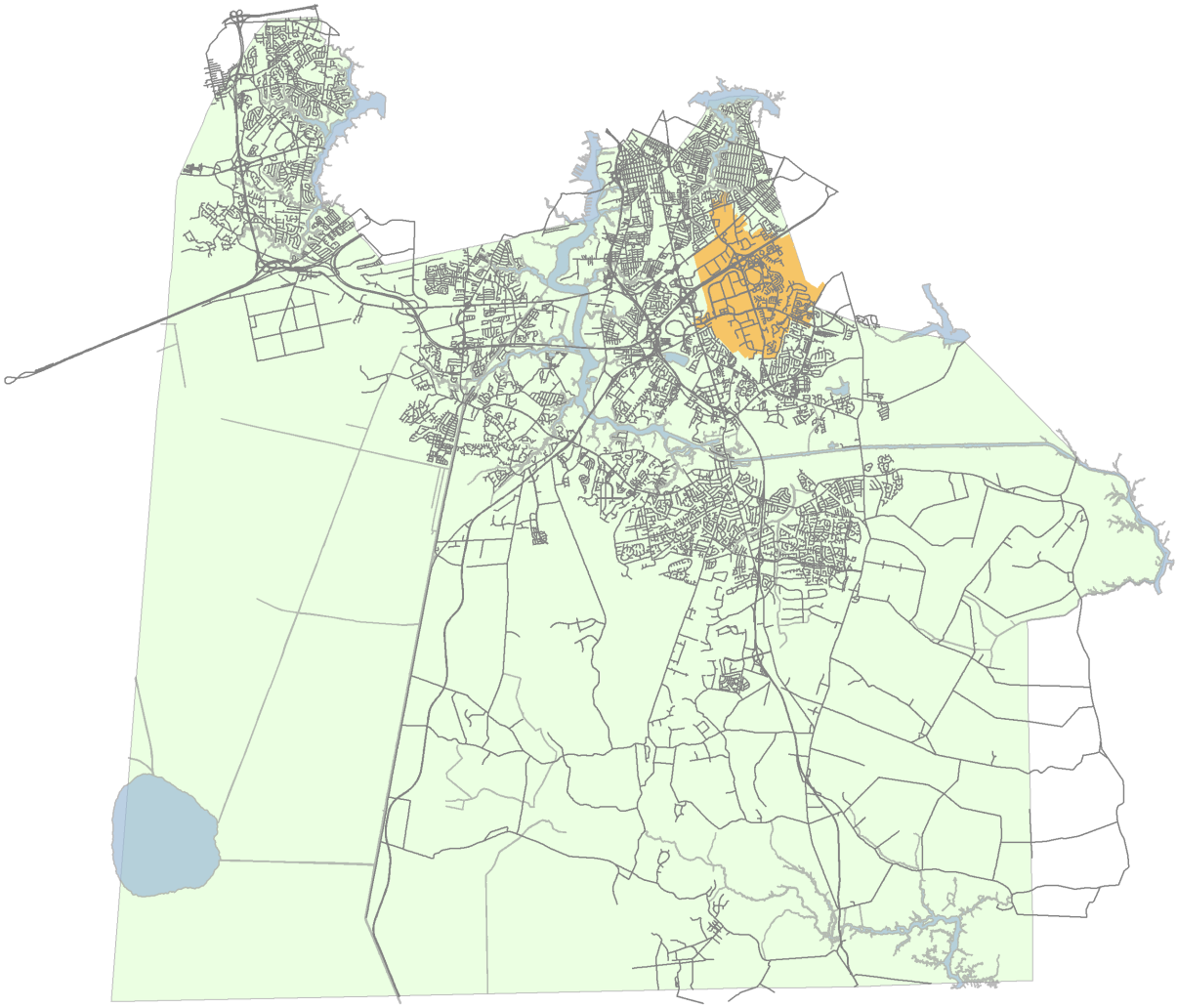


Table A-1. Cost Opinion, Indian River High School Lake Weir

Pricing in 2020 Dollars

Number	Item	Unit	Quantity	Unit Price	Extended Price
1	Mobilization/Demobilization	LS	1	$ 8,000.00	$ 8,000
2	Maintaining Traffic	LS	1	$ 10,000.00	$ 10,000
3	Erosion and Sediment Control to Include Maintenance	LS	1	$ 10,850.00	$ 10,850
4	Sediment Excavation Upstream from Weir	CY	200	$ 70.00	$ 14,000
5	Dewatering/Lake Drawdown	LS	1	$ 24,500.00	$ 24,500
6	Install Temporary Coffer Dam	LS	1	$ 7,500.00	$ 7,500
7	Demolition of Existing Weir and Concrete Apron	LS	1	$ 10,000.00	$ 10,000
8	Construct New Concrete Weir and Spillway Apron	CY	14	$ 1,000.00	$ 14,000
9	#57 Stone for Weir and Apron Bedding	CY	61	$ 150.00	$ 9,150
				Total of All Prices (Base Bid):	**$ 108,000**
	Engineering and Design Services	LS	1	$ 70,000.00	$ 70,000
	Survey/Utility Location	LS	1	$ 15,000.00	$ 15,000
				Project Subtotal	**$ 193,000**
				20% Contingency	$ 38,600
				PROJECT TOTAL	**$ 231,600**

Table A-2. Cost Opinion, South Military Highway Culvert Replacement

Pricing in 2020 Dollars

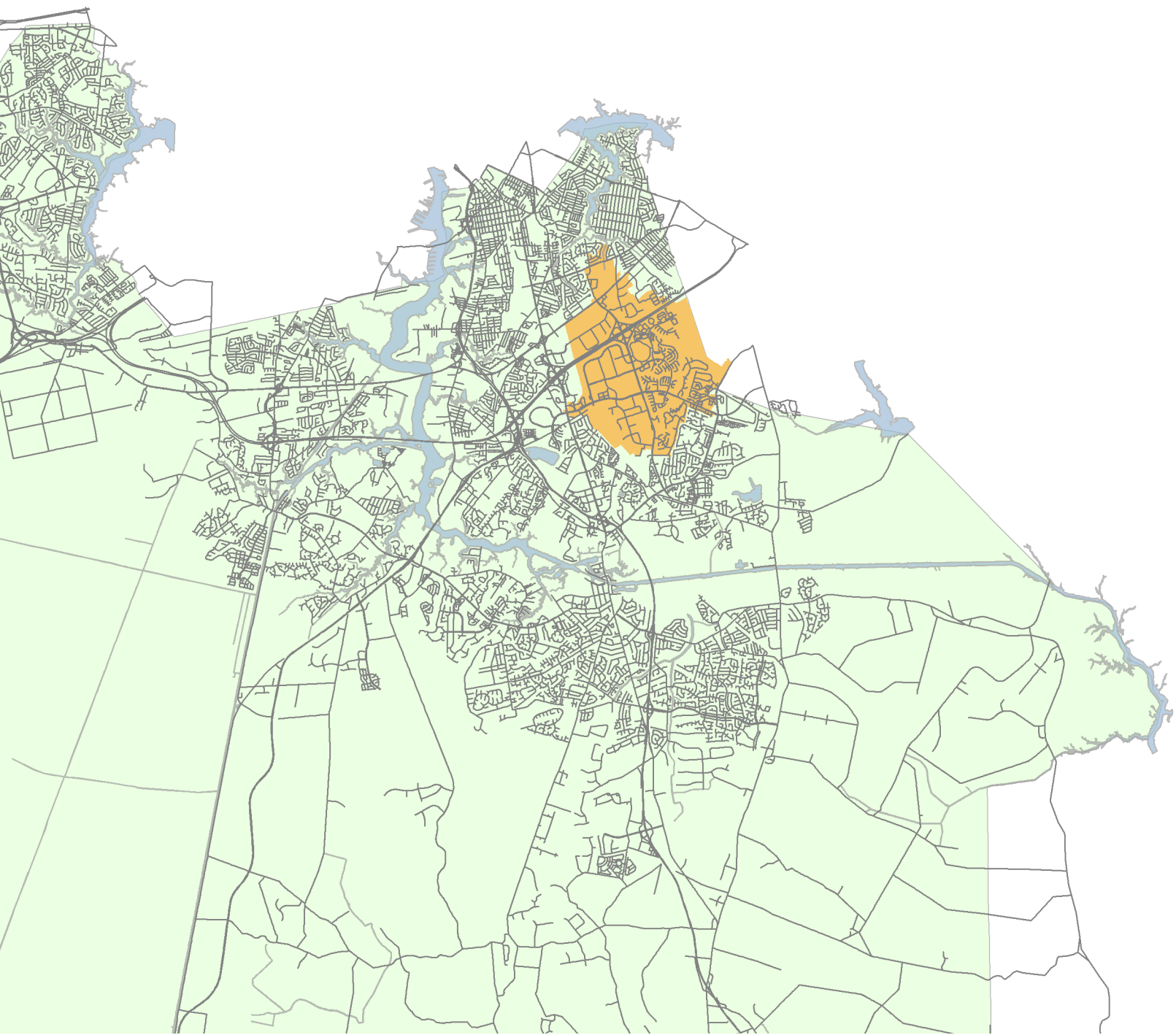
Number	Item	Unit	Quantity	Unit Price	Extended Price
1	Mobilization/Demobilization	LS	1	$ 57,554.10	$ 57,554
2	Maintaining Traffic	LS	1	$ 100,000.00	$ 100,000
3	Erosion and Sediment Control to Include Maintenance	LS	1	$ 16,000.00	$ 16,000
4	Undercut Excavation and Dispose Offsite	CY	260	$ 60.00	$ 15,600
5	Backfill of Undercut Excavation	CY	260	$ 130.00	$ 33,800
6	Regular Excavation	CY	1250	$ 50.00	$ 62,500
7	VDOT CG-6 Curb and Gutter	LF	70	$ 30.00	$ 2,100
8	VDOT MC-1 Median Curb	LF	45	$ 20.00	$ 900
9	VDOT Double 8'x8' Box Culvert	LF	121	$ 4,500.00	$ 544,500
10	VDOT BCW-21 Wingwall, Precast	EA	2	$ 11,000.00	$ 22,000
11	VDOT BCW-22 Wingwall, Precast	EA	2	$ 14,000.00	$ 28,000
12	Culvert Backfill - Select Material, Type I (Min. CBR=20)	CY	363	$ 35.00	$ 12,705
13	Culvert Backfill - Regular Fill	CY	300	$ 25.00	$ 7,500
14	VDOT Riprap EC-1, Class I, 24" Thick w/ Geotextile Fabric	TONS	60	$ 100.00	$ 6,000
15	Existing Curb and Gutter Demolition	LF	70	$ 10.00	$ 700
16	Existing Median Curb Demolition	LF	45	$ 10.00	$ 450
17	Remove/Reinstall Guardrail	LS	1	$ 4,500.00	$ 4,500
18	Remove/Reinstall Existing Wooden Bulkhead	LS	1	$ 12,000.00	$ 12,000
19	Relocating or Modifying Existing Miscellaneous Items	LS	1	$ 8,000.00	$ 8,000
20	Offset/Relocate Existing Utilities	LS	1	$ 50,000.00	$ 50,000
21	Existing Pavement Demolition	SY	260	$ 14.00	$ 3,640
22	Aggregate Base Material (8" VDOT 21A or 21B)	SY	260	$ 19.00	$ 4,940
23	Asphalt Concrete - 2" SM-2A Surface Course	SY	260	$ 15.00	$ 3,900
24	Asphalt Concrete - 2" IM-1A Intermediate Course	SY	260	$ 15.00	$ 3,900
25	Asphalt Concrete - 8" BM-2 Base Course	SY	260	$ 60.00	$ 15,600
				Total of All Prices (Base Bid):	**$ 1,016,789**
	Engineering and Design Services	LS	1	$ 122,014.69	$ 122,015
	Survey/Utility Location	LS	1	$ 40,000.00	$ 40,000
				Project Subtotal	**$ 1,178,804**
				20% Contingency	$ 235,761
				PROJECT TOTAL	**$ 1,414,565**

Table A-3. Cost Opinion, I-64 Additional Culvert

Pricing in 2020 Dollars

Number	Item	Unit	Quantity	Unit Price	Extended Price
1	Mobilization/Demobilization	LS	1	$ 119,314.80	$ 119,315
2	Maintaining Traffic	LS	1	$ 100,000.00	$ 100,000
3	Clearing and Grubbing	AC	1.5	$ 40,000.00	$ 60,000
4	Erosion and Sediment Control to Include Maintenance	LS	1	$ 105,000.00	$ 105,000
5	Undercut Excavation for EW-2 Endwalls and Dispose Offsite	CY	32	$ 60.00	$ 1,920
6	Backfill of Undercut Excavation for EW-2 Endwalls.	CY	32	$ 130.00	$ 4,160
6	Regular Excavation	CY	3,500	$ 50.00	$ 175,000
7	Regular Fill	CY	975	$ 20.00	$ 19,500
8	Microtunnel 60" Outfall Pipe	LF	348	$ 4,000.00	$ 1,392,000
9	VDOT EW-2 Endwall for 60" RCP	EA	2	$ 10,000.00	$ 20,000
10	VDOT Riprap EC-1, Class I, 24" Thick w/ Geotextile Fabric	TONS	110	$ 100.00	$ 11,000
11	Upstream Impoundment Bank Treatments	LS	1	$ 100,000.00	$ 100,000
				Total of All Prices (Base Bid):	**$ 2,107,895**
	Engineering and Design Services	LS	1	$ 150,000.00	$ 150,000
	Geotechnical Engineering	LS	1	$ 50,000.00	$ 50,000
	Survey/Utility Location	LS	1	$ 40,000.00	$ 40,000
				Project Subtotal	**$ 2,347,895**
				20% Contingency	$ 469,579
				PROJECT TOTAL	**$ 2,817,474**

Note: If 60" culvert could be jack-and-bored, project cost could drop by as much as $1,000,000. If multiple culverts are installed, price could increase.



National Flood Hazard Layer FIRMette

FEMA

76°14'34"W 36°48'3"N

76°13'56"W 36°47'34"N

0 250 500 1,000 1,500 2,000 Feet

1:6,000

Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- 20.2 Cross Sections with 1% Annual Chance
- 17.5 Water Surface Elevation
- Coastal Transect
- Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 4/5/2022 at 5:57 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

High Water Signs

For the
CITY OF CHESAPEAKE

Road Flood Monitoring Sensor
High Water Signs
Water Bodies
4.30 Road Elevation, NAVD 1983

Identifier	Location	SignFacing	SignText	TidalMark	Mounted	Foldable
01	Bunch Walnuts @ .1 mile from Bri	SB	C SHW	No	FreeStand	Foldable
02	Bunch Walnuts at Triple R Ranch	NB	C HW	No	FreeStand	Foldable
03	Bunch Walnuts at Ballahack Rd	NB	RCHW	No	FreeStand	Foldable
04	Bunch Walnuts at Buskey	SB	RCHW	No	FreeStand	Foldable
05	3806 Bainbridge Blvd (Cider Tire)	SB	HW	No	Utility Pole	Foldable
06	4217 Bainbridge Blvd	NB	HW	No	FreeStand	Foldable
07	Triple Decker Northbound (missin	NB	SHW	No	FreeStand	Foldable
08	Triple Decker Southbound	SB	SHW	No	FreeStand	Foldable
11	Lakeside Park at Bainbridge Blvd	SB	RMF	Yes	FreeStand	Fixed
12	Lakeside Park at Bainbridge Blvd	NB	RMF	Yes	FreeStand	Fixed
13	1428 Bainbridge Blvd	SB	HW	No	Utility Pole	Foldable
15	212 Deepwater Rd	NB	HW - Purple	No	FreeStand	Foldable
16	212 Deepwater Rd	SB	HW - Purple	No	FreeStand	Foldable
18	224 Deepwater	SB	HW	Yes	FreeStand	Fixed
20	Cedar Rd near Grassfield Rd	WB	RMF	Yes	FreeStand	Fixed
20A	Cedar Rd near Grassfield Rd	WB	HW	No	FreeStand	Foldable
21	Dock Landing at Devon	NB	HW	No	FreeStand	Foldable
21A	Dock Landing in Gully	NB	RMF	Yes	FreeStand	Fixed
21B	Dock Landing in Gully	SB	RMF	Yes	FreeStand	Fixed
22	Dock Landing at Mariner	SB	HW	No	FreeStand	Foldable
27	2417 Gilmerton Rd	EB	HW	No	FreeStand	Foldable
28	2309 Gilmerton Rd	WB	HW	No	FreeStand	Foldable
29	1848 Head of River Rd	EB	CHW	No	FreeStand	Foldable
30			HW			
31	Across from 3229 Taylor Rd	SB	CHW	No	FreeStand	Foldable
34	3000 block Taylor Rd	SB	RMF	Yes	FreeStand	Fixed
35	3000 block Taylor Rd	NB	RMF	Yes	FreeStand	Fixed
36	2400 block Taylor Rd at Drum Cr	NB	CHW	No	FreeStand	Foldable
37	Shell at Faulk	SB	HW	No	FreeStand	Foldable
38	Shell Rd at Currie St	NB	HW	No	FreeStand	Foldable
39	Mapleshore at Fernwood Farms	WB	HW	No	FreeStand	Foldable
40	316 Mapleshore at Cherry Tree	EB	HW	No	FreeStand	Foldable
41	Mapleshore near the curve	WB	TM	Yes	FreeStand	Fixed
42	877 Mains Creek	WB	HW	No	FreeStand	Foldable
43	Across from 802 Mullen Rd	SB	HW	No	FreeStand	Foldable
45A	Whittamore Dr	NB	CHW	No	FreeStand	Foldable
45b	Whittamore Dr	NB	CHW	No	FreeStand	Foldable
46	Whittamore	SB	CHW	No	FreeStand	Foldable
47						
48	Freeman at 464 NB Exit	EB	CHW	No	FreeStand	Foldable
49	Near 5117 Bainbridge at Libertyvil	SB	CHW	No	FreeStand	Foldable
50	5001 Bainbridge Blvd at Booker S	SB	SHW	No	FreeStand	Foldable

Date: 9/4/2019

1:42,000

N

Work Order List

Site: COC

Work Order	Description	Type	Status	Priority	Lead	Location:	Asset	Job Plan	Parent WO	Schedule Start	Schedule Finish
1401157	Volvo Pkwy & Crossways Blvd - FLOODING - possible roadside ditch or storm drain blocked	CM	CLOSE			PW-ST-3787	PW-STS-3787124				
1903952	CROSSWAYS BLVD & EDEN WAY N--INTERSECTION/STREET	CM	CLOSE	3	ROLSEN	PW-ST-4443	PW-STS-4443001				

Number of Records: 2

Work Order List

Site: COC

Work Order	Description	Type	Status	Priority	Lead	Location:	Asset	Job Plan	Parent WO	Schedule Start	Schedule Finish
2067054	VOLVO PKWY & EDEN WAY N--ROAD IMPASSABLE	CM	CLOSE	6							
2067059	VOLVO PKWY & EDEN WAY N--ROAD IMPASSABLE	CM	CLOSE	6							
2067060	VOLVO PKWY & EDEN WAY S--ROAD IMPASSABLE	CM	CLOSE	6							
2067075	VOLVO PKWY & EDEN WAY S--ROAD IMPASSABLE	CM	CLOSE	6							
2067085	145 eden way--Flooding	CM	CLOSE	6							
2067086	GREENBRIER PKWY & EDEN WAY N--Flooding	CM	CLOSE	6							
2067090	GREENBRIER PKWY & EDEN WAY N-23320-Flooding	CM	CLOSE	6							
2067091	GREENBRIER PKWY & EDEN WAY N--Flooding	CM	CLOSE	6							
2067095	GREENBRIER PKWY & EDEN WAY N--Flooding	CM	CLOSE	6							
2361101	Greenbrier @ Eden Way Flooding	CM	WAPPR	3	MDIONNE	PW-ST-2750	PW-STS-2750036				
2362448	23320 - Flooding - 713 Eden Way N	CM	FIELDCOMP	3	ROLSEN	PW-ST-2553	PW-STS-2553016				
543345	800 Eden Way N - flooding	EM	CLOSE			PW-ST-2553	PW-STS-2553017		542707		
543682	Eden Way & Greenbrier at Town Bank - Trash Rack - Flooding	EM	CLOSE						542707		

Number of Records: 13

Work Order List

Site: COC

Work Order	Description	Type	Status	Priority	Lead	Location:	Asset	Job Plan	Parent WO	Schedule Start	Schedule Finish
1884844	23320-- 1150 FAIRWAY--Flooding	CM	CLOSE	6		PW-ST-4372	PW-STS-4372003		1884775		
1884859	23320-- 1144 FAIRWAY--INTERSECTION/STREET	CM	CLOSE	3		PW-ST-4372	PW-STS-4372003		1884775		

Number of Records: 2

Work Order List

Site: COC

Work Order	Description	Type	Status	Priority	Lead	Location:	Asset	Job Plan	Parent WO	Schedule Start	Schedule Finish
1478860	23325-- 2250 Old Greenbrier Rd - flooding in front of this location	CM	CLOSE	3	RLSYKES	PW-ST-3262	PW-STS-3262004		1478506		
1616226	Jubilee site - Greenbrier Pkwy - flooding due to heavy rain	CM	CLOSE			PW-ST-2750	PW-STS-2750027		1616164		
1616259	Greenbrier Pkwy & Volvo Pkwy -- flooding - INTERSECTION/STREET	CM	CLOSE	3		PW-ST-2750	PW-STS-2750027		1616164		
1616394	23325-- 2250 Old Greenbrier Rd - flooding - flush two storm drains	CM	CLOSE	3		PW-ST-3262	PW-STS-3262004		1616164		
1632945	Greenbrier Pkwy (near Fazolis) - flush a blocked catch basin - flooding	CM	CLOSE			PW-ST-2750	PW-STS-2750027		1632757		
2022761	23320 - 1515 S Military Hwy - flooding on Old Greenbrier side - street	CM	CLOSE	3	ROLSEN	PW-ST-3170	PW-STS-3170027		2022644		
2067086	GREENBRIER PKWY & EDEN WAY N--Flooding	CM	CLOSE	6							
2067089	GREENBRIER PKWY & S MILITARY HWY--Flooding	CM	CLOSE	6							
2067090	GREENBRIER PKWY & EDEN WAY N-23320-Flooding	CM	CLOSE	6							
2067091	GREENBRIER PKWY & EDEN WAY N--Flooding	CM	CLOSE	6							
2067095	GREENBRIER PKWY & EDEN WAY N--Flooding	CM	CLOSE	6							
2361101	Greenbrier @ Eden Way Flooding	CM	WAPPR	3	MDIONNE	PW-ST-2750	PW-STS-2750036				
543682	Eden Way & Greenbrier at Town Bank - Trash Rack - Flooding	EM	CLOSE						542707		
970582	FLOODING - Woodlake Dr & Greenbrier Pkwy - street flooded	CM	CLOSE		PLAMOREE	PW-ST-3909	PW-STS-3909005	PW-SWCRW04		5/19/11	

Number of Records: 14

Work Order List

Site: COC

Work Order	Description	Type	Status	Priority	Lead	Location:	Asset	Job Plan	Parent WO	Schedule Start	Schedule Finish
2022761	23320 - 1515 S Military Hwy - flooding on Old Greenbrier side - street	CM	CLOSE	3	ROLSEN	PW-ST-3170	PW-STS-3170027		2022644		

Number of Records: 1

Work Order List

Site: COC

Work Order	Description	Type	Status	Priority	Lead	Location:	Asset	Job Plan	Parent WO	Schedule Start	Schedule Finish
1884834	23320-- Simon Dr & Corbin - flooding at this intersection	CM	CLOSE	3		PW-ST-5910	PW-STS-5910002		1884775		
1884835	----SIMON DR & CORBIN DR--INTERSECTION/STREET	CM	CLOSE	3							
1884911	----PEYTON LN & SIMON DR--INTERSECTION/STREET	CM	CLOSE	3		PW-ST-5911	PW-STS-5911003		1884775		
1884913	23320-- 1356 SIMON--INTERSECTION/STREET	CM	CLOSE	3		PW-ST-5910	PW-STS-5910002		1884775		
1884934	23320-- 1304 SIMON--INTERSECTION/STREET	CM	CLOSE	3		PW-ST-5910	PW-STS-5910001		1884775		
1885043	23320-- 1324 SIMON--Flooding-PW	CM	CLOSE	3		PW-ST-5910	PW-STS-5910001		1884775		

Number of Records: 6

Work Order List

Site: COC

Work Order	Description	Type	Status	Priority	Lead	Location:	Asset	Job Plan	Parent WO	Schedule Start	Schedule Finish
1885153	23320-- 217 THRASHER--Flooding-PW	CM	CLOSE	3		PW-ST-3717	PW-STS-3717004		1884775		

Number of Records: 1

Work Order List

Site: COC

Work Order	Description	Type	Status	Priority	Lead	Location:	Asset	Job Plan	Parent WO	Schedule Start	Schedule Finish
1546140	23320-- 600 Volvo Pkwy - flooding within the street	CM	CLOSE	3	WDGOODMAN	PW-ST-3787	PW-STS-3787055		1546136		
1616259	Greenbrier Pkwy & Volvo Pkwy -- flooding - INTERSECTION/STREET	CM	CLOSE	3		PW-ST-2750	PW-STS-2750027		1616164		
206157	Professional & Volvo - FLOODING	EM	CLOSE								
2067054	VOLVO PKWY & EDEN WAY N--ROAD IMPASSABLE	CM	CLOSE	6							
2067059	VOLVO PKWY & EDEN WAY N--ROAD IMPASSABLE	CM	CLOSE	6							
2067060	VOLVO PKWY & EDEN WAY S--ROAD IMPASSABLE	CM	CLOSE	6							
2067061	VOLVO PKWY & EDEN WAY N--ROAD IMPASSABLE	CM	CLOSE	6							
2067065	VOLVO PKWY & BATTLEFIELD BLVD N--ROAD IMPASSABLE	CM	CLOSE	6							
2067075	VOLVO PKWY & EDEN WAY S--ROAD IMPASSABLE	CM	CLOSE	6							
2246334	23320- 517 Volvo Pkwy (FLOODING) 2020	CM	CLOSE		ROLSEN						
2265686	23320- Summit Pointe Dr/ Volvo Pkwy (flooding) 2020	CM	CLOSE		ROLSEN						
2361100	Volvo @ Executive Flooding	CM	APPR	3	MDIONNE	PW-ST-3787	PW-STS-3787042				
543349	1200 Volvo Pkwy - flooding	EM	CLOSE			PW-ST-3787	PW-STS-3787084		542707		

Number of Records: 13

Work Order List

Site: COC

Work Order	Description	Type	Status	Priority	Lead	Location:	Asset	Job Plan	Parent WO	Schedule Start	Schedule Finish
543737	1420 Waterside Dr S - flooding	EM	CLOSE			PW-ST-3809	PW-STS-3809001		542707		

Number of Records: 1

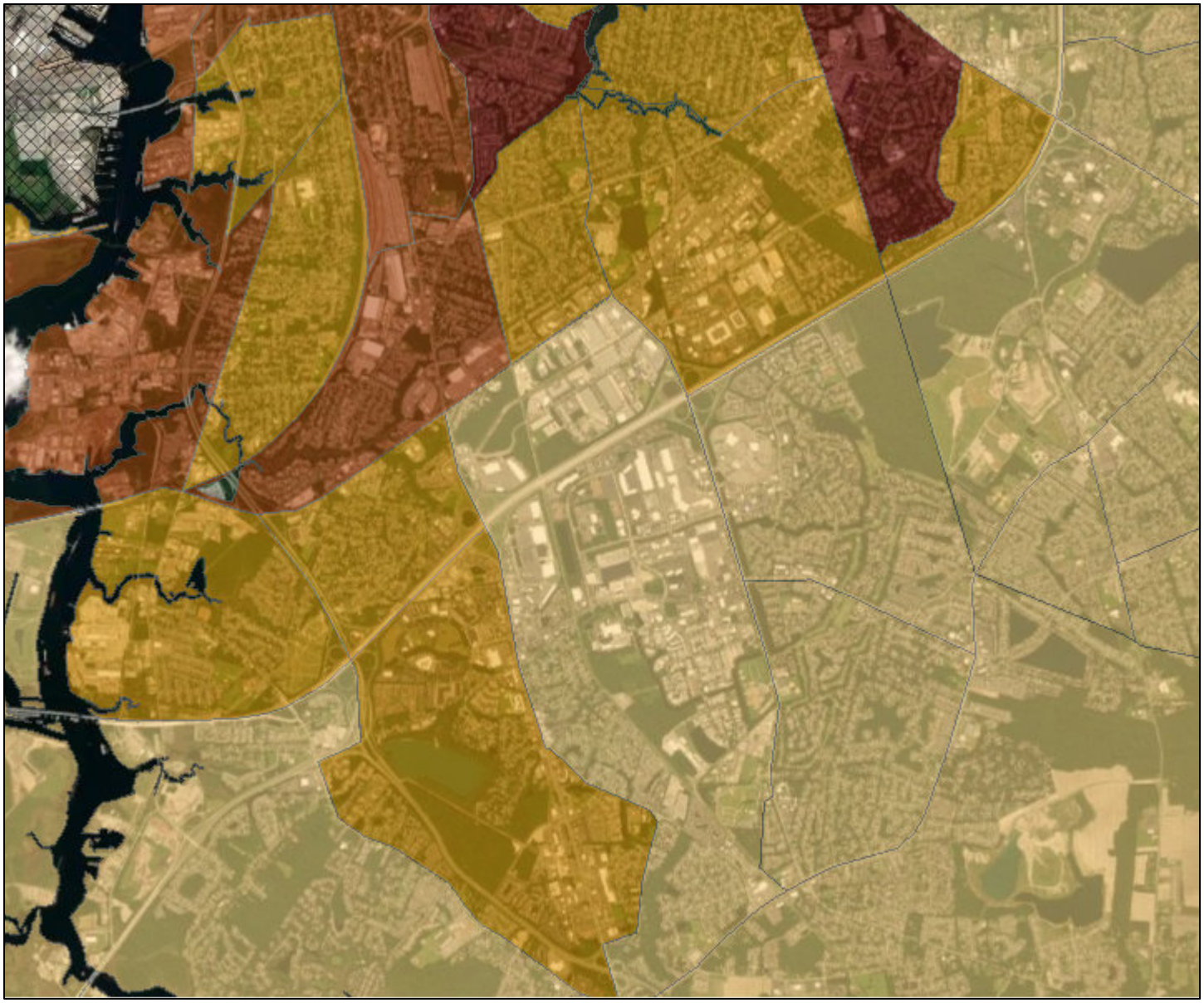
Work Order List

Site: COC

Work Order	Description	Type	Status	Priority	Lead	Location:	Asset	Job Plan	Parent WO	Schedule Start	Schedule Finish
1873921	23328- Greenbrier Pkwy @ 716 Woodlake Dr- City Manager's ofc- street flooding	CM	CLOSE		ROLSEN	PW-ST-2750	PW-STS-2750074				
1879008	----GREENBRIER CIR & WOODLAKE DR--INTERSECTION/ STREET	CM	CLOSE	3		PW-ST-2749	PW-STS-2749001		1877641		
206102	701 Woodlake Dr - FLOODING	EM	CLOSE								
970582	FLOODING - Woodlake Dr & Greenbrier Pkwy - street flooded	CM	CLOSE		PLAMOREE	PW-ST-3909	PW-STS-3909005	PW-SWCRW04		5/19/11	

Number of Records: 4

Greenbrier



April 5, 2022

Social Vulnerability Index Score

- Very Low Social Vulnerability
- Low Social Vulnerability
- Moderate Social Vulnerability
- High Social Vulnerability
- Very High Social Vulnerability
- Not inlcuded in the analysis

1:72,224

0 0.35 0.7 1.4 mi

0 0.5 1 2 km

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Created from the Virginia Vulnerability Viewer

Center for Coastal Resources Management
Virginia Institute of Marine Science

ADAPTVA

Department of Public Works		Chesapeake VIRGINIA	
Directive:	Departmental Regulation	Number: 755	
Subject:	**Drainage Infrastructure Management**	Supersedes: 10/15/14	Next Review: 10/30/20
Approved: Director of Public Works		Effective Date: 10/30/18	
		Initiator: Ali Asgharpour	

I. Purpose

The purpose of this Departmental Regulation is to establish policy and procedures to manage the City's street drainage infrastructure.

II. Policy

A. Public Works shall maintain the open and closed drainage systems within the City's rights of way and easements to provide for the original design capacity to the extent possible.

B. Open systems are defined as roadside ditches, lead or perimeter ditches within rights of way or existing easements. Closed systems include inlet structures, manholes, catch basins, pipes, and culverts.

C. Public lakes and ponds that serve as holding facilities to temporarily store and gradually release stormwater shall be maintained to provide for positive flow. The maintenance activities shall be limited to the outfall structures. All other maintenance work such as mowing and bank restoration shall be the property owner's responsibility. Public Works is not responsible for dredging of recreational or navigational purposes.

D. The placement of new driveway culverts or the extension of existing driveway culverts is the responsibility of the property owner. The property owner must obtain a permit from the Department of Development and Permits, prior to installing new culverts or extending existing culverts.

E. All non-emergency repairs shall be coordinated within Planning/Scheduling team to ensure resources are adequately estimated in advance.

Related Regulations: City of Chesapeake City Code Chapter 26, Article VIII.

III. Procedures

Cave Ins or Structural Repairs

The Planner Scheduler Group handles securing safety issues for cave ins or structures and investigating the location to determine whether the repairs will be performed by city crews or an outside contractor.

Securing and/or filling cave ins or structures, when necessary, shall be performed by a cave in crew assigned to the Planner Scheduler Group within twenty-four (24) hours of receiving the report. Securing may consist of placing cones, barrels, safety signs, safety fencing or filling the location with dirt and/or crush & run.

The Planner Scheduler Group cave in crew will fill out a Maximo Log Entry Form for each cave in and/or structure noting the pipe or structure material, pipe diameter, invert depth, number of cave ins, type of structure, number of pictures taken (there should at least be two showing the structure & street view), location of the cave in, and whether asphalt, concrete, curb & gutter or driveway apron repairs will be needed. The estimated amount of and material for asphalt, concrete, curb & gutter, and driveway apron repairs will also be provided.

If the cave in, damaged section of pipe or structure is not easily visible or if further investigation is needed, the Planner Scheduler Group will coordinate with the Stormwater Superintendent or the General Supervisor (in charge of the job) to have either a pole camera or CCTV truck used.

If flushing is needed to assist with determining the amount of damage or the location is flooded due to the damaged pipe and/or cave in, the Planner Scheduler Group will coordinate with the Stormwater Superintendent or the General Supervisor (in charge of the job) to have the pipes flushed or cleared of water.

The Planner Scheduler Group Cave In Coordinator shall estimate the schedule for cave in repairs by coordinating with the Stormwater Superintendent or the General Supervisor (in charge of the job). The Planner Scheduler Group shall evaluate the severity of the cave in and determine whether the repair shall be performed by city crews or given to a contractor.

Any structure that needs to be immediately repaired (broken basin tops, broken brickwork, etc.) because it is a danger to the public and/or vehicles shall be scheduled by the Planner Scheduler Group. If a specially sized structure cover is needed, the Planner Scheduler Group will coordinate the ordering and purchase of the item with the Public Works Storeroom.

Cave Ins – To Be Repaired by City Crews

If the damaged pipe section is less than six (6) feet deep (measured from the ground surface to the invert), and pipe access does not pose an undue risk for city crews, a Stormwater crew shall excavate around the damaged pipe section and assess whether the section needs to be replaced or repaired.

If the cave in is caused by a separation of less than four (4) inches between pipe joints, a brick collar will be placed around the pipe, filter fabric shall be placed around the separated joint and the area will be backfilled. Separations greater than four (4) inches shall require that the separated pipe joints be re-laid or replaced.

If the pipe is large enough to crawl into, Stormwater may choose to perform the repair by placing mortar on the damaged section from inside the pipe. Confined space entry procedures MUST be followed for this type of repair. The Public Work Safety Office shall be consulted BEFORE the work begins.

If the pipe or culvert repair requires pavement to be removed, Stormwater shall backfill and compact the repair area with select fill and/or crusher run in compacted six (6) inch lifts so that the final grade is between one (1) and one and half (1 ½) below the adjacent pavement edges. The Stormwater Superintendent or the General Supervisor (in charge of the job) shall coordinate with the Planner Scheduler Group to ensure that Streets & Highways has been scheduled to perform the replacement of asphalt, curb & gutter, etc.

It shall be the responsibility of the Stormwater Superintendent or the General Supervisor (in charge of the job) to provide the size of the repair in length, width and depth and the Maximo work order number used for the job. This will assist the Planner Scheduler Group with the creation of a child work order for Streets & Highways.

If the pipe or culvert repair is made in an unpaved area, Stormwater shall restore the area by compacting the sub-grade fill in six (6) inch lifts and placing at least two (2) inches of topsoil. The topsoil shall be seeded and stabilized with straw, jute mesh, or other landscaping measures to reduce the likelihood of erosion, while the grass seed germinates and becomes established.

It will NOT be the responsibility of city crews to replace illegally placed fencing, sprinkler systems, or other landscape features located in the city drainage easement or right-of-way. The Stormwater Superintendent or the General Supervisor (in charge of the job) shall leave a door hanger advising the citizen that the item (fence, bush, etc.) will be removed and not replaced. If there are multiple items or further notification to residents is needed, the Planner Scheduler Group will send letters to those residents affected by the repair.

Updating Inventory & GIS – Stormwater Structures

Discrepancies in inventory information noted during repair work shall be provided to the Operations GIS analyst for updating the system.

As part of a continual updating of the Stormwater structures and information in Arc GIS, the structures throughout the city (catch basins, manholes, drop inlets, junction boxes, pipes, etc.) shall be inspected (by either pole camera or CCTV truck) every six (6) to eight (8) years.

During the investigation, the crew shall annotate the pipe size, depth, structural material, any conflicts, flow direction, etc. A still picture and/or video shall be taken to capture the condition of the structure and pipe.

Any cave ins or defects in the structure shall be noted and the information provided to the Planner Scheduler Group for review and/or to have a work order created.

Cave Ins – To Be Repaired By A Contractor

If the cave in and/or structure repair work will be given to an outside contractor, the Planner Scheduler Group will update the Maximo work order, assign it to Contractual Services and add the information to the contractor's spreadsheet located in Sharepoint.

The following conditions must be met in order to assign the work to a contractor:

1. Excavation required is greater than six (6) feet deep and/or exceeds the pipe diameter of forty-eight (48) inches.

2. Extensive or complicated confined space entry will be needed.

3. Major reconstruction of structure walls or basin is needed.

4. A long stretch of pipe, more than one hundred (100) feet, with a diameter greater than twelve (12) inches, will need to be slip-lined.

5. There are multiple cave ins along a stretch of pipe.

6. Cave in(s) are located under a high volume roadway (i.e. Battlefield Blvd, Greenbrier Parkway, etc.).

7. The existing workload is such that service level agreements cannot be met by city forces.

Plans or Requests for New Pipes or Structures

Any plans and/or requests for new pipes and/or structures requested through the Drainage Engineer's Office or other city department shall be reviewed by the Planner Scheduler Group.

The Planner Scheduler Group shall determine whether the work will be performed by city crews or given to a contractor to handle.

Pipe washing Requests

When a report of a clogged structure (catch basin, drop inlet, driveway pipe, etc.) is received, the Planner Scheduler Group will schedule a pipe washer to respond.

If there is a flooding situation due to a heavy rain event, and a structure is suspected of being blocked, a pipe washer will be dispatched immediately.

Pipe washers may be scheduled at the request of the CCTVing crew to flush a pipe thereby allowing them to TV the pipe and/or structure, or at the cave in crew to flush a basin or pipe to assist with cave in repairs. These instances will be scheduled through the Planner Scheduler Group.

Ditches

Ditch requests are broken into two categories for investigation. Roadside ditch requests are divided amongst the General Supervisors for investigation and recommendation of work (cleaning, regrading, etc.). Side, lead and rear ditch requests are investigated by the Planner Scheduler Group. The Planner Scheduler Group will provide pertinent information – if the ditch private or public, or if there are any easements, access issues, or other special instructions (wetlands, if permits are needed, railroad approval, etc.).

Once the investigation is completed, the work order is assigned to a General Supervisor. The Planner Scheduler Group Ditch Coordinator will work closely with the Stormwater Superintendent and the General Supervisor (in charge of the job) and schedule the work.

There are various types of ditch work that can take place – cleaning & clearing (blockage removal), regrading (small area or large area), and erosion repairs. The location – concrete or earthen ditch, wetlands area, stretch of road needing traffic control – will have an impact on what type of work may be performed and when it should be scheduled (eg. - some ditch cleaning has to be scheduled when school is out).

The Planner Scheduler Group will review any plans or requests that are submitted by the Drainage Engineer's Office or any other city department to determine if the work will be performed by city crews or given to a contractor to handle.

City crews are not responsible for removing leaf and lawn debris that is placed or has fallen into the ditches, unless there is a blockage causing flooding or the ditch is over three (3) feet deep. Citizens shall be responsible for removing leaves and other debris (lawn clippings, etc.) that may be blocking ditches that are three (3) feet and under.

Lead ditch cleaning will be performed in compliance with the MS-4 permit. The Planner Scheduler Group Ditch Coordinator will maintain a list of the lead ditches that have been cleaned, the date, and the date of the next cleaning. A map showing the ditch to be cleaned, along with any pertinent information (easements, wetlands, etc.) shall be attached to the Maximo work order.

Roadside ditches on a preventive maintenance schedule will be cleaned in compliance with the MS-4 permit, depending on the backlog of work orders.

Citizen Requests – Driveway Pipes & Piping In Ditches

A property owner wishing to install a new driveway pipe or extend an existing driveway pipe within the city right-of-way or drainage easement abutting their property, shall be responsible for obtaining a permit from the Department of Development & Permits (382-6304) and for purchasing and installing the pipe in accordance with the permit.

Any public or private utility work required for, or resulting from the pipe or culvert work shall be paid for by the property owner. Replacement pipes must be the same material, sized equal to, or greater than, the existing culvert.

A property owner wishing to pipe a ditch that carries public water shall obtain a permit from the Department of Development & Permits. The design for the piping and structures shall conform to the City's Public Facilities Manual and be approved by the Public Works Engineering Division. The property owner shall be responsible for purchasing and installing the piping and structures, in accordance with the approved design. Any public or private utility work required for, or resulting from, the pipe or culvert work shall be paid for by the property owner.

Department of Public Works		Chesapeake VIRGINIA	
Directive:	Departmental Regulation	Number: 756	
Subject:	**Stormwater Operation Plan**	Supersedes: 10/15/14	Next Review: 10/30/20
Approved: Director of Public Works		Effective Date: 10/30/18 Initiator: Ali Asgharpour	

I. Purpose

The purpose of this Departmental Regulation is to establish a policy for the maintenance of Stormwater and flood control facilities.

II. Policy

All Stormwater infrastructures in the City of Chesapeake shall be maintained following the standards in Chapter 5 of the City's most recent Public Facilities Manual.

Related Regulations: City of Chesapeake, City Code, Chapter 26

SECTION B-12: OPERATION AND MAINTENANCE

This section presents general operation, maintenance and inspection guidelines for principal spillways and components. However, these guidelines are not intended to be all-inclusive. Specific structures may require special measures not discussed here. The engineer is responsible for determining what, if any, additional items are necessary.

1. Spillway structures should be cleared of debris periodically and after any significant rainfall event where inspection reveals a significant blockage.

2. During low water conditions, concrete spillway structures should be inspected to decide if water is passing through any joints or other structure contacts and to identify any cracks, spalling, broken or loose sections. Any cracked, spalled, broken or loose sections should be cleaned and refilled with an appropriate concrete patching material. A professional engineer should be consulted to repair extensive leakage, spalls or fractures.

3. Outlet protection (stilling basins) and discharge channels should be cleared of brush at least once per year.

4. Trash racks and locking mechanisms should be inspected and tested periodically to make sure they are intact and operative.

5. All sluice gates (or other types of gates or valves used to drain an impoundment) should be operated periodically to insure proper function. The gate and stem should be periodically lubricated and all exposed metal should be painted to protect it from corrosion.

6. Any repairs made to the principal spillway (riser or barrel) should be reviewed by a professional engineer. Vertical trenching to expose the barrel should not be allowed under any circumstances. The trench side slopes should be stepped back at a 2:1 slope, minimum.

SECTION B-13: REFERENCES

American Society of Civil Engineers. *Stormwater Detention Outlet Control Structures*. Task Commission On the Design of Outlet Control Structures, ASCE. New York, NY: 1985.

Brater, E.F., and H.W. King. *Handbook of Hydraulics*. 6th ed. New York: McGraw Hill Book Company, 1976.

Debo, T.N., and A.J. Reese. *Municipal Stormwater Management*. 1995.

Federal Highway Administration. *Debris-Control Structures*. Hydraulic Engineering Circular No. 9, 1971.

VDOT
Virginia Department of Transportation

Maintenance Best Practices

Maintenance Division
1401 East Broad Street
Richmond, VA 23219
June 10, 2021

5. ROADWAY DRAINAGE

Asset Type: **ROADWAY DRAINAGE**

Policy: *The Department shall maintain drainage facilities to; 1) Provide safety and protection to the traveling motorist; and 2) Provide reasonably adequate drainage of the roadway surfaces, shoulders, and other drainage items; and 3) Preserve the structural integrity of the roadway.*

5.1 Cleaning and Flushing of Pipes and Culverts (Machine or Hand Cleaning)

5.1.1 Activity Description: The inspection and machine or hand cleaning of all drainage structures. May include water jetting of drainage structures, using a water pump to flush out debris.

5.1.2 Purpose of Activity: To identify and promptly remove sediment deposits or obstructions in order to keep culverts and other drainage structures clean and unimpeded. Critical areas should be patrolled during periods of severe storms and any evidence of drainage problems should be corrected immediately.

5.1.3 General Guidelines:

A. Patrol, identify, and evaluate evidence of blockage of drainage structures during routine maintenance activities, especially after rain events.

B. Patrol critical areas during or after periods of severe rain events, particularly those where backed up water would cause property damage.

C. Any evidence of drainage problems should be corrected as soon as feasible.

5.1.4 Procedure to Conduct Maintenance Activity:

A. Identify and adhere to applicable environmental requirements and regulations.

B. Verify the limits of state right of way (R.O.W.) and drainage easements.

C. Determine the need for and type of Erosion and Sedimentation (E & S) controls prior to starting work.

D. Check that all required permits, tools, and materials have been loaded prior to leaving area headquarters.

E. Place traffic control devices in accordance with current Virginia Work Area Protection Manual.

F. Install E & S Controls where necessary.

G. Clean drainage structure using machine cleaning, hand cleaning, or pressure washer as appropriate.

H. After pipe is clean, inspect for rust, deterioration, bituminous coating, and structural integrity, and report any deficiencies to Area HQ Manager.

I. Remove and dispose of any accumulated debris in accordance with current Department guidelines.

1. Do not place debris on private property.

2. Avoid placing debris upslope from drainage structures.

3. Any abnormal oil sheen odors or water colors shall be investigated and reported as necessary. Refer to best management practices for Illicit Discharge Detection and Elimination (IDEE).

J. Recover traffic control devices.

K. Remove E & S Controls when appropriate.

Type of Staffing	**Suggested Equipment**	**Materials**
• 1 Lead Crewperson • 2 Operators • 1-2 Laborers	• 1 Dump Truck • 1 Gradall/Backhoe • 1 Water Tank and Pump	• Appropriate Personal Protective Equipment(PPE) • Water • Hand tools
Include as required: • 2 Flaggers	Include as required: • 1 MicroTrax Machine • Truck Mounted Attenuator (TMA)	Include as required: • E & S Controls

Note: Staffing, equipment, and materials are based on general guidelines. Terrain, vegetation and other factors may create a need for modification to the information above. Appropriate VDOT staff is expected to make logical informed decisions on the needs of the maintenance activity being performed.

5.2 Sweeping of Curbs and Gutters

5.2.1 Activity Description: The inspection and removal of sediment deposits or obstructions from curbs, gutters, and shoulders. May also include intersections or other surfaces.

5.2.2 Purpose of Activity: To clean curb and gutter, paved ditches, drop inlets, and drainage elements constructed along shoulders, sidewalks or trails in order to remove collected debris which impedes the flow of water.

10. STRUCTURES

Asset Type: **STRUCTURES**

Policy: The Department shall maintain all structures to the level of service they were initially constructed to or better by subsequent improvements. This objective will be achieved by performing regular preventive maintenance activities, providing regularly scheduled inspections to determine structural deficiencies, and performing restorative maintenance and repair activities as needed.

10.1 Preventative Maintenance

10.1.1 Activity Description: Preventive maintenance (PM) includes any planned cyclical activity performed in advance of a critical need for repair, to reduce or arrest the rate of future deterioration. Preventive maintenance activities consist of the following characteristics: planned and cyclical; proactive (not reactive); and activities that are condition based as determined in safety inspections.

10.1.2 Purpose of Activity: The purpose of preventive maintenance is to extend the useful life of VDOT's assets and to preserve their related public investment. The activities may correct minor defects as a secondary benefit, but are not typically initiated based upon an observed deterioration.

10.1.3 General Guidelines for Preventative Maintenance:

A. Responsibility for Correction of Structure Defects

1. Structure defects and their correction can be classified as major or minor.

a. Minor repairs may be made by field maintenance forces through routine ordinary maintenance or preventative maintenance activities, which typically do not require plan development and thus does not need a review by the S&B Engineer. Minor repairs should be made upon discovery of defects, subject to compliance with all appropriate environmental regulations, and the work may be performed by the State Forces or Contractors.

b. Major repairs require the review by the State Structure and Bridge Engineer and usually require the development of engineering plans, and specialized equipment, or a specific allocation.

B. Guidelines for Minor Repair

1. Keeping bridges cleared of debris is an important routine maintenance item in preventing or curtailing structural repairs.

a. Abrasives and chemicals used in snow removal should be flushed from the bridge after each storm, if possible.

b. The bridge should receive a thorough cleaning at the end of the winter season.

c. Bridge seats, bearing assemblies, all joints and the lower chord of trusses shall be kept clean.

d. All scuppers and down drains should receive frequent attention to ensure proper functioning at all times.

e. Environmental considerations shall be addressed before bridge washings.

2. Brush should be kept cut under all bridges over land to reduce the fire hazard, and all debris accumulated against piers and abutments shall be removed as soon as possible.

3. Debris and vegetation build-up should be removed from culverts and channels to ensure the proper hydraulic opening is maintained.

C. Guidelines for Defects Requiring Major Repairs

1. Examples of defects requiring major repairs

a. Large spalls/potholes in concrete deck,

b. Complete replacement of timber decks,

c. Extensive washouts of approaches,

d. Damaged beams, girders or truss members,

e. Corroded steel members, and

f. Settlement of piers and abutments.

2. In emergencies, the District S&B Engineer should be contacted immediately to determine the procedure to follow to restore the structure to a practical and safe level of service as soon as possible.

D. Recommended Frequency for Various Maintenance Tasks

Maintenance Tasks for all Systems by recommended yearly frequency

TASK	**Recommended Frequency***
Bridge Deck Washing	Every year
Deck Sweeping	Every year
Seat and Beam Ends Washing	Every 2 years
Cutting and Removing Vegetation	Every 2 years
Routine Maintenance of Timber Structures	Every 2 years
Lubricate Bearing Devices	Every 4 years
Removing Debris from Culverts	Every 5 years
Scheduled Replacement of Pourable Joints	Every 6 years
Scheduled Replacement of Compression Seal Joints	Every 10 years
Beam Ends Painting	Every 10 years (At years 10 and 20. Replace paint system at year 30)
Scheduled Installation of Thin Epoxy Concrete Overlay	Every 15 years

*Or as necessary and determined from recommendations in the specific structure's safety inspection report

10.1.4 Procedure to Conduct Preventative Maintenance Activities:

A. Bridge Deck Washing

1. Include the removal and disposal of debris and pressure washing of the bridge roadway surface, joints, sidewalks, curbs, parapet walls, drainage grates, scuppers, and drain pipes.

2. All concrete decks and slabs without asphalt overlay.

3. Environmental Operating Procedures shall apply to State Forces and contractors during bridge washing procedures.

a. Primary Requirements

i. Wash-water must not be allowed to discharge directly to the underlying waterbody. Discharges of this sort require an environmental permit from the Virginia Department of Environmental Quality (VDEQ).

ii. Sediments and debris accumulated during the bridge washing procedures must not be disposed of in the underlying water body or on adjacent wetlands, if they exist.

b. Environmental Protection Procedures

i. Utilize water from the underlying water body as wash water, whenever possible, unless there are drought conditions or your withdrawal would "dry" the water body.

ii. Accumulated sediments or other debris must not be disposed within the underlying water body or adjacent wetlands. Sediments that have been swept or shoveled off the bridge deck may be placed along the right-of-way in a vegetated area along the bridge approach.

iii. Wash-water shall be prevented from directly discharging to the underlying water body. All deck drains, scuppers, inlets and flumes on the structure shall be blocked during washing operations. For open-sided bridges such as corral-style (Kansas-style) bridges, berms must be placed along the sides to prevent wash-water from flowing over the sides and into the underlying water body. Wash-water may be directed to a vegetated area within the right-of-way, along the bridge approach; however, it must not be discharged to wetlands.

iv. Painted surfaces must not be power-washed; however they may be "rinsed" at water pressures that will not cause paint chips to flake off.

B. Deck Sweeping

1. Include the removal and disposal of debris and sweeping of the bridge roadway surface, joints, sidewalks, and curbs.

2. All concrete decks and slabs with asphalt, metal decks, and timber decks and slabs.

C. Seat and Beam Ends Washing

1. Include the removal and disposal of debris and pressure washing of the bridge seat and bearing areas. Bridge seat and bearing areas to be cleaned include abutment seats, pier seats, bearing devices, the end five feet of beams and girders, and end diaphragms.

D. Cutting and Removing Vegetation

1. Include cutting, removing and disposing of vegetation, brush and trees that are on, adjacent to, or under bridges that cross over waterways.

E. Routine Maintenance of Timber Structures

1. Include tightening and/or replacing fasteners such as those used on timber decks, railing systems, and other miscellaneous connections. Sealing end sections of timber elements, such as deck boards, bent caps, railings, posts, etc.

F. Lubricate Bearing Devices

1. Include removal and disposal of debris, and lubricating moveable type of bearings.

G. Removing Debris From Culverts

1. Include the removal and disposal of debris that is collected inside and/or at inlets or outlets of box and pipe culverts.

H. Scheduled Replacement of Pourable Joints

1. Include removal of existing joint material, prepare and install new joint material.

2. For planning and budgeting purposes for this type of joints in the PM program, only joints that are in good condition will be considered. Joints that are not in good condition will be accounted for and addressed in Pontis (BMS).

I. Scheduled Replacement of Compression Seal Joints

1. Include removal of existing joint material, prepare and install new joint material.

2. For planning and budgeting purposes for this type of joints in the PM program, only joints that are in good condition will be considered. Joints that are not in good condition will be accounted for and addressed in Pontis (BMS).

J. Beam Ends Painting

1. Include preparing and over coating the end 5 feet of painted steel beams or girders that are located under open joints, except for bridges with timber decks.

2. For planning and budgeting purposes in this program, only steel members that are in overall good condition will be considered. Steel members that are not in good condition will be accounted for and addressed in Pontis (BMS).

K. Scheduled Installation of Thin Epoxy Concrete Overlay

1. Include the installation of new overlay system and or replacement of existing overlay systems.

2. Only bridge decks that are in overall good condition are considered in this program.

10.1.5 Maintenance Responsibility for Structures within Towns, Cities, and Counties: Where the Interstate, Arterial, or Toll Road system provides an interchange within a municipality charged with the responsibility for maintenance of its street systems, the Department will be responsible for the maintenance of the complete highway facility within the interchange. Under this provision, maintenance payment will not be paid to any municipality for street or road mileage maintained by VDOT. Municipalities desiring to maintain municipal streets passing through Interstate, Arterial, or toll interchanges may maintain such streets in accordance with following Bridge Maintenance Reasonability Table.

The maintenance of interchanges and grade separation bridges at all intersections of Interstate and Primary routes, including Arlington and Henrico counties, will be the responsibility of VDOT.

PRELIMINARY RESILIENCE PLAN

CITY OF CHESAPEAKE, VIRGINIA

April 2022

PREPARED FOR:

THE CITY OF CHESAPEAKE

PREPARED BY:

TIMMONS GROUP
YOUR VISION ACHIEVED THROUGH OURS.

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Table of Contents

List of Tables & Figures

Executive Summary

The City of Chesapeake has developed this Preliminary Resilience Plan (Plan) to meet the requirements of the Department of Conservation and Recreation (DCR) Community Flood Preparedness Fund (CFPF) grant program. The Plan was developed using funding awarded during the inaugural round of the CFPF program. The Plan was crafted to incorporate all Resilience Plan requirements and criteria as provided in the 2022 Grant Manual for the Virginia Community Flood Preparedness Fund.

In addition to the overarching five (5) requirements for the Plan as provided below, the Plan incorporates all Elements of Resilience Plans (as provided in Appendix G of the Grant Manual) hereafter referred to as criteria. A guide those criteria and associated reference documents can be found in Appendix A while Plan content that addresses corresponding criteria is referenced throughout the Plan as "[c#]" at the end of applicable statements.

- It is project-based with projects focused on flood control and resilience
- It incorporates nature-based infrastructure to the maximum extent possible
- It includes considerations of all parts of a local government regardless of socioeconomics or race
- It includes coordination with other local and interjurisdictional projects, plans, and activities and has a clearly articulated timeline or phasing for plan implementation
- Is based on the best available science, and incorporates climate change, SLR, storm surge (where appropriate), and current flood maps

This Plan was developed by compiling a wide range of existing City of Chesapeake and regional documents and was done in collaboration with multiple City departments, though sponsored by the Department of Public Works. The Plan provides narrative on the requirements defined in the CFPF Grant Manual and has been organized into four (4) main sections:

Section 1, Introduction, provides a description of the Plan development process and a brief history of Chesapeake with respect to flooding.

Section 2, Natural Hazards & Vulnerabilities, describes those hazards that threaten the City as well as where socially vulnerable populations intersect with those hazards.

Section 3, Current Efforts to Reduce Flooding & Develop Resilience, details the various efforts already undertaken or underway by the City and regional partners that relate to flooding and resilience.

Section 4, A Plan for Resilience, provides information on ongoing coordination efforts, the current science guiding resilience efforts, and those study, program, and project opportunities that the City of Chesapeake plans to explore looking forward. At this time, the City has identified twenty-six (26) projects representing planned improvements to improve flooding resilience. These projects vary in scope, cost, funding availability, and anticipated implementation.

Ultimately, the City of Chesapeake seeks continued participation in the CFPF program through identification and application for funding assistance for opportunities as they are identified and vetted.

1.0 Introduction

As a coastal community, the City of Chesapeake has the benefit of enjoying the habitat associated with shore access. Unfortunately, life in coastal regions also comes at a cost. Flooding vulnerabilities not only threaten the safety of residents, but also have the potential to damage or destroy property and disrupt the local economy and overall quality of life. While impending natural hazards are impossible to prevent, designing for resilience can minimize the damage done and prepare the City to bounce back better.

1.1 Plan Development Process

The City of Chesapeake intends to participate in the CFPF grant program. This funding program was established to provide support for Virginia's localities efforts in reducing impacts of flooding – including flooding driven by climate change. The CFPF program intends to prioritize projects coinciding with local, state, and federal floodplain management standards, local resilience plans, and the Virginia Coastal Resilience Master Plan. This Fund will empower communities to complete studies and implement programs to bolster flood preparedness and resilience.

According to the CFPF program, a Resilience Plan describes the entire local government's approach to flooding and addresses the following five (5) requirements:

- It is project-based with projects focused on flood control and resilience
- It incorporates nature-based infrastructure to the maximum extent possible
- It includes considerations of all parts of a local government regardless of socioeconomics or race
- It includes coordination with other local and interjurisdictional projects, plans, and activities and has a clearly articulated timeline or phasing for plan implementation
- Is based on the best available science, and incorporates climate change, SLR, storm surge (where appropriate), and current flood maps

Intended to elaborate on the City's intentions to establish a resilient community, this Plan identifies the vulnerabilities: physical, natural, and social, due to flooding, reviews the previous and ongoing efforts, and provides information related to future opportunities to combat flooding and develop resilience. The aim of the proposed projects included in the Plan is to strengthen flood management systems to reduce damage caused by flooding. These projects identify opportunities to address weaknesses or provide additional hazard reduction in the City of Chesapeake.

To assist in the development of this Plan, a document review process was undertaken to identify documents or portions thereof that could be combined to meet the requirements of a resilience plan as presented in the 2022 Grant Manual for the Virginia Community Flood Preparedness Fund. The list of documents reviewed can be found in Appendix B.

In addition to addressing the overarching five (5) requirements for the Plan as listed above, the Plan incorporates all fifteen (15) Elements of Resilience Plans (as provided in Appendix G of the Grant Manual) hereafter referred to as criteria. A guide those criteria and associated reference documents can be found in Appendix A while Plan content that addresses corresponding criteria is referenced throughout the Plan as "[c#]" at the end of applicable statements.

Development of the Plan was sponsored by the Department of Publics Works. However, other City departments – including Planning, Development and Permits, and Emergency Management – were invited to participate and had the opportunity to provide input and review and comment on the Plan. Supporting documents were sourced from departments throughout the City as well as from regional partners, including the Hampton Roads Planning District Commission.

1.2 Chesapeake's History

The banks of the Elizabeth River were first settled by the British around 1620 beginning Chesapeake's history [c14]. In the early 1900's, the northern sector of the Chesapeake region began to develop as a Southern Norfolk suburb outside the growing City of Norfolk. By 1900, South Suffolk had independent waterworks, public schools, and post office. Today's Chesapeake grew from residential and commercial development of community crossroads; some still referred to with established names, such as: Deep Creek, Fentress, Great Bridge, Hickory, Indian River, Oak Grove, Pleasant Grove, South Norfolk, Portlock, and Western Branch. In June of 1962, the citizens voted to select the name of the new city, "Chesapeake," as both Norfolk County and Southern Norfolk agreed to merge. The present City of Chesapeake was established in 1963 through the consolidation of the City of South Norfolk and Norfolk County[1].

The City of Chesapeake is a diverse and growing community with a heritage deeply rooted in the history of our developing nation. Chesapeake's landmarks and communities have a long and diverse history, stretching back to the early days of the Colony of Virginia. Over the last fifty (50) years, the City of Chesapeake has experienced unprecedented changes in population and land use, the majority of new housing units being single-family units. In 2017 the 224,640-acre community had a population of around 222,000 individuals, or approximately 1 person per acre of land area [c14]. Although the growth rate has declined in recent years, the City continues to grow at a rate of approximately 1% each year. An increase in flooding and natural hazards has accompanied growth experienced by the City[2]. Chesapeake is located partially in the Elizabeth River Watershed, a tributary of the James River Watershed, which can be seen in Figure 1, along with the Southern Watershed. Approximately 58,880 acres of the City, or 26%, drains to the Chesapeake Bay, primarily through the Elizabeth River. Approximately 167,040 acres, or 74%, of the City lies within the Southern Watershed area.

For decades, the City has been committed to stormwater management. Chesapeake was one of the first in Hampton Roads to become a Municipal Separate Storm Sewer System (MS4) in 1996 through the Virginia Pollutant Discharge Elimination System (VPDES) program as well as abiding by their Virginia Stormwater Management Program (VSMP) in place since 1991 [c11]. The City's Master Drainage Plans for specified regions and MS4 documents address the quality and quantity of our stormwater runoff while meeting state and federal regulations[3].

Upon observing tide elevation data for the last 100-years, it is evident the City is facing escalating danger from SLR[4]. The Code of Virginia mandates localities to plan for and address flooding and SLR. Flooding, SLR, coastal storms, and shoreline erosion are considered the most significant hazards that threaten Hampton Roads Region[5] [c3]. Floodplain management plans which cover floodplains and City studies that cover broad areas of the City combine

[1] (Hampton Roads Planning District Commission, 2017)
[2] (Hampton Roads Planning District Commission, 2017)
[3] (Whitman Requardt and Associates, LLC, 2018)
[4] (Hampton Roads Planning District Comission, 2017)
[5] (Hampton Roads Planning District Comission, 2017)

together to create a unified pattern of identified hazards beyond those just identified in the National Flood Insurance Program (NFIP). These examine issues such as causations of localized flooding, identify vulnerabilities due to flooding, analyze the locality flood management practices, and provide feasible solutions to strengthen the flood management system, reducing damages caused by flooding[6].

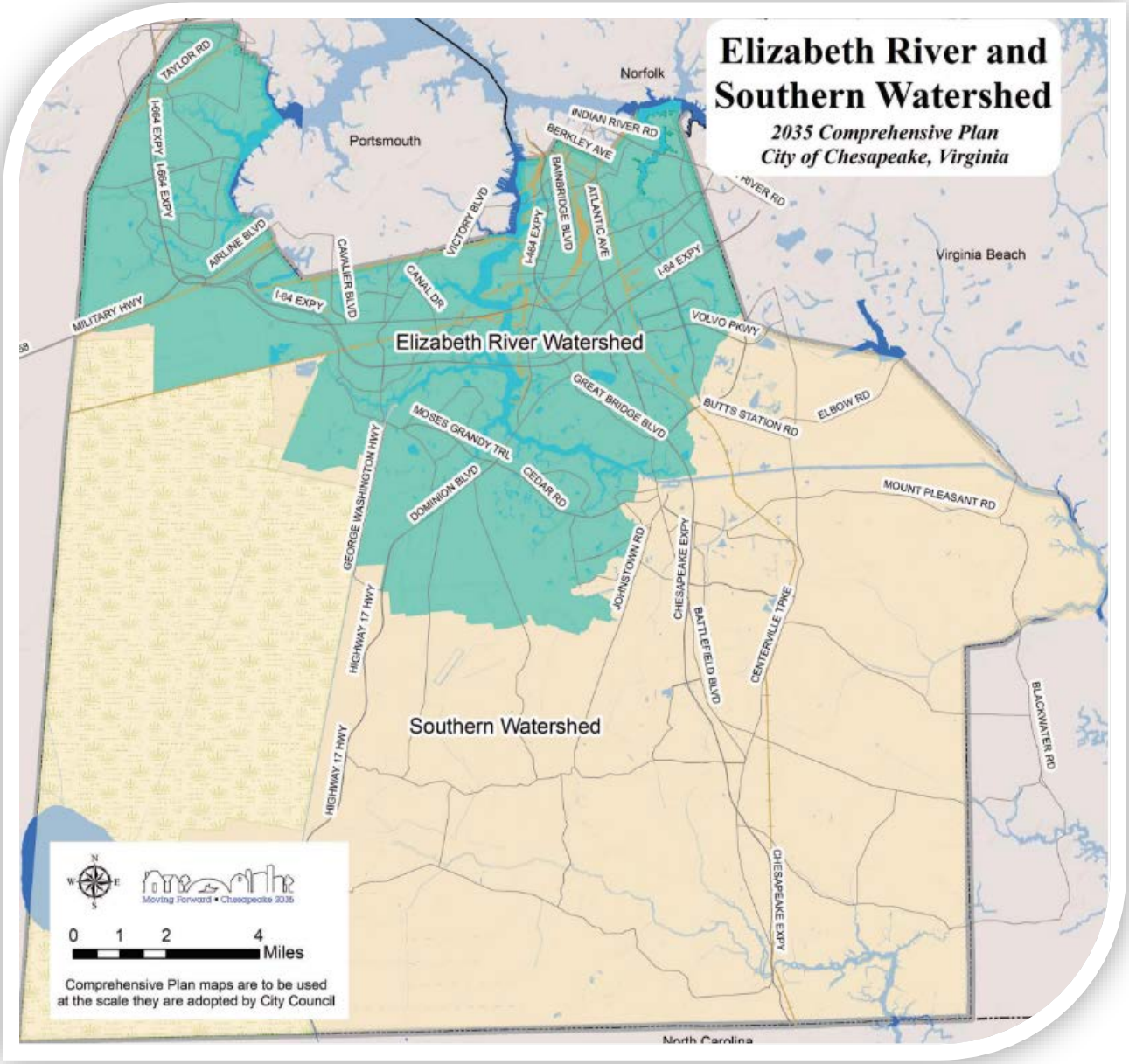


Figure 1: Elizabeth and Southern Watershed

[6] (Hampton Roads Planning District Comission, 2017)

2.0 Natural Hazards & Vulnerabilities

While natural hazards can be unavoidable, projects can be implemented to minimize the damage felt by the communities disturbed. Unfortunately, living in a coastal region means the likelihood of flooding events is elevated. Where communities most vulnerable to natural hazards coincide with societally vulnerable populations, addressing flooding in an equitable manner is essential. [c1]

2.1 Flooding & Related Hazards

Flooding is a major concern for a coastal city and has the potential to exacerbate other hazards and vulnerabilities. The City of Chesapeake experiences precipitation and tidal flooding, as well as the two in concert. The frequency and intensity of storms and consequently flooding events are increasing as a result of climate change, including sea level rise (SLR). In coastal areas, flood zones established by FEMA represent both riverine and coastal flooding hazards. However, what is often missing from these established data are localized areas of inland flooding. Chesapeake's floodplain can be seen in Figure 2[7]. [c3, c14]

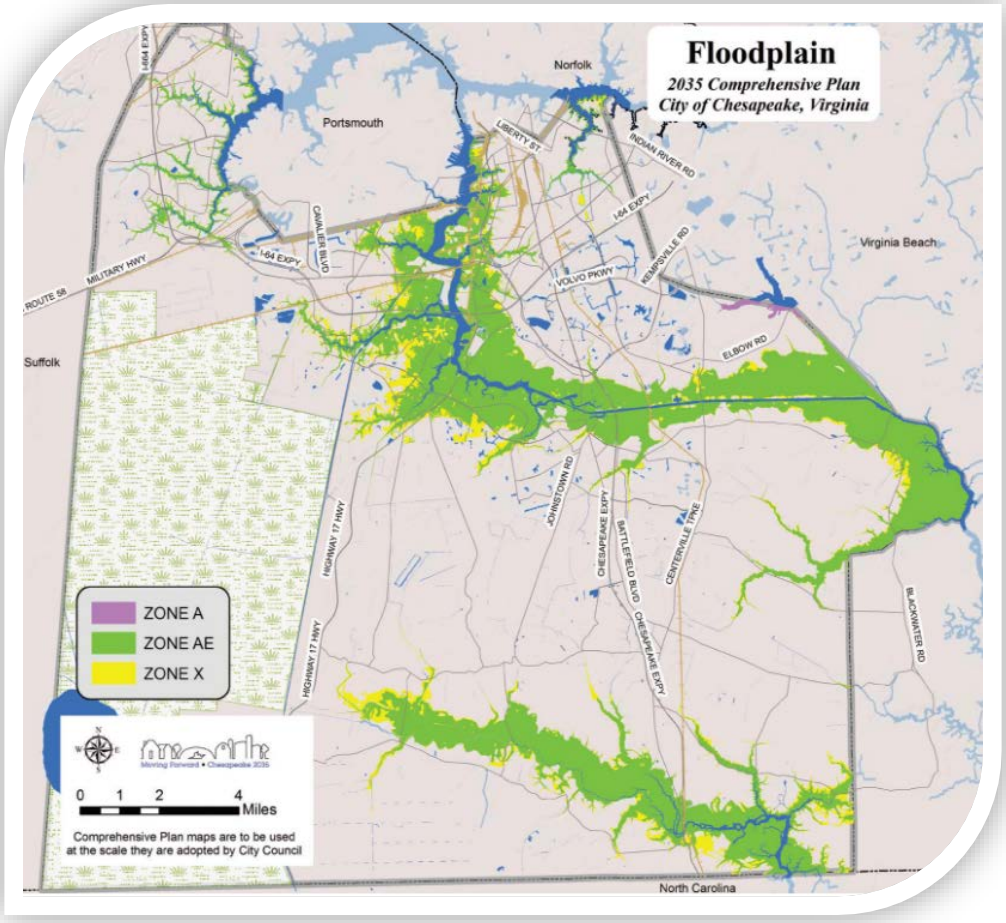


Figure 2: Floodplains in the City of Chesapeake

[7] (City of Chesapeake Planning Department, 2016)

- Zones A and AE shown are high flood risk areas, referred to as a 100-year (1% chance) floodplain
- Zone X (shaded) regions pose a moderate flood risk and is referred to as a 500-year (0.2% chance) floodplain.

Additionally, the city sees negative impacts of beavers and dams restricting flow in major outfall systems that results in flooding.

2.1.1 Precipitation Flooding

Old, undersized, stormwater infrastructure or lack thereof is a leading contributor to flooding issues; the capacity to which infrastructure is designed to convey relative quantities of water is essential to managing flooding. Policies and regulations pertaining to stormwater management requirements have changed over time. Depending on when a neighborhood or other development was established, the formal drainage system could be nonexistent or undersized compared to today's design standards. Systems designed to convey smaller storms will experience flooding more frequently. Since the 1990s, the City of Chesapeake has worked to develop and update studies throughout the City to identify and recommend improvements for undersized infrastructure. [c1] These studies will be discussed in greater detail in Section 3.3.4.

2.1.2 Tidal Flooding

Flat terrain, low ground elevation and minimal slope aid in the impact of flooding, including on sunny days, where there is no rain event, but water is backed up in the system due to high tides, storm events, or as a result of SLR. Downstream portions of drainage systems that connect to tidal water bodies often experience water backups due to tidal influence.

Wind-driven can impact non-coastal areas. In the Southern Watershed of Chesapeake, southerly winds influence water levels and can lead to flooding of inland areas.

2.1.3 Storm Events

Coastal regions, like Chesapeake, are especially vulnerable to flooding from extreme weather events, including hurricanes and nor'easters. Between 1851 and 2005, 78 storms have passed within 75-miles of the region. Of these, two were Category 3 hurricanes, eight were Category 2 hurricanes, 16 were Category 1 hurricanes and 49 were tropical storms. The remainder were tropical or extratropical depressions. An image of storm paths since 2005 within 75 miles of Hampton Roads can be seen in Figure 3 on the following page. These various tropical cyclones have caused approximately 230 deaths and cost the Commonwealth more than one billion dollars in damages[8].

The main destructive elements of these storms are high-level sustained winds, heavy precipitation, and tornadoes. Coastal regions are specifically prone to storm surge, wind-driven waves, and tidal flooding that could prove more damaging than cyclone wind[9]. A storm surge is a large dome of water often 50 to 100-miles wide and rising anywhere from 4 to 20-feet. A storm surge arrives in advance of the storm's landfall – the greater the storm is, the earlier the surge arrives. Water rise is extremely rapid, posing severe hazard to those who have not evacuated flood-prone areas. Such a surge of high water topped by waves driven by storm force winds are devastating to coastal regions, inflicting extreme beach erosion and property damage[10].

[8] (Hampton Roads Planning District Commission, 2017)
[9] (Hampton Roads Planning District Commission, 2017)
[10] (Hampton Roads Planning District Commission, 2017)

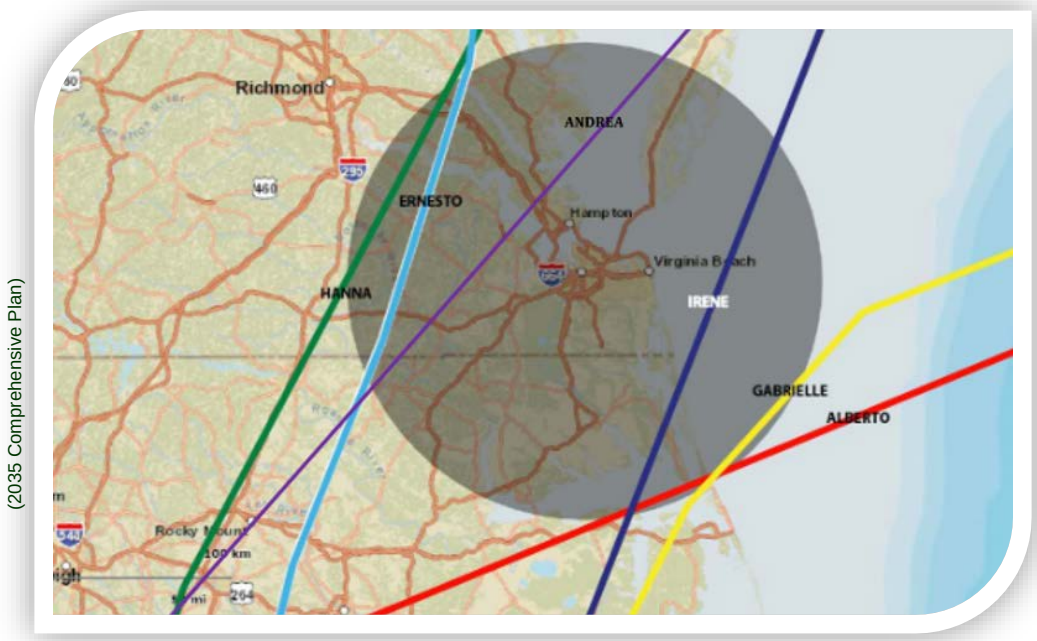


Figure 3: Storm Tracks in 75 miles of Hampton Roads since 2005

Wind damage in the area from events, in most recent accounts, have been marked by a wide variety of downed trees, damage to roofs, siding and signs, power outages due to downed power lines and trees across lines, and wind-blown debris accumulation. Since wind and flood events generally occur simultaneously, the combined effects are greater in flood-inclined regions. Roof damage from wind can also result in rain damage to structures, as well. Combined storm surge and wind affects to shorefront regions make some homes and businesses uninhabitable for days to weeks at a time[11].

The probability of Chesapeake experiencing a hurricane or tropical storm in the future is high. The Atlantic hurricane season typically runs from August 15th to Nov 30, peaking in mid-September. In Hampton Roads, it is uncommon to experience the direct affects from hurricanes category 3 and 4. This is a result of historical tracks remaining offshore or impacting land earlier than arriving in the Hampton Roads. Additionally, cooler Atlantic Ocean water temperatures north of Cape Hatteras decrease a storm's capacity to maintain intensity. A Category 5 hurricane is considered unlikely in Hampton Roads because of the cooler water temperatures mentioned above. The effects of smaller hurricanes and tropical storms will be frequent, as storms making landfall along the North Carolina and Virginia coastlines could impact the region in any given year[12].

Nor'easters are also a primary cause of coastal flooding as the wind's direction pushes water up into smaller creeks and tributaries, overwhelming their capacity for rainwater.

[11] (Hampton Roads Planning District Commission, 2017)
[12] (Hampton Roads Planning District Commission, 2017)

2.1.4 Shoreline Erosion

Shoreline erosion along the banks of the Elizabeth River is a concerning natural hazard pressing Chesapeake's community. Shoreline erosion is often correlated with extreme storm events and the impacts are expected to increase as sea level rises. Human activities can worsen erosion as well. While it is ideal to avoid sensitive regions entirely, it is imperative designs for land disturbing activities along the shore incorporate resilience[13].

2.2 Other Hazards

There are other natural (and manmade) hazards that could cause, affect, or result from flooding events. Strategies to address these hazards can be found in the Hampton Roads Hazard Mitigation Plan.[14] [c15]

2.2.1 Earthquakes & Landslides

An earthquake is the trembling of the ground produced by sudden displacement of rock in the Earth's crust. Earthquakes result from crustal strain, volcanism, landslides or the collapse of caverns. Hampton Roads is in an area which would feel effects of earthquakes in the Central Virginia Seismic Zone, an area of frequent, yet very weak, earthquake activity. Since 1774, there have been only three earthquake epicenters within 65 miles of Hampton Roads, two in the Hampton Roads area and one on the Delmarva Peninsula. Earthquakes of significant magnitude are unlikely occurrences for Hampton Roads, though the proximity of the region to the Charleston Fault could increase the possibility of feeling some impact of a large earthquake if it were to occur along that fault line[15] .

Only minor structural damage as a result of these earthquakes has been reported in the region. If a significant earthquake were to occur, damage to local structures would likely be severe because buildings in the region are not typically designed to withstand high magnitude quakes. Underground infrastructure damage is also expected to be severe and could cause long-term power, water, and sewer service interruptions in the region. Likewise, damage to bridges, tunnels and roads could disrupt transportation routes for much of the population[16].

2.2.2 Wildfires

With the exception of fire under prescription, a wildfire is any fire occurring in a wildland area. Wildfires are part of the natural management of the Earth's ecosystems; they may be caused by natural or human factors. Over 80% of forest fires are started by negligent human behavior such as improperly extinguishing campfires or smoking in wooded areas. The second most common cause for wildfire is lightning. Fire probability depends on local weather conditions, outdoor activities, debris burning, construction, and the degree of public cooperation with fire prevention measures. Drought conditions and other natural disasters (such as hurricanes, tornadoes, and lightning) increase the probability of wildfires by producing fuel in both urban and rural settings.

Great Dismal Swamp National Wildlife Refuge was struck by lightning on August 4, 2011 that hit land primed for wildfire due to drought. The Lateral West fire has burned a minimum of 2,000

[13] (Hampton Roads Planning District Commission, 2017)
[14] (Hampton Roads Planning District Commission, 2017)
[15] (Hampton Roads Planning District Commission, 2017)
[16] (Hampton Roads Planning District Commission, 2017)

acres. Forest damage from hurricanes and tornadoes may block interior access roads and fire breaks, pull down overhead power lines, or damage pavement and underground utilities[17].

The impacts of wildfire in the Hampton Roads region are both economic and environmental. From an economic perspective, fires destroy homes, businesses and infrastructure; communities in the region spend significant capital funds fighting wildfires, training staff, and preparing equipment to fight wildfire. Loss of life is a possible impact of severe wildfire in the region, although the lack of mountainous terrain makes escape somewhat easier. Environmentally, wildfires raise the temperature of forest soils, potentially eliminating organic value of the soil. Although soils eventually recover, impacts on watersheds in the interim can be detrimental to water bodies of the region. Burned soils may negatively affect infiltration and percolation, making soil surfaces water repellant – infiltration to groundwater decreases and runoff quantity increases. Both factors may negatively impact water quality downstream. Wildfires remain a highly likely occurrence for the region, though most will likely continue to occur in less urban areas and be small in size before being contained and suppressed[18].

2.2.3 Hazardous Material Incidents

Chesapeake's Code of Ordinances Sec. 26-606 prohibits storage or deposit of contaminants or hazardous, radioactive, nuclear or industrial waste in watershed areas[19]. [c15] Hazardous Material (HAZMAT) incidents can apply to fixed facilities as well as mobile, transportation-related accidents in the air, by rail, on the Nation's highways, and on the water. HAZMAT incidents can happen anywhere at any time. Per the Federal Emergency Management Agency (FEMA) approximately seven thousand HAZMAT events occur each year, 81% of those are highway incidents. In the Hampton Roads Region from 1988-2015, 454 documented HAZMAT events occurred; 73% of these HAZMAT incidents were in Chesapeake. HAZMAT incidents consist of solid, liquid, and/or gaseous contaminants released from their proper vessel. These events can have far reaching effects on the surrounding communities. In tandem with an extreme storm, the severity of the situation can escalate even further. A HAZMAT incident can last hours to days, while some chemicals can be corrosive or otherwise damaging over longer periods of time. In addition to the primary release, explosions and/or fires can result from a release and contaminants can be extended beyond the initial area by persons, vehicles, water, wind, and wildlife[20].

HAZMAT incidents can also occur as a result of, or in tandem with, natural hazard events which can also hinder response efforts. HAZMAT incidents can include the spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping or disposing into the environment of a hazardous material, but exclude:

- Any release which results in exposure to poisons solely within the workplace
- Emissions from the engine exhaust of a motor vehicle, rolling stock, aircraft, vessel, or pipeline pumping station engine
- Release of source, byproduct, or special nuclear material from a nuclear incident
- The proper application of fertilizer

[17] (Hampton Roads Planning District Commission, 2017)
[18] (Hampton Roads Planning District Commission, 2017)
[19] (Chesapeake, Code of Ordinances IV, VII, IX, X, and XI, 2013)
[20] (Hampton Roads Planning District Commission, 2017)

Negative impacts of hazardous materials incidents are dependent on the nature of the materials involved. While each chemical transported has unique qualities, there are generally three types of impacts:

1. Economic
2. Environmental
3. Safety of residents and first responders

In cases where evacuations are necessary to protect human life and safety, lost wages can be significant. Environmental impacts of highest concern in Hampton Roads include spills of petroleum products into the region's waterways. The region's emergency managers have contingency plans in place with the U.S. Coast Guard and others. However, a spill could still impact water quality, aquatic life, and valuable wetlands along the shoreline. Future occurrences of HAZMAT incidents, accidents, or issues within Hampton Roads are considered highly likely[21].

2.3 Critical Facilities

Impacts from flooding and other hazards can reduce or block access to emergency response activities; effects on roadways can prevent personnel from travelling and limit access to critical facilities [c3]. Critical facilities can be considered as those essential for delivery of critical services and crisis management, those identified by Chesapeake can be seen in the map provided in Appendix C. [c8]

Critical facilities can be broken into 6 categories, seen below in Figure 4[22] [c8].

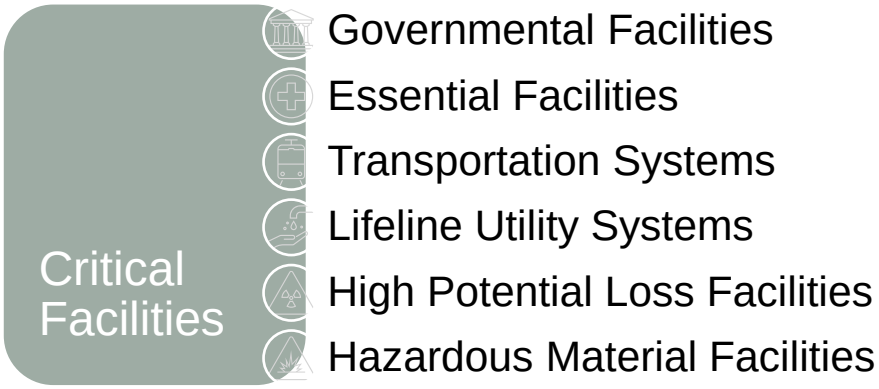


Figure 4: Critical Facilities

These facilities include data and communication centers, key government complexes, and similar facilities as determined by the floodplain administrator and emergency management department staff; those vital to health and welfare of entire populations, including hospit ,d other medical facilities, retirement homes, police and fire facilities, emergency operations centers, prisons, evacuation shelters, schools, and any other facilities such as:

- Systems necessary for transport of people and resources
- Facilities vital to public health and safety, including potable water, wastewater, oil, natural gas, electric power, communication systems, and similar facilities

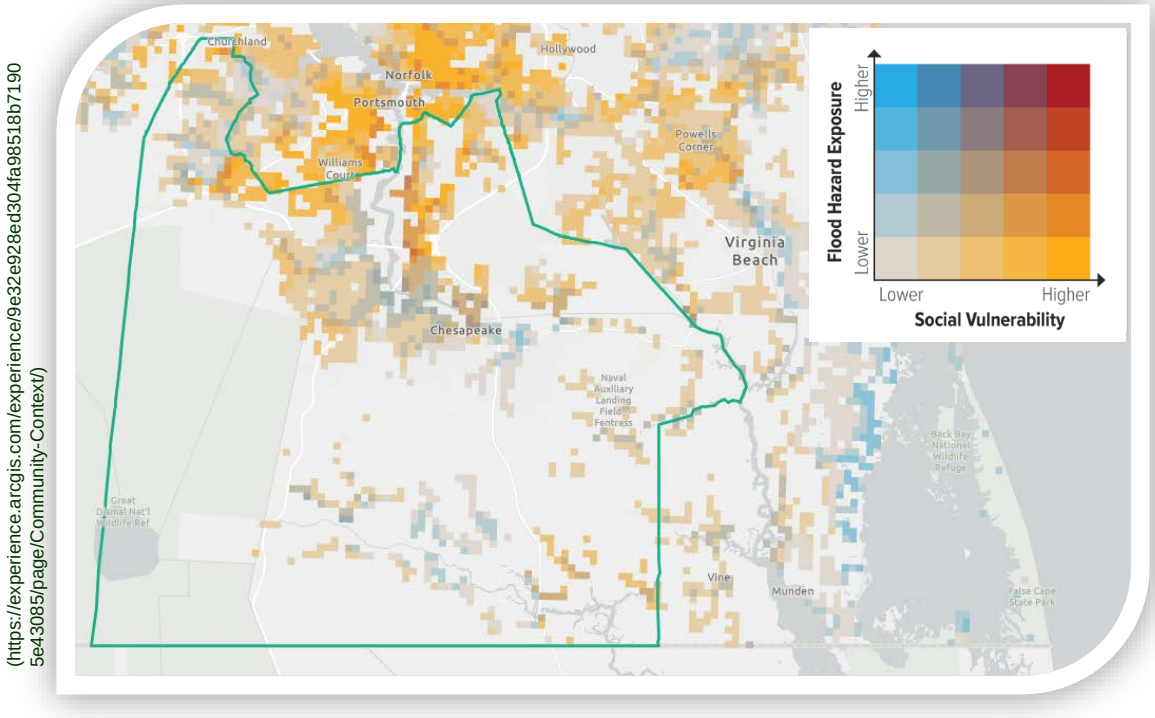
[21] (Hampton Roads Planning District Commission, 2017)
[22] (Hampton Roads Planning District Commission, 2021)

- Facilities whose disruption may significantly impact neighboring communities, including nuclear power plants, high hazard dams, and military installations
- Facilities involved in production, storage, and/or transport of hazardous materials

2.4 Vulnerable Populations

Flood damage and harm are more likely to occur in communities where many residents share economic and social traits that hinder their ability to prepare for and recover from flooding catastrophes. Disadvantaged groups and those with lesser incomes suffer the most from the physical and economic consequences of disasters, making recovery even more difficult. Flood-prone residents are more likely to suffer the direct consequences of coastal flooding, such as compromised health and safety, flooded highways, and school and business closures. Flooded properties may become hazardous or inconvenient to live in, making it impossible for residents to stay. Flooding that is severe or regular may force residents and businesses to relocate. [c4]

When addressing natural hazards, the communities facing the largest impending threats should be a focal point. Flood-affected citizens in Hampton Roads are more likely to be urban dwellers, economically pressured families, and individuals of color. The following graphic, borrowed from the Virginia Coastal Resilience Web Explorer, depicts the interaction of community socioeconomic vulnerability and coastal flood hazard exposure. Neighborhoods in red have a high level of social vulnerability (based on 2020 demographics) as well as a high level of exposure to coastal flood threats (based on all modeled 2080 flood scenarios).[23] [c3]



(https://experience.arcgis.com/experience/9e32e928ed304fa98518b7190 5e43085/page/Community-Context/)

Figure 5: Social Vulnerability and Flood Hazard Exposure in Chesapeake

[23] (Commonwealth of Virginia Department of Conservation and Recreation, 2021)

3.0 Current Efforts to Reduce Flooding & Develop Resilience

The City of Chesapeake has already established a myriad of processes, programs, and plans that address flooding and resilience.

3.1 Community Involvement, Outreach, and Notification

The City of Chesapeake strives to ensure that resilience efforts are all inclusive of the locality regardless of socioeconomics or race. Individual citizen involvement provides the City with a greater understanding of local concerns and increases the success of resilient efforts by developing an invested community and by involving those directly affected by public policy and future development.

3.1.1 Involvement

The City intends to continue encouraging its citizens to become more involved in decisions that affect their life and safety. Knowledge of the natural hazards present in their community will aid in the process of the community taking personal steps to reduce hazard impacts. Public awareness is a key component of an overall mitigation strategy aimed at making a home, neighborhood, school, business, or city safer from the effects of natural hazards[24]. [c12]

The City currently sponsors several committees or working groups that engage residents and create community leaders [c11, c12]:

- Chesapeake Environmental Improvement Council (CEIC) – comprised of 18 volunteers appointed by the Mayor to promote interest in improving the environment of Chesapeake, Virginia thereby making Chesapeake a greener, cleaner, and healthier city in which to live, work, and visit. The CEIC will accomplish its purpose through outreach, education, and volunteer efforts to include litter and pollution prevention, waster reduction and recycling, beautification, conservation landscaping, and other environmental and conservation issues.

- Chesapeake Stormwater Committee – comprised of 11 City Council appointed representatives and 3 Ex-Officio members from City staff, their duties include:
    - Reviewing the status of City-wide drainage projects, study areas, maintenance operations and issues of wetlands permitting
    - Reviewing rates and providing utility rate recommendations to the City Manager
    - Preparing drainage and stormwater utility-rated recommendations for the City Manager
    - Serving as a “sounding board for citizens concerned about drainage in neighborhoods and subdivisions
    - Reviewing recommendations from Public Works to improve drainage and maintenance operations
    - Providing recommendations on changes to the Stormwater Utility Fee, Capital Improvement Projects, and Level of Services

- Natural Event Mitigation Advisory Committee (NEMAC) – the committee monitors the efficiency and effectiveness of various natural hazard mitigation strategies and makes recommendations to city council for additional improvements.

[24] (Hampton Roads Planning District Commission, 2017)

3.1.2 Outreach

The City currently implements public education and outreach programs to help educate the community, focusing on impacts of stormwater discharge to surrounding water bodies[25]. The program provides information on how the community can help reduce these impacts and protect the waters quality. In order to promote public reporting of illicit discharges, the City provides stormwater education to the public through multiple media outlets such as web sites, radio, cable television, local television, publications, and a Customer Service Center.

Through a partnership with the HRPDC, the City participates in askHRgreen.org, a public awareness campaign administered by HRPDC. The website is a resource for environmental stewardship, including green landscaping practices and other topics related to stormwater quality and the MS4 permit. Beginning in 2011, HRPDC environmental programs were combined into a single public awareness program and central resource for environmental education in Hampton Roads known as askHRgreen.org – this and other resources are provided below[26] [c11, c12]:

http://askhrgreen.org/

http://www.cityofchesapeake.net/government/City-Departments/Departments/Public-Works-Department/stormwatermanagement-publiceducation.htm

http://www.cityofchesapeake.net/online-Services.htm

3.1.3 Notification

Chesapeake Alert was developed to establish a combine policy for the authorized use, administration, and support for the City of Chesapeake's Emergency notification/Citizen Information/Employee Notification System. The system has three designated purposes, as follows[27] [c12]:

- Citizen Information
- Emergency Notification
- Employee Notification

Utilizing a variety of telecommunications paths, Chesapeake Alert provides information to targeted recipients rapidly. Messaging may be in voice or text-data forms, depending upon the situation, capabilities of the receiving device(s), and choice(s) of the recipient[28].

3.2 Participation in State and Federal Programs

Regulations differ from a state and federal level. Localities must be sure to fall within both state and federal limits. Participation in both forms of programs is an active mode of ensuring this result.

[25] (City of Chesapeake, 2017)
[26] (Southern Rivers TMDL Action Plan, 2018)
[27] (City of Chesapeake, 2011)
[28] (City of Chesapeake, 2011)

3.2.1 FEMA

The City assists residents with acquiring federally funded hazard mitigation grants, including but not limited to, FEMA's Hazard Mitigation grant to acquire repetitive loss properties through the OEM Property Buyout Program City assistance. [c5, c7]

3.2.2 Community Rating System (CRS)

City of Chesapeake Participates in the CRS and recently graduated to a class 7 rating. This incentive program encourages communities to undertake defined flood mitigation activities that go above and beyond the minimum requirements of the NFIP, adding extra local measures to provide protection from flooding. The CRS mitigation activities are assigned a range of point values. As these points are accumulated and thresholds are reached, communities can apply for an improved CRS class rating. Class ratings, which run from 10 to 1, are tied to flood insurance premium reductions[29]. Currently, the City has been successful in acquiring points in the following activities: [c5]

- 310 Elevation Certificates
- 330 Outreach Projects
- 350 Flood Protection Information
- 420 Open Space Preservation
- 430 Higher Regulatory Standards
- 440 Flood Data Maintenance
- 450 Stormwater Management
- 510 Floodplain Management Planning
- 520 Acquisition and Relocation
- Flood Damage Reduction
- Mapping & Regulations

3.2.3 MS4

The City of Chesapeake is a Phase I MS4 and was first permitted in 1996 under the VPDES program administered by DEQ. As it relates to flooding, the City must manage construction site runoff as well as quantity and quality of post-construction site runoff. Chesapeake also manages various public outreach and education campaigns through the MS4 program. Through the HRPDC, the Regional Stormwater Management Program coordinates actions and leverages funding for technical and advisory assistance to help localities meet the requirements of state-issued stormwater permits. The program includes cooperative initiatives in the following areas[30]:

- Construction runoff control
- Environmental Education
- Illicit discharge detection & elimination
- Post-construction impacts management
- Monitoring of regulatory changes
- Municipal pollution prevention
- Regional cooperative data tracking
- Regional cooperative monitoring

[29] (Hampton Roads Planning District Commission, 2017)
[30] (City of Chesapeake, 2017)

3.3 City Planning, Policies, and Guidance

Planning and regulatory capabilities are based on implementation of plans, ordinances, and programs which demonstrate the City's commitment to guiding and managing growth, including:

- Capital improvements planning
- Comprehensive land use planning
- Emergency response
- Enforcement of zoning or subdivision ordinances and building codes
- Mitigation and recovery planning
- Reconstruction after disaster
- Transportation planning

These planning initiatives present significant opportunities to integrate hazard mitigation principles and practices into local decision-making processes. Conservation efforts have far reaching benefits to affected ecosystems as well as surrounding populations. Abiding by and maintaining resilient goals and objectives is crucial to ensuring the success of the City's existing and future effort. Types of action can be interrelated and broken down into the categories seen in Figure 6 [c4].

Figure 6: Chesapeake's Action Efforts

The focus of parking strategies includes improving parking utilization and connectivity, managed properly including internal and external instillations. Parking lots create ample impervious space; runoff increases with percentage of impervious groundcover. Multimodal strategies highlight an expanded and improved transit and improving cyclist/pedestrian access; flood mitigation strategies identify approaches to combat flooding along critical corridors for accessing instillations and providing important network functionality. Improving accessibility enables ease of access during emergency situations. Controlling land use and development targets using recommended joint use planning efforts to manage responsible growth, reuse, and redevelopment considering both local and federal lands. Responsible growth is critical to a resilient community. Access strategies focus on improving instillation access points and enhancing directional signage and information to assist commuters and visitors. Access is beneficial in everyday life and especially under emergency circumstances. Utility strategies focus on improving resiliency for instillations and local economic development opportunities. Resilience is the way to ensure longevity in a community.

Chesapeake has multiple policies and programs in place to benefit the community, as follows[31]:

- Building and Fire Code
- Capital Improvements Plan
- Comprehensive Land Use Plan
- Continuity of Operations Plan
- Disaster Recovery Plan
- Economic Development Program
- Emergency Operations Plan
- Evacuation Plan
- Flood Damage
- Hazard Mitigation Plan
- Historic Preservation Plan
- National Flood Insurance Program
- NFIP Community Rating System
- Open Space Management Plan
- Prevention Ordinance
- Radiological Emergency Plan
- SARA Title III Plan
- Stormwater Management Program
- Subdivision Ordinance
- Zoning Ordinance

3.3.1 Comprehensive Plan

The City's current growth management system has evolved during the past two decades or so since adoption of the 1990 Comprehensive Plan. It is now firmly rooted in a three-pronged approach addressing timing, form, and funding of new development. City Council recognized that all three factors have to be integrated and be in relative harmony to create and sustain a community that is resilient, viable, healthy, and livable now and into the future[32].

The central component of the City's system is the process of controlling the approval of new development projects, rezoning applications, based upon the levels of service (LOS) available for major public facilities. The LOS policies were adopted in 1995 and subsequently amended in 1997, 2001, 2004 and 2009. Current City LOS standards address three areas of adequate public facilities: school capacity, road capacity and sewer utility capacity. Responsible land development is a major component in creating a resilient community. In terms of growth management, Chesapeake puts forth good effort – particularly with its use of a LOS approach for managing growth. LOS standards focus on the two most critical aspects of growth management, timing and funding of new development[33].

Responsible timing can be seen through the City's ability to plan density and intensity of land development generally to be highest in areas with utilities. These include public water and sewer service, as well as good roads and transit access; in this regard, the City will design and locate its future utility and transportation facilities in an effort to guide location, pattern, character and timing of growth [c5]. Targeted funding is the City's objective. Chesapeake plans to enact this through coordination and balance of policy for funding and construction of public facilities. This includes maintaining a reasonable, moderate tax rate to support an optimum level of City services[34] [c1].

The City will achieve an economic development base that is both flexible and resilient by supporting a diverse work force that takes advantage of Chesapeake's economic and physical assets. The City will educate residents and business owners concerning environmental contamination and will investigate and prosecute environmental crimes. Chesapeake will enhance citizen preparedness through expanded public outreach and education programs[35].

[31] (Hampton Roads Planning District Commission, 2017)
[32] (City of Chesapeake Planning Department, 2016)
[33] (City of Chesapeake Planning Department, 2016)
[34] (City of Chesapeake Planning Department, 2016)
[35] (City of Chesapeake Planning Department, 2016)

The City will protect, maintain, and improve the quality of the natural environmental systems – air, water, natural habitats, and wetlands. [c9, c10] In order to fulfil its resource conservation goals and objectives set forth in the Comprehensive Plan, the City must continue to work toward implementing a comprehensive environmental program; suggested action strategies and recommendations from the City of Chesapeake Sustainability Plan would be incorporated into this program. To properly gauge the success in fulfilling these goals and objectives, a primary component of this program should include a periodic update of the natural resource inventory, as well as a report to be issued to City Council on the status of the health of the City's natural resources. The Chesapeake City Council generated a list to contribute to ecological stewardship, that list is as follows[36] [c11, 12]:

1. Provides for renewal of the environment through reducing, reusing, and recycling
2. Encourages energy conservation and green initiatives through incentives, awareness, education, and community involvement
3. Ensures preservation of green and open spaces, protects its natural resources, and safeguards its agricultural lands
4. Develops, regulates, and maintains a clean and orderly community
5. Mitigates factors which impact the environmental quality of its water and air

The City will continue to promote water quality protection by implementing its existing protection program as well as seeking new solutions as additional information and technology become available. Although the City currently implements a variety of water quality protection programs, surface water quality in the City continues to show signs of impairment, potentially threatening human and environmental health[37].

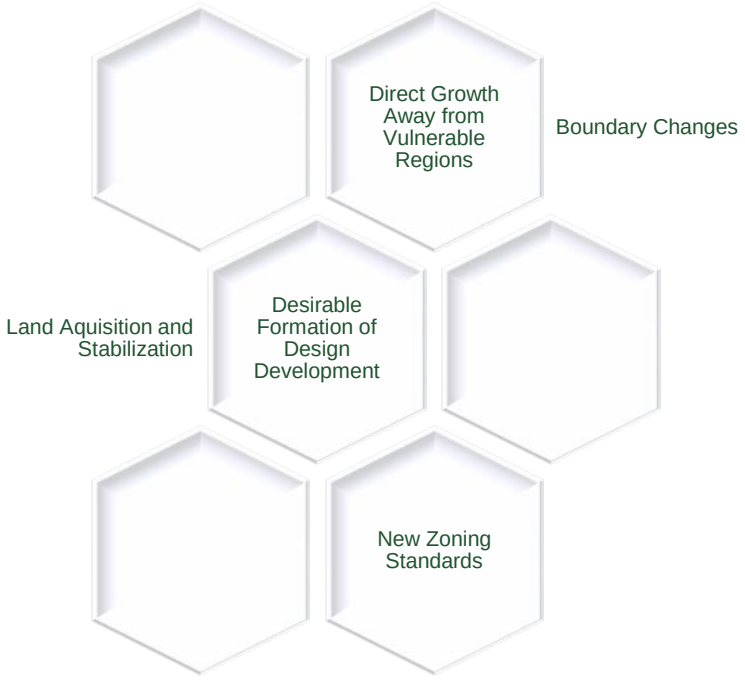


Figure 7: 2035 Action Strategies

[36] (City of Chesapeake Planning Department, 2016)
[37] (City of Chesapeake Planning Department, 2016)

Chesapeake has 6 Action Strategies seen above in Figure 7. The City will direct growth to areas as designated on the 2035 Land Use Plan [c5]. Orderly expansions of utilities will be encouraged to avoid scattered or "leapfrog" development. Changes to the boundaries of either the Suburban Overlay District or the Public Utilities Franchise Area, approved by City Council, shall be co-terminus; impacts of the extension of both shall be considered in the decision. The City will amend its Zoning Ordinance provisions to reflect necessary changes in the Overlay District standards to be consistent with this Plan. The City will implement a land acquisition and stabilization, purchase, or lease of conservation easements such as OSAP. [c6] Design of development, clustered housing development with residual open space and "conservation design" for rural subdivisions, should be used as a tool to develop a desirable form for the City[38]. [c5]

Provided there is capacity for such development, infill development complementing existing communities will be encouraged in developed areas to maximize the use of existing public facilities, utilities, buildings, and services. Planning for density and intensity of land development to be aligned with areas having existing public water and sewer service, good roads, and transit access – thus the City will use the design and location of its future utility and transport to guide local pattern, character, and timing of growth. Implementation of proper infrastructure and a revitalization of established neighborhoods in conjunction with preservation and creation of open space places a focus on balanced growth[39].

3.3.2 Code of Ordinances

Land disturbance activities provide opportunities for compromised water bodies. The city council has determined natural ground cover, especially woody vegetation, to be most effective in preventing site erosion and holding soil in place. Natural vegetation, with its adaptability to local conditions and without the use of harmful fertilizers or pesticides, serves the important function of filtering stormwater runoff. Additionally, minimizing impervious cover enhances rainwater infiltration and effectively reduces stormwater runoff[40].

The Chesapeake Code of Ordinances has 9 sections relating to creating open space and flood mitigation seen in Table 1[41]. [c6, c9]

Table 1: Code of Ordinances Relating to Flooding

Sec. 19-600	Zoning and landscaping throughout Chesapeake
Sec. 19-701	Properly zoned recreational space in subdivisions
Sec. 19-702	Standard for determining zoning percentages
Sec. 19-704	Characteristics of recreational land apart of subdivision
Sec. 26-513	Creation of the CBPA District
Sec. 26-517	Interpretation of CBPA boundaries

[38] (City of Chesapeake Planning Department, 2016)
[39] (City of Chesapeake Planning Department, 2016)
[40] (Chesapeake, Code of Ordinances IV, VII, IX, X, and XI, 2013)
[41] (Chesapeake, Code of Ordinances IV, VII, IX, X, and XI, 2013)

Sec. 26-519	Permitted development in the RPA
Sec. 26-520	General performance standards for the RPA, RMA, and IDA
Sec. 26-522-2	Relationship of CBPA standards to other ordinances

The Chesapeake Bay Preservation Area District (CBPA) of the city was created and then adopted by city council on January 21, 1992 as part of the city zoning ordinance. Any person contemplating development or land-disturbing activities within the city should consult the CBPA map prior to engaging in the proposed activity. All land disturbance, uses, development and redevelopment in the CBPA District are required to retain an undisturbed vegetated 100-foot buffer area around resource protection area (RPA) features, such as wetlands, shorelines and along waterbodies with perennial flow [c10]. The following figure presents the City CBPA.

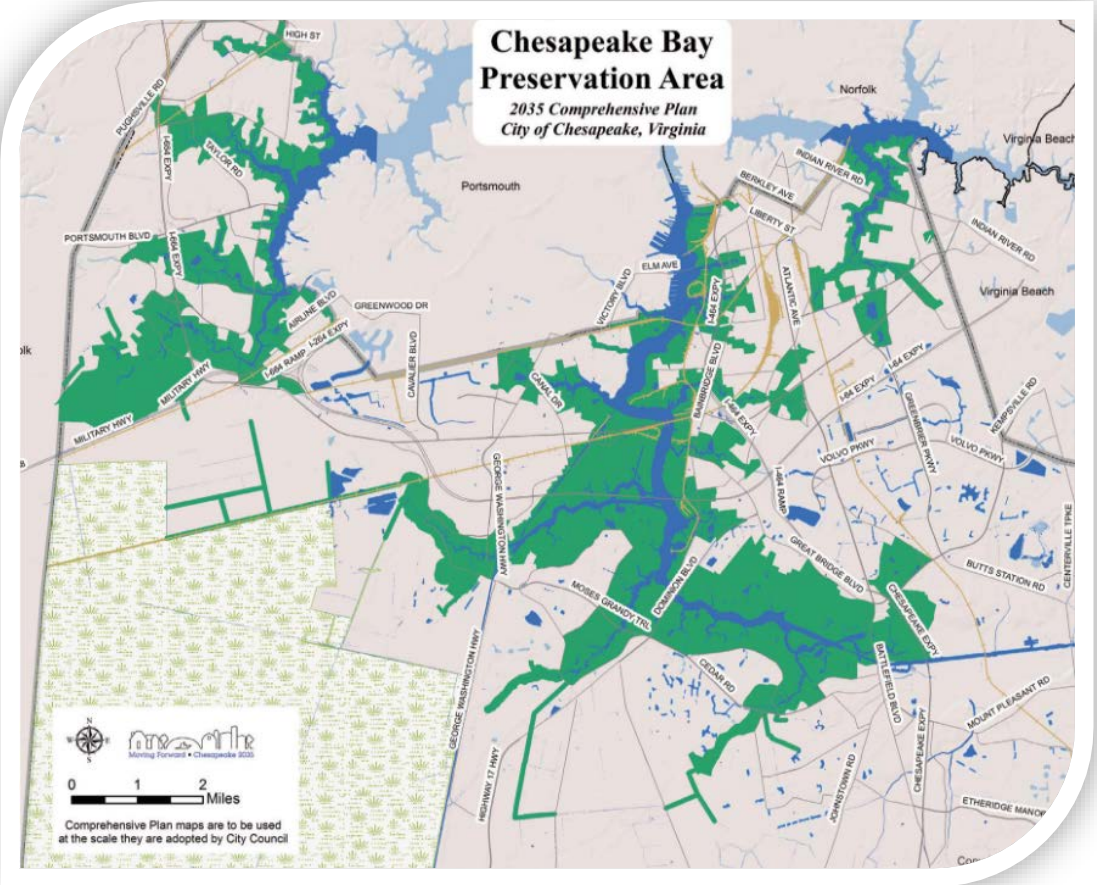


Figure 8: Chesapeake CBPA

The City of Chesapeake also offers owners of non-residential property an opportunity to qualify for a credit on their utility fee by utilizing BMPs. BMPs are practices used for on-site control of stormwater runoff and to provide water quality improvements. These BMPs include, but are not limited to, detention lakes, retention ponds, vegetated buffer strips, and grassed swales. The

City of Chesapeake has established a Stormwater Utility Credit Criteria in accordance with City Code. [c10]

3.3.3 City Public Facilities Manual (PFM)

Chapter 5 in the PFM references stormwater design standards and requirements. Current City standards meet or are more stringent than State requirements or industry standards and require the use of a downstream tailwater elevation that is variable depending on location. The design storm for system capacity also increases with increased contributory drainage area.

The City is able to fund some stormwater infrastructure improvements through the Pro Rata program which is defined in the City PFM as responsibility of cost in development of suitable stormwater infrastructure is shared by the City and developers. The City accepts portions of improvements required by existing developments and areas to remain undisturbed; the developer is required to pay their share of improvements based on rate of runoff generated by given development. The developer has an option to pay into a fund in lieu of making improvements and the City must use that funding to benefit the area local to the development.

3.3.4 City-wide Master Drainage Plans and Other Focused Studies

Much of Chesapeake has been studied as part of a Master Drainage Plan (MDP)or other focused study. The goal of the MDPs is to identify capacity improvements for the City's major drainage facilities. The City started preparing MDPs in the 1980s and subsequent updates, or MDPUs, have been developed in the 2000s and more recently in the past decade. Appendix C contains a map depicting the status of MDP development as of late 2021. The map also shows the progress of implementation of some of the resulting improvement projects. The City considerations of all parts of the locality regardless of socioeconomics or race. [c4]

In addition to the MDPs, the City has also developed dozens of more detailed, localized studies to look at chronic flooding issues that cannot be adequately assessed at the coarser watershed-scale of the MDPs.

The full list of MDPs, MDPUs, and other studies undertaken by the City can be found in the list of documents reviewed prior to developing this Plan, included as Appendix B.

Studies are beneficial in providing the science to back sound programs and projects to combat flooding. Most of the projects listed in Section 4 come from these MDPUs and studies.

3.3.5 Total Maximum Daily Load (TMDL) Action Plans

A TMDL Action Plan is a plan that is developed to identify projects and programs that should be undertaken to reduce the loading of a pollutant of concern into a waterbody. The City of Chesapeake has developed several TMDL Action Plans as follows:

- Chesapeake Bay TMDL Action Plan (2021)
- Southern Rivers TMDL Action Plan (2018)
- Southern Rivers TMDL Action Plan Conceptual Water Quality Projects (2018)
- Elizabeth River Bacterial TMDL Action Plan (2018)

Though all projects identified in TMDL Action Plans address water quality, some may also have a flood reduction benefit. Many are also nature-based. Those multiple benefit, nature-based

projects are more advantageous to move through the CFPF program. Several of the projects presented in Section 4 were recommended in City TMDL Action Plans.

The City also partners with the Elizabeth River Project; an independent non-profit environmental group that is dedicated to improving water quality in the Elizabeth River through public education and outreach. The Elizabeth River Project recruit's residents into a pledge program to encourage environmental stewardship and facilitates implementation of water quality BMPs on individual residential lots. The City's stormwater utility fee helps fund the design and construction of these BMPs recommended in the Chesapeake Bay TMDL Action Plan[42]. [c11]

3.4 Regional Efforts

3.4.1 Joint Land Use Study (JLUS)

The Portsmouth and Chesapeake JLUS focuses on reducing flood impacts to the transportation network, expanding access opportunities for getting to installations, reducing impacts on neighborhoods related to congestion and parking, promoting compatible and managed growth and redevelopment that also benefits the local tax base, and fostering improved coordination among JLUS partners to advance regional priorities..

3.4.2 Hampton Roads Hazard Mitigation Plan

Execution of hazard mitigation activities involves a broad range of professions. Stakeholders may include local planners, public works officials, economic development specialists, and others. Concurrent local planning efforts complement hazard mitigation goals even though they may not be designed as such. Balanced growth is a large component of establishing resilience within the community and providing proper infrastructure is essential for good quality of life. Restricting growth in sensitive regions is ideal while incentivizing growth in non-sensitive regions is ideal from a quality-of-life standpoint and an environmental one[43]. [c5]

The City will continue to devote available and applicable resources to implementing the identified Hazard Mitigation Actions. Chesapeake Mitigation Action Items 2, 3, 13, and 14 involve efforts to mitigate flooding damage, these are elaborated on in the following[44] [c15]:

1. Maintain participation in NFIP and Community Rating System. Continue enforcement of standards in existing ordinance that meet and exceed NFIP minimum requirements.
2. Actions which may include Climate Resilient Mitigation Activities (CRMA) such as Mitigation Reconstruction projects, minor localized flood reduction projects. These may include activities such as relocating, and retrofitting floodproof structures in flood prone areas.
3. Cross referencing of homes and parks correlated with repetitive flood loss areas and new FEMA 100-year floodplains. [c8] This is done by reviewing their vulnerability to flood and wind hazards. Solutions include implementation of measures to retrofit, relocate, or acquire vulnerable properties. [c15] This action may include Mitigation Reconstruction projects. The Emergency Management Department, with support from the Geographic Information System (GIS) and Engineering Division, are responsible for this action.

[42] (AECOM, 2021)
[43] (Hampton Roads Planning District Commission, 2017)
[44] (City of Chesapeake Planning Department, 2016)

4. Replace structures or implement retrofits, which may include but are not limited to: installation of emergency backup power, elevation of structure or components, relocation or retrofit of building components. [c5]
5. Flow test and inspect existing City-owned and grant-funded dry hydrants annually to help maintain operability.
6. Seek and use additional revenue sources and local matching funds for mitigation planning and projects.
7. Develop and implement a Pre-Disaster Homeowner Tree Preventative Maintenance and Hazard Awareness Program.
8. Improving stormwater management infrastructure, preparing, and implementing preventive maintenance schedule, and providing a replacement schedule for stormwater management and inspection equipment and vehicles. It also aims to implement updates on older stormwater infrastructure that was repaired previously and should be examined to ensure it is up to current standards.
9. Part I: Maximize training and educational opportunities for the National Event Management Advisory Committee (NEMAC), City staff, elected officials, Central Emergency Response Team (CERT) members and citizen/neighborhood leaders regarding hazard mitigation, disaster preparedness and the relationship of mitigation to reduced recovery needs. Part II: Accommodate training and related support for at least two staff in the Department of Department and Permits to receive and maintain Certified Floodplain Manager (CFM) certification through the ASFPM.
10. Conduct Hazardous Environmental Action Team (HEAT) program to industrial facilities, particularly hazardous facilities, to discuss hazards and mitigation alternatives.
11. Support and maintain City's new Reverse-911 system. Prepare messages to release to citizens before and after a natural hazard event.
12. Prevent sanitary sewer inflows to the system during flood events. Smoke test public and private sanitary sewer infrastructure to determine priorities.
13. Continuation of the lease and maintenance of facilities along the Dismal Swamp Canal Trail. This is a high priority action. Parks and Recreation is the department responsible.
14. Continue outreach efforts through a strategically developed Plan for Public Information (PPI) using the 7 actions seen below:
    a) Create a PPI Committee
    b) Assess public information needs
    c) Formulate multi-hazard messages
    d) Identify outreach projects
    e) Examine public information initiatives
    f) Prepare PPI document
    g) Implement, monitor, and evaluate program
15. Acquire open space sites capable of providing multi-objective management. Some objectives of this action are flood control, water quality, public access to waterways, preserving or creating tree canopy, and preserving diverse ecological and cultural heritage sites [c10]. CRMA may be included in this action.

16. Identify, create database, and plan uses for data regarding vulnerable populations. Uses may include target outreach, emergency notification and specialized evacuation planning.

Flooding, SLR, coastal storms, and winter storms are some of the hazards addressed by these actions. There are approximately 400 properties and 2,000 structures identified as being within repetitive loss areas[45] [C7].

3.4.3 Other HRPDC Efforts

Resilience related participation from the City on other Hampton Roads Planning District Commission (HRPDC) items include:

- Coastal Resilience Committee and Working Group
- Floodfluent Program
- Hampton Roads All Hazards Advisory Committee (AHAC)
- Regional Environmental Committee
- Stormwater Committee
- Watershed Technical Workgroup
- Coastal Resiliency Committee and Working Group
- Regional Stormwater Management Workgroup

3.5 Preparation for Severe Weather Events

3.5.1 Public Works Emergency Operations Center (PWEOC) Hurricane Preparation

The City has a policy and procedures in place to assure an efficient and coordinated response pre-, during, and post-emergencies. The PWEOC defines tasks and responsibilities of the Department of Public Works (DPW) and designated Mosquito Control, and Parks, Recreation and Tourism crews to assist in restoring essential City services as quickly and safely as possible. DPW maintains traffic flow, streets and drainage clearance, public infrastructure, and debris removal. Staff conduct an annual mock emergency condition drill and maintain a manual. [c15]

3.5.2 Emergency Management Disaster Training

Emergency Management staff both initiate and take part in regular training and exercises on disasters. The City has a robust Training & Exercise Program which is managed through the Office of Emergency Management (OEM). The training is developed to coincide with hazards that are recognized at both the federal and state level. OEM staff routinely attend training on flooding, natural and manmade disasters, hurricanes, and tropical storms, as well as city preparedness activities to ready city response and recovery operations before the start of the season. Staff also take part in webinars, meetings, and training courses geared around flood and mitigation efforts, that tie into the Community Rating System, Sea Level Rise, Resiliency, and City related projects that have a mitigation focus or nexus to them. Training and meetings are attended by all staff within the department. [c11]

[45] (Hampton Roads Planning District Commission, 2017)

3.5.3 Power Franchisees

The City will work with power franchisees to improve the safety, efficiency, dependability, and aesthetic impact of power utilities. The traditional method of providing electrical service has been via a network of poles to support power lines. The conventional method of supplying electrical service has been through a network of poles to support power lines. These are affected by extreme weather, car accidents and interference from growing trees. Minor storms can cause inconvenient power outages while more major storms can cause an extensive amount of damage and loss of power for days at a time. For these reasons, it is preferable to have utilities located underground whenever possible[46]. [c15]

[46] (City of Chesapeake Planning Department, 2016)

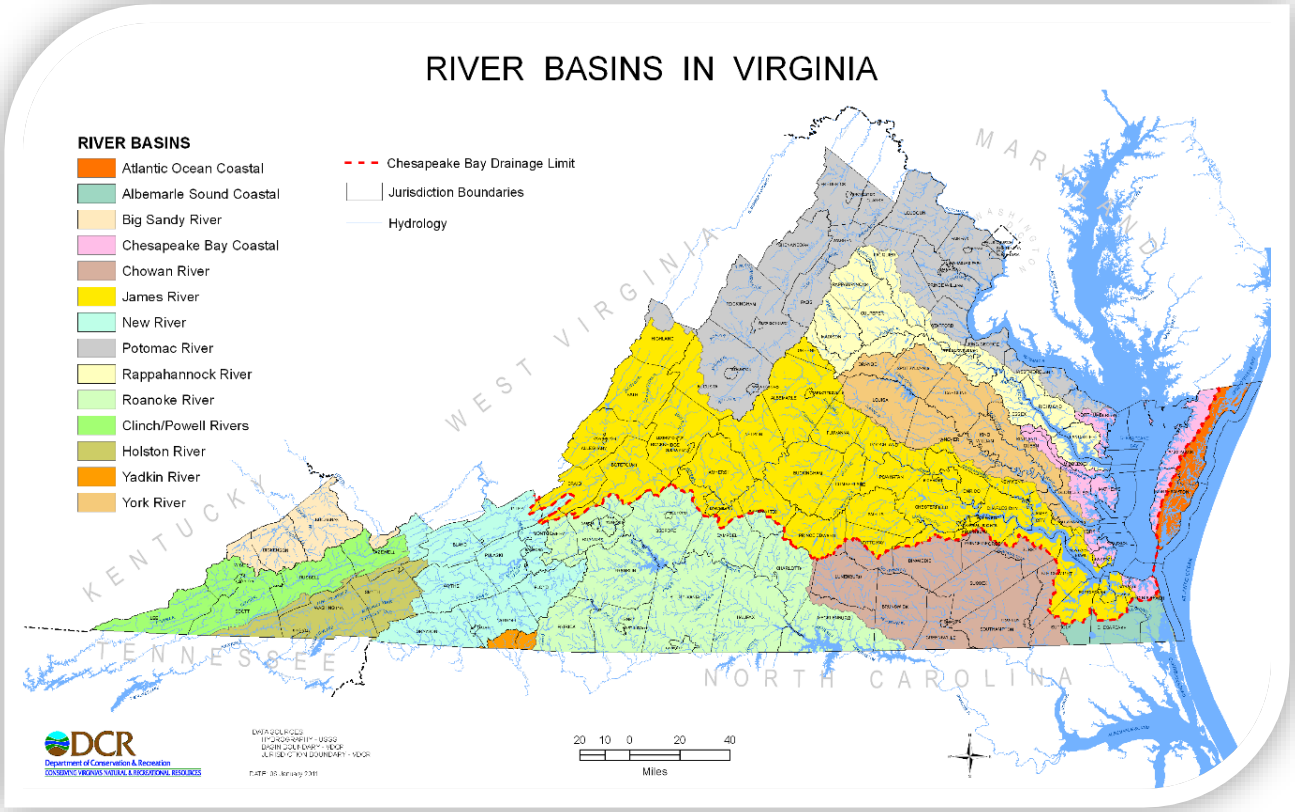
4.0 A Plan for Resilience

The City of Chesapeake is committed to continuing those efforts already underway to improve resilience as descried in the previous section. Additionally, there are programs, studies, and projects that the City is considering to further advance efforts towards developing resilience for the entire locality.

Successful projects grow out of scientifically sound studies derived from firmly rooted programs. The following subsections will discuss Chesapeake's efforts to contribute quality projects, programs, and studies in order to fight flooding and increase the resiliency of the City.

4.1 Continued Coordination with other Entities

Partnership with neighboring localities and other entities is essential for a successful, resilient community. As seen in Figure 9, watersheds cross locality borders. Therefore, it is impossible to address their vulnerabilities without collaboration. To be resilient, we all must work together.



(https://www.dcr.virginia.gov/soil-and-water/hu)

Figure 9: River Basins in Virginia

The City has and will continue to coordinate with adjacent localities when watershed boundaries overlap governmental boundaries.

The City also plans to continue its participation on several regional workgroups and committees hosted by the HRPDC, discussed in Section 3.1.

The City of Chesapeake is committing to building, maintaining, and strengthening its relationships with other entities as it works toward greater community resilience.

4.2 The Science

One of the guiding principles of the CFPF program is to "acknowledge climate change and its consequences, and base decision making on the best available science."[47] To that end, the City will endeavor to use current flood maps and incorporate climate change, SLR, and storm surge, where appropriate, into proposed initiatives.

Projections of SLR are available from various sources, based on varying underlying assumptions and climate models. An October 18, 2018, resolution by the HRPDC localities recommended three different SLR scenario values for planning purpose. Each had an associated future planning horizon, summarized below and shown in Figure 10. The JLUS utilized the near- and mid-term SLR values consistent with the HRPDC guidance[48].

- 1.5-feet of SLR for near-term planning, represented by the timeframe 2018–2050
- 3.0-feet of SLR for medium-term planning, represented by the timeframe 2050–2080
- 4.5-feet of SLR for long-term planning relevant to timeframes beyond year 2080

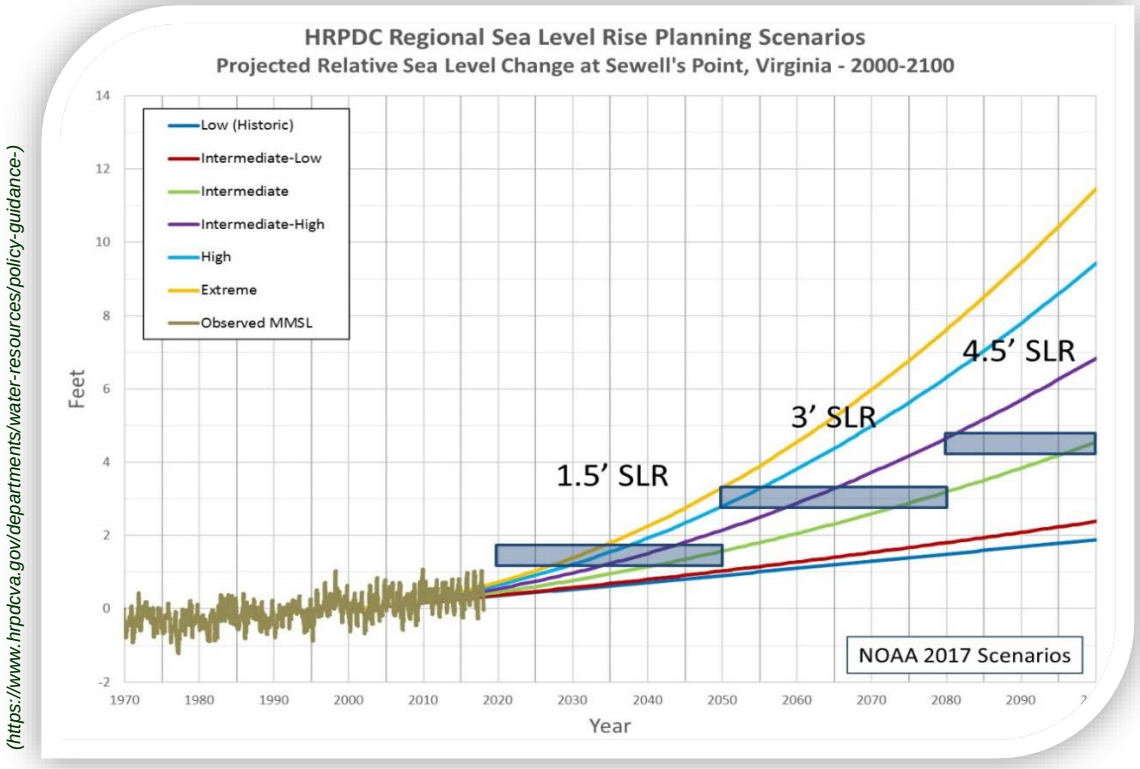


Figure 10: Projected SLR

[47] (Commonweath of Virginia Department of Conservation and Recreation, 2022)
[48] (Hampton Roads Planning District Commission, 2021)

Figure 2: Rationale Behind HRPDC SLR

Rational behind this study can be seen in Figure 11. Recommendations from the HRPDC SLR are as follows:

- Localities should plan for SLR using 1.5-feet of relative SLR above current mean higher high water (MHHW) for near-term planning, 3-feet of relative SLR above current MHHW for medium-term planning, and 4.5-feet of relative SLR above current MHHW for long-term planning
- For engineering and design, localities should calculate project-appropriate SLR scenarios by using a tool such as the U.S. Army Corps of Engineers (USACE) Sea Level Change Calculator and conduct a benefit-cost analysis of various adaptation strategies to determine an appropriate amount of SLR for a specific project
- These scenarios should be reevaluated as appropriate based upon new information developed by the NOAA, USACE, or Virginia Institute of Marine Science (VIMS)

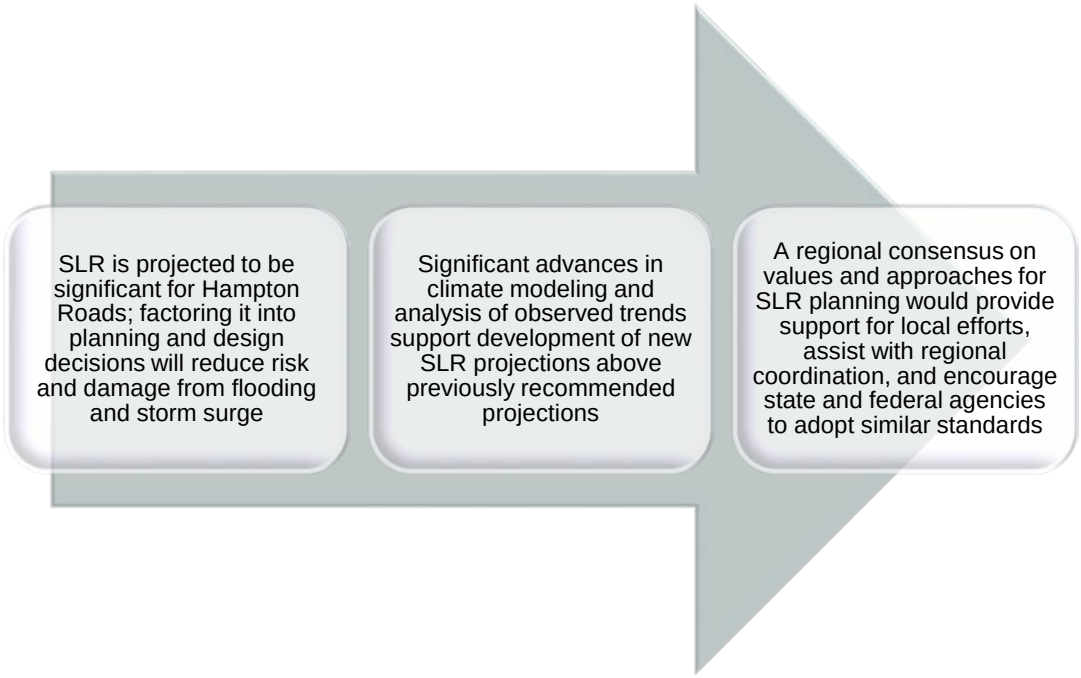


Figure 11: Rationale Behind HRPDC SLR

In January 2017, NOAA partnered with the U.S. Geological Survey, the U.S. Environmental Protection Agency (USEPA), and Rutgers University, and published a report updating regional and global SLR scenarios for the United States. This report takes advantage of additional observations of sea level change and ongoing research into global and regional drivers of SLR including rapid ice melt, ice sheet instability, shifts in ocean circulation patterns, changes in the Earth's gravitational field, and vertical land movement[49].

[49] (City of Chesapeake, 2017)

The overall result is that the upper bound of plausible global SLR is higher than considered in the NOAA's 2012 report. In addition, regional drivers – such as vertical land movement, ocean circulation, and shifts in the gravitational field – account for a significant amount of projected SLR in Hampton Roads. Overall, the report projects between 1.9-feet of SLR in Hampton Roads between 2000 and 2100 at best and 11.5-feet of SLR at worst. According to the report's most statistically probably assessment, the predicted outcome is approximately 4.5-feet of SLR by 2100[50].

Sea level trends are continuously being monitored and updated by both federal (NOAA, USACE) and state (VIMS) entities. In addition, research, and analysis into the dynamics of sea level and how it responds to changing climatic conditions are also ongoing. The HRPDC recommends that the HRPDC staff and localities reevaluate and consider updating these scenarios as appropriate based upon new information developed by NOAA, USACE, or VIMS[51].

4.3 Studies

The CFPF defines a flood prevention or protection study as any hydraulic or hydrologic study of a floodplain with historical and predicted floods, the assessment of flood risk, and the development of strategies to prevent or mitigate damage from coastal or riverine flooding. Utilizing the most recent flood maps, engineering software, and ensuring minimal human error when collecting and recording data are just a few components to producing a scientifically sound study.

Some studies may be the result of a recommendation from large-scale MDPUs. Others include opportunities for coordination with other entities in Hampton Roads or as a result of citizen input.

The City will continue to look for opportunities to identify and conduct additional studies. Future studies may:

- Conducting large-scale master plans of areas of the City that have not been previously covered
- Updating existing studies and large-scale master plans to incorporate additional resilience/equity features
- Look at community scale flooding issues not addressed by large-scale studies

There may be an opportunity to modify the scope of these planned studies to incorporate flooding and resilience:

- Greenbrier Redevelopment Study
- Industrial Waterfront Study
- Western Branch Redevelopment Study
- Joint planning study of St. Juliens Creek corridor and/or Blows Creek corridor to explore options for expanded public recreation access to the water around St. Juliens Creek Annex
- Study options for interconnecting water service to St. Juliens Creek Annex and evaluate alternatives for extending water and sewer service eastward towards the Elizabeth River to support future development

[50] (City of Chesapeake, 2017)
[51] (City of Chesapeake, 2017)

As opportunities are identified and vetted, the City plans to seek grant funding though the CFPF program.

4.4 Programs

The CFPF program defines capacity building programs as "improving the ability of a local government through training of existing staff, hiring personnel, contracting with expert consultants or advisors, and other related actions that allow a local government to identify and mitigate risk and flood impacts[52]." A program could be considered essential to a sustainable community that is economically, socially, and environmentally based.

A possible program is a modification to the OSAP Program. This project would supplement the existing, city-wide competitive, OSAP program. This program allows the City to purchase development rights from willing landowners in exchange for preservation easement on their property. In addition to capacity building, programs can also be considered preparation for the future. The City will review opportunities to be involved in planning programs. For example, the City will look into and identify types of staff support that may be helping in planning future needs such as staff capacity, on-call contracts, and training.

The City will seek to ensure an equitable and proportionate share of public facility and infrastructure improvements attributable, in whole or part, to a proposed development project which will be financed by the owners, developers, users or beneficiaries. Development and redevelopment will be designed in such a way as to mitigate for the potential impacts from flooding and SLR[53]. [c1]

The City continues to explore different strategies of flood mitigation, including tidal flooding, such as removing structures and preserving properties subject to repetitive losses from flooding, in part by exploring funding mechanisms for purchasing such properties. New development, redevelopment, and critical infrastructure will be directed towards higher ground to the greatest extent practicable [c9]. Chesapeake will continue to work with businesses and community organizations, such as civic leagues, potentially affected by SLR to proactively adapt to future conditions [c4, c12].

Natural resource protection activities reduce the impact of natural hazards by preserving or restoring natural areas and their protective functions [c10]. Natural areas could include floodplains, wetlands, streams, steep slopes, barrier islands and sand dunes. Parks, recreation or conservation agencies and organizations often implement these measures, examples include[54]:

- Beach and dune preservation
- Erosion and sediment control
- Floodplain protection
- Forest and vegetation management
    - i.e., fire resistant landscaping, fuel breaks
- Habitat preservation
- Historic properties and archaeological site preservation

[52] (Commonweath of Virginia Department of Conservation and Recreation, 2022)
[53] (City of Chesapeake Planning Department, 2016)
[54] (Hampton Roads Planning District Commission, 2017)

- Land acquisition
- Riparian buffers
- Slope stabilization
- Watershed management
- Wetland preservation and restoration

Chesapeake is also considering establishing forested buffers on conserved properties, providing stormwater filtering to receiving waters. The City currently plants trees as a part of municipal projects and based on Expert Panel recommendations, tree plantings can reduce the total phosphorous load by 24% for tree canopy over lawn and 11% for canopy over impervious surfaces. In 2018, the City planted 2,000 loblolly pine seedlings in the TMDL watersheds[55].

Moving residential living away from sensitive regions does not mean their beauty cannot be appreciated. By creating public access, people can visit and live more well in other regions. Thus, acquisition of new public waterfront access sites, such as those identified in the City's 2026 Comprehensive Plan and the Private and Public Waterfront Access Study, will be pursued including:

- Continue efforts to expand and enhance multi-purpose trail along Dismal Swamp Canal
- Increase shoreline pedestrian and boating access to the Albemarle and Chesapeake Canal by means of a proposed hiking trail on the northeast side of the Canal
- Pocaty Creek and St. Julian Creek
- The abandoned Route-168 bridge over the Northwest River could be used to provide an additional boat ramp, as could a portion of Northwest Preserve No. 1
- The Eastern Branch of the Elizabeth River and the Indian River should also be further explored for future public waterfront access points
- The Western Branch area of the City should be further explored for future access points; possible sites include Western Branch Park and former Lake Ahoy site

Land deemed probable for acquisition include properties which are currently leased for agricultural use; however, City policy allows the City to prioritize these lands for recreational use, BMPs, or debris sites during storm events. Specifically, the City will evaluate converting the following leased properties from agriculture to forest in future permit terms[56] [c6&7]:

- 1564 Mount Pleasant Road, 8-acres, North Landing River (AS12)
- 1653 Mt Pleasant Road, 16-acres, North Landing River (AS12)
- 1736 Mount Pleasant Road, 17-acres, North Landing River (AS12)
- 1102 Centerville Turnpike South, 15-acres, Pocaty River (AS15)
- 2500 Land of Promise Road, 133-acres, Pocaty River (AS15)
- Ballahack Road, 404-acres, Northwest River (AS09)

As opportunities are identified and vetted, the City plans to seek grant funding though the CFPF program.

4.5 Projects

Projects can be defined, for the CFPF program, as activities which include the development of flood protection facilities, acquisition of land, restoration of natural features or other activities

[55] (Southern Rivers TMDL Action Plan, 2018)
[56] (Southern Rivers TMDL Action Plan, 2018)

that involve design, construction, or installation of facilities[57]. As opportunities are identified and vetted, the City plans to seek grant funding though the CFPF program.

The City of Chesapeake is blessed with ample water access, this critical resource needs to be protected from anthropomorphic pollutants. Proper utilization of land, identifying incentives for restoring riparian and wetland vegetation, and incorporation of nature-based infrastructure are some of the key factors in deeming a project as resilient. Forward-looking projects designed for resilience are critical to mitigating impacts of climate change on infrastructure – specifically in coastal regions.

As has been presented in Section 3, the City of Chesapeake has developed Master Drainage Plans and, in some instances, more detailed neighborhood studies for the majority of the locality. Through a review of approximately 40 of these studies and other documents, approximately 200 discrete projects were identified. The City has selected the following 26 projects to include in the Preliminary Resilience Plan, listed in order implementation status and anticipated construction start. Project details can be found in Appendix D.

- Under Design
  1. Oakdale Area BMP and Drainage Improvements
  2. Norfolk Highlands Drainage Improvements
  3. Welch Ln Drainage Improvements – Phase I & II
  4. Cooper's Ditch – Phase II
  5. Washington Manor Outfall Improvements
  6. Hickory Ridge Outfall Improvements
  7. Herring Ditch Outfall Improvements
  8. Royce Dr Drainage Outfall Improvements – Phase II
  9. Lamberts Trail Area Drainage Improvements – Phase II
  10. Pughsville Area Outfall Improvements

- Design Scoping Underway
  11. Elmwood Landing Area Drainage Improvements – Phase I & II
  12. Providence Rd Crossing Replacement
  13. Mount Pleasant Rd Crossing Replacement
  14. Shell Rd Drainage Improvements

- Not Yet Under Design
  15. Greenbrier Outfall Resiliency Improvements – Phase I & II
  16. Greenbrier Outfall Resiliency Improvements – Phase III
  17. Drum Creek Farms Drainage Improvements – Phase II
  18. Poplar Branch Ditch Regrading
  19. Buskey Rd Crossing Replacement
  20. Carawan Ln Drainage Improvements
  21. Weiss Lane Outfall Improvements
  22. Pleasant View Drainage Improvements
  23. Mount Pleasant Rd Outfall Improvements
  24. Homemont Outfall Improvements
  25. Forest Lakes Outfall Improvements – Phase II
  26. Scenic Blvd Drainage Improvements

[57] (Commonweath of Virginia Department of Conservation and Recreation, 2022)

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Appendices

Appendix A: Plan Criteria Matrix

Appendix B: Plan and Program Inventory

Appendix C: Critical Facilities Map

Appendix D: Resilience Plan Project Table

Appendix A
Plan Criteria Matrix

Resilience Plan **Criteria Matrix**								
	Document Name	Hampton Roads Hazard Mitigation Plan	2035 Chesapeake Comprehensive Plan	HRPDC Sea Level Rise Planning Policy and Approach	HRPDC Integrating Coastal Resilience into Local Plans, Policies, and Ordinances	Norfolk Highlands Master Plan (Timmons job)	Chesapeake, Code of Ordinances IV, VII, IX, X, and XI	Portsmouth & Chesapeake Joint Land Use Study
	URL	https://www.hrpdcva.gov/uploads/docs/2017%20Hampton%20Roads%20Hazard%20Mitigation%20Plan%20Update%20FINAL.pdf	https://resources.cityofchesapeake.net/comp-plan-2035/#page=1	https://www.hrpdcva.gov/uploads/docs/05A_Attachment%20-%20HRPDC%20Sea%20Level%20Rise%20Planning%20Policy%20and%20Approach%20-%20Adopted%20101818.pdf	https://www.hrpdcva.gov/uploads/docs/HRPDC%20FY%2015%20Task%2094.01%20Final%20Report%20-%20Coastal%20Resilience.pdf	not available	https://library.municode.com/va/chesapeake/codes/code_of_ordinances	https://www.hrpdcva.gov/uploads/docs/ChsPorJLUS_Report_Draft_June2021.pdf
	Published date	2017	2014	2018	2017	2019	2013	2021
Criterion	Amended/Revised date	2017	2016			2019		
1	Equity based strategic polices for local government wide flood protection and prevention.	Table 7.4 page 243	Pages 11, 56, 206				Code of Ordinances are City policies (Ref Doc)	Section 1.5 Starting on page 28, and 6.3 (page 182), Policies and Practices, page 20, Section 6.0, page
2	Documentation of existing social, economic, natural, and other conditions present in the local government.	page 3:9-10 (29-30)	Chapter 2 (Page 22)		Code of Virginia (page 7)			Economy page 22-23, Section 1.1, page 21-23 Section 1.5, page 28-31
3	Review of the vulnerabilities and stressors, both natural and social in the local government.	Vulnerability Assessment Page 5:1 (Page 153), Overview of Vulnerability (page 5:5, 156)	Pages 68, 113, 170, 178		FMP (page 11)		26-89-b (page 5)	Section 4.6 (page 76), 4.6.2 (page 79), Summary of Challenges, page 15-17
4	- Forward looking goals, actionable strategies, and priorities through as seen through an equity based lens.	Chesapeake Mitigation Actions 1-16 (Page 7:151, 383)	Page 45-58 and Appendix C (good summary, but really most of the document addresses this item)	Yes pages 1-4	page 68-69	Page 23	26-99 (page 11-12), 26-100-3 (Page 13),	3.2.5 (page 50), 5.3.17 (Risk Assessment), JLUS Goals, page 16 Table ES.1, page 17 Priority Actions, page 18-19 Section 1.2, page 23-25 Section 5.0, page 103
5	Strategies that guides growth and development away from high risk locations that may include strategies in comprehensive plans or other land use plans or ordinances or other studies, plans or strategies adopted by a local government.	Mitigation Action 2, 3 and 15			page 68-69		26-519 (page 47-49)	Project specific
6	Proposed acquisition of land or conservation easements or identification of areas suitable for conservation particularly areas identified as having high flood attenuation benefit by Conserve Virginia or similar data driven tools.	Mitigation Action 2, 3, 13, and 15	Pages 34, 58, 73		page 68-69		OSAP (page 62-66, 70)	REPI Page 29, Section 1.3, page 25-26 Section 3.2, page 43-47
7	Identification of areas suitable for property buyouts in frequently flooded areas.	Mitigation Action 2, 3, 13, and 15	pages 67, 68 (no specific mention of property buyouts however, only alluded), New property acquisitions page 73		page 68-69		OSAP (page 66-67, 70)	#2 (page 226)
8	Identification of critical facilities and their vulnerability throughout the local government such as water and sewer or other types identified as "lifelines" by FEMA.	Mitigation Action 16	Pages 122		page 68-69		Defined (page 1-2), 26-100-5 (page14)	4.6.5 (page 95), Table 1 Ches (page 219)
9	Identified ecosystems/wetlands/floodplains suitable for permanent protection.	Page 6:24 (230), #3 page 7:5 (237)	Pages 14, 34, 59, 61, 66, 69-71,				26-513 (page 39-40), 26-520 (page 49)	5.3.29 (Page 164), Section 1.3, page 25-26
10	Identified incentives for restoring riparian and wetland vegetation.	Page 6:10 (216), #3 page 7:5 (237)					26-516 (page 45), 26-522-2 (page 54)	
11	A framework for implementation, capacity building and community engagement.	Page 6:2 (208), 6:5 (211), 6:10 (216), 7:1 (233),	Pages 32, 76,		page 68-69	Page 23	Sec 26-93 (page 6-9), 26-358 & 360 (page 29-30), 26-518 (page 46-47)	7.0 (page (191), Section 1.4.3, page 27
12	Strategies for creating knowledgeable, inclusive community leaders and networks.	Pages 17-18, HMPS Committee members table 2.2 (page 2:4-5, 12-13)	Pages 130 and 170		Page 49, 51		26-86 (page 1)	Sect. 6.1 and 6.2, Section 1.4, page 26
13	A community dam safety inventory and risk assessment posed by the location and condition of dams.	Table 4.2 (Page 4:18, 64)			National Flood Insurance Program (page 8-9)			
14	A characterization of the community including population, economics, cultural and historic resources, dependence on the built environment and infrastructure and the risks posed to such infrastructure and characteristics by flooding from climate change, sea level rise, tidal events or storm surges or other weather.	Population (Page 3:2, 22), Historic (3:9-10, 29-30), Infrastructure (3:15, 35), Sea level rise (4:32, 78)	Pages 68, 125		Chesapeake is CRS Class 8 (Pages 14-15), page 68	Page 6, 43		Intro (page 21), Roadway Flooding, page 15-16, Section 4.6, page 76-101
15	Strategies to address other natural hazards that would cause, affect or result from flooding events including: • Earthquakes. • Storage of hazardous materials • Landslides/mud/debris flow/rock falls. • Prevention of wildfires that would result in denuded lands making flooding, mudslides or similar events more likely. • Preparations for severe weather events including tropical storms or other severe storms, including winter storms.	Pages 90-152, 187-206, Table 7.5 (page 7:13, 245)	Page 127 - prepare power utilities for severe weather	Severe Storms		Page 23	26-606 (page 73)	Section 4.6, page 76-79

Resilience Plan Criteria Matrix								
	Document Name	Public Facilities Manual (Chapt. 5, 15, and 17)	Chesapeake Bay TMDL Action Plan	Southern Rivers TMDL Action Plan	Southern Rivers TMDL Action Plan Conceptual Water Quality Projects	Elizabeth River Bacterial TMDL Action Plan	Community Rating System data	2021 Legislative Priorities
	URL	https://www.cityofchesapeake.net/government/city-departments/departments/Department-of-Development-and-Permits/Development-Engineering-and-Construction/pfm/volume1/chapters.htm	https://www.norfolk.gov/DocumentCenter/View/38025/Final-Report---Chesapeake-Bay-TMDL-Action-Plan---06_28_2018_FINAL?bidId=	https://www.cityofchesapeake.net/Assets/documents/departments/public_works/TMDL/Chesapeake+Southern+Rivers+TMDL+Action+Plan+-+July+24$!2c+2018.pdf	https://www.cityofchesapeake.net/Assets/documents/departments/public_works/TMDL/Draft+Conceptual+Water+Projects.pdf	https://norfolk.gov/DocumentCenter/View/38026/Norfolk-ER-Bacteria-TMDL---Final-Action-Plan---06-28-2018_FINAL?bidId=	not available	https://www.cityofchesapeake.net/Assets/documents/departments/city_manager/2021+Legislative+Program/Proposed+2021+Legislative+Package.pdf
	Published date	2016, 2018, 2010	2018	2018	2018	2018	2021	2021
Criterion	Amended/Revised date					2018		
1	Equity based strategic polices for local government wide flood protection and prevention.		Section 3.2, page 10	Table 1-2, page 13 Section 12, page 71-73 Section 15, page 78		Section 5.0, page 16-17		Page 6 & 7, and Page 12 "Preserve Legal Standards"
2	Documentation of existing social, economic, natural, and other conditions present in the local government.		Section 1.3, page 8	Section 1, page 11-13		Section 1.1, Page 1		Page 22 "Deep Creek AIWW Bridge & North Landing AIWW Bridge Replacements"
3	Review of the vulnerabilities and stressors, both natural and social in the local government.			Section 6, page 41-43		Section 2.0, page 5 Section 3.0, page 6-7		Page 15 "Barriers to Human Service Providers" Page 18 "Uranium Mining"
4	- Forward looking goals, actionable strategies, and priorities through as seen through an equity based lens.		Section 1.2 & 1.3, page 7 & 8	Section 3, page 21-22 Section 7, page 44-57 Section 8, page 58-62		Table 1-2, page 4 Section 7.1, page 20 Section 7.3, page 21		Page 8
5	Strategies that guides growth and development away from high risk locations that may include strategies in comprehensive plans or other land use plans or ordinances or other studies, plans or strategies adopted by a local government.		Section 3.3, page 11	Section 7.5, page 54 Section 7.6.1, page 55				
6	Proposed acquisition of land or conservation easements or identification of areas suitable for conservation particularly areas identified as having high flood attenuation benefit by Conserve Virginia or similar data driven tools.			Section 8.3.3, page 61				
7	Identification of areas suitable for property buyouts in frequently flooded areas.		Section 3.3, page 11	Table 2-1, page 17 Section 8.3.4, page 61				
8	Identification of critical facilities and their vulnerability throughout the local government such as water and sewer or other types identified as "lifelines" by FEMA.		Section 3.3, page 11	Section 6, page 41-43		Section 2.0, page 5 Section 3.0, page 6-7	CRS program	Page 10 & 11
9	Identified ecosystems/wetlands/floodplains suitable for permanent protection.		Section 3.3, page 11	Table 2-1, page 17		Section 1.2, page 2 Figure 1-1, page 3		
10	Identified incentives for restoring riparian and wetland vegetation.			Section 8.3.4, page 61				
11	A framework for implementation, capacity building and community engagement.		Section 3.9 & 3.10, page 15	Section 7.2, page 50-51 Section 13, page 74		Section 6, page 18-19 Section 8.0, page 22		
12	Strategies for creating knowledgeable, inclusive community leaders and networks.		Section 3.9, page 15	Section 7.2, page 50-51 Section 13, page 74		Section 6, page 18-19 Section 8.0, page 22		
13	A community dam safety inventory and risk assessment posed by the location and condition of dams.							
14	A characterization of the community including population, economics, cultural and historic resources, dependence on the built environment and infrastructure and the risks posed to such infrastructure and characteristics by flooding from climate change, sea level rise, tidal events or storm surges or other weather.							Page 16 "Virginia Commonwealth Flooding Board" Page 17 "Real Estate Disclosures for Flooding"
15	Strategies to address other natural hazards that would cause, affect or result from flooding events including: • Earthquakes. • Storage of hazardous materials • Landslides/mud/debris flow/rock falls. • Prevention of wildfires that would result in denuded lands making flooding, mudslides or similar events more likely. • Preparations for severe weather events including tropical storms or other severe storms, including winter storms.		Table 3.4-1 (Annual Pollutant Loads)					

Resilience Plan Criteria Matrix								
	Document Name	Capital Improvement Projects Summary – Stormwater Projects	Crestwood 2&3 Calibration	Sterns Creek Watershed Master Drainage Plan	Bedford Study Area	MS4 Program Plan	Greenbrier Resiliency Plan	Chesapeake Citizen Stormwater Committee - Annual Report to Council (2018)
	URL	not available but full CIP can be found at: https://www.cityofchesapeake.net/Assets/documents/departments/budget/CIP+Approved+2020-2024/CIP+Approved+2021-2025/FY21-25+Approved+CIP+Document.pdf	not available	not available	not available	https://resources.cityofchesapeake.net/vsmp/ms4-plan/#page=1	not available	not available
	Published date	2021	2021	2021	1986	2017	2020	2018
Criterion	Amended/Revised date		2022	2022				
1	Equity based strategic polices for local government wide flood protection and prevention.		Section 4, page 4	Section 6, page 6-1 - 6-5		Section 2.4, page 8-9 Section 2.5, page 9-10	Section 2, page 8	
2	Documentation of existing social, economic, natural, and other conditions present in the local government.		Section 2, page 2 Section 3, page 3 Figure 1-15, page 23-37 Figure 18-20, page 41-43	Executive Summary, page ES-1 - ES-3 Section 2.4, page 2-7	Existing Conditions, page 1-2 Table 1, page 4 Figure 1, page 8			
3	Review of the vulnerabilities and stressors, both natural and social in the local government.					Water Quality Impact Assessments, page 222 & 318		
4	Forward looking goals, actionable strategies, and priorities through as seen through an equity based lens.	Page 1-34	Section 1, page 1 Table 5, page 20-22	Executive Summary, page ES-1 - ES-3 Section 1.1, page 1-2 Section 4.3, page 4-5 - 4-6 Section 4.4, page 4-6 - 4-9 Table 5-1, page 5-2	Future Conditions, page 2-3 Table 2, page 5			
5	Strategies that guides growth and development away from high risk locations that may include strategies in comprehensive plans or other land use plans or ordinances or other studies, plans or strategies adopted by a local government.							
6	Proposed acquisition of land or conservation easements or identification of areas suitable for conservation particularly areas identified as having high flood attenuation benefit by Conserve Virginia or similar data driven tools.	Page 1-34		Section 1.3, page 1-5 & 1-6				page 2 of 4
7	Identification of areas suitable for property buyouts in frequently flooded areas.							page 2 of 4
8	Identification of critical facilities and their vulnerability throughout the local government such as water and sewer or other types identified as "lifelines" by FEMA.					Section 4.9, page 36-40		
9	Identified ecosystems/wetlands/floodplains suitable for permanent protection.	Page 1-34		Section 1.3, page 1-5 & 1-6				page 2 of 4
10	Identified incentives for restoring riparian and wetland vegetation.		Table 5, Scenario F, page 21 Figure 17a, page 40					
11	A framework for implementation, capacity building and community engagement.					Section 4.10, page 41-43		All
12	Strategies for creating knowledgeable, inclusive community leaders and networks.					Section 4.10, page 41-43 Section 4.11, page 44-46		All
13	A community dam safety inventory and risk assessment posed by the location and condition of dams.					Dam Safety and Floodplain Management		
14	A characterization of the community including population, economics, cultural and historic resources, dependence on the built environment and infrastructure and the risks posed to such infrastructure and characteristics by flooding from climate change, sea level rise, tidal events or storm surges or other weather.				Introduction, page 1			
15	Strategies to address other natural hazards that would cause, affect or result from flooding events including: • Earthquakes. • Storage of hazardous materials • Landslides/mud/debris flow/rock falls. • Prevention of wildfires that would result in denuded lands making flooding, mudslides or similar events more likely. • Preparations for severe weather events including tropical storms or other severe storms, including winter storms.			50 and 100 year storm	50 year storm			

Resilience Plan Criteria Matrix								
	Document Name	Chesapeake Citizen Stormwater Committee - Annual Report to Council (2020)	Contract for Elizabeth River Project to Provide Environmental Conservation Services for the City of Chesapeake	City of Chesapeake 2022 Mitigation Action Items (internal update)	Essential Facilities	Administrative Regulation 1.29: Facilitating Procurement Opportunities for Small Businesses and Businesses Owned by Women, Minorities, and Service Disabled Veterans	City Directive 2.09: Department of Human Resources Equal Employment Opportunity Policy	Administrative Regulation 1.30: Chesapeake Alert Emergency Notification/Citizen Information/Employee Notification System
	URL	not available	not available	not available	not available	https://www.cityofchesapeake.net/Assets/documents/departments/human_resources/administrative_regulations/AR129.pdf	https://www.cityofchesapeake.net/Assets/documents/departments/human_resources/administrative_regulations/AR209.pdf	https://www.cityofchesapeake.net/Assets/documents/departments/human_resources/administrative_regulations/AR130.pdf
	Published date	2020	2020	2022	2022	2011	2004	2011
Criterion	Amended/Revised date						2021	2014
1	Equity based strategic polices for local government wide flood protection and prevention.			All		Pg. 1 - 3	Equity Statement	
2	Documentation of existing social, economic, natural, and other conditions present in the local government.					Page 3	Page 2-4	
3	Review of the vulnerabilities and stressors, both natural and social in the local government.							
4	- Forward looking goals, actionable strategies, and priorities through as seen through an equity based lens.					Pg. 1 - 3		
5	Strategies that guides growth and development away from high risk locations that may include strategies in comprehensive plans or other land use plans or ordinances or other studies, plans or strategies adopted by a local government.			Mitigation 2 & 3		Pg. 1-3		Page 1, 2-6
6	Proposed acquisition of land or conservation easements or identification of areas suitable for conservation particularly areas identified as having high flood attenuation benefit by Conserve Virginia or similar data driven tools.			Mitigation 2 & 3 & 15				
7	Identification of areas suitable for property buyouts in frequently flooded areas.			Mitigation 2 & 3 & 15				
8	Identification of critical facilities and their vulnerability throughout the local government such as water and sewer or other types identified as "lifelines" by FEMA.			Mitigation 10	All			
9	Identified ecosystems/wetlands/floodplains suitable for permanent protection.	Page 3 of 4	Page 3					
10	Identified incentives for restoring riparian and wetland vegetation.		Page 4					
11	A framework for implementation, capacity building and community engagement.	All	Page 1					Page 1-6
12	Strategies for creating knowledgeable, inclusive community leaders and networks.	All				Pg. 1-3		
13	A community dam safety inventory and risk assessment posed by the location and condition of dams.							
14	A characterization of the community including population, economics, cultural and historic resources, dependence on the built environment and infrastructure and the risks posed to such infrastructure and characteristics by flooding from climate change, sea level rise, tidal events or storm surges or other weather.							
15	Strategies to address other natural hazards that would cause, affect or result from flooding events including: • Earthquakes. • Storage of hazardous materials • Landslides/mud/debris flow/rock falls. • Prevention of wildfires that would result in denuded lands making flooding, mudslides or similar events more likely. • Preparations for severe weather events including tropical storms or other severe storms, including winter storms.							

Resilience Plan Criteria Matrix								
	Document Name	Administrative Regulation 1.33: City Manager's Office Authority to Apply for Grant Policy	City Policies and Processes for Budget	Mobile Home Displacement Policy	Budget Work Session: Policy and Programmatic Levers	Public Facilities Manual Chapter 5 - Stormwater Management and Drainage Design	Program Year 47 2021/2022 Annual Action Plan	City of Chesapeake Strategic Plan
	URL	https://www.cityofchesapeake.net/Assets/documents/departments/human_resources/administrative_regulations/AR133.pdf	https://www.cityofchesapeake.net/Assets/documents/departments/budget/FY2021-22/CIP/Policies+and+Process.pdf	https://www.cityofchesapeake.net/Assets/documents/departments/planning/2035compplan/supporting-docs/mobile-home-displacement-policy.pdf	not available	https://www.cityofchesapeake.net/Assets/documents/departments/development_permits/pfm/volumei/chapters/05-Stormwater-Management-and-Drainage-Design.pdf	https://www.cityofchesapeake.net/Assets/documents/departments/planning/housing/PY+47+2021-2022+Annual+Action+Plan.pdf	not available
	Published date	2015	2022	2011	2021		2021	2021
Criterion	Amended/Revised date					2016		
1	Equity based strategic polices for local government wide flood protection and prevention.	Page 1-3	Pg. 8	Pg. 1-4	Slide 9		2-7, 8-13, 14, 15-16, 27-32, 37-38, 39-43, maps	slide 4-9, 15
2	Documentation of existing social, economic, natural, and other conditions present in the local government.	Page 1-3	Pg. 1-6	Pg. 1-4	Slide 11		2-7, 8-13, 14, 15-16, 27-32, 37-38, 39-43, maps	
3	Review of the vulnerabilities and stressors, both natural and social in the local government.							
4	Forward looking goals, actionable strategies, and priorities through as seen through an equity based lens.			Pg. 1-4			2-7, 8-13, 14, 15-16, 27-32, 37-38, 39-43, maps	
5	Strategies that guides growth and development away from high risk locations that may include strategies in comprehensive plans or other land use plans or ordinances or other studies, plans or strategies adopted by a local government.		Pg. 19				19-26	
6	Proposed acquisition of land or conservation easements or identification of areas suitable for conservation particularly areas identified as having high flood attenuation benefit by Conserve Virginia or similar data driven tools.		Pg. 59				19-26	
7	Identification of areas suitable for property buyouts in frequently flooded areas.		Pg. 59				19-26	
8	Identification of critical facilities and their vulnerability throughout the local government such as water and sewer or other types identified as "lifelines" by FEMA.		Pg. 59				19-26	
9	Identified ecosystems/wetlands/floodplains suitable for permanent protection.		Pg. 59				19-26	
10	Identified incentives for restoring riparian and wetland vegetation.						19-26	
11	A framework for implementation, capacity building and community engagement.		Pg. 203				19-26	
12	Strategies for creating knowledgeable, inclusive community leaders and networks.		Pg. 19	Pg. 1-4			19-26	
13	A community dam safety inventory and risk assessment posed by the location and condition of dams.						19-26	
14	A characterization of the community including population, economics, cultural and historic resources, dependence on the built environment and infrastructure and the risks posed to such infrastructure and characteristics by flooding from climate change, sea level rise, tidal events or storm surges or other weather.		Pg. 59				19-26	
15	Strategies to address other natural hazards that would cause, affect or result from flooding events including: • Earthquakes. • Storage of hazardous materials • Landslides/mud/debris flow/rock falls. • Prevention of wildfires that would result in denuded lands making flooding, mudslides or similar events more likely. • Preparations for severe weather events including tropical storms or other severe storms, including winter storms.							

Appendix B
Plan and Program Inventory

Documents Reviewed for Plan Requirements

- 2021 Legislative Priorities (2021)
- 2021 Regional Legislative Agenda (2020)
- 2021 Regional Legislative Agenda for the 757 (n.d.)
- 2035 Chesapeake Comprehensive Plan (2016)
- Administrative Regulation 1.30: Chesapeake Alert Emergency Notification/Citizen Information/Employee Notification System (2014)
- Administrative Regulation 1.33: City Manager's Office Authority to Apply for Grant Policy (2015)
- Administrative Regulation 1.29: Facilitating Procurement Opportunities for Small Businesses and Businesses Owned by Women, Minorities, and Service Disabled Veterans (2011)
- Budget Work Session: Policy and Programmatic Levers (2021)
- Chesapeake Citizen Stormwater Committee – Annual Report to Council (2020)
- Chesapeake Citizen Stormwater Committee – Annual Report to Council (2018)
- Chesapeake, Code of Ordinances IV, VII, IX, X, and XI (2013)
- City Directive 2.09: Department of Human Resources Equal Employment Opportunity Policy (2021)
- City of Chesapeake Strategic Plan (2021)
- City Policies and Processes for Budget (2022)
- Essential Facilities (2022)
- HRPDC Integrating Coastal Resilience into Local Plans, Policies, and Ordinances (2017)
- HRPDC Sea Level Rise Planning Policy and Approach (2018)
- Mobile Home Displacement Policy (2011)
- Public Facilities Manual [Chapters 5, 15, and 17] (2016)
- Ranking Scale Description for Stormwater Project Prioritization (2021)
- Stormwater Utility Fee (2013)

Documents Reviewed for Projects and Plan Requirements

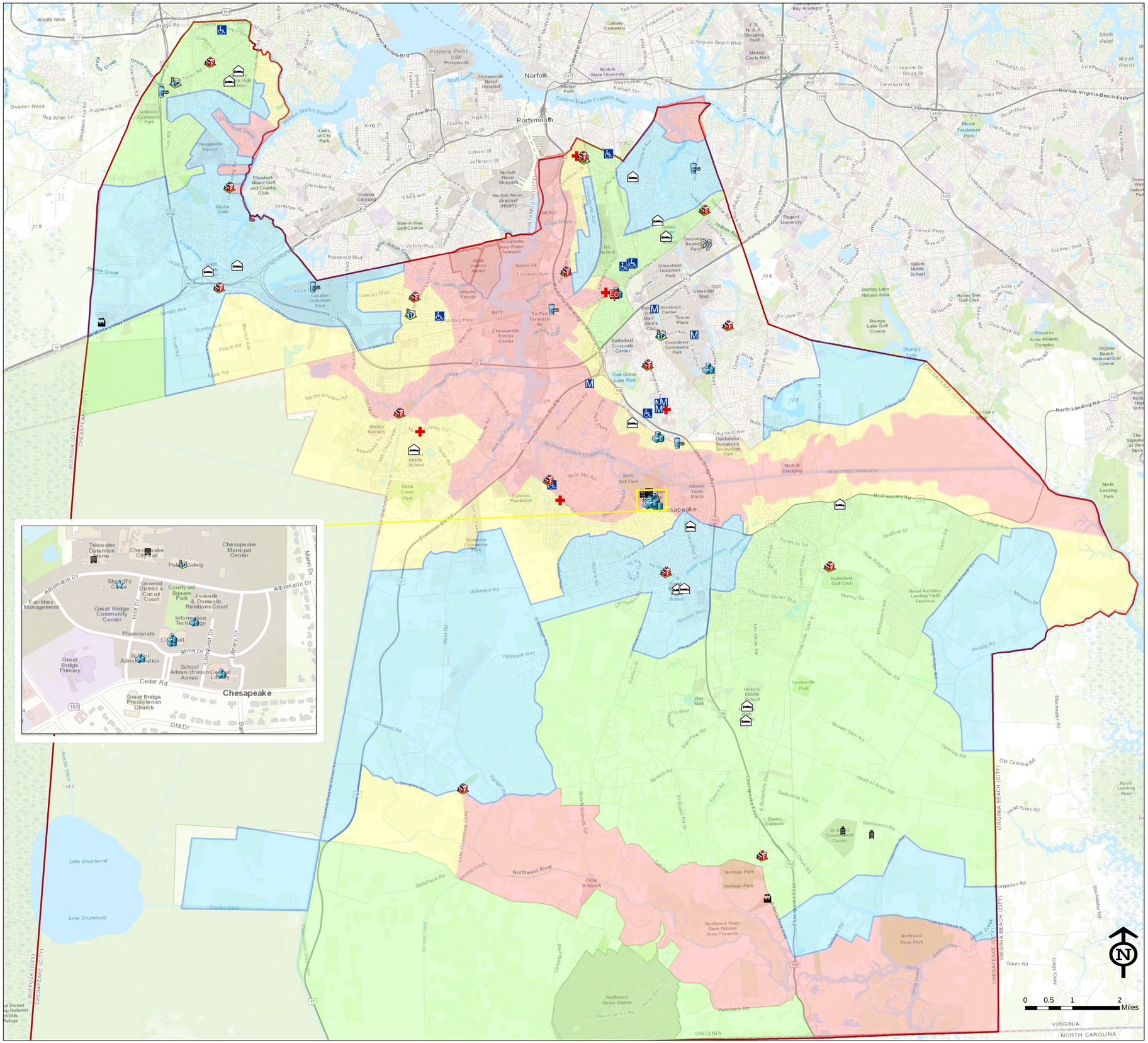
- Bailey Creek Watershed MDPU (2012)
- Bells Mill Creek Watershed MDPU (2009)
- Butts Station Road / Kemp Woods Outfall [NS-2] Watershed MDPU (2005)
- Capital Improvement Program FY 2022-2026 (2021)
- Capital Improvement Projects Summary – Stormwater Projects (2021)
- Capital Improvement Projects Progress Report – Stormwater – FY21-23 (n.d.)
- Chesapeake Avenue Area Drainage and Sanitary Sewer Improvements - SWMM Modeling (2020)
- Chesapeake Bay TMDL Action Plan (2021)
- Chesapeake Citizen Stormwater Committee – Annual Report to Council (2018)

- Chesapeake Citizen Stormwater Committee – Annual Report to Council (2020)
- Chesapeake Essential Facilities (2022)
- City of Chesapeake 2022 Mitigation Action Items (2022)
- Contract for Elizabeth River Project to Provide Environmental Conservation Services for the City of Chesapeake (2020)
- Cooper's Ditch Watershed Technical Memorandum (2012)
- Crestwood 2&3 Calibration (2022)
- Crestwood Drainage Study (2000)
- Crestwood-1 Master Drainage Plan Update (2021)
- Deal Drive Drainage Improvements Drainage Analysis Report (2019)
- Deep Creek Watershed MDPU (2006)
- Deep Creek Watershed Technical Memorandum (2010)
- Drum Point Creek Watershed Master Drainage Plan – Identified Improvements (2018)
- Drum Point Creek Watershed Master Drainage Plan – Link Node Diagram (2018)
- Drum Point Creek Watershed Master Drainage Plan (2018)
- Elizabeth River Bacterial TMDL Action Plan (2018)
- Elmwood Landing Drainage Study (2021)
- Elmwood Landing Offsite Drainage Analysis – SWMM Modeling (2020)
- Existing and Future Hydrology and Hydraulics Albemarle and Chesapeake Canal Drainage Basin Southside Albemarle and Chesapeake Canal Sub-Basin, Bedford Study Area (1986)
- Existing and Future Hydrology and Hydraulics Albemarle and Chesapeake Canal Drainage Basin Southside Albemarle and Chesapeake Canal Sub-Basin (1986)
- Existing and Future Hydrology and Hydraulics Albemarle and Chesapeake Canal Drainage Basin Northside Albemarle and Chesapeake Canal Sub-Basin (1985)
- Existing and Future Hydrology and Hydraulics for Bowers Hill Area of the Goose Creek Drainage Basin (1985)
- Existing and Future Hydrology and Hydraulics Southern Branch of the Elizabeth River Drainage Basin Crestwood Sub-Basin (1985)
- Existing and Future Hydrology and Hydraulics Western Branch Elizabeth River Drainage Basin Goose Creek Sub-Basin (1985)
- Existing and Future Hydrology and Hydraulics Western Branch Elizabeth River Drainage Basin Sterns Creek Sub-Basin (1986)
- Forest Lakes Drainage Study – Pre-Storm Pumping Technical Memorandum (2021)
- Forest Lakes Drainage Study – Recommended Mitigation Measures (2020)
- Greenbrier Resiliency Plan (2020)
- Hampton Roads Hazard Mitigation Plan (2017)
- Hodges Creek Outfall Study Area (1985)
- Horse Run Ditch East Watershed MDPU (2011)

- Indian River Watershed MDPU (2011)
- Master Drainage Reports Identified Projects (2021)
- Milldam Creek Watershed Technical Memorandum (2011)
- MS4 Program Plan (2017)
- New Mill Creek Watershed MDPU (2006)
- New Mill Creek Watershed MDPU [New Mill 3&4] (2011)
- New Mill Creek Watershed SWMM Conversion [New Mill 1 & 2] (2011)
- Newton Creek Outfall Study Area (1985)
- Norfolk Highlands Master Plan (2019)
- Northside Canal-3 Watershed Study (2021)
- Oak Grove Watershed MDPU (2010)
- Pocaty River Watershed MDP (2009)
- Portsmouth & Chesapeake Joint Land Use Study (2021)
- Program Year 47 2021/2022 Annual Action Plan (2021)
- Public Works Capital Projects Summary – Stormwater Projects (2021)
- South Norfolk Master Drainage Study (2009)
- Southern Chesapeake [2&3] Watershed Technical Memorandum (2012)
- Southern Chesapeake 1 Watershed MDP (2008)
- Southern Chesapeake 4 Watershed Study (2010)
- Southern Chesapeake Watershed MDPU [Study Area 2&3] (2007)
- Southern Rivers TMDL Action Plan (2018)
- Southern Rivers TMDL Action Plan Conceptual Water Quality Projects (2018)
- St. Julian Creek Watershed Technical Memorandum (2012)
- Stern Creek Watershed Master Drainage Plan (2021)
- The Virginia Coastal Resilience Master Plan (2020)
- Washington Manor Outfall [GL-1] Watershed Study (2015)

Appendix C
Maps

Chesapeake Essential Facilities



Essential Facilities

- Emergency Operations
- Fire Station
- Medical
- Municipal Bldgs
- Plant
- Police Station
- Senior Disabled
- Shelter
- Sheriff
- Special Needs
- Urgent Care
- Water Storage Tank
- Corrections - Medium
- Corrections - Maximum

Evacuation Zone

- A
- B
- C
- D

2/8/2022

Chesapeake VIRGINIA

Chesapeake River Basins

Eastern Branch Elizabeth River
- Berkley Drainage - BK
- Eastern Branch - EB
- Indian river - IR

Albermarle and Chesapeake Canal
- Coopers Ditch - CD
- Horse Run Ditch - HR
- Northside Canal - NS
- Southside Canal - SS

Western Branch Elizabeth River
- Baily Creek - BC
- Cavalier - CV
- Drum Point Creek - DP
- Goose Creek - GC
- Sterns Creek - ST

Southern Branch Elizabeth River
- Bells Mill Creek - BM
- Camden Mills - CM
- Crestwood - CW
- Deep Creek - DC
- Gilmerton Canal - GL
- Mill Creek - MC
- New Mill Creek - NM
- Oak Grove - OG
- St. Julian Creek - SJ
- South Norfolk - SN
- Southern Chesapeake - SC

North Landing River
- Blackwater Creek - BL
- Gum Swamp - GS
- Pocaty River - PR
- Stumpy Lake - SL

City of Suffolk

City of Portsmouth

City of Norfolk

City of Virginia Beach

City of Virginia Beach

Watershed Study Status
- Complete (2009 - present)
- In Progress
- Complete (1980s)

Master Drainage Improvement Projects
- Complete (2006 - present)
- Complete (1995 - 2005)
- In progress

Master Drainage 2021

Chesapeake VIRGINIA

0 0.5 1 2 Miles

Appendix D
Resilience Plan Project Table

Resilience Plan Project Table				
Parameter — Name of Project:	Oakdale Area BMP and Drainage Improvements	Norfolk Highlands Drainage Improvements (5 Improvement Phases)	Welch Lane Drainage Improvement Phase I & II	Cooper's Ditch Phase II
On Virginia Costal Resilience Web Explorer?	Yes	Yes	Yes	No
Name of the Document the Project is included in:	Approved Capital Improvement Plan; Oakdale Area Drainage Study	Approved Capital Improvement Plan; Norfolk Highlands Area Drainage Study	SW CIP Progress Report	Approved Capital Improvement Plan
Date the Document was published:	March 2021; July 2020	March 2021; ?	March 2022	March 2021
Chesapeake River Basin Watershed is located in (see master drainage map on Chesapeake watershed page):	Eastern Branch Elizabeth River	Eastern Branch Elizabeth River	Southern Branch Elizabeth River	Albemarle and Chesapeake Canal
Name of the Watershed the Project is located in:	Berkley (BK)	Indian River (IR)	Oak Grove (OG)	Coopers Ditch (CD), Coopers Ditch (CD-1)
Rain Fall Events (for 24hr storms) Analyzed:	2-, 5-, 10-, 100-yr	2-, 5-, 10-yr	2-, 5-, 10-yr	50-, 100-yr
Tailwater (or water surface elevation) Analyzed:	Current PFM Std	Current PFM Std	Current PFM Std	Current PFM Std
Short Summary of Project (I.E. Storm System Upgrades, Detention Basin, Channel/Channel widening):	Construct wet pond, dry pond, storm sewer pipe upgrades to reduce flooding in surrounding neighborhood and enhance water quality in Cloverdale area of South Norfolk.	Replace, upsize, and realign pipe and ditch conveyance systems to reduce flooding in surrounding neighborhood.	Construct new drainage conveyance system along Welch Lane including storm structures, storm pipe, curb & gutter, re-sloping of pavement to reduce flooding in surrounding neighborhood.	Restore hydraulic capacity of Cooper's Ditch needed to serve the watershed by removing significant amounts of silt and sediment between Gloria Dr and Forest Rd.
Is the Project Nature-based?	Yes	No	No	No
What issues or problems are being addressed by the project?	Flooding, Pollution	Flooding	Flooding	Flooding
Does the proposed Project enable communities to adapt to and thrive through natural or human hazards?	Yes	Yes	Yes	Yes
Does the Project include forward-looking goals, actionable strategies, and priorities as seen through an equity-based lens?	Yes	Yes	Yes	Yes
Level of Protection / Design Storm	100-yr for ponds	10-yr	10-yr	50-yr
Size of the Drainage Area related to the Project if listed	~ 228 AC	Varies for each phase (< 200 AC)	~ 10 AC	> 200 AC
How many alternatives were developed/analyzed for the issues being solved	3	3	3	None
Does this Project require future maintenance	Yes	Yes	Yes	Yes
Estimated total project cost (includes Engineering, Land Acq, Construction as appropriate)	$7,567,485	$1,200,000	$1,280,000	$1,500,000
Does the Project have funding available at present?	Yes (Partial)	Yes (Partial)	Yes (Partial)	Yes (Partial)
Timing for implementation (contingent on funding availability)	Active (Construction start 2022)	Active (Construction start 2022)	Active (Construction Start 2023)	Active (Construction start 2023)
What other project(s) must be completed prior to installation of this Project?	None	None	None	None
Project Status - Completed, Under Construction, Design Complete (not yet constructed), Under Design, Scoping (design not yet started), On Hold, Future (not yet started & MAY have funding in a future year)	Under Design	Under Design	Under Design	Under Design
	1	2	3	4

Resilience Plan Project Table					
Parameter	Name of Project:	Washington Manor Drainage Improvements	Hickory Ridge Outfall Improvements	Herring Ditch Outfall Improvements	Royce Dr Drainage Outfall Improvements Phase II
On Virginia Costal Resilience Web Explorer?		Yes (previously called Meads Court BMP/Drainage Improvements)	Yes	Yes	Yes
Name of the Document the Project is included in:		Approved Capital Improvement Plan; Washington Manor Outfall (GL-1) Watershed Study	Approved Capital Improvement Plan	Bells Mill Creek Watershed MDPU	SW CIP Progress Report
Date the Document was published:		March 2021; ?	March 2021	January 2010	March 2022
Chesapeake River Basin Watershed is located in (see master drainage map on Chesapeake watershed page):		Southern Branch Elizabeth River	Northwest River	Southern Branch Elizabeth River	Albemarle and Chesapeake Canal
Name of the Watershed the Project is located in:		Gilmerton Canal (GL), Washington Manor (GL-1)	Southern Chesapeake (SC), St. Brides Ditch (SC-3)	Bells Mill Creek (BM), Herring Ditch (BM-1)	Coopers Ditch (CD), Poplars Branch (CD-2)
Rain Fall Events (for 24hr storms) Analyzed:		2-,10-, 50-, 100-year	10-, 50-yr	2-, 10-, 50-, 100-year	2-, 5-, 10-yr
Tailwater (or water surface elevation) Analyzed:		Current PFM Std	Current PFM Std	Current PFM Std	Current PFM Std
Short Summary of Project (I.E. Storm System Upgrades, Detention Basin, Channel/Channel widening):		Replace and upsize pipes along Old George Washington Hwy and re-grade eastern outfall ditch to increase system capacity and reduce area flooding.	Correct erosion, increase outfall ditch capacity, replace pipes with box culvert in the conveyance system between Battlefield Blvd S. and Benefit Rd to reduce area flooding.	Widen outfall ditch and upsize culverts east of Shillelagh Rd to increase system capacity and reduce area flooding.	Regrade roadside ditches and replace driveway culverts to increase capacity and reduce flooding in surrounding neighborhood.
Is the Project Nature-based?		No	Yes	Yes	No
What issues or problems are being addressed by the project?		Flooding	Flooding, Erosion	Flooding	Flooding
Does the proposed Project enable communities to adapt to and thrive through natural or human hazards?		Yes	Yes	Yes	Yes
Does the Project include forward-looking goals, actionable strategies, and priorities as seen through an equity-based lens?		Yes	Yes	Yes	Yes
Level of Protection / Design Storm		50-yr	10-yr	50-yr	5-yr
Size of the Drainage Area related to the Project if listed		~ 560 AC	~140 AC	~ 1,500 AC	~ 20 AC
How many alternatives were developed/analyzed for the issues being solved		3	None	1	1
Does this Project require future maintenance		Yes	Yes	Yes	Yes
Estimated total project cost (includes Engineering, Land Acq, Construction as appropriate)		$1,550,000	$850,000	$2,500,000	$750,000
Does the Project have funding available at present?		Yes (Partial)	Yes (Partial)	No	No
Timing for implementation (contingent on funding availability)		Active (Construction start 2023)	Active (Construction start 2024)	Active	Active
What other project(s) must be completed prior to installation of this Project?		None	None	None	Phase I
Project Status - Completed, Under Construction, Design Complete (not yet constructed), Under Design, Scoping (design not yet started), On Hold, Future (not yet started & MAY have funding in a future year)		Under Design	Under Design	Under Design	Under Design
		5	6	7	8

Resilience Plan Project Table					
Parameter	Name of Project:	Lamberts Trail Area Drainage Improvements Phase II	Pughsville Area Outfall Improvements	Elmwood Landing Area Drainage Improvements Phases I & II	Providence Rd Crossing Replacement
On Virginia Costal Resilience Web Explorer?		Yes	No	Yes	No
Name of the Document the Project is included in:		SW CIP Progress Report	PW SW Eng Unfunded Project List	SW CIP Progress Report; Elmwood Landing Drainage Study Elmwood Landing Offsite Drainage Analysis	PW SW Eng Unfunded Project List; PW Ops Condition Report
Date the Document was published:		December 2021	March 2022	March 2022; December 2021; January 2020	March 2022
Chesapeake River Basin Watershed is located in (see master drainage map on Chesapeake watershed page):		Southern Branch Elizabeth River	Western Branch Elizabeth River	Southern Branch Elizabeth River	Eastern Branch Elizabeth River
Name of the Watershed the Project is located in:		St. Julian Creek (SJ), Camelot (SJ-1)	Drum Point Creek (DP), Pughsville (DP-1)	Deep Creek (DC), Deep Creek (DC-2)	Indian River (IR), Georgetown (IR-1)
Rain Fall Events (for 24hr storms) Analyzed:		2-, 5-, 10-yr	50-yr, 100-yr	2-1000-yr	10-, 50-yr
Tailwater (or water surface elevation) Analyzed:		Current PFM Std	Current PFM Std	Current PFM Std / road elevation	Current PFM Std
Short Summary of Project (I.E. Storm System Upgrades, Detention Basin, Channel/Channel widening):		Replace aging storm pipes and improve ditches to increase system capacity and provide a higher level of protection	Regrade major outfall channel and remove beaver dams to restore hydraulic capacity.	A new neighborhood outfall pipe. Also, replace existing poor-condition cross pipes under both Martin Johnson Rd and Cookes Mill Rd to provide a higher level of protection.	Replace existing poor-condition cross pipes under Providence Rd near Georgetown Blvd with a new box culvert to provide a higher level of protection, for both flood events and transportation network.
Is the Project Nature-based?		Hybrid	Yes	No	No
What issues or problems are being addressed by the project?		Flooding	Flooding	Flooding, Erosion	Flooding, Erosion, Road Stability, Cave-Ins
Does the proposed Project enable communities to adapt to and thrive through natural or human hazards?		Yes	Yes	Yes	Yes
Does the Project include forward-looking goals, actionable strategies, and priorities as seen through an equity-based lens?		Yes	Yes	Yes	Yes
Level of Protection / Design Storm		10-yr	100-yr	50-yr for neighborhood, 1000-yr for culvert crossings	50-yr
Size of the Drainage Area related to the Project if listed		~ 100 AC	> 200 AC	94 AC fo neighborhood, 92,000 AC for culvert crossings	~200 AC
How many alternatives were developed/analyzed for the issues being solved		1	None	Multiple	None
Does this Project require future maintenance		Yes	Yes	Yes	Yes
Estimated total project cost (includes Engineering, Land Acq, Construction as appropriate)		$1,250,000	$1,544,055	$3,000,000	$1,400,000
Does the Project have funding available at present?		No	Yes (partial)	Yes (partial)	No
Timing for implementation (contingent on funding availability)		Active	Active	2023	Active
What other project(s) must be completed prior to installation of this Project?		Phase I	None	None	None
Project Status - Completed, Under Construction, Design Complete (not yet constructed), Under Design, Scoping (design not yet started), On Hold, Future (not yet started & MAY have funding in a future year)		Under Design	Under Design	Scoping	Scoping
		9	10	11	12

Resilience Plan Project Table				
Parameter — Name of Project:	Mount Pleasant Rd Crossing Replacement	Shell Rd Drainage Improvements	Greenbrier Outfall Resiliency Improvements Phase I & II (Weir Lowering at IR HS Lake & S. Military Hwy Culvert Upsize)	Greenbrier Outfall Resiliency Improvements Phase III (I-64 Additional Culvert)
On Virginia Costal Resilience Web Explorer?	No	Yes	No	No
Name of the Document the Project is included in:	PW SW Eng Unfunded Project List; PW Ops Condition Report	SW CIP Progress Report	Greenbrier Resiliency Plan	Greenbrier Resiliency Plan
Date the Document was published:	March 2022	March 2022	November 2020	November 2020
Chesapeake River Basin Watershed is located in (see master drainage map on Chesapeake watershed page):	Albemarle and Chesapeake Canal	Southern Branch Elizabeth River	Eastern Branch Elizabeth River	Eastern Branch Elizabeth River
Name of the Watershed the Project is located in:	Coopers Ditch (CD), Fentress (CD-3)	Gilmerton Canal (GL)	Indian River (IR)	Indian River (IR)
Rain Fall Events (for 24hr storms) Analyzed:	10-, 50-yr	2-, 5-, 10-yr	100-, 500-, 1,000-year	100-, 500-, 1,000-year
Tailwater (or water surface elevation) Analyzed:	Current PFM Std	Current PFM Std	Current PFM Std + SLR	Current PFM Std + SLR
Short Summary of Project (I.E. Storm System Upgrades, Detention Basin, Channel/Channel widening):	Replace existing poor-condition cross pipe and box culvert under Mount Pleasant Rd near railroad tracks/Butts Road Pimary School with a new box culvert to provide a higher level of protection, for both flood events and transportation network.	Replace aging storm pipes and improve ditches to increase system capacity and provide a higher level of protection	Lower Indian River HS lake weir crest and upsize existing poor-condition box culvert under S. Military Hwy to lower upstream hydraulic grade line and provide additional flood storage in Greenbrier business corridor.	Construct new pipe crossing under I-64 (microtunneling) near Greenbrier Pkwy to lower permanent pool elevations of upstream impounds and provide additional flood storage in Greenbrier business corridor.
Is the Project Nature-based?	No	Hybrid	Hybrid	Hybrid
What issues or problems are being addressed by the project?	Flooding, Erosion, Road Stability	Flooding	Flooding	Flooding
Does the proposed Project enable communities to adapt to and thrive through natural or human hazards?	Yes	Yes	Yes	Yes
Does the Project include forward-looking goals, actionable strategies, and priorities as seen through an equity-based lens?	Yes	Yes	Yes	Yes
Level of Protection / Design Storm	50-yr	10-yr	1,000-yr	1,000-yr
Size of the Drainage Area related to the Project if listed	~ 450 AC	~ 10 AC	~ 3,800 AC	~ 3,000 AC
How many alternatives were developed/analyzed for the issues being solved	None	1	Multiple	2
Does this Project require future maintenance	Yes	Yes	Yes	Yes
Estimated total project cost (includes Engineering, Land Acq, Construction as appropriate)	$500,000	$900,000	$1,975,398	$3,200,000
Does the Project have funding available at present?	No	No	Yes (Partial)	No
Timing for implementation (contingent on funding availability)	Active	TBD	2022	TBD
What other project(s) must be completed prior to installation of this Project?	None	None	None	Phase I and Phase II
Project Status - Completed, Under Construction, Design Complete (not yet constructed), Under Design, Scoping (design not yet started), On Hold, Future (not yet started & MAY have funding in a future year)	Scoping	Scoping	Future	Future
	13	14	15	16

Resilience Plan Project Table				
Parameter — Name of Project:	Drum Creek Farms Drainage Imporvements Phase II	Poplar Branch Ditch Regrading	Buskey Rd Crossing Replacement	Carawan Lane Drainage Improvements
On Virginia Costal Resilience Web Explorer?	No	No	No	No
Name of the Document the Project is included in:	Approved Capital Improvement Plan	PW SW Eng Unfunded Project List	PW SW Eng Unfunded Project List; PW Ops Condition Report	PW SW Eng Unfunded Project List
Date the Document was published:	March 2021	March 2022	March 2022	March 2022
Chesapeake River Basin Watershed is located in (see master drainage map on Chesapeake watershed page):	Western Branch Elizabeth River	Albemarle and Chesapeake Canal	Northwest River	Albemarle and Chesapeake Canal
Name of the Watershed the Project is located in:	Drum Point Creek (DP)	Coopers Ditch (CD), Poplars Branch (CD-2)	Southern Chesapeake (SC), Homestead Outfall (SC-2)	Horse Run Ditch East (HR)
Rain Fall Events (for 24hr storms) Analyzed:	10-, 50-yr	50-, 100-yr	10-, 50-yr	2-, 5-, 10-yr
Tailwater (or water surface elevation) Analyzed:	Current PFM Std	Current PFM Std	Current PFM Std	Current PFM Std
Short Summary of Project (I.E. Storm System Upgrades, Detention Basin, Channel/Channel widening):	Correct major erosion, increase outfall ditch capacity and enhance water quality in the conveyance system along Drum Creek Rd to reduce flooding in surrounding neighborhood.	Restore hydraulic capacity of Poplar Branch Ditch needed to serve the watershed by removing significant amounts of silt and sediment between Hanbury Rd and Battlefield Blvd.	Replace existing poor-condition cross pipes under Buskey Rd near Bunch Walnuts Rd with a new box culvert to provide a higher level of protection, for both flood events and transportation network.	Regrade roadside/outfall ditches and replace driveway culverts to increase capacity and reduce flooding in surrounding neighborhood.
Is the Project Nature-based?	Yes	Yes	No	No
What issues or problems are being addressed by the project?	Flooding, Erosion, Pollution	Flooding	Flooding, Road Stability, Cave-Ins	Flooding
Does the proposed Project enable communities to adapt to and thrive through natural or human hazards?	Yes	Yes	Yes	Yes
Does the Project include forward-looking goals, actionable strategies, and priorities as seen through an equity-based lens?	Yes	Yes	Yes	Yes
Level of Protection / Design Storm	10-yr	50-yr	50-yr	10-yr
Size of the Drainage Area related to the Project if listed	~ 100 AC	> 200 AC	~ 1,300 AC	~ 40 AC
How many alternatives were developed/analyzed for the issues being solved	None	None	1	1
Does this Project require future maintenance	Yes	Yes	Yes	Yes
Estimated total project cost (includes Engineering, Land Acq, Construction as appropriate)	$1,400,000	$1,000,000	$600,000	$1,350,000
Does the Project have funding available at present?	No	No	No	No
Timing for implementation (contingent on funding availability)	2024	2024	UNK	TBD
What other project(s) must be completed prior to installation of this Project?	None	None	None	None
Project Status - Completed, Under Construction, Design Complete (not yet constructed), Under Design, Scoping (design not yet started), On Hold, Future (not yet started & MAY have funding in a future year)	Future	Future	Future	Future
	17	18	19	20

Resilience Plan Project Table				
Parameter — Name of Project:	Weiss Lane Outfall Improvements	Pleasant View Drainage Improvemt	Mount Pleasant Rd Outfall Improvement	Homemont Outfall Improvements
On Virginia Costal Resilience Web Explorer?	No	No	No	No
Name of the Document the Project is included in:	Deep Creek Watershed MDPU	PW SW Eng Unfunded Project List	PW SW Eng Unfunded Project List	PW SW Eng Unfunded Project List
Date the Document was published:	July 2010	March 2022	March 2022	March 2022
Chesapeake River Basin Watershed is located in (see master drainage map on Chesapeake watershed page):	Southern Branch Elizabeth River	Southern Branch Elizabeth River	Albemarle and Chesapeake Canal	Southern Branch Elizabeth River
Name of the Watershed the Project is located in:	Deep Creek (DC), Deep Creek (DC-2)	Deep Creek (DC), Deep Creek Locks (DC-3)	Horse Run Ditch East (HR)	Bells Mill Creek (BM), Herring Ditch (BM-1)
Rain Fall Events (for 24hr storms) Analyzed:	2-, 5-, 10-, 25-, 50-, 100-year	2-, 5-, 10-yr	50-, 100-yr	2-, 5-, 10-yr
Tailwater (or water surface elevation) Analyzed:	Current PFM Std	Current PFM Std	Current PFM Std	Current PFM Std
Short Summary of Project (I.E. Storm System Upgrades, Detention Basin, Channel/Channel widening):	Widen outfall ditch, upsize culverts under Weiss Lane, lower inverts to increase system capacity and reduce area flooding.	Regrade roadside/outfall ditches and replace driveway culverts to increase capacity and reduce flooding in surrounding neighborhood.	Regrade and improve major lead outfall ditch between Mount Pleasant Rd and rear of Ravenna subdivision to provide a higher level of protection.	Regrade roadside/outfall ditches and replace driveway culverts to increase capacity and reduce flooding in surrounding neighborhood.
Is the Project Nature-based?	Hybid	No	Yes	No
What issues or problems are being addressed by the project?	Flooding	Flooding	Flooding	Flooding
Does the proposed Project enable communities to adapt to and thrive through natural or human hazards?	Yes	Yes	Yes	Yes
Does the Project include forward-looking goals, actionable strategies, and priorities as seen through an equity-based lens?	Yes	Yes	Yes	Yes
Level of Protection / Design Storm	50-yr	10-yr	50-yr	10-yr
Size of the Drainage Area related to the Project if listed	~ 80 AC	~ 30 AC	~ 300 AC	~ 50 AC
How many alternatives were developed/analyzed for the issues being solved	3	1	None	None
Does this Project require future maintenance	Yes	Yes	Yes	Yes
Estimated total project cost (includes Engineering, Land Acq, Construction as appropriate)	$1,300,000	$1,300,000	$600,000	$1,100,000
Does the Project have funding available at present?	No	No	No	No
Timing for implementation (contingent on funding availability)	TBD	TBD	TBD	TBD
What other project(s) must be completed prior to installation of this Project?	None	None	None	None
Project Status - Completed, Under Construction, Design Complete (not yet constructed), Under Design, Scoping (design not yet started), On Hold, Future (not yet started & MAY have funding in a future year)	Future	Future	Future	Future
	21	22	23	24

Resilience Plan Project Table		
Parameter — Name of Project:	Forest Lakes Outfall Improvements Phase II	Scenic Blvd Drainage Improvements
On Virginia Costal Resilience Web Explorer?	No	No
Name of the Document the Project is included in:	PW SW Eng Unfunded Project List	PW SW Eng Unfunded Project List
Date the Document was published:	March 2022	March 2022
Chesapeake River Basin Watershed is located in (see master drainage map on Chesapeake watershed page):	Southern Branch Elizabeth River	Southern Branch Elizabeth River
Name of the Watershed the Project is located in:	Bells Mill Creek (BM), Herring Ditch (BM-1)	Bells Mill Creek (BM), Herring Ditch (BM-1)
Rain Fall Events (for 24hr storms) Analyzed:	50-yr, 100-yr	2-, 5-, 10-yr
Tailwater (or water surface elevation) Analyzed:	Current PFM Std	Current PFM Std
Short Summary of Project (I.E. Storm System Upgrades, Detention Basin, Channel/Channel widening):	Pre-storm pumping of the front lake in the Forest Lakes neighborhood as an alternative to replace or supplement capacity improvements	Regrade roadside/outfall ditches and replace driveway culverts to increase capacity and reduce flooding in surrounding neighborhood.
Is the Project Nature-based?	Hybrid	No
What issues or problems are being addressed by the project?	Flooding	Flooding
Does the proposed Project enable communities to adapt to and thrive through natural or human hazards?	Yes	Yes
Does the Project include forward-looking goals, actionable strategies, and priorities as seen through an equity-based lens?	Yes	Yes
Level of Protection / Design Storm	50-yr	10-yr
Size of the Drainage Area related to the Project if listed	~ 50 AC	~ 30 AC
How many alternatives were developed/analyzed for the issues being solved	10	1
Does this Project require future maintenance	Yes	Yes
Estimated total project cost (includes Engineering, Land Acq, Construction as appropriate)	$4,000,000	$1,000,000
Does the Project have funding available at present?	No	No
Timing for implementation (contingent on funding availability)	TBD	TBD
What other project(s) must be completed prior to installation of this Project?	None	None
Project Status - Completed, Under Construction, Design Complete (not yet constructed), Under Design, Scoping (design not yet started), On Hold, Future (not yet started & MAY have funding in a future year)	Future	Future
	25	26

Chesapeake VIRGINIA

PUBLIC WORKS

MEMORANDUM

TO: Crystal Bloom, P.E., Assistant City Engineer
Jay Tate, P.E., CFM, Director of Development and Permits

FROM: Deva Borah, PhD, P.E., Senior Project Engineer

DATE: April 7, 2022

SUBJECT: **AUTHORIZATION TO REQUEST FUNDING THROUGH COMMUNITY FLOOD PREPAREDNESS FUND (CFPF) GRANT PROGRAM FOR GREENBRIER OUTFALL RESILIENCY IMPROVEMENTS PHASE I & II**

The City of Chesapeake requests funding through the Community Flood Preparedness Fund (CFPF) grant program for the above-referenced flood prevention and protection project in accordance with the grant program requirements as provided in the 2022 Grant Manual for the Virginia Community Flood Preparedness Fund.

The City has dedicated funding for this specific type of project in the Capital Improvement Budget (CIB) that will be used to provide the required local match, see Project #29-230 Resiliency & Reliability Program. The CIB Project Summary page and documentation to verify the availability of adequate funding to cover the local match amount are provided for your records.

The total project cost is $1,975,398. The amount of funding requested through the CFPF is 60% of the project cost or $1,185,238. The remaining cost of $790,160 will be a local match funded through Project #29-230 Resiliency & Reliability Program.

The grant program also requires a locality-certified floodplain manager (CFM) to confirm the project area is subject to recurrent flooding to ensure moneys from the program will be utilized for the primary purpose of implementing flood prevention and protection projects. This confirmation by the City's designated CFM is requested below.

Should you have any questions or need additional information, please contact me at extension 6472.

Crystal Bloom, P.E., Assistant City Engineer
(Approval of Request)

4/8/22
Date

Jay Tate, P.E., CFM, Director of Development and Permits
(Confirmation of Project)

4/8/22
Date

DB

Attachments

29-230: Resiliency & Reliability Program

Department:	**Storm Water Capital Projects**		
Project Type:	Addition or Expansion	Comprehensive Plan Goal Area:	Stormwater Management
Year identified:	2019	Planning Area:	Greenbrier
Start Date:	7/1/2018	Project Status:	Adopted
Est. Completion Date:	12/30/2024		

Description:

This project will provide for drainage improvements with related acquisition of easements, replacement of pipes, re-grading of ditches, and associated activities to provide a higher level of protection and improved stormwater systems in city areas with inter-connected lake systems that are dependent on a single outlet control structure. This program will look at providing an improved outlet control structure in areas such as the Greenbrier lakes system, Etheridge lakes system, Stonegate lakes system, and other lake systems with drainage deficiencies. This project will also include the replacement of downstream culverts.

Justification:

Major investments in improvements are necessary to increase drainage capacity and upgrade deficient drainage systems in these areas.

Comments:

The frequency and intensity of storms impacting the City of Chesapeake and the region as a whole have been observed to be much greater than in the past. These project improvements will provide critical systems with added levels of protection that will help reduce the impact of flooding during major storm events.

Project Forecast:

Year	Total Expense	Total Revenue	Difference
2022			0
2023			0
2024			0
	0	**0**	**0**

Project Details 2022:

	Prior Years	2022	2023 - 26	Future Years	Total Amount
Revenue					
Cash - Stormwater	1,600,000				**1,600,000**
Total Revenue	**1,600,000**				**1,600,000**
Expense					
Design & Engineering	500,000				**500,000**
Construction	900,000				**900,000**
Land Acquisition	200,000				**200,000**
Total Expense	**1,600,000**				**1,600,000**

My Expenses by Proj

1292300900 RESILIENCY&RELIABILITY PROGRAM

2022-04-06

Activity	Total Appropriation	Pre-Enc	Enc	Exp	Remaining	% Spent
CONSTRUCTION	900,000.00	-	-	-	900,000.00	0.00%
ENG/DESIGN	500,000.00	-	54,766.15	45,229.65	400,004.20	20.00%
GB_RESILIANCY	-	-	2,511.53	90,090.09	(92,601.62)	100.00%
LAND	200,000.00	-	-	-	200,000.00	0.00%
Total Expenditures	**$ 1,600,000.00**	**$ -**	**$ 57,277.68**	**$ 135,319.74**	**$ 1,407,402.58**	**12.04%**

*Note: All amounts reflect transactions currently budget checked against commitment control definitions.

Commonwealth of Virginia

CFPF, rr <cfpf@dcr.virginia.gov>

CID510034_ChesapeakeCity_CFPF-2: CFPF 2022 Grant Application on Greenbrier Outfall Resiliency Improvements Phase I & II

1 message

Deva K. Borah <dborah@cityofchesapeake.net> Fri, Apr 8, 2022 at 2:48 PM
To: Virginia Department of Conservation & Recreation <cfpf@dcr.virginia.gov>
Cc: Sam Sawan <sawan@cityofchesapeake.net>, "Crystal V. Bloom" <cbloom@cityofchesapeake.net>, Liz Scheessele <Liz.Scheessele@timmons.com>

Dear DCR CFPF Program Manager,

Please find the City of Chesapeake's Grant Application **CID510034_ChesapeakeCity_CFPF-2** on Greenbrier Outfall Resiliency Improvements Phase I & II **PROJECT** for 2022 CFPF Grant Funding in the **downloadable link provided below** as the file size is too large to attach.

We look forward to hearing from you if you are able to download the application with no issues and also as an acknowledgement of receipt of this application.

Sincerely,

Deva

Deva K. Borah, Ph.D., P.E., F.ASCE

Senior Engineer

City of Chesapeake – Department of Public Works

306 Cedar Road,, Chesapeake, Virginia 23322

Main: (757) 382-6101; Direct: (757) 382-6472

Cellular: (757) 705-6341
Email: dborah@cityofchesapeake.net
www.cityofchesapeake.net

Shared File

Name: CID510034_ChesapeakeCity_CFPF-2.pdf

Size:	55.5 MB
Public Link:	CID510034_ChesapeakeCity_CFPF-2.pdf
Expires On:	Fri, 15 Apr 2022 16:27:27 GMT

Click on the link below to download the shared file.

Download

Chesapeake VIRGINIA

PUBLIC WORKS

MEMORANDUM

TO: Crystal Bloom, P.E., Engineering Manager

FROM: Deva Borah, PhD, P.E., Senior Project Engineer

DATE: November 30, 2022

SUBJECT: **REVISED AUTHORIZATION WITH INCRTEASED LOCAL MATCH TO REQUEST FUNDING THROUGH COMMUNITY FLOOD PREPAREDNESS FUND (CFPF) GRANT PROGRAM FOR GREENBRIER OUTFALL RESILIENCY IMPROVEMENTS PHASE I & II**

The City of Chesapeake is amending its request for funding through the Community Flood Preparedness Fund (CFPF) grant program for the above-referenced flood prevention and protection project in accordance with the grant program requirements as provided in the 2022 Grant Manual for the Virginia Community Flood Preparedness Fund.

The City has dedicated funding for this specific type of project in the Capital Improvement Budget (CIB) that will be used to provide the required local match, see Project #29-230 Resiliency & Reliability Program. The CIB Project Summary page and documentation to verify the availability of adequate funding to cover the local match amount are provided for your records.

The total project cost is $1,975,398. The revised amount of funding requested through the CFPF is 55% of the project cost or $1,086,468. The remaining cost of $888,930 will be a local match funded through Project #29-230 Resiliency & Reliability Program. This is an increase in local match based on comments from the grant program as to the type of project. Your approval is requested to authorize the amendment of funding.

Should you have any questions or need additional information, please contact me at extension 6472.

Crystal Bloom, P.E., Engineer Manager
(Approval of Request)

11/30/22
Date

DB ls

Attachments

29-230: Resiliency & Reliability Program

Department:	**Storm Water Capital Projects**		
Project Type:	Addition or Expansion	Comprehensive Plan Goal Area:	Stormwater Management
Year identified:	2019	Planning Area:	Greenbrier
Start Date:	7/1/2018	Project Status:	Adopted
Est. Completion Date:	12/30/2024		

Description:

This project will provide for drainage improvements with related acquisition of easements, replacement of pipes, re-grading of ditches, and associated activities to provide a higher level of protection and improved stormwater systems in city areas with inter-connected lake systems that are dependent on a single outlet control structure. This program will look at providing an improved outlet control structure in areas such as the Greenbrier lakes system, Etheridge lakes system, Stonegate lakes system, and other lake systems with drainage deficiencies. This project will also include the replacement of downstream culverts.

Justification:

Major investments in improvements are necessary to increase drainage capacity and upgrade deficient drainage systems in these areas.

Comments:

The frequency and intensity of storms impacting the City of Chesapeake and the region as a whole have been observed to be much greater than in the past. These project improvements will provide critical systems with added levels of protection that will help reduce the impact of flooding during major storm events.

Project Forecast:

Year	Total Expense	Total Revenue	Difference
2022			0
2023			0
2024			0
	0	**0**	**0**

Project Details 2022:

	Prior Years	2022	2023 - 26	Future Years	Total Amount
Revenue					
Cash - Stormwater	1,600,000				**1,600,000**
Total Revenue	**1,600,000**				**1,600,000**
Expense					
Design & Engineering	500,000				**500,000**
Construction	900,000				**900,000**
Land Acquisition	200,000				**200,000**
Total Expense	**1,600,000**				**1,600,000**

My Expenses by Proj

1292300900 RESILIENCY&RELIABILITY PROGRAM

2022-11-09

Activity	Total Appropriation	Pre-Enc	Enc	Exp	Remaining	% Spent
CONSTRUCTION	900,000.00	-	-	-	900,000.00	0.00%
ENG/DESIGN	500,000.00	-	20,920.05	79,075.75	400,004.20	20.00%
GB_RESILIANCY	-	-	2,511.53	90,090.09	(92,601.62)	100.00%
LAND	200,000.00	-	-	-	200,000.00	0.00%
Total Expenditures	**$ 1,600,000.00**	**$ -**	**$ 23,431.58**	**$ 169,165.84**	**$ 1,407,402.58**	**12.04%**

*Note: All amounts reflect transactions currently budget checked against commitment control definitions.

November 30, 2022

Wendy Howard-Cooper
Director, Dam Safety and Floodplain Management
Department of Conservation and Recreation
600 East Main Street, 24th Floor
Richmond, VA 23219
wendy.howard-cooper@dcr.virginia.gov

**RE: COMMUNITY FLOOD PREPAREDNESS FUND (CFPF)
CY2022 ROUND 3 GRANT APPLICATION: GRANT NUMBER: CFPF-22-03-42
APPLICATION CATEGORY: PROJECTS THAT WILL RESULT IN HYBRID
SOLUTIONS: COMMUNITY NAME: CHESAPEAKE, CITY OF, CID: 510034**

Dear Ms. Howard-Cooper:

Thank you for the opportunity to undergo supplemental review for the project, **Greenbrier Outfall Resiliency Improvements Phase I & II**. The City has supplied the requested information. There are attachments for both the revised, detailed budget and authorization for the increased match.

However, the City would like to request that the project be reconsidered as a hybrid project. The City believes that the project agrees with the project category from the grant application: *All hybrid approaches whose end result is a nature-based solution.*

As is documented in the grant application and supporting documents, the end result of the grey infrastructure improvements – installation of replacement outfall pipes while lowering the existing invert (which acts as a weir) – will be additional storage volume available in a pond system. We believe that creating storage in a pond is a nature-based project. Therefore, if DCR agrees, we would ask that the determination that the project is not hybrid be reconsidered.

Should you have any questions or need additional information, please contact me at cbloom@cityofchesapeake.net or 757-382-6101.

Regards,

Crystal V. Bloom, P.E.
Engineering Manager

Attachments

c: Sam Sawan, P.E., Deputy Director of Public Works
Deva Borah, Senior Project Engineer

B. Budget Narrative- Required for All Grant Categories Revised text in red

Each application must include a detailed Budget Narrative explaining all proposed expenditures. A budget narrative is applicable to requests from any category of grants in this manual. The following items must be included in the Budget Narrative:

● *Estimated total project cost*: **$1,975,398**

This amount represents the estimated total project cost including engineering ($355,702) and construction ($1,619,696). See pages 50 and 51 of *Attachment 1* for a detailed breakdown of the estimated total project cost. A 20% increase was applied to these values to account for present day costs as well as observed increases in the construction industry.

● *Amount of funds requested from the Fund*: **$1,086,468**

This is the total amount of any grant assistance sought from the Fund. It represents 55% of the estimated total project cost.

Estimated Funding Request Breakdown

- **Salaries, 0**
- **Fringe Benefits, 0**
- **Travel, 0**
- **Equipment, 0**
- **Supplies, 0**
- **Construction, $890,904**
- **Contracts, $195,564**
- **Other Direct Costs, 0**

● *Amount of cash funds available*: **$888,930**

The source of these funds is CIB 29-230.

See *Attachment 7* for a letter indicating the availability of and ability to obtain funding for the local match including a description of the fund allowable expenditures and funding plan as well as a financial statement indicating sufficient funds to cover the match requirement for this grant application.

● *Authorization to request for funding: Local governments seeking funding shall also attach signed documentation authorizing the request for funding.* (**Supporting Documentation**.)

See *Attachment 7* for a letter authorizing a request for funding through the program.