

# Broad Bay and Oceanfront Drainage Basins **Stormwater Master Plan**

APRIL 2022



PREPARED FOR:



PREPARED BY:



# Table of Contents

- 1 **Introduction** ..... 1
- 2 **Methodology and Assumptions** ..... 5
  - 2.1 Hydraulic Modeling and Design ..... 5
    - 2.1.1 Pump Modeling and Design ..... 7
  - 2.2 Level of Service ..... 7
    - 2.2.1 Application of the Public Works Design Standards Manual (PWDSM) to LOS ..... 7
    - 2.2.2 Additional LOS Assumptions and Considerations ..... 8
    - 2.2.3 Variances ..... 9
  - 2.3 Alternative and Project Scoring ..... 9
  - 2.4 Project Figures ..... 10
  - 2.5 Opinions of Probable Construction Cost (OPCC) ..... 11
  - 2.6 Benefit-Cost Ratio (BCR) and Benefit Ratio (BR) Calculations ..... 12
- 3 **Broad Bay and Oceanfront SWMP SFAs** ..... 13
  - 3.1 Alanton Drive at Valhalla Arch ..... 14
  - 3.2 Alanton Estates and Baycliff ..... 16
  - 3.3 Alanton Neighborhood ..... 19
  - 3.4 Atlantic Avenue at 24<sup>th</sup> Street Park ..... 22
  - 3.5 Atlantic Avenue at 28<sup>th</sup> Street ..... 24
  - 3.6 Atlantic Avenue at 33<sup>rd</sup> Street ..... 26
  - 3.7 Atlantis Drive and Norfolk Avenue ..... 28
    - 3.7.1 **Phase 1: Norfolk Avenue at Marshview Drive** ..... 28
    - 3.7.2 **Phase 2: Atlantis Drive** ..... 30
    - 3.7.3 **Atlantis Drive and Norfolk Avenue Combined Summary** ..... 32
  - 3.8 Bay Breeze Drive at Sunset Point ..... 33
  - 3.9 Bay Colony ..... 35
  - 3.10 Bay Drive at Linkhorn Drive ..... 38
  - 3.11 Bay Island ..... 39
  - 3.12 Bobolink Drive North ..... 40
  - 3.13 Bobolink Drive South ..... 41
  - 3.14 Brant Road at Huntsman Drive ..... 42
  - 3.15 Broad Bay Colony ..... 44
  - 3.16 Caton Drive at Will O Wisp Drive ..... 45
  - 3.17 Chelsea and Green Hill Farms Neighborhood ..... 47
  - 3.18 Croatan Beach Neighborhood ..... 50

3.18.1	<b>Phase 1A: Kerry Lane at Croatan Road</b> .....	50
3.18.2	<b>Phase 1B: South Maryland Avenue</b> .....	52
3.18.3	<b>Phase 1C: Virginia Dare Drive at Croatan Hills Drive</b> .....	53
3.18.4	<b>Phase 1D: Croatan Lot Pump Station at Croatan Beach</b> .....	54
3.18.5	<b>Phase 2A: Christine Drive at Croatan Road</b> .....	55
3.18.6	<b>Phase 2B: Twilight Lane at Vanderbilt Avenue</b> .....	57
3.18.7	<b>Phase 3: Surfside Avenue at Virginia Dare Drive</b> .....	58
3.18.8	<b>Croatan Beach Neighborhood Combined Summary</b> .....	60
3.19	Croatan Beach Park .....	61
3.20	Crystal Lake Circle .....	63
3.21	Curlew Place .....	64
3.22	Duke of Norfolk Quay at Green Hill Road .....	65
3.23	East Bay Shore Drive at Cavalier Drive .....	67
3.24	Fielding Lane at Gregory Lane.....	69
3.25	First Colonial Road at Camelot Drive.....	71
3.26	Fishermans Bend at Harbour Point.....	73
3.27	Frazee Lane at South Birdneck Road .....	75
3.28	General Booth Boulevard at the Virginia Aquarium .....	77
3.29	Goodspeed Road at Discovery Road .....	79
3.30	Graham Road at Woodhurst Drive.....	80
3.31	Great Neck Farms.....	83
3.32	Great Neck Manor.....	86
3.33	Harbour Point at San Marcos Lane.....	88
3.34	Haversham Key and Middlemost Key .....	90
3.35	Island Lane.....	92
3.36	Lakeside Avenue at 52 <sup>nd</sup> Street .....	93
3.37	Laskin Road at Little Neck Creek.....	94
3.38	Longstreet Avenue at Hughes Avenue .....	97
3.39	Mill Dam Road at Brighton on the Bay Neighborhood .....	100
3.40	North Great Neck Road at First Colonial Road.....	103
3.41	North Great Neck Road at Great Neck Middle School .....	105
3.42	North Virginia Beach .....	107
3.42.1	<b>Phase 1: Atlantic Avenue at 70th Street</b> .....	107
3.42.2	<b>Phase 2: Bay Colony Drive at Myrtle Drive</b> .....	109
3.42.3	<b>North Virginia Beach Combined Summary</b> .....	111

3.43	Ocean Hills Road at Oakridge Circle .....	112
3.44	Old Dominion Lane and Seward Lane .....	114
3.45	Old Donation Parkway and First Colonial Road at Hilltop .....	116
3.46	Oriole Drive North .....	119
3.47	Oriole Drive South .....	121
3.48	Owls Creek Lane .....	122
3.49	Pinewood Road at Linkhorn Drive .....	124
3.50	Pinewood Road at Willow Drive .....	126
3.51	Preserve Drive at Huntsman Drive .....	127
3.52	Quail Point Road at Covey Street .....	129
3.53	Sea Pines Road at Pacific Avenue .....	131
3.54	Shorehaven Drive and Dey Cove Drive .....	133
3.55	South Bay Shore Drive at Bruton Lane .....	136
3.56	South Birdneck Road at General Booth Boulevard .....	137
3.57	South Birdneck Road at Ocean Breeze Parkway .....	139
3.58	South Birdneck Road at Olds Lane .....	141
3.59	Stratem Court and Brooklyn Avenue .....	143
3.60	Sylvan Lake .....	146
3.61	Tahitian Drive at Mill Dam Road .....	149
3.62	The Reserve at Great Neck .....	151
3.63	Thomas Bishop Lane at Thomas Bishop Court .....	153
3.64	Tottenham Lane at Southall Drive .....	155
4	<b>Conclusion</b> .....	157

## Abbreviations

AACE – Association for the Advancement of Cost Engineering

AAL – Average Annual Loss

ASC – Alternative Selection Criteria

BCR – Benefit-Cost Ratio

BMP – Best Management Practice

BR – Benefit Ratio

CFS – Cubic Feet per Second

CIP – Capital Improvement Program

CLOMR – Conditional Letter of Map Revision

DEQ – Department of Environmental Quality

DPU – Department of Public Utilities (City)

ENR – Engineering News-Record

ER – Easement Required (width available)

ER\* - Easement Required (PWDSM width not available, but improvements can likely be constructed/maintained)

FEMA – Federal Emergency Management Agency

FSI – Formed Suction Intake

GIS – Geographic Information System

HAZUS – FEMA Flood Loss Estimate Software Hazards US

HGL – Hydraulic Grade Line

LiDAR – Light Detection and Radar

LOMR – Letter of Map Revision

LOS – Level of Service

MDM – Master Drainage Model

NAVD88 – North American Vertical Datum of 1988

NOAA – National Oceanic and Atmospheric Administration

NPV – Net Present Value

NWI – National Wetlands Inventory

OPCC – Opinion of Probable Construction Cost

PA – Property Acquisition Required

PPC – Project Performance Criteria

PSMS – Primary Stormwater Management System

PWDSM – Public Works Design Standards Manual (2020)

PW-SWEC – Public Works Stormwater Engineering Center

ROW – Right-of-Way

SFA – Simulated Flooding Area

SGA – Strategic Growth Area

SLR – Sea Level Rise

SWMM – Stormwater Management Model

SWMP – Stormwater Master Plan

TMDL – Total Maximum Daily Load

USACE – United States Army Corps of Engineers

USC – United States Code

USGS – United States Geological Survey

VMRC – Virginia Marine Resources Commission

VDOT – Virginia Department of Transportation

VGIN – Virginia Geographic Information Network

VSMP – Virginia Stormwater Management Program

## List of Figures

Figure 1. City Drainage Basins Location Map.....	2
Figure 2. Broad Bay and Oceanfront Drainage Basins Overall Map .....	3
Figure 3. Stormwater Master Plan Process Flowchart .....	4
Figure 4. SFAs Overlapping Existing CIPs and excluded from the Broad Bay and Oceanfront SWMP .....	6
Figure 5. Broad Bay and Oceanfront SWMP Detailed SFA Map.....	13
Figure 6. Location Map of Alanton Drive at Valhalla Arch SFA .....	14
Figure 7. Location Map of Seafarer Cove, Cutty Sark Road at East Road, Bay Point Drive at Echo Cove, and Cutty Sark Road at Columbia Road SFAs .....	16
Figure 8. Location Map of North Alanton Drive at Linkhorn Bay, Whiteside Lane at Ashley Drive, Franklin Drive at North Woodhouse Road, Cooper Road at Whittier Road, and Ashley Drive at Stephens Road SFAs.....	19
Figure 9. Location Map of Atlantic Avenue at 24 <sup>th</sup> Street Park SFA .....	22
Figure 10. Location Map of Atlantic Avenue at 28 <sup>th</sup> Street SFA .....	24
Figure 11. Location Map of Atlantic Avenue and 33 <sup>rd</sup> Street SFA .....	26
Figure 12. Location Map of Atlantis Drive, Beach Town Drive, Hope Avenue at North Birdneck Road, and Norfolk Avenue at Marshview Drive SFAs .....	28
Figure 13. Location Map of Bay Breeze Drive and Sunset Point SFA .....	33
Figure 14. Location Map of Chumley Road at Wythe Lane, Ditchley Road at Bruton Lane, Greentree Arch, and East Bay Shore Drive at Greentree Arch SFAs.....	35
Figure 15. Location Map of Bay Drive at Linkhorn Drive SFA .....	38
Figure 16. Location Map of Bay Island SFA .....	39
Figure 17. Location Map of Bobolink Drive North SFA .....	40
Figure 18. Location Map of Bobolink Drive South SFA .....	41
Figure 19. Location Map of Brant Road at Huntsman Drive SFA .....	42
Figure 20. Location Map of Broad Bay Colony SFA .....	44
Figure 21. Location Map of Caton Drive at Will O Wisp Drive SFA .....	45
Figure 22. Location Map of Hunt Meet Circle, Oxen Court, Duke of Norfolk Quay, North Great Neck Road at Lords Landing, Greensward Quay, and Lords Landing SFAs .....	47
Figure 23. Location Map of Coastal Drive at Virginia Dare Drive, Kerry Lane at Croatan Road, South Maryland Avenue, Virginia Dare Drive at Croatan Hills Drive, Virginia Dare Drive at Twilight Lane, Surfside Avenue at Croatan Hills Drive, Croatan Court at Croatan Road, Fort Raleigh Drive at Bushnell Drive, and Fort Raleigh Drive at Lake Christine SFAs.....	50
Figure 24. Location Map of Croatan Beach Park SFA.....	61
Figure 25. Location Map of Crystal Lake Circle SFA.....	63
Figure 26. Location Map of Curlew Place SFA.....	64
Figure 27. Location Map of Duke of Norfolk Quay at Green Hill Road SFA .....	65
Figure 28. Location Map of East Bay Shore Drive at Cavalier Drive SFA .....	67
Figure 29. Location Map of Fielding Lane at Gregory Lane SFA .....	69
Figure 30. Location Map of First Colonial Road at Camelot Drive SFA .....	71
Figure 31. Location Map of Fishermans Bend at Harbour Point SFA .....	73
Figure 32. Location Map of Frazee Lane at South Birdneck Road SFA.....	75
Figure 33. Location Map of General Booth Boulevard at the Virginia Aquarium SFA.....	77
Figure 34. Location Map of Goodspeed Road at Discovery Road SFA .....	79
Figure 35. Location Map of Graham Road at Woodhurst Drive SFA .....	80
Figure 36. Location Map of Middleburg Road at Paramore Drive and North Great Neck Road at Coach Lane SFAs.....	83
Figure 37. Location Map of Great Neck Manor SFA.....	86

Figure 38. Location Map of Harbour Point at San Marcos Lane SFA .....	88
Figure 39. Location Map of Haversham Key and Middlemost Key SFAs .....	90
Figure 40. Location Map of Island Lane SFA.....	92
Figure 41. Location Map of Lakeside Avenue at 52 <sup>nd</sup> Street SFA .....	93
Figure 42. Location Map of 33 <sup>rd</sup> Street at Arctic Avenue, Laskin Road Roundabout, and 30 <sup>th</sup> and ½ Street and Pacific Avenue SFAs.....	94
Figure 43. Location Map of Longstreet Avenue at Burford Avenue and Longstreet Avenue at Bishop Thoroughgood Avenue SFAs.....	97
Figure 44. Location Map of Mill Dam Forest, Wivenhoe Way at Templeton Lane, Starr Way at Valhalla Archway SFAs.....	100
Figure 45. Location Map of North Great Neck Road at First Colonial Road SFA.....	103
Figure 46. Location Map of North Great Neck Road at Great Neck Middle School SFA .....	105
Figure 47. Location Map of Atlantic Avenue at Shore Drive, Atlantic Avenue at 61 <sup>st</sup> Street, Atlantic Avenue at 49 <sup>th</sup> Street, and Bay Colony Drive at Myrtle Drive SFAs .....	107
Figure 48. Location Map of Ocean Hills Road at Oakridge Circle SFA .....	112
Figure 49. Location Map of Dendron Drive at Old Dominion Lane and Seward Lane at Bailey Lane SFAs .....	114
Figure 50. Location Map of Forest Park and Great Neck Pines, Old Donation Parkway at Calypso Lane, Old Donation Parkway at First Colonial Road, Country Mill Road at First General Parkway SFAs .....	116
Figure 51. Location Map of Oriole Drive North SFA .....	119
Figure 52. Location Map of Oriole Drive South SFA.....	121
Figure 53. Location Map of Owls Creek Lane SFA .....	122
Figure 54. Location Map of Pinewood Road at Linkhorn Drive SFA .....	124
Figure 55. Location Map of Pinewood Road at Willow Drive SFA.....	126
Figure 56. Location Map of Preserve Drive at Huntsman Drive SFA .....	127
Figure 57. Location Map of Quail Point Road at Covey Street SFA.....	129
Figure 58. Location Map of Sea Pines Road at Pacific Avenue SFA .....	131
Figure 59. Location Map of Shorehaven Drive and Dey Cove Drive and Dey Cove Drive at Chamberling Key SFAs .....	133
Figure 60. Location Map of South Bay Shore Drive at Bruton Lane SFA.....	136
Figure 61. Location Map of South Birdneck Road at General Booth Boulevard SFA .....	137
Figure 62. Location Map of South Birdneck Road at Ocean Breeze Parkway SFA .....	139
Figure 63. Location Map of Olds Lane and South Birdneck Road at Bells Road SFAs .....	141
Figure 64. Location Map of Stratem Court and Brooklyn Avenue SFAs .....	143
Figure 65. Location Map of Sylvan Lake SFA.....	146
Figure 66. Location Map of Tahitian Drive at Mill Dam Road SFA .....	149
Figure 67. Location Map of The Reserve at Great Neck SFA .....	151
Figure 68. Location Map of Thomas Bishop Lane at Thomas Bishop Court SFA.....	153
Figure 69. Location Map of Tottenham Lane at Southall Drive SFA .....	155
Figure 70. Broad Bay and Oceanfront SWMP Tier 1 and Tier 2 Projects .....	159

**List of Tables**

Table 1. Alanton Drive at Valhalla Arch Project Summary ..... 15

Table 2. Alanton Estates and Baycliff Project Summary ..... 18

Table 3. Alanton Neighborhood Project Summary ..... 21

Table 4. Atlantic Avenue at 24<sup>th</sup> Street Park Project Summary ..... 23

Table 5. Atlantic Avenue at 28<sup>th</sup> Street Project Summary ..... 25

Table 6. Atlantic Avenue at 33<sup>rd</sup> Street Project Summary ..... 27

Table 7. Norfolk Avenue at Marshview Drive Project Summary ..... 29

Table 8. Atlantis Drive Project Summary ..... 32

Table 9. Atlantis Drive Project Summary ..... 32

Table 10. Bay Breeze Drive at Sunset Point Project Summary ..... 34

Table 11. Bay Colony Project Summary ..... 37

Table 12. Brant Road at Huntsman Drive Project Summary ..... 43

Table 13. Caton Drive at Will O Wisp Drive Project Summary ..... 46

Table 14. Chelsea and Green Hill Farms Neighborhood Project Summary ..... 49

Table 15. Kerry Lane at Croatan Road Project Summary ..... 51

Table 16. South Maryland Avenue Project Summary ..... 53

Table 17. Virginia Dare Drive at Croatan Hills Drive Project Summary ..... 54

Table 18. Croatan Lot Pump Station at Croatan Beach Project Summary ..... 55

Table 19. Christine Drive at Croatan Road Project Summary ..... 57

Table 20. Twilight Lane at Vanderbilt Avenue Project Summary ..... 58

Table 21. Surfside Avenue at Virginia Dare Drive Project Summary ..... 59

Table 22. Croatan Beach Neighborhood Project Summary ..... 60

Table 23. Croatan Beach Park Project Summary ..... 62

Table 24. Duke of Norfolk Quay at Green Hill Road Project Summary ..... 66

Table 25. East Bay Shore Drive at Cavalier Drive Project Summary ..... 68

Table 26. Fielding Lane at Gregory Lane Project Summary ..... 70

Table 27. First Colonial Road at Camelot Drive Project Summary ..... 72

Table 28. Fishermans Bend Project Summary ..... 74

Table 29. Frazee Lane at South Birdneck Road Project Summary ..... 76

Table 30. General Booth Boulevard at the Virginia Aquarium Project Summary ..... 78

Table 31. Graham Road at Woodhurst Drive Project Summary ..... 82

Table 32. Great Neck Farms Project Summary ..... 85

Table 33. Great Neck Manor Project Summary ..... 87

Table 34. Harbour Point at San Marcos Lane Project Summary ..... 89

Table 35. Haversham Key and Middlemost Key Project Summary ..... 91

Table 36. Laskin Road at Little Creek Project Summary ..... 96

Table 37. Longstreet Avenue at Hughes Avenue Project Summary ..... 99

Table 38. Mill Dam Road at Brighton on the Bay Project Summary ..... 102

Table 39. North Great Neck Road at First Colonial Road Project Summary ..... 104

Table 40. North Great Neck Road at Great Neck Middle Project Summary ..... 106

Table 41. Atlantic Avenue at 70<sup>th</sup> Street Project Summary ..... 109

Table 42. Bay Colony Drive at Myrtle Drive Project Summary ..... 111

Table 43. North Virginia Beach Project Summary ..... 111

Table 44. Ocean Hills Road at Oakridge Circle Project Summary ..... 113

Table 45. Old Dominion Road and Seward Lane Project Summary ..... 115

Table 46. Old Donation Parkway and First Colonial Road at Hilltop Project Summary ..... 118

Table 47. Oriole Drive North SFA Project Summary ..... 120

Table 48. Owls Creek Lane Project Summary.....	123
Table 49. Pinewood Road at Linkhorn Drive Project Summary.....	125
Table 50. Preserve Drive at Huntsman Drive Project Summary.....	128
Table 51. Quail Point Road at Covey Street Project Summary.....	130
Table 52. Sea Pines Road at Pacific Avenue Project Summary.....	132
Table 53. Shorehaven Drive at Dey Cove Drive Project Summary.....	135
Table 54. South Birdneck Road at General Booth Boulevard Project Summary.....	138
Table 55. South Birdneck Road at Ocean Breeze Parkway Project Summary.....	140
Table 56. South Birdneck Road at Olds Lane Project Summary.....	142
Table 57. Stratem Court and Brooklyn Avenue Project Summary.....	145
Table 58. Sylvan Lake Project Summary.....	148
Table 59. Tahitian Drive at Mill Dam Road Project Summary.....	150
Table 60. The Reserve at Great Neck Project Summary.....	152
Table 61. Thomas Bishop Lane at Thomas Bishop Court Project Summary.....	154
Table 62. Tottenham Lane at Southall Drive Project Summary.....	156
Table 63. Broad Bay and Oceanfront SWMP Tier 1 Projects.....	160
Table 64. Broad Bay and Oceanfront SWMP Tier 2 Projects.....	161
Table 65. Broad Bay and Oceanfront SWMP Tier 3 Projects.....	163

## List of Appendices

A	Benefit-Cost Analysis (BCA) Methodology
B-1	Alanton Drive at Valhalla Arch
B-2	Alanton Estates and Baycliff
B-3	Alanton Neighborhood
B-4	Atlantic Avenue at 24 <sup>th</sup> Street Park
B-5	Atlantic Avenue at 28 <sup>th</sup> Street
B-6	Atlantic Avenue at 33 <sup>rd</sup> Street
B-7	Atlantis Drive and Norfolk Avenue
B-7-1	Phase 1: Norfolk Avenue at Marshview Drive
B-7-2	Phase 2: Atlantis Drive
B-8	Bay Breeze Drive at Sunset Point
B-9	Bay Colony
B-10	Bay Drive at Linkhorn Drive
B-11	Bay Island
B-12	Bobolink Drive North
B-13	Bobolink Drive South
B-14	Brant Road at Huntsman Drive
B-15	Broad Bay Colony
B-16	Caton Drive at Will O Wisp Drive
B-17	Chelsea and Green Hill Farms Neighborhood
B-18	Croatan Beach Neighborhood
B-18-1	Phase 1A: Kerry Lane at Croatan Road
B-18-2	Phase 1B: South Maryland Avenue
B-18-3	Phase 1C: Virginia Dare Drive at Croatan Hills Drive
B-18-4	Phase 1D: Croatan Lot Pump Station at Croatan Beach
B-18-5	Phase 2A: Christine Drive at Croatan Road
B-18-6	Phase 2B: Twilight Lane at Vanderbilt Avenue
B-18-7	Phase 3: Surfside Avenue at Virginia Dare Drive
B-19	Croatan Beach Park
B-20	Crystal Lake Circle
B-21	Curlew Place
B-22	Duke of Norfolk Quay at Green Hill Road
B-23	East Bayshore Drive at Cavalier Drive
B-24	Fielding Lane at Gregory Lane
B-25	First Colonial Road at Camelot Drive
B-26	Fishermans Bend at Harbour Point
B-27	Fraze Lane at South Birdneck Road
B-28	General Booth Boulevard at the Virginia Aquarium
B-29	Goodspeed Road at Discovery Road
B-30	Graham Road at Woodhurst Drive
B-31	Great Neck Farms
B-32	Great Neck Manor
B-33	Harbour Point at San Marcos Lane
B-34	Haversham Key and Middlemost Key
B-35	Island Lane
B-36	Lakeside Avenue at 52 <sup>nd</sup> Street
B-37	Laskin Road at Little Neck Creek
B-38	Longstreet Avenue at Hughes Avenue
B-39	Mill Dam Road at Brighton on the Bay Neighborhood
B-40	North Great Neck Road at First Colonial Road
B-41	North Great Neck Road at Great Neck Middle School
B-42	North Virginia Beach
B-42-1	Phase 1: Atlantic Avenue at 70 <sup>th</sup> Street
B-42-2	Phase 2: Bay Colony Drive at Myrtle Drive

B-43 Ocean Hills Road at Oakridge Circle  
B-44 Old Dominion Lane and Seward Lane  
B-45 Old Donation Parkway and First Colonial Road at Hilltop  
B-46 Oriole Drive North  
B-47 Oriole Drive South  
B-48 Owls Creek Lane  
B-49 Pinewood Road at Linkhorn Drive  
B-50 Pinewood Road at Willow Drive  
B-51 Preserve Drive at Huntsman Drive  
B-52 Quail Point Road at Covey Street  
B-53 Sea Pines Road at Pacific Avenue  
B-54 Shorehaven Drive and Dey Cove Drive  
B-55 South Bay Shore Drive at Bruton Lane  
B-56 South Birdneck Road at General Booth Boulevard  
B-57 South Birdneck Road at Ocean Breeze Parkway  
B-58 South Birdneck Road at Olds Lane  
B-59 Stratem Court and Brooklyn Avenue  
B-60 Sylvan Lake  
B-61 Tahitian Drive at Mill Dam Road  
B-62 The Reserve at Great Neck  
B-63 Thomas Bishop Lane at Thomas Bishop Court  
B-64 Tottenham Lane at Southall Drive

# Introduction



# 1 Introduction

The City of Virginia Beach (City) is located in a low-lying coastal area bordered by the Chesapeake Bay and the Atlantic Ocean. Over the years, flooding from relatively minor storm events has been a challenge for many areas of the City. Rain events can flood roadways—causing them to become impassable—and even damage homes and businesses.

In an effort to combat this challenge, the City of Virginia Beach Public Works Stormwater Engineering Center (PW-SWEC) is updating the *Comprehensive Stormwater Management Plan* (CDM 1990) to address the growing stormwater challenges within the City. The process contains two components: a Master Drainage Model (MDM) and a Comprehensive Stormwater Master Plan (SWMP). The MDM consists of a City-wide stormwater Master model that contain all the major drainage networks in the City. The City uses this model to identify the areas where flooding occurs, known as Simulated Flooding Areas (SFAs). The purpose of the SWMP is to develop and prioritize projects to improve the SFAs that are identified in the MDM.

SFAs are categorized by the storm event that begins to cause flooding, such as 1-, 2-, 10-, or 100-year storm. These categories indicate how often a storm event, and its associated flooding, are likely to happen. For example, a 1-year storm event has a 100 percent chance of occurring each year, whereas a 100-year storm event has a one percent chance (or 1 in 100 chance) of occurring in any given year.

The City has five major outfalls: Elizabeth River, Little Creek, Lynnhaven River, the Atlantic Ocean, and the Southern Rivers. These five outfalls are subdivided into 15 drainage basins. Consequently, stormwater runoff from a storm event drains into one of the 15 drainage basins and ultimately into one of the five major outfalls, no matter where it falls in the City. Figure 1 presents the 15 drainage basins and identifies the locations of the Broad Bay and Oceanfront Drainage Basins. The Broad Bay and Oceanfront Drainage Basins were considered simultaneously and combined into one SWMP. Figure 2 gives an overview of the extent of the Broad Bay and Oceanfront Drainage Basins.

The first step in the SWMP was to develop a standardized set of criteria based on consensus from key stakeholders. The Alternative Selection Criteria (ASC) and the Project Performance Criteria (PPC) were used to identify and prioritize improvements for each SFA. Refer to the Virginia Beach Stormwater Master Plan Criteria Technical Memorandum (October 2019) for further detail on how the City developed these criteria.

To ensure the applicability and soundness of the criteria, they were tested on a sample of proposed stormwater projects. Multiple alternatives were created for each SFA, and the ASC was applied to determine the highest ranked alternative. The highest-ranked alternative then became a project. A cost estimate, Benefit-Cost Ratio (BCR), and Benefit Ratio (BR) was determined for each project, and the projects were evaluated using the PPC. The last step was to calculate a combined ranking score for each project, which is the product of the selected ASC, PPC, BCR, and BR. The combined ranking score was used to separate the projects into three tiers. Upon confirming the criteria and the SWMP process as summarized above, the same process is being deployed to the remaining drainage basins and is illustrated in Figure 3 below.

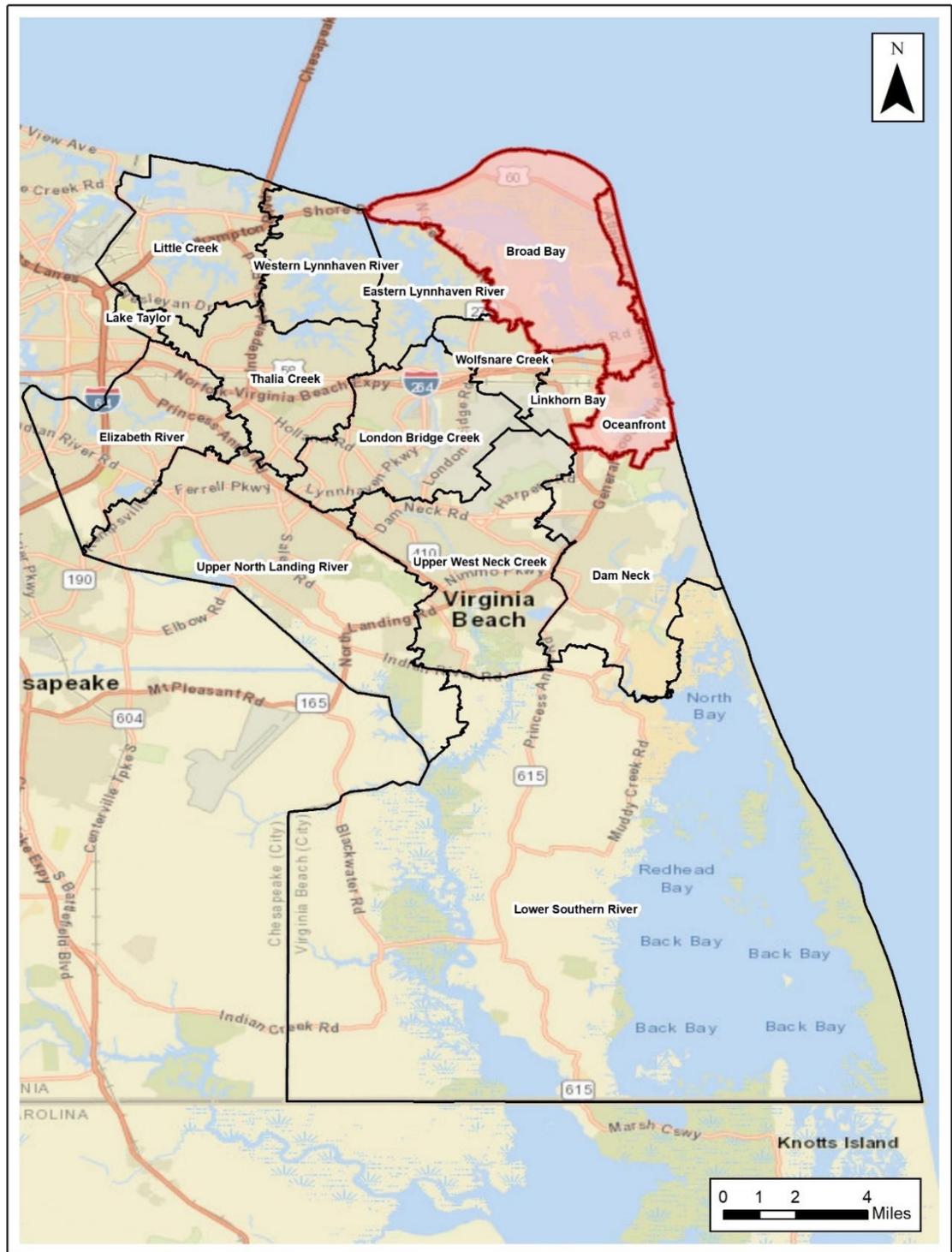


Figure 1. City Drainage Basins Location Map



Figure 2. Broad Bay and Oceanfront Drainage Basins Overall Map

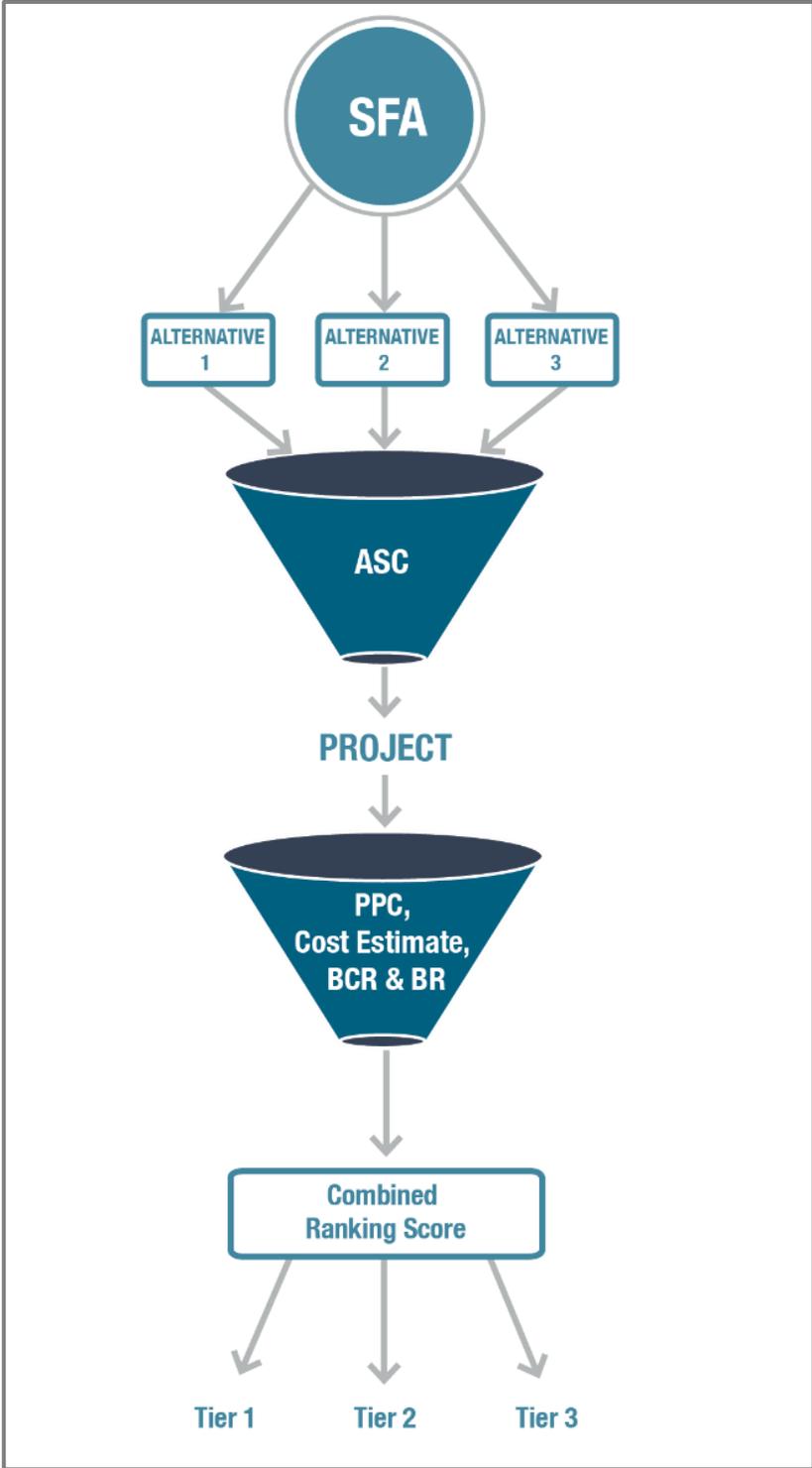


Figure 3. Stormwater Master Plan Process Flowchart

# Methodology and Assumptions



## 2 Methodology and Assumptions

### 2.1 Hydraulic Modeling and Design

The existing conditions for the alternative analysis associated with the Broad Bay and Oceanfront SWMP were based on the City Stormwater Management Model (SWMM) for the Broad Bay and Oceanfront Drainage Basins, part of the MDM, updated in May 2021. Throughout the process of developing the alternatives, several adjustments were made to the existing condition in the master model in consultation with City staff. Some examples of modifications included updating stormwater pipes per recent Geographic Information System (GIS) data, survey information, and site observations. All other portions of the MDM were based on 2013 Light Detection and Ranging (LiDAR) information. Changes to the existing model and the proposed alternative modeling were consistent with the City's stormwater modeling development methodology, as described in the *Stormwater Model Development Methodology Final* (March 2020) by CDM Smith.

Flooding depths were mapped for the existing and proposed project conditions. The depths were calculated using peak Hydraulic Grade Line (HGL) values and comparing them to existing land surface elevations represented by LiDAR information for each subcatchment. All flood depths shown are greater than one-tenth of a foot (1.2 inches).

Individual inlet capacity was not considered in the hydraulic analysis. As a result, upon more detailed design of the proposed projects, the extent of improvements may need to increase to comply with design requirements for gutter spread. This may affect the opinions of probable construction cost (OPCC) developed as part of the SWMP.

Capital Improvement Program (CIP) projects currently under design that overlap with SFAs were not included in the alternative analysis. The objective of the SWMP is to identify and rank projects that resolve SFAs across the entire City. Tracking individual CIP project design details and status as well as schedules for implementation was a hindrance towards accomplishing this objective. As a result, preliminary designs of the CIP projects (as-is) were not considered as potential alternatives, nor were the proposed conditions of these projects considered during the development of SWMP alternatives and OPCCs; however, where overlaps do exist, the potential opportunity to construct multiple projects simultaneously was noted in the applicable project summaries and scoring. As projects are selected for design and construction from the SWMP, coordination is recommended across City departments to identify projects and improvements that can be constructed concurrently.

Similarly, other areas were excluded entirely from the SWMP as comprehensive planning and design efforts were already in progress, and including these areas would duplicate those efforts. Notable projects within the Broad Bay and Oceanfront Drainage Basins include the North Lake Holly Watershed (CIP 7005000), South Lake Holly Watershed (CIP 7016000), Central Resort Drainage Improvements (CIP 7041000), Central Resort District – Redirect Stormwater to 16<sup>th</sup> Street Pump Station (CIP 7084000), and Laskin Road Phase I-B (CIP 2156000). The 48 SFAs within these CIP limits, shown in Figure 4, were not included in the SWMP and were assumed to be mitigated as part of other planning and design efforts or will be analyzed, after project construction, in a future update to the Broad Bay and Oceanfront SWMP.

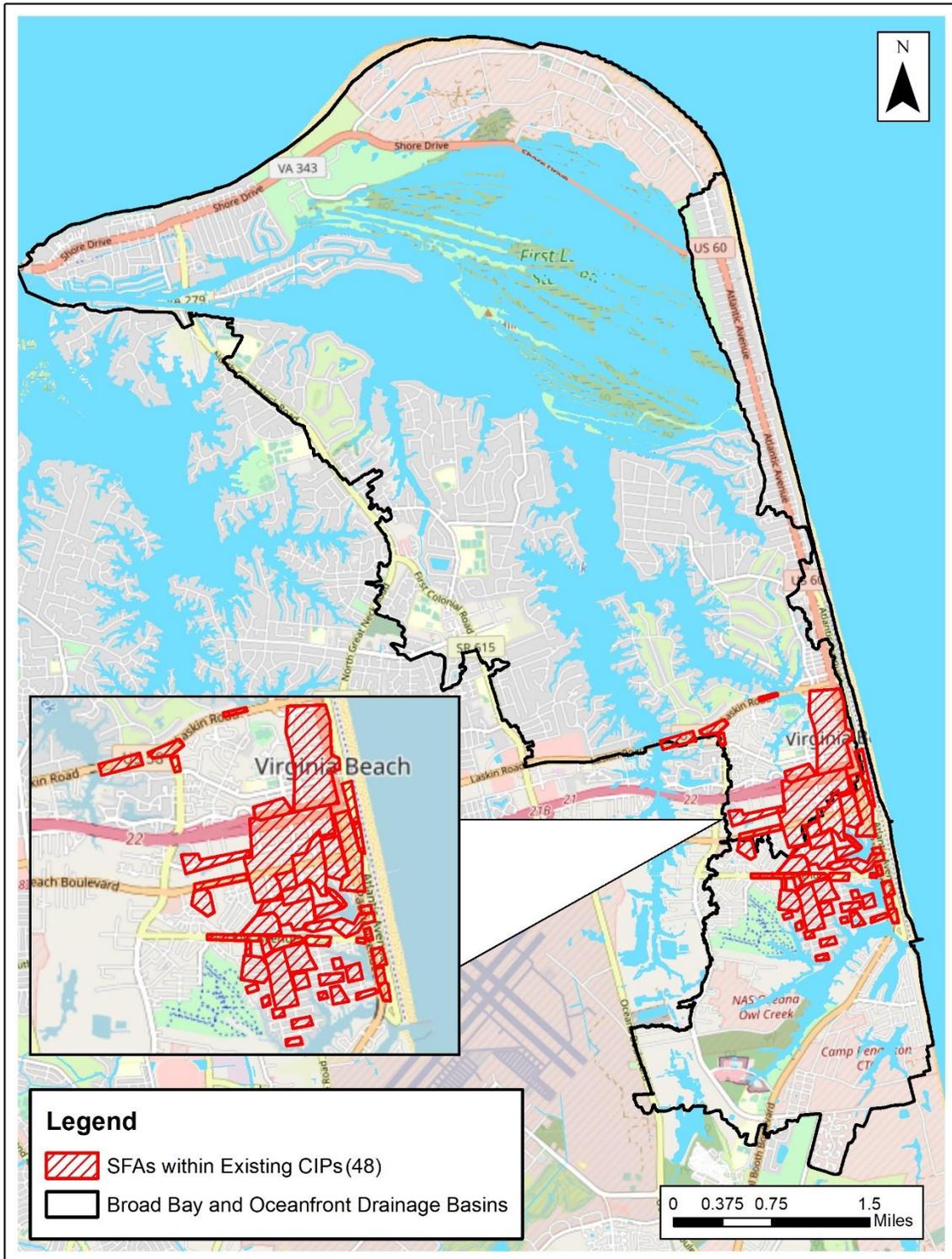


Figure 4. SFAs Overlapping Existing CIPs and excluded from the Broad Bay and Oceanfront SWMP

### 2.1.1 Pump Modeling and Design

In the Broad Bay and Oceanfront SWMP, stormwater pumps and lift stations were included in several alternative designs.

Assumptions that governed the design of the pumps included:

- Pumps were modeled in PCSWMM with typical pump curves.
- Each pump was designed to discharge approximately 100-180 cubic feet per second (cfs).
- The lift station footprint was based on the number of pumps needed for the given alternative. It was assumed the pumps are programmed with different start elevations and the same stop elevation, so the lead-on pump alternates for each cycle, providing resiliency and a factor of safety against pump failure.
- All pumps have formed suction intake (FSI), which reduces the total depth and footprint of the station. FSI also requires the station to be directly adjacent to the waterbody.
- Continuous pumping was considered for configurations that allow for traditional float-based operations. In these cases, pumps are activated in storms less than the 100-year storm event and do not require real-time weather monitoring and remote pump controls.

Assumptions that governed ocean outfalls included:

- New ocean outfalls were modeled as pressurized pipes with backflow preventers, consistent with other existing pressurized ocean outfalls in the model.

## 2.2 **Level of Service**

Alternatives developed for the primary stormwater management system (PSMS) improvements, for each SFA, achieved a consistent design level of service (LOS). Up to three alternatives were developed for each SFA. Alternatives were only scored with the ASC if it could be demonstrated that they achieved the LOS summarized in Sections 2.2.1 and 2.2.2. For some SFAs, three alternatives could not be developed that achieved the LOS, and/or engineering judgment eliminated the alternative for reasons of cost, constructability, etc., without having to use the ASC. The summaries for each SFA include those alternatives considered with an official ASC score and those alternatives that did not achieve the required LOS or were eliminated. The assumptions made in defining the LOS are described below.

### 2.2.1 Application of the Public Works Design Standards Manual (PWDSM) to LOS

The LOS for the stormwater drainage network was based on the requirements of the PWDSM (June 2020). It should be noted that the PWDSM is a living document and will be updated over time. The following information was considered for the LOS:

- Design storms were based on the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 rainfall depth with a 20 percent increase above values last updated in 2006.
- Existing SFAs were determined with a 20 percent increase in rainfall without incorporating sea-level rise (SLR).

- No flooding shall occur during the 10-year storm event. The maximum HGL shall remain below the rim elevation of drop inlet structures and below the flowline for curb inlet structures.
- The crown of the road shall be visible during the 100-year storm event.

During the development of the Broad Bay and Oceanfront SWMP, PW-SWEC made the decision to implement all Sea Level Wise City-wide solutions for all SWMPs documented in the *Virginia Beach Sea Level Wise Adaptation Strategy Report* (March 2020). While City-wide solutions will eliminate SLR influence for the 100-year storm event, the City-wide solutions will not be closed for more frequent storm events. Full solutions were still conceptualized for the 10-year storm event with SLR for each SFA. To eliminate duplicate efforts, the alternatives and projects initially developed with SLR for the 100-year storm event, prior to this decision, were not revised as the higher tailwater elevation results in a more conservative design. However, many of these projects were ultimately updated to no longer consider SLR for the 100-year storm event during the normal course of addressing comments and producing this report.

Critical infrastructure, as defined in the PWDSM, shall be designed to incorporate 3.0 feet SLR. Given the assumed implementation of the City-wide solutions, the 3.0 feet SLR scenario was only applied to the 10-year storm event for critical infrastructure design. For SWMP efforts, reducing flooding at sanitary sewer pump stations is considered a benefit, but pump stations were not designed to incorporate 3.0 feet SLR. New City sanitary sewer pump stations will account for City model flood elevations to establish finished floor elevations. The Department of Public Utilities (DPU) implemented waterproofing improvements to existing sanitary sewer systems and, as funding is available, plans to install generators at each pump station.

### 2.2.2 Additional LOS Assumptions and Considerations

Additional LOS assumptions were developed during the application of the PWDSM requirements to the SWMP analysis. These additional assumptions and considerations included:

- All elevations were in the North American Vertical Datum of 1988 (NAVD88) unless otherwise specified.
- The design storm and tide joint probability pairs were simplified to reduce the number of required model runs. All alternative designs were based on the following joint probability pairs:
  - 10-year rain and 1-year tide
  - 100-year rain and 3-year tide
- Some projects solved multiple SFAs with different existing flood frequencies. In these cases, the project was scored based on the SFA with the highest flood frequency.
- Where a road is superelevated, a minimum of one lane shall be passable during the 100-year storm event.
- Secondary evacuation routes were not considered critical infrastructure. Secondary evacuation routes were designed for the 10-year storm event with 1.5 feet SLR and checked with the 10-year storm event with 3.0 feet SLR.
- Habitable structure flooding was defined as the intersection of GIS building footprints with the mapped flood extents.

### 2.2.3 Variances

For SFAs highly susceptible to tailwater conditions, meeting PWDSM requirements may not be practicable. In these conditions, alternatives were provided that improve the existing condition, to the maximum practical extent, but may not meet all PWDSM requirements:

- A 10-year LOS maintains the HGL in the system in the 10-year storm event with 1.5 feet SLR and resolves any habitable structure flooding with less than 6 inches of flooding above the crown of the road in the 100-year storm event with no SLR.
- A 50-year LOS maintains the HGL in the system for the 10-year storm event with 1.5 feet SLR and resolves any habitable structure flooding with less than 3 inches of flooding above the crown of the road in the 100-year storm event with no SLR.
  - A 50-year LOS is assumed in these cases because the 50-year models are not part of the SWMP.
  - This approach provides a means to have a lower PPC score for a project that allows minimal flooding above the crown of road (less than 3 inches, 50-year LOS) compared to one that provides a visible crown (100-year LOS).
- Six inches of flooding above the crown of the road is considered the maximum passable depth above the crown of the road for emergency vehicles.
- Three inches of flooding above the crown of the road is considered the maximum passable depth above the crown of the road for all other vehicles.

## 2.3 **Alternative and Project Scoring**

Alternatives were scored based on criteria in the ASC and projects were scored with the PPC. The assumptions and considerations for scoring developed during the Broad Bay and Oceanfront SWMP process included:

- Environmental Permitting — The level of effort required to obtain permits from various agencies was dependent on the definitions and regulations surrounding wetlands, which are subject to change. The approximate locations of wetlands were determined using the National Wetland Inventory (NWI) Mapper from the U.S. Fish and Wildlife Service. The scoring in this category for the Broad Bay and Oceanfront SWMP was based on the 2020–2021 state and federal wetland regulations.
  - Adding new MS4 outfalls required minimal effort to update MS4 program related documents and would be undertaken concurrent with detailed design of improvements; therefore, new MS4 outfalls do not have an adverse impact on project scoring.
  - The proposed force main outfalls across the Atlantic Ocean beaches will require coordination with both the United States Army Corps of Engineers (USACE) Regulatory Branch and the USACE Operations Branch, as the beach is part of the Virginia Beach Hurricane and Storm Damage Reduction Project. This coordination is required under Title 33 of the United States Code (USC) Section 408 to ensure these improvements do not jeopardize the continued operation of the Congressionally authorized federal project. The outfalls themselves can be authorized by the USACE Regulatory Branch under a Nationwide Permit 7.
  - Based on preliminary discussions with Virginia Marine Resources Commission (VMRC), where existing shoreline structures such as bulkheads require replacement to accommodate drainage infrastructure improvements, it was assumed that “in-kind” replacement will be permitted by the Virginia

Beach Wetlands Board and natural shoreline stabilization techniques will not be required.

- Land Acquisition/Available Easements – Easement acquisition on federally owned property was minimized. However, easement acquisition on federal property was determined to be required in a limited number of projects in this SWMP. These projects were discussed with PW-SWEC and easement acquisition on federal property was determined to be necessary to meet the PWDSM.
- Other Accrued Benefits — The scoring for this category did not take into consideration pending neighborhood storm drain rehabilitation projects. Coordination with Public Works Operations indicated that these projects move through planning and construction within two to three years. Accounting for benefits associated with overlapping projects is not recommended based on the anticipated differences in implementation frequency between this program and the SWMP; however, as projects are selected for implementation from the SWMP, coordination with Public Works Operations is recommended to adjust upcoming project prioritization accordingly.
- As a result of the formal adoption of the PWDSM standards, the Broad Bay and Oceanfront SWMP includes SFAs from the 1-year storm event. The PPC scoring required adjustment to include the benefits of solving flooding for 1-year storm events; however, the Linkhorn Bay Stormwater Master Plan did not account for 1-year SFAs because it was initiated prior to the adoption of the PWDSM. To account for the additional benefit of resolving lower-frequency SFAs and avoiding re-scoring projects in Linkhorn Bay, the total PPC score increased from 10 to 14.4. This scoring methodology is expected to be maintained throughout the remaining drainage basins.

## 2.4 Project Figures

Figures for each project are included in the appendices to convey the conceptual design. The following assumptions and clarifications should be noted:

- In some cases, the partial or total acquisition of public and private property was required for additional easements to increase existing pipes and channels or for the construction of stormwater best management practices (BMPs). These locations, shown graphically in the figures, are conceptual in nature and subject to changes based on additional information that may be obtained during a more detailed design.
- The type of acquisition is differentiated on the figures as easement required (ER and ER\*) and property acquisition (PA).
  - Improvements with an ER\* designation indicate locations that do not have adequate space for the full easement width, as required in the PWDSM, based on the size and depth of the proposed pipe or other requirements. However, in these cases, there is available space to acquire some additional easement as well as the space needed to install the pipe or other improvements. Where feasible, these situations were avoided by proposing parallel systems where additional room was available to acquire the minimum easement widths that are required by the PWDSM.
  - Improvements with an ER designation indicate that space is available to acquire the full easement width required by PWDSM based on the size and depth of the proposed pipe or other requirements.
  - Improvements with a PA designation indicate that acquisition of the entire or portions of the parcel is required for the proposed improvements.

## 2.5 Opinions of Probable Construction Cost (OPCC)

The OPCCs represent a Class 3 Estimate as defined by the Association for the Advancement of Cost Engineering (AACE) International recommended practice No. 18R-97. These estimates are based on conceptual designs, limited by little or no survey or geotechnical information. Street and surface elevations used for cost estimating are based on Virginia LiDAR, which includes data from NOAA, United States Geological Survey (USGS), and Virginia Geographic Information Network (VGIN). All costs are reported in 2021 dollars and the City will need to account for inflation when projecting required CIP funding. The 20-city average *Engineering News-Record* (ENR) construction cost index of 12481, the average index for December 2021 should be used as a baseline for future inflation calculations. Unit costs are based on a combination of current regional averages, recent construction bids available to the engineer, and engineering judgment. All construction cost subtotals are rounded up to the nearest \$10,000.

In some cases, the stormwater BMP chosen for SFAs, when additional runoff storage was required, was a Level 2 Wet Pond, as specified in the Virginia Department of Environmental Quality (DEQ) BMP Clearinghouse. Wet ponds are recommended BMPs for areas, such as Virginia Beach, with low topography and high groundwater tables. Level 2 Wet Ponds are well-suited for large drainage areas, maximize the amount of nutrients removed for water quality credit, and can provide significant dry storage volume to mitigate flooding. All components of Level 2 Wet Ponds were incorporated into the OPCCs as several lump sum items. These lump sum items include quantities such as excavation and grading, cell divisions, wetlands, and aeration. Quantities were extrapolated from the stage-storage information and surface area of the BMP as estimated using GIS and the SWMM model. Other DEQ BMPs were considered in some locations and similar lump sum quantities were used for these BMPs. For example, underground detention basins were considered in the event above-ground storage was not an option.

Costs for pump and lift stations were derived from recent and historic City project cost data compiled and reviewed by City staff. For lift stations that outflow 30 cfs or less, a unit cost of \$95,000 per cfs was assumed. Lift stations that outflow over 30 cfs assumed a unit cost of \$60,000 per cfs. Pressurized ocean outfalls were itemized separately from other pipe outfalls and based on the North Beach Storm Drainage Pump Station & Ocean Outfall Project (CIP 7-902), adjusted for inflation.

Permanent drainage easement costs were based on the assessed values of the impacted properties. The value of the property was divided by the total square footage to determine an average cost per square foot for the easement. Costs for temporary construction easements were 25 percent of the cost for a permanent easement. A minimum of \$5 and \$1.25 per square foot was assumed for permanent easements and temporary construction easements, respectively. Property acquisition costs were assumed to be twice the 2021 assessed value of the property as reported in the City GIS database. The methodology for determining the costs of permanent and temporary easements is consistent with other recent projects for the City.

Mitigation is typically required for permanent impacts to wetlands. Costs in 2021 for mitigating impacts to tidal wetlands were approximately \$1 million per acre and approximately \$100,000 per acre for non-tidal wetlands. Temporary impacts do not require mitigation and are not included in the cost estimates.

Replacement costs were only included for shoreline structures such as bulkheads when the proposed improvements required a pipe size increase greater than or equal to two standard pipe sizes. When pipe sizes were increased by one pipe size, replacement costs were not included as it was assumed that the existing penetration is structurally reinforced. Furthermore, “new” penetrations through existing bulkheads were avoided when possible.

## 2.6 Benefit-Cost Ratio (BCR) and Benefit Ratio (BR) Calculations

The BCR and BR were calculated for each project. Refer to Appendix A for a detailed description of the BCR and BR methodology.

# Broad Bay and Oceanfront SFAs



### 3 Broad Bay and Oceanfront SWMP SFAs

The analysis and results for each SFA, shown in Figure 5, are summarized below. Project exhibits and other supporting documentation are included in Appendices B-1 through B-64.

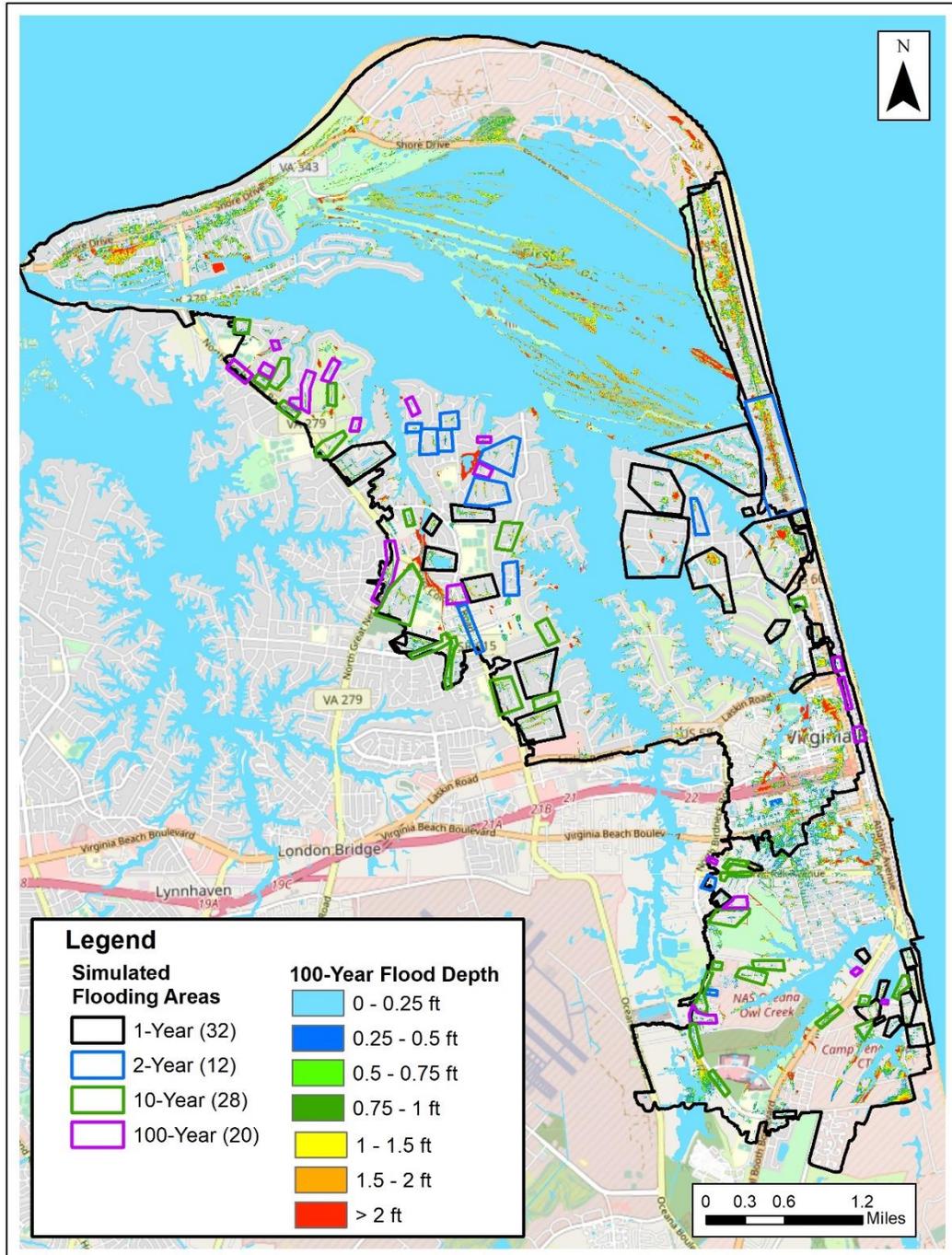


Figure 5. Broad Bay and Oceanfront SWMP Detailed SFA Map

### 3.1 Alanton Drive at Valhalla Arch

#### 3.1.1 SFA Description

Alanton Drive at Valhalla Arch experiences flooding on the streets and adjacent private property. The flooding is due to inadequate stormwater infrastructure and a high tailwater condition in the outfall pipe. The models indicate Alanton Drive at Valhalla Arch begins to experience flooding in the 10-year storm event, as shown in Figure 6.



**Figure 6. Location Map of Alanton Drive at Valhalla Arch SFA**

#### 3.1.2 Project Description

This project upsizes the inadequate pipes at the intersection of Alanton Drive and Valhalla Arch.

#### 3.1.3 Project Benefits

The major benefits of the project include mitigating street flooding on Alanton Drive and Valhalla Arch, as well as the flooding occurring on surrounding private property.

#### 3.1.4 Project Analysis Assumptions

No habitable structures are impacted in the 100-year storm event, so the project is given a BCR value of 1.0. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM.

Easement acquisition will be required to expand the existing drainage easement. Minimal maintenance of traffic will be required along Alanton Drive during construction of the project. It is anticipated that minimal utility relocations will be required during construction of the project.

Minimal effort is anticipated to obtain environmental permits to impact the outfall in nontidal wetlands.

3.1.5 Other Alternatives Scored

Another alternative, as described below, was considered, but was not scored.

3.1.6 Other Alternatives Not Scored

One additional alternative was considered that would add additional storage to the system with pipes in the right-of-way (ROW) to eliminate pipe improvements between residential parcels. However, the amount of storage needed was not feasible with pipes in the ROW and would require more easement acquisition than proposed in Alternative 1. This alternative was not considered further.

3.1.7 Project Analysis Summary

Table 1 below provides a summary of the Alanton Drive at Valhalla Arch project analysis. Refer to Appendix B-1 for project exhibits and supporting documentation.

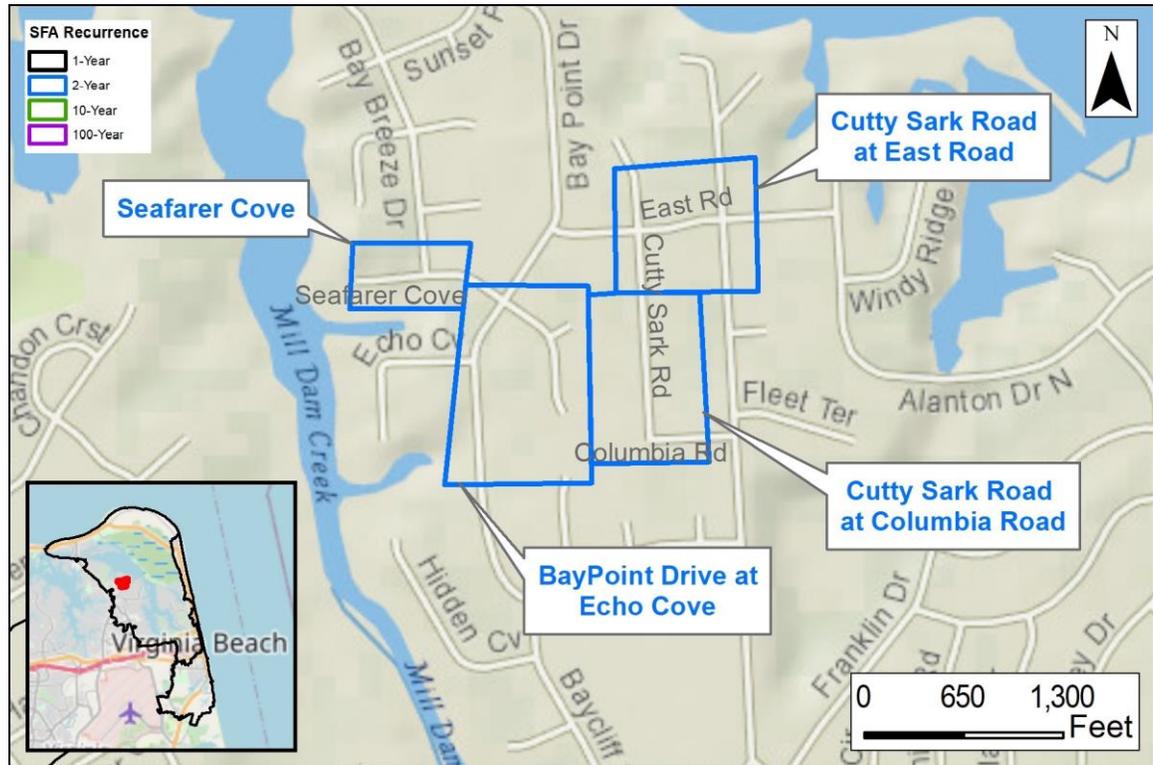
**Table 1. Alanton Drive at Valhalla Arch Project Summary**

<b>SFA Recurrence</b>	10-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	5.52/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	1.18/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0 (no habitable structure flooding)
<b>Project Cost</b>	\$1,290,000

## 3.2 Alanton Estates and Baycliff

### 3.2.1 SFA Description

The Seafarer Cove, Cutty Sark Road at East Road, Bay Point Drive at Echo Cove, and Cutty Sark Road at Columbia Road SFAs are combined into the Alanton Estates and Baycliff project. As all four SFAs are located in the same neighborhood and require similar solutions, combining them into one project provides efficiency in design and construction. Individual SFA locations are shown in Figure 7 and are further described below.



**Figure 7. Location Map of Seafarer Cove, Cutty Sark Road at East Road, Bay Point Drive at Echo Cove, and Cutty Sark Road at Columbia Road SFAs**

#### ***Seafarer Cove SFA***

The Seafarer Cove SFA floods due to limited and undersized stormwater infrastructure. The models indicate Seafarer Cove begins to experience flooding in the 2-year storm event, as shown in Figure 7.

#### ***Cutty Sark Road at East Road SFA***

The Cutty Sark Road at East Road SFA floods due to limited and undersized stormwater infrastructure. The models indicate Cutty Sark Road at East Road begins to experience flooding in the 2-year storm event, as shown in Figure 7.

### ***Bay Point Drive at Echo Cove SFA***

The Bay Point Drive at Echo Cove SFA floods due to limited and undersized stormwater infrastructure. The models indicate Bay Point Drive at Echo Cove begins to experience flooding in the 2-year storm event, as shown in Figure 7.

### ***Cutty Sark Road at Columbia Road SFA***

The Cutty Sark Road at Columbia Road SFA floods due to limited and undersized stormwater infrastructure. In addition, two habitable structures flood in this area. The models indicate Cutty Sark Road at Columbia Road begins to experience flooding in the 2-year storm event, as shown in Figure 7.

#### 3.2.2 Project Description

This project adds stormwater infrastructure throughout the neighborhood. One new outfall is proposed and four additional outfalls are upsized. The proposed outfall is located west of Bay Breeze Cove. The four upsized outfalls are located on the northern end of Cutty Sark Road, to the south of the Echo Cove and Bay Point Drive intersection, and two on the western end of Seafarer Cove. New pipes are proposed on Cutty Stark Road, Seafarer Lane, and Bay Breeze Drive. Existing pipes are also upsized upstream of the outfalls.

#### 3.2.3 Project Benefits

The major benefits of the project include mitigating habitable structure flooding for two structures on Cutty Sark Road, and street flooding along Seafarer Cove, Bay Point Drive, Cutty Sark Road, East Road, Stephens Road, and surrounding private property. The project also addresses several flood reports that have been documented in the area.

#### 3.2.4 Project Analysis Assumptions

HAZUS data is available for the flooded habitable structures along Cutty Sark Road. The structures no longer flood in the 100-year storm event. Based on the BCR methodology, the project BCR is 1.0360. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM.

Easements are required as part of this project but are minimized. It is anticipated that moderate maintenance of traffic and utility relocations will be required during construction of the project and minimal effort will be required to obtain environmental permits. The extent of outfall upsizing west of Bay Point Drive will likely impact the structural integrity of the existing bulkhead. Mitigation of these impacts is included in the OPCC.

#### 3.2.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

#### 3.2.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

#### 3.2.7 Project Analysis Summary

Table 2 below provides a summary of the Alanton Estates and Baycliff project analysis. Refer to Appendix B-2 for project exhibits and supporting documentation.

**Table 2. Alanton Estates and Baycliff Project Summary**

<b>SFA Recurrence</b>	2-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	5.36/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	6.4/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0360
<b>Project Cost</b>	\$8,500,000

### 3.3 Alanton Neighborhood

#### 3.3.1 SFA Description

The North Alanton Drive at Linkhorn Bay, Whiteside Lane at Ashley Drive, Franklin Drive at North Woodhouse Road, Cooper Road at Whittier Road, and Ashley Drive at Stephens Road SFAs are combined into the Alanton Neighborhood project. Individual SFA locations are shown in Figure 8 and are further described below. All five SFAs were combined since they require similar solutions and are located within the same neighborhood.



Figure 8. Location Map of North Alanton Drive at Linkhorn Bay, Whiteside Lane at Ashley Drive, Franklin Drive at North Woodhouse Road, Cooper Road at Whittier Road, and Ashley Drive at Stephens Road SFAs

#### ***North Alanton Drive at Linkhorn Bay SFA***

North Alanton Drive floods because the existing culvert beneath the road, which is draining into Linkhorn Bay, is undersized. No habitable structures or private properties are impacted by the flooding occurring in the area. The models indicate North Alanton Drive begins to experience flooding in the 100-year storm event, as shown in Figure 8.

#### ***Whiteside Lane at Ashley Drive SFA***

Ashley Drive and Whiteside Lane flood due to the existing undersized 36-inch trunkline on Whiteside Lane. No habitable structures or private properties are impacted by the flooding occurring in the area. The models indicate Whiteside Lane and Ashley Drive begin to experience flooding in the 2-year storm event, as shown in Figure 8.

### ***Franklin Drive at North Woodhouse Road SFA***

Franklin Drive floods due to the existing undersized 36-inch outfall located at the intersection of North Woodhouse Road and Franklin Drive. Flooding occurs on surrounding private property and one habitable structure on Franklin Drive is impacted. The models indicate Franklin Drive begins to experience flooding in the 100-year storm event, as shown in Figure 8.

### ***Cooper Road at Whittier Road SFA***

Cooper Circle, Whittier Road, and Ashley Drive all flood due to the undersized existing drainage infrastructure. No habitable structures or private properties are impacted by the flooding occurring in the area. The models indicate Cooper Circle, Whittier Road, and Ashley Drive begin to experience flooding in the 2-year storm event, as shown in Figure 8.

### ***Ashley Drive at Stephens Road SFA***

Ashley Drive floods due to a lack of stormwater infrastructure. Flooding occurs on surrounding private property, and two structures on Ashley Drive and one structure on Stephens Road are impacted. The models indicate Ashley Drive begins to experience flooding in the 1-year storm event, as shown in Figure 8.

#### 3.3.2 Project Description

This project upsizes existing undersized stormwater infrastructure and proposes new stormwater trunklines within the Alanton Neighborhood. Existing infrastructure on Whiteside Lane, Franklin Drive, and Ashley Drive is upsized. Five proposed stormwater trunklines are also added. The new trunklines on Whittier Road and Rutland Drive drain to the existing outfall at the intersection of Franklin Drive and North Woodhouse Road. The new trunklines on Cooper Road and Ashley Drive drain to a proposed outfall on Stephens Road. The new trunkline on North Woodhouse Road drains to a proposed outfall into Linkhorn Bay. This project also requires removing existing pipes on Franklin Drive and Whittier Road as well as reversing a 27-inch pipe between Whittier Road and Rutland Drive.

#### 3.3.3 Project Benefits

The major benefits of the project include mitigating street flooding on Ashley Drive, Cooper Circle, Franklin Drive, Whiteside Lane, and Whittier Road. This project mitigates habitable structure flooding for two habitable structures on Ashley Drive, one structure on Stephens Road, and one structure on Franklin Drive. Private property flooding on Ashley Drive and Stephens Road has also been mitigated. The project addresses several flood reports that have been documented in the area.

#### 3.3.4 Project Analysis Assumptions

HAZUS data is available for some, but not all, flooded habitable structures. The structures no longer flood in the 100-year storm event. Based on the BCR methodology, the project BCR is 1.0672. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM. Property acquisition of a vacant lot is required to construct a new outfall south of North Woodhouse Road into Linkhorn Bay. Easement acquisition will be required from multiple private landowners to upsize existing pipes as well as construct new pipes.

It is anticipated that moderate maintenance of traffic and utility relocations will be required during construction of the project. Moderate effort will be required to obtain environmental

permits for outfall improvements into non-tidal wetlands at Stephens Road, Franklin Drive, and Branch Circle, as well as tidal wetlands at North Woodhouse Road and North Alanton Drive.

Ashley Drive is much lower than the other streets experiencing flooding within the Alanton Neighborhood. To meet the PWDSM requirements on Ashley Drive, two existing pipes (Franklin Drive and Whittier Road) will be removed to reduce the flow being directed to the upsized outfall on Franklin Drive and decrease the HGLs in the proposed system on Rutland Road.

During initial development of Alternative 1 for the Alanton Neighborhood, preliminary modeling showed 3 inches of flooding remaining at the intersection of Ashley Drive and Whiteside Lane. The existing model was refined by adding the existing pipes equal to or greater than 24-inches along Ashley Drive into the model as well as refining the original subcatchments. This refinement resulted in the elimination of street flooding at the intersection, allowing the project to meet the PWDSM requirements.

3.3.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

3.3.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.3.7 Project Analysis Summary

Table 3 below provides a summary of the Alanton Neighborhood project analysis. Refer to Appendix B-3 for project exhibits and supporting documentation.

**Table 3. Alanton Neighborhood Project Summary**

<b>SFA Recurrence</b>	1-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	4.31/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	7.7/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0672
<b>Project Cost</b>	\$20,050,000

### 3.4 Atlantic Avenue at 24<sup>th</sup> Street Park

#### 3.4.1 SFA Description

A portion of Atlantic Avenue near the 24<sup>th</sup> Street Park floods due to undersized pipes. One habitable structure floods adjacent to the road. The models indicate Atlantic Avenue at 24<sup>th</sup> Street Park begins to experience flooding in the 100-year storm event, as shown in Figure 9.



**Figure 9. Location Map of Atlantic Avenue at 24<sup>th</sup> Street Park SFA**

#### 3.4.2 Project Description

This project adds underground storage underneath the 24<sup>th</sup> Street Park. Runoff is directed into the underground storage from the existing 15-inch and 21-inch pipes along Atlantic Avenue. The underground storage outfalls into the existing elliptical pipes east of the park.

#### 3.4.3 Project Benefits

The major benefits of the project include mitigating habitable structure flooding for one structure and street flooding on Atlantic Avenue. The project also addresses multiple flood reports that have been documented in the area. The project mitigates flooding in an area that is a Strategic Growth Area (SGA). There is a potential cost-sharing opportunity with DPU for water leak prioritization in the area.

#### 3.4.4 Project Analysis Assumptions

HAZUS data is available for the flooded habitable structure along Atlantic Avenue. The structure no longer floods in the 100-year storm event. Based on the BCR methodology, the project BCR is 1.2317. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM. Property or easement acquisition is not required as all the construction will occur within the ROW or City property.

It is anticipated that minimal maintenance of traffic and utility relocations will be required during the construction of the project. Environmental permits will not be required.

3.4.5 Other Alternatives Scored

One additional alternative was scored as a part of this analysis. Alternative 1 upsized the pipes from Atlantic Avenue to the pipe system underneath the boardwalk and did not require any underground storage. The alternative did not score as high because it required coordination with the USACE.

3.4.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.4.7 Project Analysis Summary

Table 4 below provides a summary of the Atlantic Avenue at 24<sup>th</sup> Street Park project analysis. Refer to Appendix B-4 for project exhibits and supporting documentation.

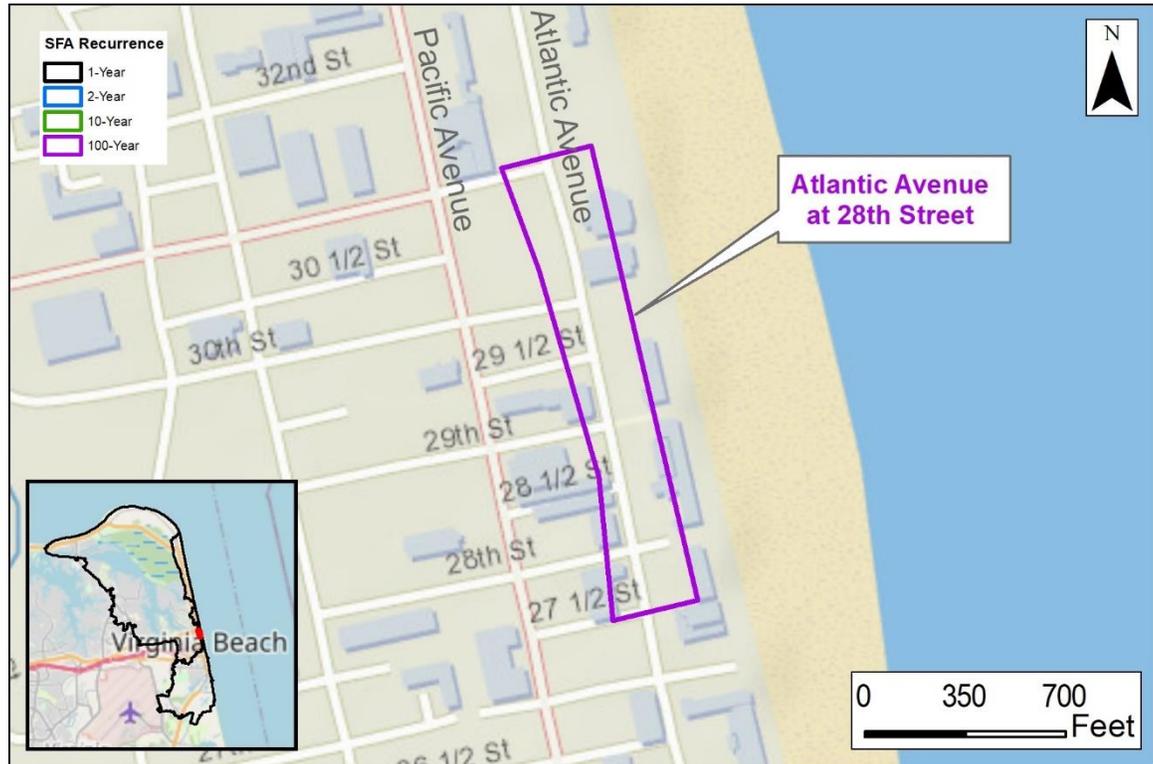
**Table 4. Atlantic Avenue at 24<sup>th</sup> Street Park Project Summary**

<b>SFA Recurrence</b>	100-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 2
<b>ASC Score</b>	5.79/10
<b>Other ASC Score(s)</b>	Alternative 1 – 5.75/10
<b>PPC Score</b>	4.87/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.2317
<b>Project Cost</b>	\$1,010,000

### 3.5 Atlantic Avenue at 28<sup>th</sup> Street

#### 3.5.1 SFA Description

A small portion of Atlantic Avenue, north of 28<sup>th</sup> Street, floods due to undersized stormwater pipes. The models indicate Atlantic Avenue at 28<sup>th</sup> Street begins to experience flooding in the 100-year storm event, as shown in Figure 10.



**Figure 10. Location Map of Atlantic Avenue at 28<sup>th</sup> Street SFA**

#### 3.5.2 Project Description

This project adds larger stormwater infrastructure to the area. Pipes are upsized along 28<sup>th</sup> Street and 27<sup>th</sup> Street, including the outfalls into the system underneath the boardwalk. Additionally, pipes are reversed along Atlantic Avenue.

#### 3.5.3 Project Benefits

The major benefits of the project include mitigating street flooding along Atlantic Avenue. The project mitigates flooding in an area that is an SGA and addresses one documented flood report. There is a potential cost-sharing opportunity with DPU for water leak prioritization.

#### 3.5.4 Project Analysis Assumptions

No habitable structures are impacted in the 100-year storm event, so the project is given a BCR value of 1.0. Based on the comparison of existing conditions and LiDAR data, the elevation data is inaccurate near the intersection of 28<sup>th</sup> Street and Atlantic Avenue, where the building flooding is shown. Therefore, the reduction of habitable structure flooding is not included in the BCR. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM.

Property or easement acquisition is not required as all the construction will occur within the ROW. It is anticipated that moderate maintenance of traffic and utility relocations will be required during the construction of the project. Environmental permits will not be required, but coordination with the USACE will likely be required to connect into the pipes underneath the boardwalk. Restoration of all amenities in this area is included in the OPCC.

3.5.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

3.5.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.5.7 Project Analysis Summary

Table 5 below provides a summary of the Atlantic Avenue at 28<sup>th</sup> Street project analysis. Refer to Appendix B-5 for project exhibits and supporting documentation.

**Table 5. Atlantic Avenue at 28<sup>th</sup> Street Project Summary**

<b>SFA Recurrence</b>	100-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	5.55/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	1.07/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0 (no habitable structure flooding)
<b>Project Cost</b>	\$7,140,000

### 3.6 Atlantic Avenue at 33<sup>rd</sup> Street

#### 3.6.1 SFA Description

A small portion of Atlantic Avenue at 33<sup>rd</sup> Street floods due to undersized pipes. One habitable structure is affected by this flooding. The models indicate Atlantic Avenue at 33<sup>rd</sup> Street begins to experience flooding in the 100-year storm event, as shown in Figure 11.



**Figure 11. Location Map of Atlantic Avenue at 33<sup>rd</sup> Street SFA**

#### 3.6.2 Project Description

This project upsizes pipes along Atlantic Avenue from 33<sup>rd</sup> Street to 34<sup>th</sup> Street. Additionally, a new pipe connection is proposed along 33<sup>rd</sup> Street to the pipes underneath the boardwalk to further alleviate the flooding.

#### 3.6.3 Project Benefits

The major benefits of the project include mitigating habitable structure flooding on the corner of Atlantic Avenue and 33<sup>rd</sup> Street and street flooding along Atlantic Avenue and 33<sup>rd</sup> Street. The project also addresses one flood report that has been documented in the area.

The project mitigates flooding in an area that is an SGA. There is a potential cost-sharing opportunity with DPU for water leak prioritization.

#### 3.6.4 Project Analysis Assumptions

The project indicates structural flooding is resolved; however, the structural flooding is not reflected in the BCR of 1.0. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM.

Property or easement acquisition is not required as all the construction will occur within the ROW. It is anticipated that moderate maintenance of traffic and utility relocations will be required during the construction of the project. Environmental permits will not be required, but coordination with the USACE will likely be required to connect into the pipes underneath the boardwalk. Restoration of all amenities in this area is included in the OPCC.

The project is in an area designated with a median household income of less than \$50,000. The proposed improvements do not appear to be affecting residences that meet the intent of the Social Vulnerability metric in the PPC. Therefore, the PPC scoring reflects this assumption.

3.6.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

3.6.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.6.7 Project Analysis Summary

Table 6 below provides a summary of the Atlantic Avenue at 33<sup>rd</sup> Street project analysis. Refer to Appendix B-6 for project exhibits and supporting documentation.

**Table 6. Atlantic Avenue at 33<sup>rd</sup> Street Project Summary**

<b>SFA Recurrence</b>	100-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	5.55/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	4.87/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0 (no HAZUS data available)
<b>Project Cost</b>	\$3,610,000

### 3.7 Atlantis Drive and Norfolk Avenue

Individual SFA locations, shown below in Figure 12 and further described below, are combined into the Atlantis Drive and Norfolk Avenue project. The Norfolk Avenue at Marshview Drive project is not dependent on the downstream improvements included for the Atlantis Drive Project. However, both projects share a common box culvert improvement under Norfolk Avenue, and are therefore combined as a phased project to save cost and minimize total disturbance to Norfolk Avenue. Project phases are defined by the individual SFA boundaries. Future refinements to the proposed project phasing may be required. Refer to Appendix B-7-1 through B-7-2 for detailed project phase maps.

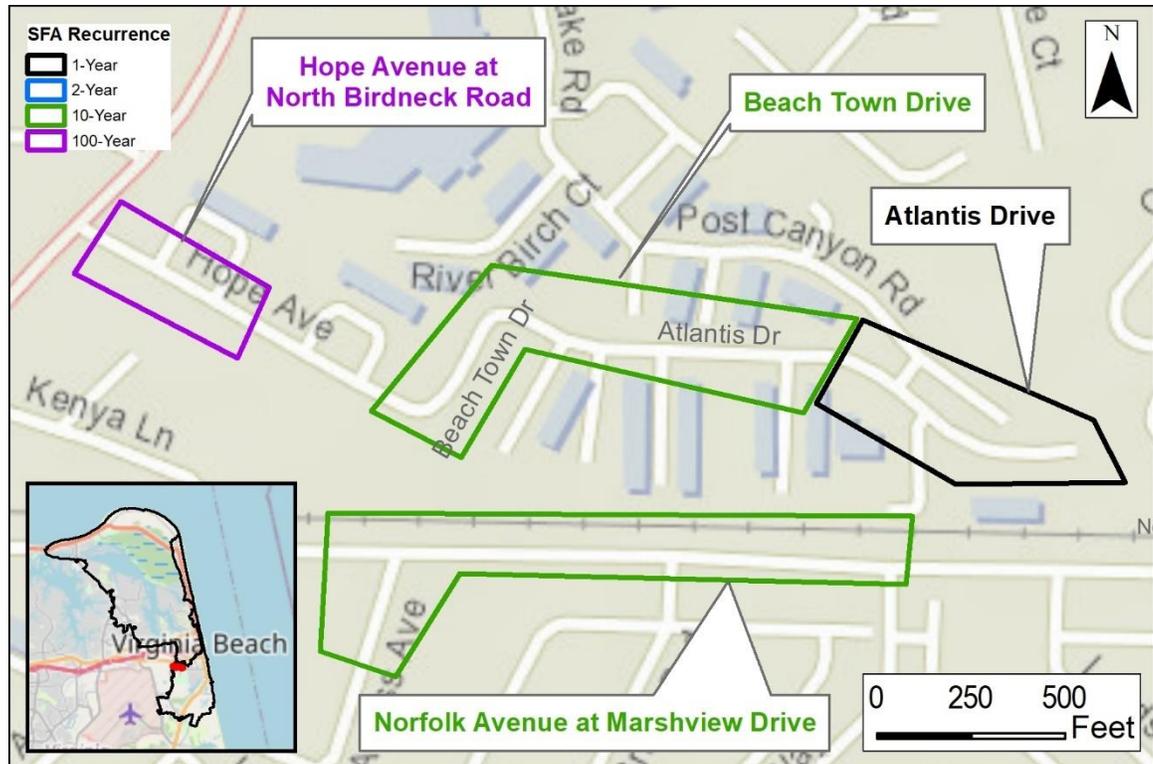


Figure 12. Location Map of Atlantis Drive, Beach Town Drive, Hope Avenue at North Birdneck Road, and Norfolk Avenue at Marshview Drive SFAs

#### 3.7.1 **Phase 1: Norfolk Avenue at Marshview Drive**

##### 3.7.1.1 SFA Description

Norfolk Avenue is a secondary evacuation route that experiences flooding due to a lack of storage and inadequate stormwater pipes. The models indicate Norfolk Avenue at Marshview Drive begins to experience flooding in the 10-year storm event, as shown in Figure 12.

##### 3.7.1.2 Project Description

This project adds a BMP along Norfolk Avenue. Runoff is collected along Norfolk Avenue and redirected to the proposed BMP. Inadequate pipes along Norfolk Avenue are upsized.

##### 3.7.1.3 Project Benefits

The major benefits of the project include mitigating street flooding on Norfolk Avenue, as well as the flooding occurring on surrounding private property. The project mitigates one habitable

structure from flooding on Ocean Pebbles Way. It also ensures that Norfolk Avenue can serve as a secondary evacuation route. The project addresses one flood report that has been documented in the area. Additionally, the project mitigates flooding in an area that is within an SGA as well as an economically disadvantaged area. There is also a potential cost sharing opportunity with DPU for future improvements along Norfolk Avenue.

3.7.1.4 Project Analysis Assumptions

HAZUS data is available for the flooded habitable structure along Ocean Pebbles Way. The structure no longer floods in the 100-year storm event. Based on the BCR methodology, the project BCR is 1.7070. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM. As a secondary evacuation route, Norfolk Avenue remains passable in the 10-year storm event with 3.0 feet SLR and the 100-year storm event with no SLR.

Property acquisition will be required of private undeveloped land for the proposed BMP, but acquisition is limited by improving pipes within the ROW and on City property. It is anticipated that moderate maintenance of traffic will be required during the construction of the project along Norfolk Avenue. Minimal utility relocations will be required, but there is a potential for possible conflicts along Norfolk Avenue with a 10-inch water line.

3.7.1.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

3.7.1.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.7.1.7 Project Analysis Summary

Table 7 below provides a summary of the Norfolk Avenue at Marshview Drive project analysis. Refer to Appendix B-7-1 for project exhibits and supporting documentation.

**Table 7. Norfolk Avenue at Marshview Drive Project Summary**

<b>SFA Recurrence</b>	10-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	5.34/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	6.24/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.7070
<b>Project Cost</b>	\$3,400,000

### 3.7.2 **Phase 2: Atlantis Drive**

#### 3.7.2.1 **SFA Description**

The Hope Avenue at North Birdneck Road, Beach Town Drive, and Atlantis Drive SFAs are combined into the Atlantis Drive project. Individual SFA locations are shown in Figure 12 and are further described below. All three SFAs are hydraulically connected and can be combined into one project.

##### ***Hope Avenue at North Birdneck Road SFA***

A small portion of Hope Avenue near the intersection of North Birdneck Road floods due to undersized stormwater pipes. The models indicate Hope Avenue at North Birdneck Road begins to experience flooding in the 100-year storm event, as shown in Figure 12.

##### ***Beach Town Drive SFA***

A significant portion of Beach Town Drive and Atlantis Drive floods due to undersized stormwater pipes and lack of storage. The roadway floods as well as adjacent private property. The models indicate Beach Town Drive begins to experience flooding in the 10-year storm event, as shown in Figure 12.

##### ***Atlantis Drive SFA***

The eastern end of Atlantis Drive floods due to undersized stormwater pipes and lack of storage. The roadway floods as well as adjacent private property. The models indicate Atlantis Drive begins to experience flooding in the 1-year storm event, as shown in Figure 12.

#### 3.7.2.2 **Project Description**

This project replaces the existing 66-inch pipes along Marshview Drive with a new open channel. The channel runs parallel to Marshview Drive and outfalls into the floodplain in Marshview Park. Additionally, pipes near Atlantis Drive are upsized to box culverts to provide increased capacity and storage. The box culverts drain south, crossing Norfolk Avenue to the new open channel.

#### 3.7.2.3 **Project Benefits**

The major benefits of the project include mitigating habitable structure flooding for three structures on Atlantis Drive. Street flooding on Hope Avenue, Beach Town Drive, and Atlantis Drive, as well as the flooding occurring on surrounding private property, is also mitigated. The project relieves flooding in an SGA and an economically disadvantaged area. There is a potential cost-sharing opportunity with DPU for transmission main prioritization and recommended future improvements.

#### 3.7.2.4 **Project Analysis Assumptions**

A 50-year LOS is achieved for this project. Pipe and channel improvements have been maximized, and adding storage to the system has minimal impact due to the proximity to the outfall. Flood depths are less than 3 inches above the crown of the road, are summarized on the 100-year flood map, and will require approval for a reduced LOS from the City Engineer.

HAZUS data is available for the flooded habitable structures on Atlantis Drive. The structures no longer flood in the 100-year storm event. Based on the BCR methodology, the project BCR is 1.0672. There is a decrease in street flooding in the 100-year storm event, but it is not completely mitigated. Therefore, the project is given a BR of 0.96.

Property acquisition of a developed residential parcel is required for this project but is minimized by proposing improvements on City property and within the ROW. It is anticipated that extensive maintenance of traffic and utility relocations will be required during the construction of the project. Moderate effort is expected to be required to obtain environmental permits. The proposed infrastructure will impact the recently constructed Marshview Park, but impacts are minimized.

#### 3.7.2.5 Other Alternatives Scored

Other alternatives, as described below, were considered, but were not scored.

#### 3.7.2.6 Other Alternatives Not Scored

Several additional alternatives were evaluated but not scored. One alternative that was evaluated included a pond to the northeast of Atlantis Drive. The pond solved the flooding on the roadway, but the pond configuration would not likely meet Virginia BMP Clearinghouse standards. This alternative was not evaluated further.

A second alternative considered raising Atlantis Drive by 1.5 feet to meet PWDSM standards. No stormwater improvements were proposed as a part of this alternative. While the road can be raised by 1.5 feet, there were concerns the elevated roadway would cause additional flooding on the adjacent properties, so this alternative was not evaluated further.

A third alternative proposed dual 72-inch pipes through Marshview Park to the floodplain. The dual 72-inch pipes did not provide enough storage or capacity, so this alternative was not evaluated further.

Since no underground public utilities are located underneath Marshview Drive, a fourth alternative proposed five 5-foot by 5-foot box culverts underneath the roadway. While this alternative did mitigate flooding along Atlantis Drive, it was determined to not be constructible and would significantly restrict access to the neighborhood along Marshview Drive, and was not considered further.

#### 3.7.2.7 Project Analysis Summary

Table 8 below provides a summary of the Atlantis Drive project analysis. Refer to Appendix B-7-2 for project exhibits and supporting documentation.

**Table 8. Atlantis Drive Project Summary**

<b>SFA Recurrence</b>	1-year (no SLR)
<b>Project LOS</b>	50-year (1.5 feet SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	2.55/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	7.54/14.4
<b>BR</b>	0.96
<b>BCR</b>	1.0672
<b>Project Cost</b>	\$20,960,000

3.7.3

**Atlantis Drive and Norfolk Avenue Combined Summary**

Table 9 below provides a summary of the Atlantis Drive and Norfolk Avenue project analysis. Refer to Appendix B-7-1 to B-7-2 for project exhibits and supporting documentation.

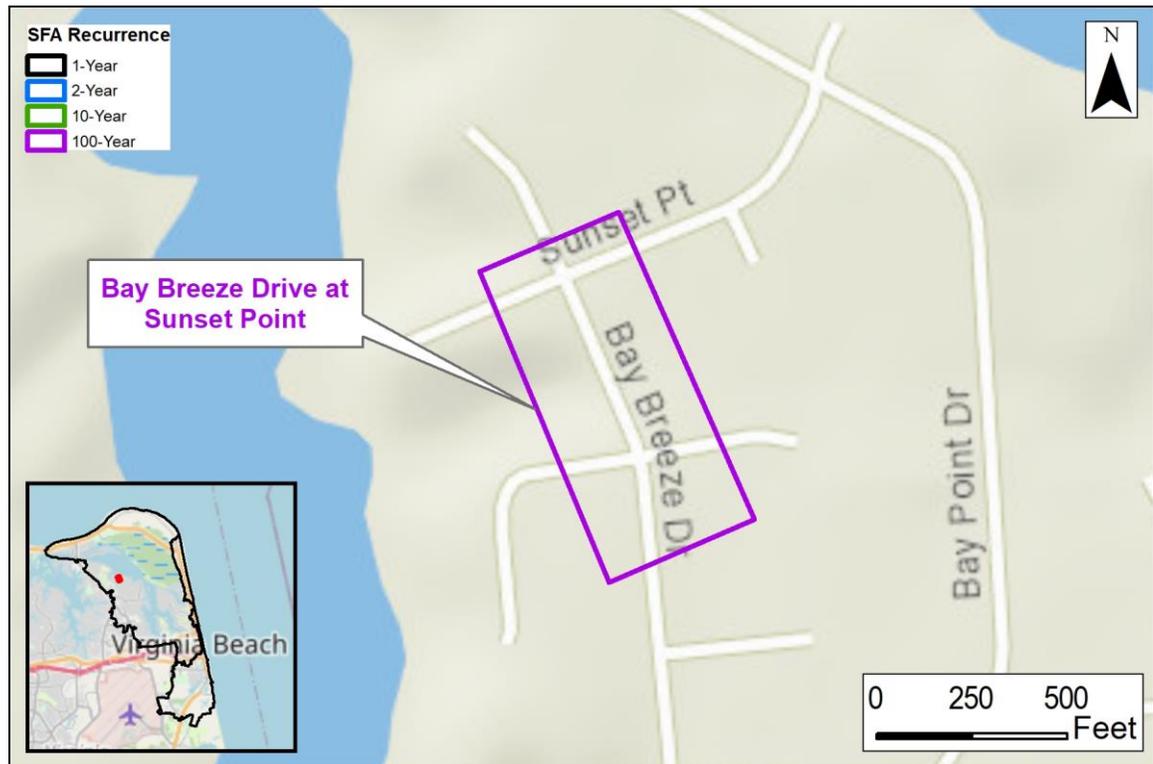
**Table 9. Atlantis Drive and Norfolk Avenue Project Summary**

	<b>Phase 1: Norfolk Avenue at Marshview Drive</b>	<b>Phase 2: Atlantis Drive</b>
<b>SFA Recurrence</b>	10-year (no SLR)	1-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)	50-year (1.5 feet SLR)
<b>Selected Alternative</b>	Alternative 1	Alternative 1
<b>ASC Score</b>	5.34/10	2.55/10
<b>Other ASC Score(s)</b>	N/A	N/A
<b>PPC Score</b>	6.24/14.4	7.54/14.4
<b>BR</b>	1.0	0.96
<b>BCR</b>	1.7070	1.0672
<b>Individual Project Cost</b>	\$3,400,000	\$20,960,000
<b>Total Project Cost</b>	\$24,360,000	

## 3.8 Bay Breeze Drive at Sunset Point

### 3.8.1 SFA Description

A small portion of Bay Breeze Drive near Sunset Point floods due to undersized stormwater pipes. The models indicate Bay Breeze Drive at Sunset Point begins to experience flooding in the 100-year storm event, as shown in Figure 13.



**Figure 13. Location Map of Bay Breeze Drive at Sunset Point SFA**

### 3.8.2 Project Description

The project creates a new outfall at the western end of Sunset Point into Broad Bay. Proposed and upsized pipes direct stormwater to the new outfall and relieve the undersized existing outfall west of Bay Breeze Drive.

### 3.8.3 Project Benefits

The major benefits of the project include mitigating street flooding on Bay Breeze Drive and the flooding occurring on surrounding private property. The project also addresses one flood report that has been documented in the area.

### 3.8.4 Project Analysis Assumptions

No habitable structures are impacted in the 100-year storm event, so the project is given a BCR value of 1.0. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM.

Easement acquisition is required for this project, but was minimized. It is anticipated that minimal maintenance of traffic and utility relocations will be required during the construction of

the project. Minimal effort is also expected to be required to obtain environmental permits for adding an outfall to Broad Bay.

3.8.5 Other Alternatives Scored

Another alternative, as described below, was considered, but was not scored.

3.8.6 Other Alternatives Not Scored

One additional alternative was considered but was not scored. While easement acquisition could have been avoided by upsizing the existing outfall on Bay Breeze Drive, there were several constraints with the existing pipe and easement making this option not feasible. The existing 30-foot easement contains part of a residential structure, and the existing pipe is located outside of the easement boundary and in close proximity to another residential structure. For these reasons, upsizing the existing outfall was not considered further.

3.8.7 Project Analysis Summary

Table 10 below provides a summary of the Bay Breeze Drive at Sunset Point project analysis. Refer to Appendix B-8 for project exhibits and supporting documentation.

**Table 10. Bay Breeze Drive at Sunset Point Project Summary**

<b>SFA Recurrence</b>	100-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	5.34/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	0.87/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0 (no habitable structure flooding)
<b>Project Cost</b>	\$1,450,000

### 3.9 Bay Colony

#### 3.9.1 SFA Description

Chumley Road at Wythe Lane, Ditchley Road at Bruton Lane, Greentree Arch, and East Bay Shore Drive at Greentree Arch SFAs are combined into the Bay Colony project. Individual SFA locations are shown in Figure 14 and are further described below. All four SFAs are located within the same neighborhood, so they are combined into one project.

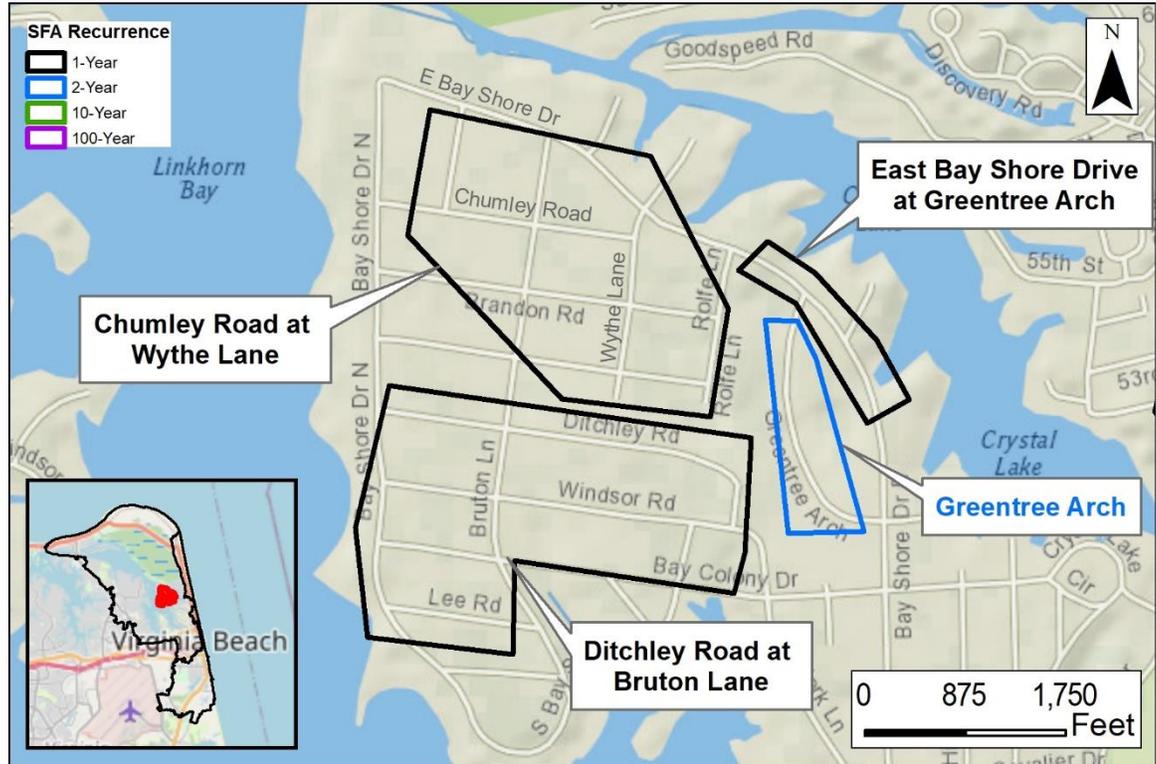


Figure 14. Location Map of Chumley Road at Wythe Lane, Ditchley Road at Bruton Lane, Greentree Arch, and East Bay Shore Drive at Greentree Arch SFAs

#### ***Chumley Road at Wythe Lane SFA***

Chumley Road at Wythe Lane floods due to a lack of stormwater infrastructure. Several structures, neighborhood streets, and private properties flood in this area. The models indicate Chumley Road at Wythe Lane begins to experience flooding in the 1-year storm event, as shown in Figure 14.

#### ***Ditchley Road at Bruton Lane SFA***

Ditchley Road at Bruton Lane floods due to a lack of stormwater infrastructure and high tailwater. Several structures, neighborhood streets, and private properties flood in this area. The models indicate Ditchley Road at Bruton Lane begins to experience flooding in the 1-year storm event, as shown in Figure 14.

### ***Greentree Arch SFA***

Greentree Arch floods due to undersized stormwater infrastructure. The models indicate Greentree Arch begins to experience flooding in the 2-year storm event, as shown in Figure 14.

### ***East Bay Shore Drive at Greentree Arch SFA***

East Bay Shore at Greentree Arch is a residential road that has low points near Greentree Arch ranging in elevation between 3.5 to 4 feet. The design tailwater elevation for the 100-year storm event with no SLR is 4.3 feet in the existing condition. The current and projected tailwater elevations, independent of rainfall flooding, flood the roadway. The models indicate East Bay Shore Drive at Greentree Arch begins to experience flooding in the 1-year storm event, as shown in Figure 14.

#### 3.9.2 Project Description

This project adds stormwater infrastructure throughout the neighborhood, modifies five existing outfalls at the northern and southern ends of the neighborhood, and adds two outfalls to the west into Linkhorn Bay. Additionally, two portions of East Bay Shore Drive are raised to allow for outfall improvements and prevent tailwater flooding.

#### 3.9.3 Project Benefits

The major benefits of the project include mitigating habitable structure flooding for 14 structures on Chumley Road, Wythe Lane, Brandon Road, Abingdon Road, Bay Colony Drive, and Windsor Road. Street flooding is mitigated along Chumley Road, Wythe Lane, Brandon Road, Greentree Arch, Abingdon Road, and Ditchley Road. The project also addresses several flood reports that have been documented in the area.

#### 3.9.4 Project Analysis Assumptions

HAZUS data is available for some, but not all, flooded habitable structures. The structures no longer flood in the 100-year storm event. Based on the BCR methodology, the project BCR is 1.3311. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM.

Easements will be required for some proposed pipes. It is anticipated that extensive maintenance of traffic and utility relocations will be required during construction of the project, and minimal effort will be required to obtain environmental permits. A Conditional Letter of Map Revision (CLOMR) or Letter of Map Revision (LOMR) will likely be required for raising the road in a FEMA floodplain.

The existing area in the neighborhood has minimal stormwater infrastructure. The infrastructure that does exist is not large enough to be included in the current existing model. As a result, conservative assumptions are made to determine the extent of the curb, gutter, and ditch improvements needed to convey stormwater runoff to the proposed drainage system. Additional analysis in the design phase is recommended to confirm the extent and cost of improvements.

#### 3.9.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

3.9.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.9.7 Project Analysis Summary

Table 11 below provides a summary of the Bay Colony project analysis. Refer to Appendix B-9 for project exhibits and supporting documentation.

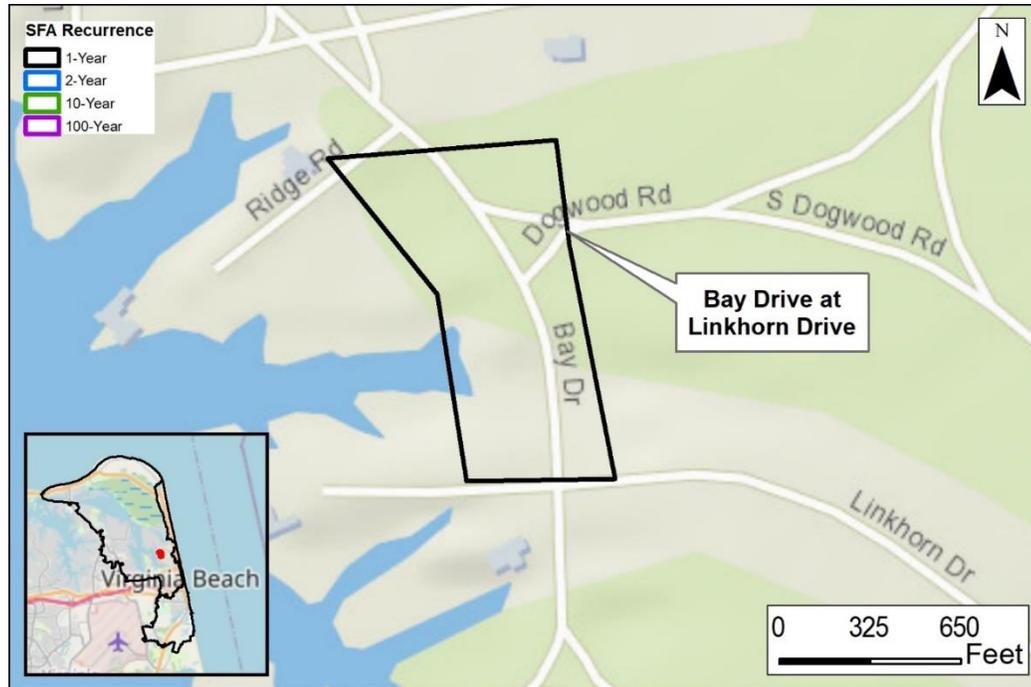
**Table 11. Bay Colony Project Summary**

<b>SFA Recurrence</b>	1-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	4.71/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	7.7/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.3311
<b>Project Cost</b>	\$31,820,000

### 3.10 Bay Drive at Linkhorn Drive

#### 3.10.1 SFA Description

Bay Drive is a residential street in the Linkhorn Park neighborhood, and the lowest street elevations range from approximately 3 to 4 feet. The design tailwater elevation for the 100-year storm event with no SLR is 4.3 feet in Little Neck Creek. The tailwater elevation, independent of existing drainage infrastructure, floods a portion of the street. The models indicate Bay Drive at Linkhorn Drive begins to experience flooding in the 1-year storm event, as shown in Figure 15.



**Figure 15. Location Map of Bay Drive at Linkhorn Drive SFA**

#### 3.10.2 Project Description

The downstream tailwater conditions severely limit the options for improvements to this neighborhood. The City will be evaluating this SFA with a Neighborhood Strategy in the future. Refer to Appendix B-10 for the extent of existing flooding in the area.

#### 3.10.3 Project Benefits

There is no project, and there are no benefits.

#### 3.10.4 Other Alternatives Scored

No alternatives were evaluated for this SFA.

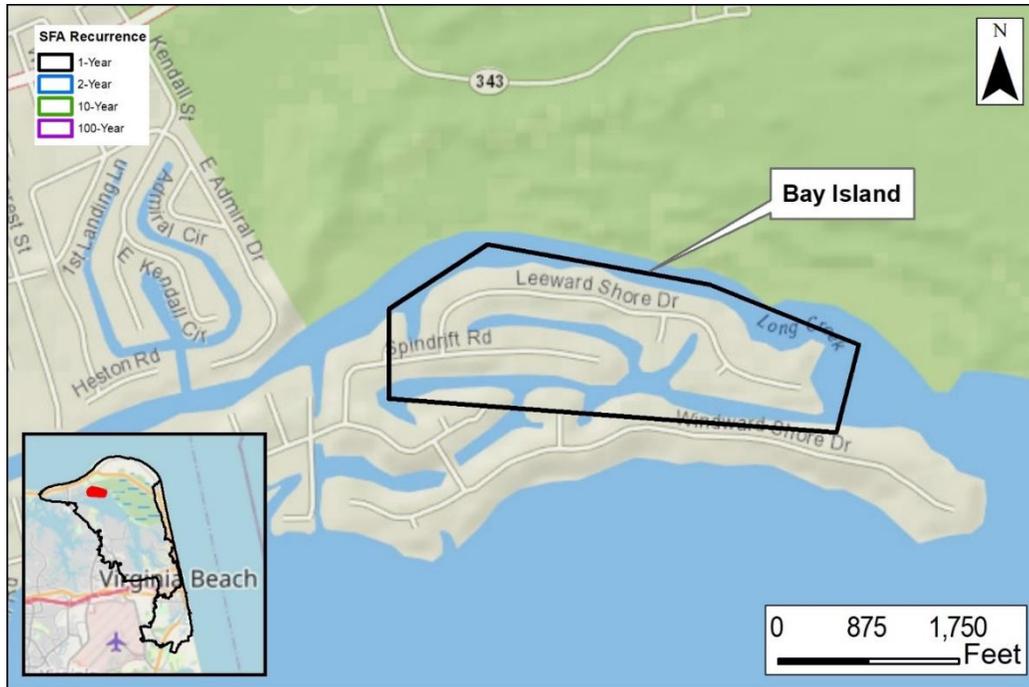
#### 3.10.5 Other Alternatives Not Scored

This neighborhood would benefit from a neighborhood solution similar to those shown in the SLR Adaptation Strategy Report. This neighborhood can be designed to resolve the flooding issues that occur from a smaller storm event. PW-SWEC will, in the future, have a neighborhood solution created to establish resiliency in this neighborhood.

### 3.11 Bay Island

#### 3.11.1 SFA Description

Bay Island experiences street, private property, and habitable structure flooding as the surrounding areas range in elevation from approximately 2.5 to 5 feet. The design tailwater elevation for the 100-year storm event with no SLR is 4.3 feet in the existing condition. The tailwater elevation, independent of existing drainage infrastructure, floods the street as well as habitable structures. The models indicate Bay Island begins to experience flooding in the 1-year storm event, as shown in Figure 16.



**Figure 16. Location Map of Bay Island SFA**

#### 3.11.2 Project Description

The downstream tailwater conditions severely limit the options for improvements to this neighborhood. The City will be evaluating this SFA with a Neighborhood Strategy in the future. Refer to Appendix B-11 for the extent of existing flooding in the area.

#### 3.11.3 Project Benefits

There is no project, and there are no benefits.

#### 3.11.4 Other Alternatives Scored

No alternatives were evaluated for this SFA.

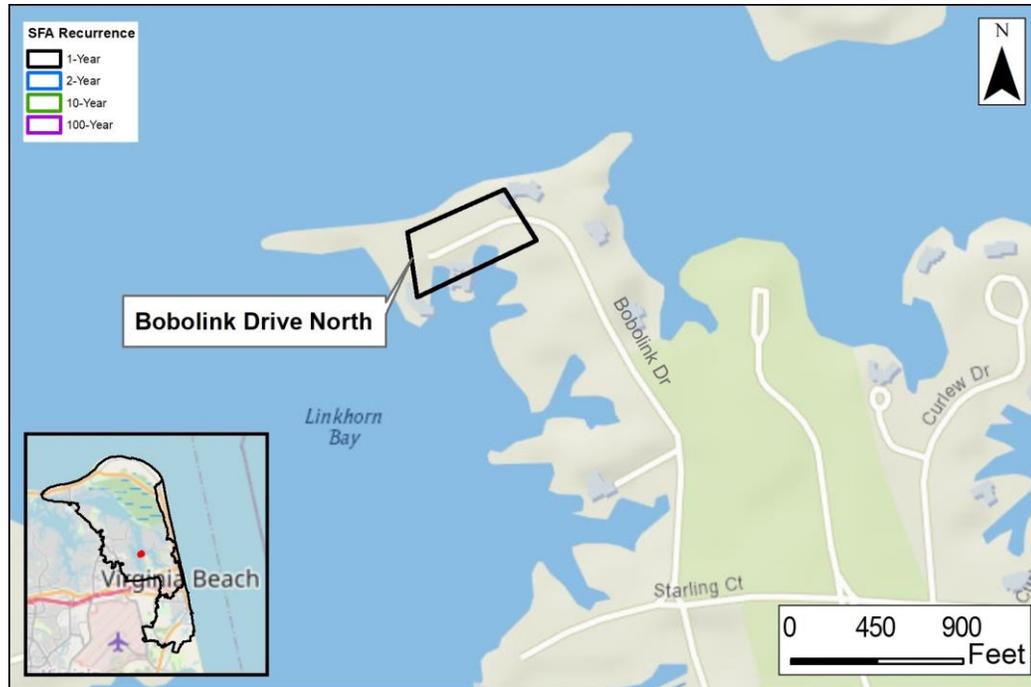
#### 3.11.5 Other Alternatives Not Scored

This neighborhood would benefit from a neighborhood solution similar to those shown in the SLR Adaptation Strategy Report. This neighborhood can be designed to resolve the flooding issues that occur from a smaller storm event. PW-SWEC will, in the future, have a neighborhood solution created to establish resiliency in this neighborhood.

## 3.12 Bobolink Drive North

### 3.12.1 SFA Description

Bobolink Drive, within the Birdneck Point neighborhood, ranges in elevation from approximately 2 to 4 feet at the northern end. The design tailwater elevation for the 100-year storm event with no SLR is 4.3 feet in the existing condition. The tailwater elevation, independent of existing drainage infrastructure, floods the street. The models indicate Bobolink Drive North begins to experience flooding in the 1-year storm event, as shown in Figure 17.



**Figure 17. Location Map of Bobolink Drive North SFA**

### 3.12.2 Project Description

The downstream tailwater conditions severely limit the options for improvements to this neighborhood. The City will be evaluating this SFA with a Neighborhood Strategy in the future. Refer to Appendix B-12 for the extent of existing flooding in the area.

### 3.12.3 Project Benefits

There is no project, and there are no benefits.

### 3.12.4 Other Alternatives Scored

No alternatives were evaluated for this SFA.

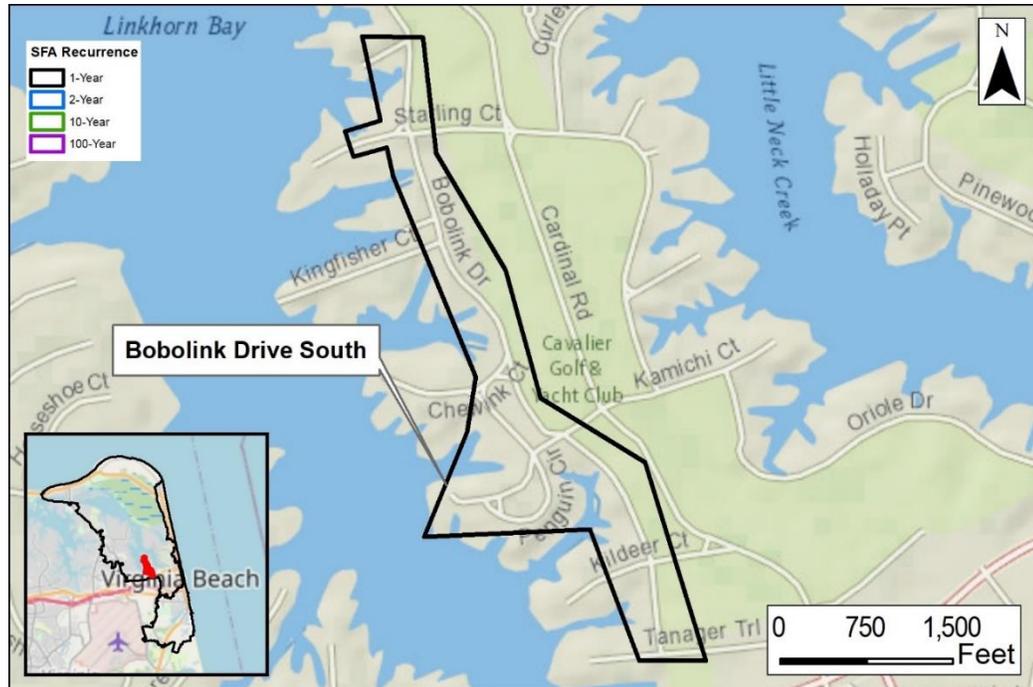
### 3.12.5 Other Alternatives Not Scored

This neighborhood would benefit from a neighborhood solution similar to those shown in the SLR Adaptation Strategy Report. This neighborhood can be designed to resolve the flooding issues that occur from a smaller storm event. PW-SWEC will, in the future, have a neighborhood solution created to establish resiliency in this neighborhood.

### 3.13 Bobolink Drive South

#### 3.13.1 SFA Description

Bobolink Drive, within the Birdneck Point neighborhood, ranges in elevation from approximately 3 to 5 feet between Starling Court and Tanager Trail. The design tailwater elevation for the 100-year storm event with no SLR is 4.3 feet in the existing condition. The tailwater elevation, independent of existing drainage infrastructure, floods the street as well as habitable structures. The models indicate Bobolink Drive South begins to experience flooding in the 1-year storm event, as shown in Figure 18.



**Figure 18. Location Map of Bobolink Drive South SFA**

#### 3.13.2 Project Description

The downstream tailwater conditions severely limit the options for improvements to this neighborhood. The City will be evaluating this SFA with a Neighborhood Strategy in the future. Refer to Appendix B-13 for the extent of existing flooding in the area.

#### 3.13.3 Project Benefits

There is no project, and there are no benefits.

#### 3.13.4 Other Alternatives Scored

No alternatives were evaluated for this SFA.

#### 3.13.5 Other Alternatives Not Scored

This neighborhood would benefit from a neighborhood solution similar to those shown in the SLR Adaptation Strategy Report. This neighborhood can be designed to resolve the flooding issues that occur from a smaller storm event. PW-SWEC will, in the future, have a neighborhood solution created to establish resiliency in this neighborhood.

### 3.14 Brant Road at Huntsman Drive

#### 3.14.1 SFA Description

Brant Road experiences flooding due to inadequate stormwater infrastructure. The models indicate Brant Road at Huntsman Drive begins to experience flooding in the 100-year storm event, as shown in Figure 19.



Figure 19. Location Map of Brant Road at Huntsman Drive SFA

#### 3.14.2 Project Description

This project upsizes existing infrastructure along Brant Road. The downstream ditch is lowered by 1 foot.

#### 3.14.3 Project Benefits

The major benefits of the project include mitigating street flooding along Brant Road. The project also addresses one documented flood report in the area and mitigates flooding in an economically disadvantaged area.

#### 3.14.4 Project Analysis Assumptions

No habitable structures are impacted in the 100-year storm event, so the project is given a BCR value of 1.0. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM.

Easement acquisition is not required as all the construction will occur within the ROW. It is anticipated that moderate maintenance of traffic and minimal utility relocations will be required during the construction of the project. There is a possible conflict with an 8-inch gravity sewer line along Marshview Drive. Moderate effort will be required to obtain environmental permits.

3.14.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

3.14.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.14.7 Project Analysis Summary

Table 12 below provides a summary of the Brant Road at Huntsman Drive project analysis. Refer to Appendix B-14 for project exhibits and supporting documentation.

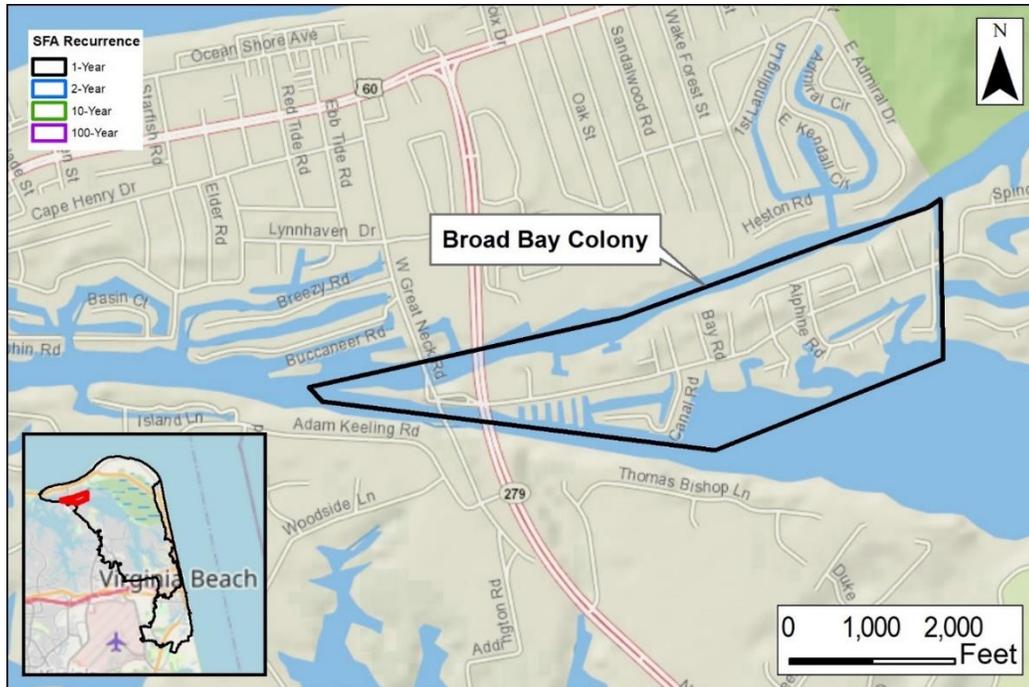
**Table 12. Brant Road at Huntsman Drive Project Summary**

<b>SFA Recurrence</b>	100-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	5.58/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	0.77/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0 (no habitable structure flooding)
<b>Project Cost</b>	\$1,020,000

### 3.15 Broad Bay Colony

#### 3.15.1 SFA Description

Broad Bay Colony is a neighborhood that experiences street, private property, and habitable structure flooding as the surrounding areas range in elevation from approximately 2 to 4 feet. The design tailwater elevation for the 100-year storm event with no SLR is 4.3 feet in the existing condition. The tailwater elevation, independent of existing drainage infrastructure, floods the street as well as habitable structures. The models indicate Broad Bay Colony begins to experience flooding in the 1-year storm event, as shown in Figure 20.



**Figure 20. Location Map of Broad Bay Colony SFA**

#### 3.15.2 Project Description

The downstream tailwater conditions severely limit the options for improvements to this neighborhood. The City will be evaluating this SFA with a Neighborhood Strategy in the future. Refer to Appendix B-15 for the extent of existing flooding in the area.

#### 3.15.3 Project Benefits

There is no project, and there are no benefits.

#### 3.15.4 Other Alternatives Scored

No alternatives were evaluated for this SFA.

#### 3.15.5 Other Alternatives Not Scored

This neighborhood would benefit from a neighborhood solution similar to those shown in the SLR Adaptation Strategy Report. This neighborhood can be designed to resolve the flooding issues that occur from a smaller storm event. PW-SWEC will, in the future, have a neighborhood solution created to establish resiliency in this neighborhood.

### 3.16 Caton Drive at Will O Wisp Drive

#### 3.16.1 SFA Description

Caton Drive and Will O Wisp Drive experience street and private property flooding due to inadequate pipes. The models indicate Caton Drive at Will O Wisp Drive begins to experience flooding in the 10-year storm event, as shown in Figure 21.



**Figure 21. Location Map of Caton Drive at Will O Wisp Drive SFA**

#### 3.16.2 Project Description

This project upsizes the inadequate pipe at the intersection of Caton Drive and Will O Wisp Drive and extends it to outfall to Linkhorn Bay.

#### 3.16.3 Project Benefits

The major benefits of the project include mitigating street flooding on Caton Drive and Will O Wisp Drive, as well as the flooding occurring on surrounding private property. The project also addresses several flood reports that have been documented in the area.

#### 3.16.4 Project Analysis Assumptions

No habitable structures are impacted in the 100-year storm event, so the project is given a BCR value of 1.0. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM.

Easement acquisition will be required from multiple private landowners for drainage easements. Minimal maintenance of traffic is anticipated along Caton Drive, and minimal effort will be required to obtain environmental permits to modify an outfall in tidal wetlands. The

extent of outfall upsizing east of Caton Drive will likely impact the structural integrity of the existing bulkhead. Mitigation of these impacts is included in the OPCC.

3.16.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

3.16.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.16.7 Project Analysis Summary

Table 13 below provides a summary of the Caton Drive at Will O Wisp Drive project analysis. Refer to Appendix B-16 for project exhibits and supporting documentation.

**Table 13. Caton Drive at Will O Wisp Drive Project Summary**

<b>SFA Recurrence</b>	10-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	5.17/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	1.58/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0 (no habitable structure flooding)
<b>Project Cost</b>	\$1,280,000

### 3.17 Chelsea and Green Hill Farms Neighborhood

#### 3.17.1 SFA Description

The Hunt Meet Circle, Oxen Court, Duke of Norfolk Quay, North Great Neck Road at Lords Landing, Greensward Quay, and Lords Landing SFAs are combined into the Chelsea and Green Hill Farms Neighborhood project. Individual SFA locations are shown in Figure 22 and are further described below. All six SFAs are hydraulically connected and can be combined into one project.

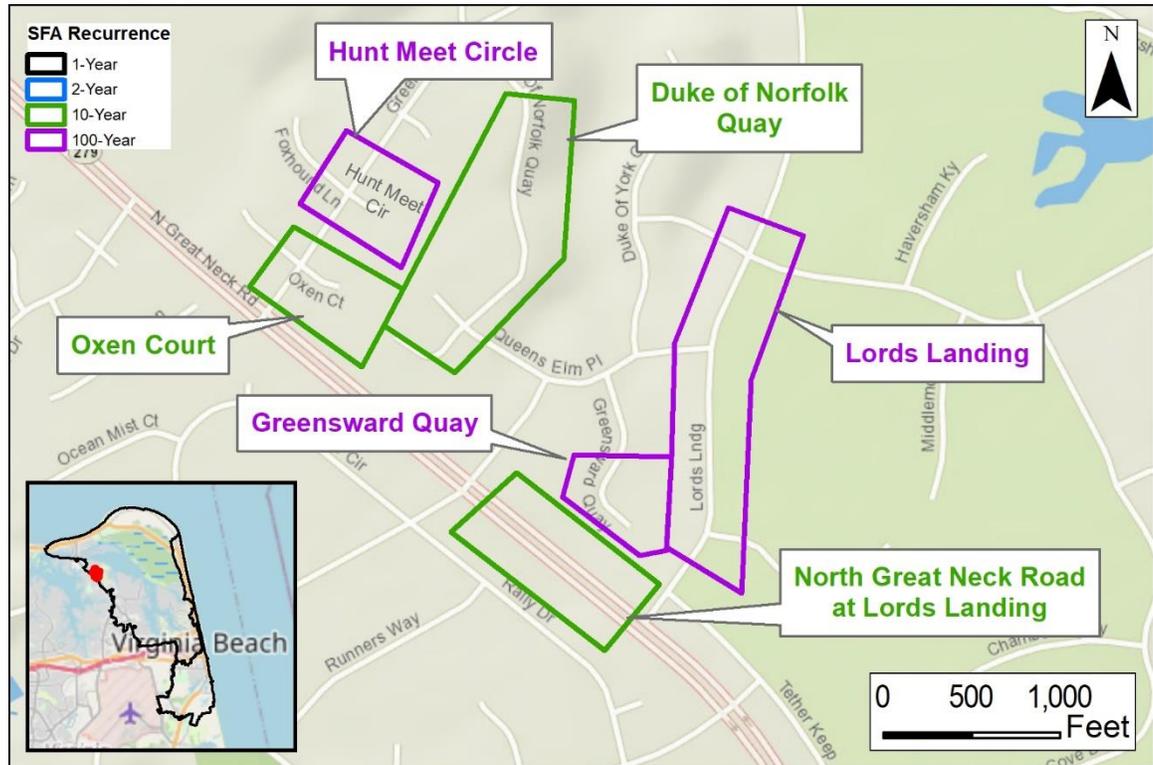


Figure 22. Location Map of Hunt Meet Circle, Oxen Court, Duke of Norfolk Quay, North Great Neck Road at Lords Landing, Greensward Quay, and Lords Landing SFAs

#### **Hunt Meet Circle SFA**

Hunt Meet Circle floods due to undersized pipes on Green Hill Road, which also causes the surrounding private property to flood. There is no habitable structure flooding. The models indicate Hunt Meet Circle begins to experience flooding in the 100-year storm event, as shown in Figure 22.

#### **Oxen Court SFA**

Oxen Court floods due to undersized pipes on Green Hill Road, which also causes the surrounding private property to flood. There is no habitable structure flooding. The models indicate Oxen Court begins to experience flooding in the 10-year storm event, as shown in Figure 22.

### ***Duke of Norfolk Quay SFA***

Duke of Norfolk Quay floods because the existing stormwater infrastructure is undersized. There is no habitable structure or private property flooding. The models indicate Duke of Norfolk Quay begins to experience flooding in the 10-year storm event, as shown in Figure 22.

### ***North Great Neck Road at Lords Landing SFA***

North Great Neck Road floods because the existing stormwater infrastructure is undersized, which also causes the surrounding private property to flood, including three habitable structures. North Great Neck Road is a secondary evacuation route. The models indicate North Great Neck Road at Lords Landing begins to experience flooding in the 10-year storm event, as shown in Figure 22.

### ***Greensward Quay SFA***

Greensward Quay floods because the existing stormwater infrastructure is undersized, which also causes the surrounding private property to flood. There is no habitable structure flooding. The models indicate Greensward Quay begins to experience flooding in the 100-year storm event, as shown in Figure 22.

### ***Lords Landing SFA***

Lords Landing floods because the existing stormwater infrastructure is undersized. There is no habitable structure or private property flooding. The models indicate Lords Landing begins to experience flooding in the 100-year storm event, as shown in Figure 22.

#### 3.17.2 Project Description

This project proposes upsizing existing trunklines and constructing new trunklines to increase conveyance capacity of the neighborhood's stormwater system. The existing stormwater systems along Haversham Close and Duke of Norfolk Quay are upsized. New trunklines are added along North Great Neck Road and Upper Chelsea Reach as well as Greensward Quay and Queens Elm Place to relieve existing infrastructure. Runoff from Hunt Meet Circle and Oxen Court is routed to the existing channel north of Queens Elm Place through proposed trunklines. The runoff from the Chelsea and Green Hill Farms neighborhoods ultimately outfalls into Broad Bay.

#### 3.17.3 Project Benefits

The major benefits of this project include mitigating street flooding on Hunt Meet Circle, Oxen Court, Duke of Norfolk Quay, North Great Neck Road, Greensward Quay, and Lords Landing, as well as flooding occurring on the surrounding private property. The project mitigates habitable structure flooding for two structures on Greensward Quay and one structure on Rally Drive. The project also addresses several flood reports that have been documented in the area.

#### 3.17.4 Project Analysis Assumptions

HAZUS data is available for some, but not all, flooded habitable structures. The structures no longer flood in the 100-year storm event. Based on the BCR methodology, the project BCR is 1.0145. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM. As a secondary evacuation route, North Great Neck Road remains passable in the 10-year storm event with 3.0 feet SLR and the 100-year storm event with no SLR. Drainage

easements are required to upsize an outfall on Haversham Close, and to upsize infrastructure along Queens Elm Place. It is anticipated that moderate maintenance of traffic and utility relocations will be required during the construction of the project. Minimal effort will be required to obtain environmental permits. The extent of outfall upsizing north of Queens Elm Place, east of Duke of Norfolk Quay, and west of Haversham Close will likely impact the structural integrity of the existing bulkhead. Mitigation of these impacts is included in the OPCC.

3.17.5 Other Alternatives Scored

Two additional alternatives were scored as part of the analysis. Alternative 1 differs from the selected alternative (Alternative 3) because it proposed an additional new trunkline along Duke of Norfolk Quay to mitigate flooding instead of upsizing outfalls into the existing channel north of Queens Elm Place. Therefore, Alternative 1 proposed more trunklines along residential streets, disrupting more community members. Alternative 2 differs from the selected alternative because it proposed a new 60-inch stormwater outfall into the existing channel north of Queens Elm Place instead of upsizing existing infrastructure on Haversham Close. The proposed outfall in Alternative 2 would require additional permitting efforts that are not required for Alternative 3.

3.17.6 Other Alternatives Not Scored

Two additional alternatives were considered but were not scored. One alternative proposed a new stormwater trunkline along Green Hill Road and connected to the existing infrastructure on Cavalletti Court. The alternative caused an increase in flooding downstream and was not considered further.

A second alternative was considered as a variation of Alternative 3 to determine if the proposed trunkline on Greensward Quay is necessary. The proposed system at North Great Neck Road was disconnected from the existing system between Greensward Quay and Lords Landing, and the proposed trunkline on Greensward Quay was removed. By disconnecting the system and removing the proposed trunkline, Greensward Quay experienced more than 6 inches of flooding. Therefore, the proposed trunkline on Greensward Quay is needed to meet PWDSM requirements, and this alternative was not considered further.

3.17.7 Project Analysis Summary

Table 14 below provides a summary of the Chelsea and Green Hill Farms Neighborhood project analysis. Refer to Appendix B-17 for project exhibits and supporting documentation.

**Table 14. Chelsea and Green Hill Farms Neighborhood Project Summary**

<b>SFA Recurrence</b>	10-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 3
<b>ASC Score</b>	5.47/10
<b>Other ASC Score(s)</b>	Alternative 1 – 5.42/10 Alternative 2 – 5.17/10
<b>PPC Score</b>	6.24/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0145
<b>Project Cost</b>	\$9,810,000

### 3.18 Croatan Beach Neighborhood

Individual SFA locations, shown below in Figure 23 and further described below, are combined into the Croatan Beach Neighborhood project. Meeting the PWDSM requirements for the upstream SFAs is dependent on the improvements proposed for Phase 1D: Croatan Lot Pump Station at Croatan Beach. A phased project is proposed considering the extent of improvements that are required to accomplish the objective of the SWMP to develop “standalone” solutions that are not dependent on downstream improvements. It should be noted that Phase 1A: Kerry Lane at Croatan Road, Phase 1B: South Maryland Avenue, and Phase 1C: Virginia Dare Drive at Croatan Beach are not dependent on Phase 1D: Croatan Lot Pump Station at Croatan Beach. However, they are included in the phased project since they are located in the same neighborhood as the other improvements. Project phases are defined by the individual SFA boundaries and begin with the most downstream improvements. Future refinements to the proposed project phasing may be required. Refer to Appendix B-18-1 through B-18-7 for detailed project phase maps.

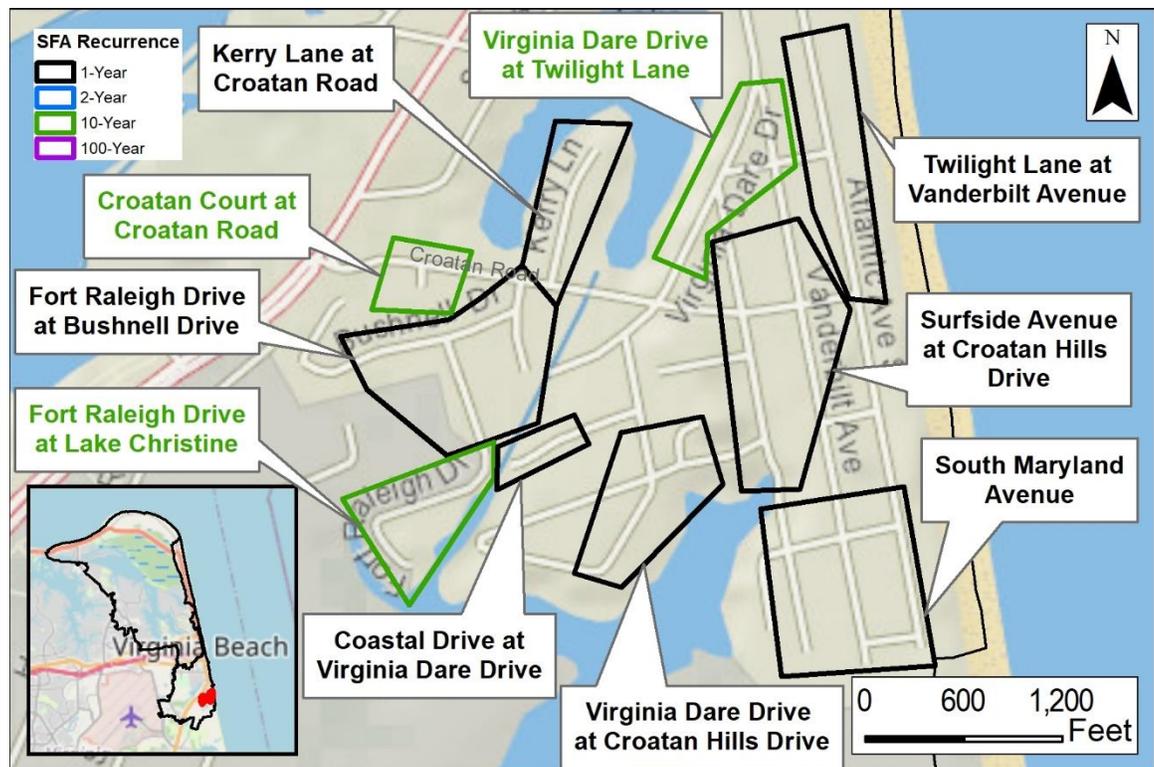


Figure 23. Location Map of Coastal Drive at Virginia Dare Drive, Kerry Lane at Croatan Road, South Maryland Avenue, Virginia Dare Drive at Croatan Hills Drive, Virginia Dare Drive at Twilight Lane, Twilight Lane at Vanderbilt Avenue, Surfside Avenue at Croatan Hills Drive, Croatan Court at Croatan Road, Fort Raleigh Drive at Bushnell Drive, and Fort Raleigh Drive at Lake Christine SFAs

#### 3.18.1 Phase 1A: Kerry Lane at Croatan Road

##### 3.18.1.1 SFA Description

Kerry Lane floods due to undersized stormwater infrastructure. The runoff on Kerry Lane ultimately outfalls into Lake Wesley, which has the same tailwater elevation as the Atlantic

Ocean. The models indicate Kerry Lane begins to experience flooding in the 1-year storm event, as shown in Figure 23.

3.18.1.2 Project Description

This project increases the capacity of the existing stormwater outfall on Kerry Lane to mitigate street flooding.

3.18.1.3 Project Benefits

The major benefits of this project include mitigating street flooding on Kerry Lane, as well as the flooding occurring on the surrounding private property.

3.18.1.4 Project Analysis Assumptions

No habitable structures are impacted in the 100-year storm event, so the project is given a BCR value of 1.0. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM. Easement acquisition is not required as all the construction can occur within the existing 20-foot drainage easement. Based on the inlet location shown in aerial and street views, the existing pipe is approximately located along the fence line of the property and does not conflict with the existing private pier. Similarly, upsizing the existing pipe is not anticipated to cause damages to the surrounding structures or pier. It is anticipated that minimal utility relocations will be required during the construction of the project (8-inch sewer gravity main), and that minimal effort will be required to obtain an environmental permit for the upsized outfall. The extent of outfall upsizing east of Kerry Lane will likely impact the structural integrity of the existing bulkhead. Mitigation of these impacts is included in the OPCC.

3.18.1.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

3.18.1.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.18.1.7 Project Analysis Summary

Table 15 below provides a summary of the Kerry Lane at Croatan Road project analysis. Refer to Appendix B-18-1 for project exhibits and supporting documentation.

**Table 15. Kerry Lane at Croatan Road Project Summary**

<b>SFA Recurrence</b>	1-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	6.33/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	3/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0 (no habitable structure flooding)
<b>Project Cost</b>	\$550,000

### 3.18.2 **Phase 1B: South Maryland Avenue**

#### 3.18.2.1 SFA Description

South Maryland Avenue SFA is located directly west of Croatan Beach and north of the Croatan Beach Parking Lot. Flooding in the area is ultimately caused by undersized existing pipes on Surfside Avenue and South Maryland Avenue. The existing infrastructure outfalls into Lake Christine, which has a high tailwater elevation and is tidally influenced by Lake Wesley. The models indicate South Maryland Avenue SFA begins to experience flooding in the 1-year storm event, as shown in Figure 23.

#### 3.18.2.2 Project Description

This project upsizes existing stormwater infrastructure along Surfside Avenue and South Maryland Avenue. New stormwater infrastructure is implemented along Surfside Avenue and the existing outfall into Lake Christine is upsized, as well.

#### 3.18.2.3 Project Benefits

The major benefits of the project include mitigating street flooding on Surfside Avenue, South Maryland Avenue, Vanderbilt Avenue, as well as the flooding occurring on surrounding private property. The project also mitigates flooding for 13 habitable structures on Surfside Avenue, Vanderbilt Avenue, and South Atlantic Avenue. This project addresses several flood reports that have been documented in the area.

#### 3.18.2.4 Project Analysis Assumptions

HAZUS data is available for the flooded habitable structures along Surfside Avenue, Vanderbilt Avenue, and South Atlantic Avenue. The structures no longer flood in the 100-year storm event. Based on the BCR methodology, the project BCR is 5.0096. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM. Easement acquisition is not required as all the construction will occur within the ROW on South Maryland Avenue and Surfside Avenue. It is anticipated that minimal maintenance of traffic and utility relocations will be required during the construction of the project. Minimal effort to obtain environmental permits is likely for the upsized outfall into Lake Christine.

#### 3.18.2.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

#### 3.18.2.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

#### 3.18.2.7 Project Analysis Summary

Table 16 below provides a summary of the South Maryland Avenue project analysis. Refer to Appendix B-18-2 for project exhibits and supporting documentation.

**Table 16. South Maryland Avenue Project Summary**

<b>SFA Recurrence</b>	1-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	5.99/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	7.2/14.4
<b>BR</b>	1.0
<b>BCR</b>	5.0096
<b>Project Cost</b>	\$2,070,000

3.18.3 **Phase 1C: Virginia Dare Drive at Croatan Hills Drive**

3.18.3.1 **SFA Description**

Virginia Dare Drive at Croatan Hills Drive is located west of Croatan Beach. Flooding is caused by undersized outfall pipes along Virginia Dare Drive and Croatan Hills Drive. The existing drainage infrastructure outfalls into Lake Christine, which has a high tailwater elevation and is tidally influenced by Lake Wesley. The models indicate Virginia Dare Drive at Croatan Hills Drive begins to experience flooding in the 1-year storm event, as shown in Figure 23.

3.18.3.2 **Project Description**

The project upsizes existing stormwater outfalls south of Virginia Dare Drive and Croatan Hills Drive.

3.18.3.3 **Project Benefits**

The major benefits of the project include mitigating street flooding on Virginia Dare Drive and Croatan Hills Drive, as well as the flooding occurring on the surrounding private property. The project mitigates habitable structure flooding on Virginia Dare Drive. The project also addresses several flood reports that have been documented in the area.

3.18.3.4 **Project Analysis Assumptions**

HAZUS data is available for the flooded habitable structure along Virginia Dare Drive. The structure no longer floods in the 100-year storm event. Based on the BCR methodology, the project BCR is 1.7520. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM. Easement acquisition from multiple private landowners is required for drainage easements. Structural damage from upsizing pipes between houses is not anticipated based on the existing inlet locations on aerial view. There is adequate space of at least 20 feet to allow for installation of the upsized pipes. It is anticipated that minimal maintenance of traffic and utility conflicts will be required during the construction of the project and minimal effort will be required to obtain environmental permits. The extent of outfall upsizing south of Virginia Dare Drive will likely impact the structural integrity of the existing bulkhead. Mitigation of these impacts is included in the OPCC.

3.18.3.5 **Other Alternatives Scored**

No additional alternatives were evaluated for this SFA.

3.18.3.6 **Other Alternatives Not Scored**

No additional alternatives were evaluated for this SFA.

### 3.18.3.7 Project Analysis Summary

Table 17 below provides a summary of the Virginia Dare Drive at Croatan Hills Drive project analysis. Refer to Appendix B-18-3 for project exhibits and supporting documentation.

**Table 17. Virginia Dare Drive at Croatan Hills Drive Project Summary**

<b>SFA Recurrence</b>	1-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	5.49/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	7.2/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.7520
<b>Project Cost</b>	\$1,590,000

### 3.18.4 **Phase 1D: Croatan Lot Pump Station at Croatan Beach**

#### 3.18.4.1 SFA Description

Coastal Drive at Virginia Dare Drive and adjacent private property experiences flooding due to high water surface elevations in Lake Christine. The models indicate Coastal Drive at Virginia Dare Drive begins to experience flooding in the 1-year storm event, as shown in Figure 23.

#### 3.18.4.2 Project Description

This project adds a 700 cfs pump station within the federal property immediately west of the Croatan Beach Parking Lot (920 Vanderbilt Avenue). The proposed pump station pumps stormwater out of Lake Christine and outfalls into the Atlantic Ocean. A proposed gate structure is required at Lake Christine's outfall near Coastal Drive. The top of the proposed gate structure is required to be at a minimum elevation of 8 feet to prevent backflow from Lake Wesley into Lake Christine.

#### 3.18.4.3 Project Benefits

The major benefits of this project include reducing street flooding on Fort Raleigh Drive, Virginia Dare Drive, Croatan Hills Drive, Surfside Avenue, and Croatan Road, as well as mitigating street flooding on Coastal Drive. This project mitigates habitable structure flooding for five structures on Fort Raleigh Drive, two on Virginia Dare Drive, one on Croatan Court, and one on Christine Drive. Flooding occurring on the surrounding private property is mitigated, as well. This project also addresses several flood reports that have been documented in the area.

#### 3.18.4.4 Project Analysis Assumptions

The project indicates structural flooding is resolved; however, the structural flooding is not reflected in the BCR of 1.0. This project is given a BR of 1.0 because all street flooding is mitigated. The Croatan Parking Lot is a facility operated by the City. While City GIS information designates the facility as a federal property, it is assumed the City has the appropriate rights to construct the proposed improvements considering the existing use. Easement acquisition will be required for the intake and outfall pipes for the pump station. It is anticipated that minimal maintenance of traffic and utility relocations will be required during the construction of the project. Extensive coordination with the USACE will be required to construct an outfall directly into the Atlantic Ocean.

### 3.18.4.5 Other Alternatives Scored

Another alternative, as described below, was considered, but was not scored.

### 3.18.4.6 Other Alternatives Not Scored

A 10-year LOS was considered for the Coastal Drive at Virginia Dare Drive, Fort Raleigh Drive at Bushnell Drive, Croatan Court at Croatan Road, Fort Raleigh Drive at Lake Christine, Virginia Dare Drive at Twilight Lane, and Surfside Avenue at Croatan Hills Drive SFAs. This approach included only the proposed 700 cfs pump station with no other neighborhood pipe improvements. The pump station alone does not meet the 10-year LOS requirements for the remaining SFAs, so this alternative was not considered further.

### 3.18.4.7 Project Analysis Summary

Table 18 below provides a summary of the Croatan Lot Pump Station at Croatan Beach project analysis. Refer to Appendix B-18-4 for project exhibits and supporting documentation.

**Table 18. Croatan Lot Pump Station at Croatan Beach Project Summary**

<b>SFA Recurrence</b>	1-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	2.94/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	7.7/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0 (no HAZUS data available)
<b>Project Cost</b>	\$127,870,000

### 3.18.5 **Phase 2A: Christine Drive at Croatan Road**

#### 3.18.5.1 SFA Description

The Fort Raleigh Drive at Bushnell Drive, Croatan Court at Croatan Road, and Fort Raleigh Drive at Lake Christine SFAs are combined into one project called Christine Drive at Croatan Road. Individual SFA locations are shown in Figure 23 and are further described below. All three SFAs are hydraulically connected and can be combined into one project.

#### ***Croatan Court at Croatan Road SFA***

Croatan Court at Croatan Road experiences flooding due to inadequate pipes. Private property adjacent to Croatan Court experiences flooding, as well. The models indicate Croatan Court at Croatan Road begins to experience flooding in the 10-year storm event, as shown in Figure 23.

#### ***Fort Raleigh Drive at Bushnell Drive SFA***

Fort Raleigh Drive at Bushnell Drive experiences flooding due to inadequate pipes as well as high tailwater. The tailwater in the outfall ditch in the existing conditions is higher than the minimum elevation of Fort Raleigh Drive. Private property adjacent to Fort Raleigh Drive and Christine Drive experiences flooding, as well. The models indicate Fort Raleigh Drive at Bushnell Drive begins to experience flooding in the 1-year storm event, as shown in Figure 23.

### ***Fort Raleigh Drive at Lake Christine SFA***

Fort Raleigh Drive at Lake Christine experiences flooding due to a high tailwater in Lake Christine. Private property adjacent to Fort Raleigh Drive experiences flooding, as well. The models indicate Fort Raleigh Drive at Lake Christine begins to experience flooding in the 10-year storm event, as shown in Figure 23.

#### 3.18.5.2 Project Description

This project upsizes the existing trunkline along Bushnell Drive and between houses on Croatan Court and Bushnell Drive. Two new trunklines are added. The first runs east along Bushnell Drive and outfalls into Lake Wesley west of Kerry Lane. The second runs south along Fort Raleigh Drive and outfalls into Lake Christine. Croatan Beach Neighborhood Phase 2A: Christine Drive at Croatan Road is dependent on Croatan Beach Neighborhood Phase 1D: Croatan Lot Pump Station at Croatan Beach.

#### 3.18.5.3 Project Benefits

The major benefits of this project include mitigating street flooding on Croatan Court, Bushnell Drive, Christine Drive, and Fort Raleigh Drive, as well as the flooding occurring on surrounding property on these roads. The project mitigates flooding for one habitable structure on Fort Raleigh Drive. The project also addresses several flood reports that have been documented in the area.

#### 3.18.5.4 Project Analysis Assumptions

HAZUS data is available for the structure on Fort Raleigh Drive. The structure no longer floods in the 100-year storm event. Based on the BCR methodology, the project BCR is 1.2118. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM. Easement acquisition is required from multiple private landowners for drainage easements. It is anticipated that moderate maintenance of traffic and utility relocations will be required during the construction of the project. Minimal effort will be required to obtain environmental permits to add an outfall into Lake Wesley and to upsize an outfall into Lake Christine. The proposed outfall north of Croatan Road will likely impact the structural integrity of the existing bulkhead. Mitigation of these impacts is included in the OPCC.

#### 3.18.5.5 Other Alternatives Scored

Another alternative, as described below, was considered, but was not scored.

#### 3.18.5.6 Other Alternatives Not Scored

A second alternative proposed a BMP on federal property west of Fort Raleigh Drive (Camp Pendleton) to reduce the proposed trunkline sizes along Fort Raleigh Drive. This alternative was ultimately not considered further as significant coordination with Camp Pendleton would be required.

#### 3.18.5.7 Project Analysis Summary

Table 19 below provides a summary of the Christine Drive at Croatan Road project analysis. Refer to Appendix B-18-5 for project exhibits and supporting documentation.

**Table 19. Christine Drive at Croatan Road Project Summary**

<b>SFA Recurrence</b>	1-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	5.12/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	7.7/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.2118
<b>Project Cost</b>	\$7,840,000

3.18.6 **Phase 2B: Twilight Lane at Vanderbilt Avenue**

3.18.6.1 SFA Description

Twilight Lane at Vanderbilt Avenue experiences flooding due to an inadequate outfall pipe and overall lack of drainage infrastructure. The models indicate Twilight Lane at Vanderbilt Avenue begins to experience flooding in the 1-year storm event, as shown in Figure 23.

3.18.6.2 Project Description

This project upsizes existing and adds new stormwater trunklines. The existing infrastructure on Twilight Lane is upsized, and the flow is reversed towards Vanderbilt Avenue. A proposed stormwater trunkline conveys runoff from Twilight Lane north to a proposed outfall into Lake Wesley through an existing undeveloped parcel. Croatan Beach Neighborhood Phase 2B: Twilight Lane at Vanderbilt Avenue is dependent on Croatan Beach Neighborhood Phase 1D: Croatan Lot Pump Station at Croatan Beach.

3.18.6.3 Project Benefits

The major benefits of this project include mitigating street flooding on South Atlantic Avenue, as well as the flooding occurring on surrounding private property. This project also addresses several flood reports that have been documented in the area.

3.18.6.4 Project Analysis Assumptions

No habitable structures are impacted in the 100-year storm event, so the project is given a BCR value of 1.0. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM. Easement acquisition from multiple private property owners is required to upsize and construct new stormwater infrastructure. It is anticipated that minimal maintenance of traffic will be required during the construction of the project because this is a low-traffic area, and the residents will have alternative routes to access their residences during construction. Moderate utility relocations will be required along Twilight Lane and Vanderbilt Avenue. Minimal effort will be required to obtain an environmental permit for the proposed outfall into Lake Wesley. The proposed outfall west of Virginia Dare Drive will likely impact the structural integrity of the existing bulkhead. Mitigation of these impacts is included in the OPCC.

South Atlantic Avenue has minimal stormwater infrastructure. The infrastructure that does exist on Twilight Lane was not large enough to be included in the current model. As a result, conservative assumptions were made to determine the extent of the curb, gutter, and pipe improvements needed to convey stormwater runoff to the proposed 42-inch trunkline. Additional analysis in the design phase is recommended to confirm the extent and cost of improvements.

3.18.6.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

3.18.6.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.18.6.7 Project Analysis Summary

Table 20 below provides a summary of the Twilight Lane at Vanderbilt Avenue project analysis. Refer to Appendix B-18-6 for project exhibits and supporting documentation.

**Table 20. Twilight Lane at Vanderbilt Avenue Project Summary**

<b>SFA Recurrence</b>	1-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	5.45/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	3.4/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0 (no habitable structure flooding)
<b>Project Cost</b>	\$3,860,000

3.18.7 **Phase 3: Surfside Avenue at Virginia Dare Drive**

3.18.7.1 SFA Description

The Virginia Dare Drive at Twilight Lane and Surfside Avenue at Croatan Hills Drive SFAs are combined into the Surfside Avenue at Virginia Dare Drive project. Individual SFA locations are shown in Figure 23 and are further described below. Both SFAs are hydraulically connected and can be combined into one project.

***Virginia Dare Drive at Twilight Lane SFA***

Virginia Dare Drive at Twilight Lane experiences flooding due to an inadequate outfall pipe. The models indicate Virginia Dare Drive at Twilight Lane begins to experience flooding in the 10-year storm event, as shown in Figure 23.

***Surfside Avenue at Croatan Hills Drive SFA***

Surfside Avenue at Croatan Hills Drive begins to experience flooding due to undersized stormwater infrastructure and a lack of storage in the area. Private property adjacent to Surfside Avenue experiences flooding as well. The models indicate Surfside Avenue at Croatan Hills Drive begins to experience flooding in the 1-year storm event, as shown in Figure 23.

3.18.7.2 Project Description

This project upsizes existing and adds new stormwater trunklines on the northeast side of the Croatan Beach Neighborhood. Existing infrastructure on Surfside Avenue is upsized. Proposed trunklines on Virginia Dare Drive and Surfside Avenue outfall into Lake Wesley near the existing culvert crossing beneath Croatan Road. Croatan Beach Neighborhood Phase 3:

Surfside Avenue at Virginia Dare Drive is dependent on Croatan Beach Neighborhood Phase 2B: Twilight Lane at Vanderbilt Avenue.

3.18.7.3 Project Benefits

The major benefits of this project include mitigating street flooding on Surfside Avenue, Croatan Road, and Croatan Hills Drive, as well as the flooding occurring on the surrounding private property. This project also addresses several flood reports that have been documented in the area.

3.18.7.4 Project Analysis Assumptions

The project indicates structural flooding is resolved; however, the structural flooding is not reflected in the BCR of 1.0. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM. No easement acquisition is required from private property owners as all proposed improvements are located within the ROW.

Moderate maintenance of traffic and utility relocations will be required during the construction of the project. Minimal effort will be required to obtain an environmental permit for the upsized and proposed outfalls.

3.18.7.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

3.18.7.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.18.7.7 Project Analysis Summary

Table 21 below provides a summary of the Surfside Avenue at Virginia Dare Drive project analysis. Refer to Appendix B-18-7 for project exhibits and supporting documentation.

**Table 21. Surfside Avenue at Virginia Dare Drive Project Summary**

<b>SFA Recurrence</b>	1-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	5.84/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	7.7/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0 (no HAZUS data available)
<b>Project Cost</b>	\$4,950,000

3.18.8 **Croatan Beach Neighborhood Combined Summary**

Table 22 below provides a summary of the Croatan Beach Neighborhood Project analysis. Refer to Appendix B-18-1 through B-18-7 for project exhibits and supporting documentation.

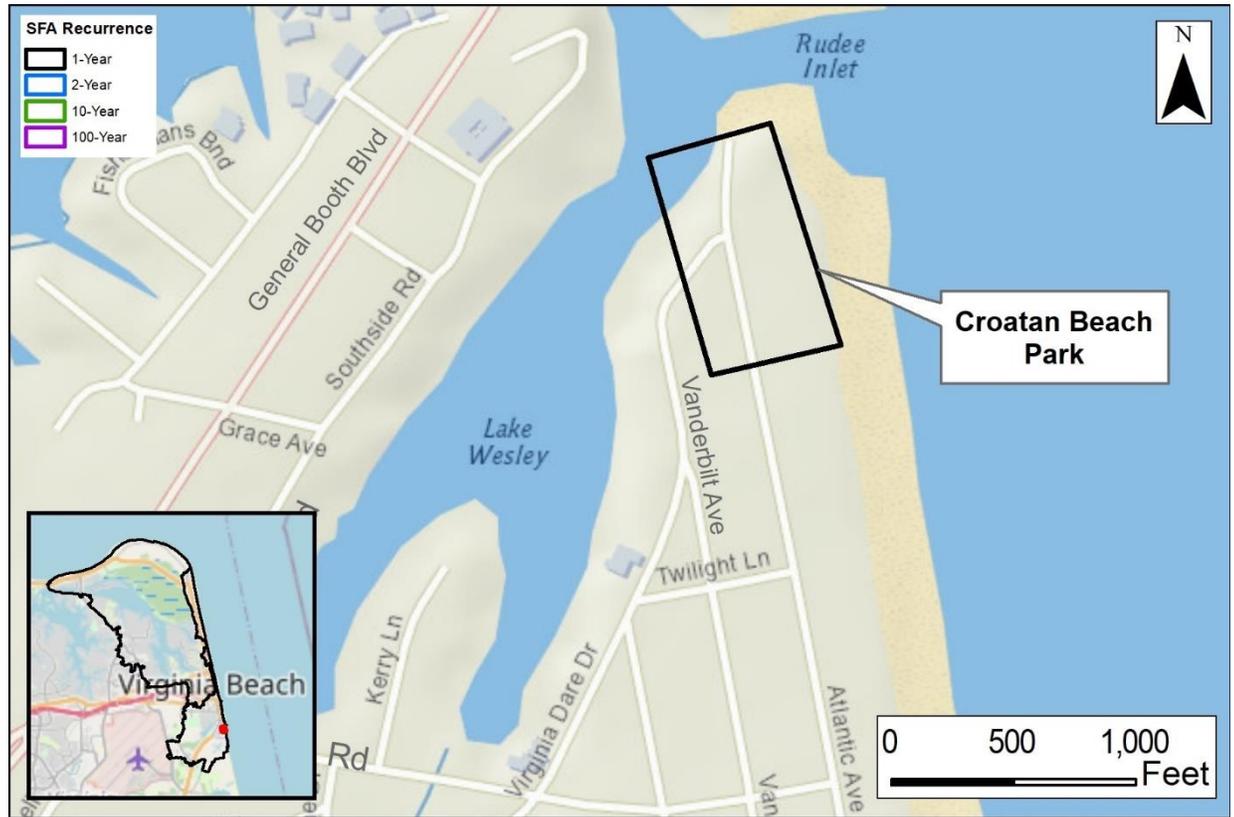
**Table 22. Croatan Beach Neighborhood Project Summary**

	<b>Phase 1A: Kerry Lane at Croatan Road</b>	<b>Phase 1B: South Maryland Avenue</b>	<b>Phase 1C: Virginia Dare Drive at Croatan Hills Drive</b>	<b>Phase 1D: Croatan Lot Pump Station at Croatan Beach</b>	<b>Phase 2A: Christine Drive at Croatan Road</b>	<b>Phase 2B: Twilight Lane at Vanderbilt Avenue</b>	<b>Phase 3: Surfside Avenue at Virginia Dare Drive</b>
<b>SFA Recurrence</b>	1-year (no SLR)	1-year (no SLR)	1-year (no SLR)	1-year (no SLR)	1-year (no SLR)	1-year (no SLR)	1-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)	100-year (no SLR)	100-year (no SLR)	100-year (no SLR)	100-year (no SLR)	100-year (no SLR)	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1	Alternative 1	Alternative 1	Alternative 1	Alternative 1	Alternative 1	Alternative 1
<b>ASC Score</b>	6.33/10	5.99/10	5.49/10	2.94/10	5.12/10	5.45/10	5.84/10
<b>Other ASC Score(s)</b>	N/A	N/A	N/A	N/A	N/A	N/A	N/A
<b>PPC Score</b>	3/14.4	7.2/14.4	7.2/14.4	7.7/14.4	7.7/14.4	3.4/14.4	7.7/14.4
<b>BR</b>	1.0	1.0	1.0	1.0	1.0	1.0	1.0
<b>BCR</b>	1.0 (no habitable structure flooding)	5.0096	1.7520	1.0 (no HAZUS data available)	1.2118	1.0 (no habitable structures flooding)	1.0 (no habitable structures flooding)
<b>Individual Project Cost</b>	\$550,000	\$2,070,000	\$1,590,000	\$127,870,000	\$7,840,000	\$3,860,000	\$4,950,000
<b>Total Project Cost</b>	\$148,730,000						

### 3.19 Croatan Beach Park

#### 3.19.1 SFA Description

Streets, private property, and habitable structures experience flooding along South Atlantic Avenue near Croatan Beach Park. The flooding is caused by inadequate pipes and a lack of storage in the area. Additionally, the outfall has high tailwater elevations from a tidally influenced outfall. The models indicate Croatan Beach Park begins to experience flooding in the 1-year storm event, as shown in Figure 24.



**Figure 24. Location Map of Croatan Beach Park SFA**

#### 3.19.2 Project Description

This project adds a box culvert beneath South Atlantic Avenue and a backflow preventer at the outfall.

#### 3.19.3 Project Benefits

The major benefits of the project include mitigating street flooding along South Atlantic Avenue and Virginia Dare Road. Habitable structure flooding is mitigated for three structures along South Atlantic Avenue. The project also addresses several flood reports that have been documented in the area.

#### 3.19.4 Project Analysis Assumptions

HAZUS data is available for some, but not all, flooded habitable structures. The structures no longer flood in the 100-year event. Based on the BCR methodology, the project BCR is

1.9922. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM.

Easement acquisition will be required for one drainage easement. Easement acquisition is limited by maintaining the majority of the improvements within the ROW. It is anticipated that moderate maintenance of traffic will be required during the construction of the project for the residents along South Atlantic Avenue. Moderate utility relocations will be required for conflicts with an 8-inch gravity sewer line and 8-inch water line along South Atlantic Avenue. Minimal effort will be required to obtain environmental permits to modify an existing outfall in tidal wetlands.

3.19.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

3.19.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.19.7 Project Analysis Summary

Table 23 below provides a summary of the Croatan Beach Park project analysis. Refer to Appendix B-19 for project exhibits and supporting documentation.

**Table 23. Croatan Beach Park Project Summary**

<b>SFA Recurrence</b>	1-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	5.3/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	7.2/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.9922
<b>Project Cost</b>	\$2,000,000

### 3.20 Crystal Lake Circle

#### 3.20.1 SFA Description

Crystal Lake Circle is a residential street in the Bay Colony neighborhood ranging in elevation from approximately 3.5 to 4 feet. The design tailwater elevation for the 100-year storm event with no SLR is 4.3 feet in the existing condition. The tailwater elevation, independent of existing drainage infrastructure, floods a portion of the street. The models indicate Crystal Lake Circle begins to experience flooding in the 1-year storm event, as shown in Figure 25.

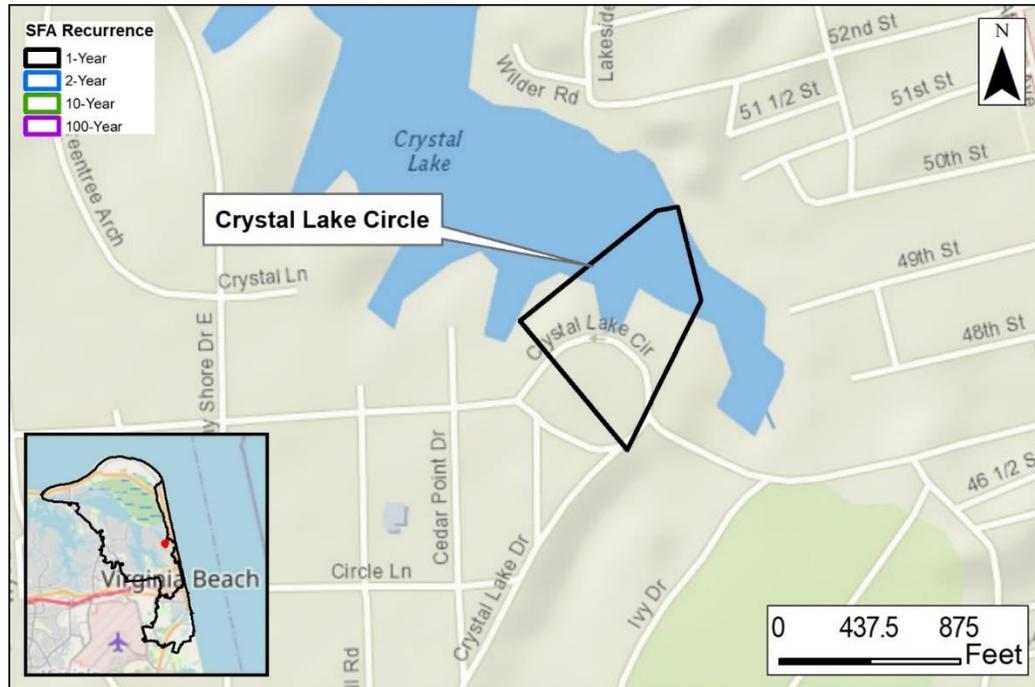


Figure 25. Location Map of Crystal Lake Circle SFA

#### 3.20.2 Project Description

The downstream tailwater conditions severely limit the options for improvements to this neighborhood. The City will be evaluating this SFA with a Neighborhood Strategy in the future. Refer to Appendix B-20 for the extent of existing flooding in the area.

#### 3.20.3 Project Benefits

There is no project, and there are no benefits.

#### 3.20.4 Other Alternatives Scored

No alternatives were evaluated for this SFA.

#### 3.20.5 Other Alternatives Not Scored

This neighborhood would benefit from a neighborhood solution, similar to those shown in the SLR Adaptation Strategy Report. This neighborhood can be designed to resolve the flooding issues that occur from a smaller storm event. PW-SWEC will, in the future, have a neighborhood solution created to establish resiliency in this neighborhood.

## 3.21 Curlew Place

### 3.21.1 SFA Description

Curlew Place is a residential street in the Birdneck Point neighborhood located off Oriole Drive. Curlew Place ranges in elevation from approximately 3 to 5 feet. The design tailwater elevation for the 100-year storm event with no SLR is 4.3 feet in the existing condition. The tailwater elevation, independent of existing drainage infrastructure, floods a portion of the street. The models indicate Curlew Place begins to experience flooding in the 1-year storm event, as shown in Figure 26.



**Figure 26. Location Map of Curlew Place SFA**

### 3.21.2 Project Description

The downstream tailwater conditions severely limit the options for improvements to this neighborhood. The City will be evaluating this SFA with a Neighborhood Strategy in the future. Refer to Appendix B-21 for the extent of existing flooding in the area.

### 3.21.3 Project Benefits

There is no project and there are no benefits.

### 3.21.4 Other Alternatives Scored

No alternatives were evaluated for this SFA.

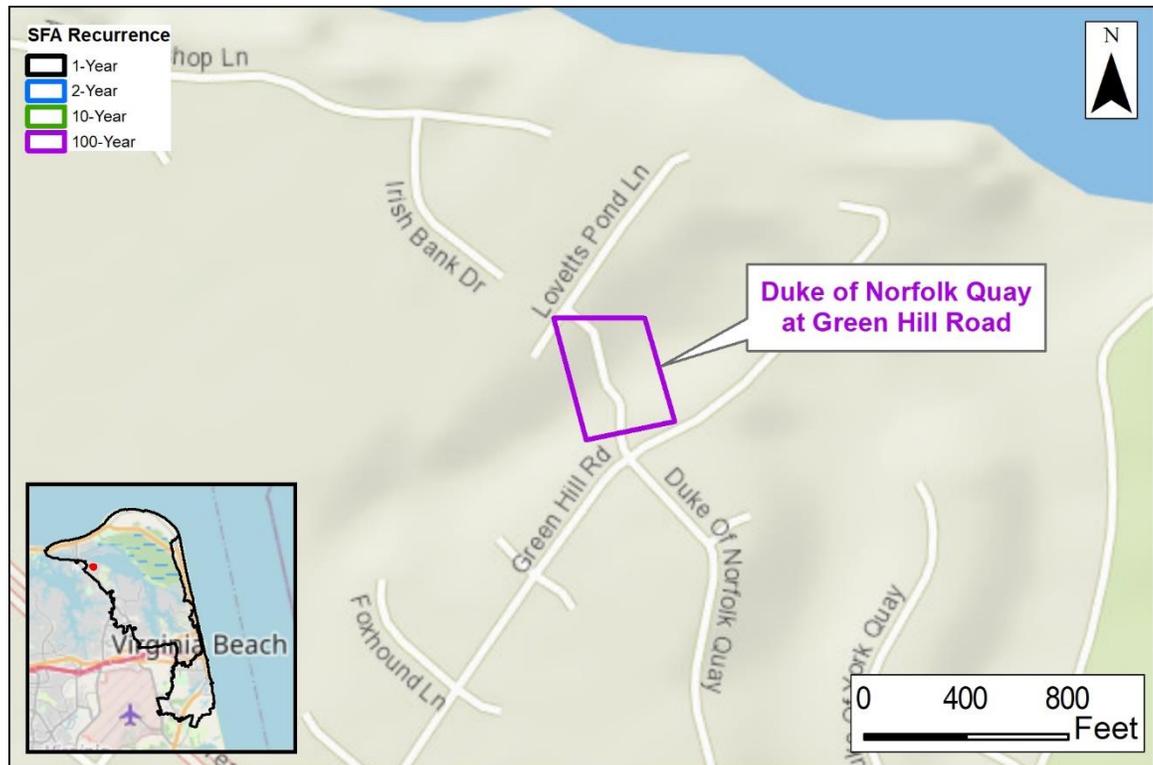
### 3.21.5 Other Alternatives Not Scored

This neighborhood would benefit from a neighborhood solution, similar to those shown in the SLR Adaptation Strategy Report. This neighborhood can be designed to resolve the flooding issues that occur from a smaller storm event. PW-SWEC will, in the future, have a neighborhood solution created to establish resiliency in this neighborhood.

## 3.22 Duke of Norfolk Quay at Green Hill Road

### 3.22.1 SFA Description

Duke of Norfolk Quay floods due to inadequate culverts under Green Hill Road. In the existing condition, stormwater flows under Duke of Norfolk Quay through quadruple 41-inch by 53-inch elliptical pipes and continues under Green Hill Road through dual 36-inch pipes. The dual 36-inch pipes are inadequate and cause habitable structure and private property flooding on Lovetts Pond Lane, Duke of Norfolk Quay, and Green Hill Road. The models indicate Duke of Norfolk Quay begins to experience flooding in the 100-year storm event, as shown in Figure 27.



**Figure 27. Location Map of Duke of Norfolk Quay at Green Hill Road SFA**

### 3.22.2 Project Description

This project upsizes the existing dual 36-inch culverts under Green Hill Road.

### 3.22.3 Project Benefits

The major benefits of the project include mitigating street flooding on Duke of Norfolk Quay, as well as the flooding on the surrounding private property. Flooding for three habitable structures on Lovetts Pond Lane, one habitable structure on Duke of Norfolk Quay, and two habitable structures on Green Hill Road is mitigated. The project also addresses several flood reports that have been documented in the area.

### 3.22.4 Project Analysis Assumptions

HAZUS data is available for some, but not all, flooded habitable structures. The structures no longer flood in the 100-year storm event. Based on the BCR methodology, the project BCR is

1.0134. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM.

This project is based on the assumption that Duke of Norfolk Quay, north of Green Hill Road, is a public road based on more recent information provided by the City but not currently reflected in the publicly available City GIS data. Easement acquisition for this project is not required as all the construction will occur within the ROW or existing easements. It is anticipated that moderate maintenance of traffic will be required during construction as the project will temporarily impact access to nine houses. Minimal utility relocations will be required, and minimal effort will be required to obtain environmental permits. The proposed outfall southwest of Green Hill Road will likely impact the structural integrity of the existing bulkhead. Mitigation of these impacts is included in the OPCC.

3.22.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

3.22.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.22.7 Project Analysis Summary

Table 24 below provides a summary of the Duke of Norfolk Quay at Green Hill Road project analysis. Refer to Appendix B-22 for project exhibits and supporting documentation.

**Table 24. Duke of Norfolk Quay at Green Hill Road Project Summary**

<b>SFA Recurrence</b>	100-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	6.01/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	4.67/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0134
<b>Project Cost</b>	\$1,780,000

### 3.23 East Bay Shore Drive at Cavalier Drive

#### 3.23.1 SFA Description

East Bay Shore Drive at Cavalier Drive floods due to a lack of stormwater infrastructure. Habitable structures, private property, and streets flood in the area. The models indicate East Bay Shore Drive at Cavalier Drive begins to experience flooding in the 1-year storm event, as shown in Figure 28.



**Figure 28. Location Map of East Bay Shore Drive at Cavalier Drive SFA**

#### 3.23.2 Project Description

This project adds a 42-inch trunkline along East Bay Shore Drive to convey stormwater from the low point and outfall south of the intersection of East Bay Shore Drive and Cavalier Drive.

#### 3.23.3 Project Benefits

The major benefits of the project include mitigating habitable structure flooding for six structures and street flooding on East Bay Shore Drive. The project also addresses several flood reports that have been documented in the area. There is a potential cost-sharing opportunity with DPU for water leak prioritization along Cavalier Drive.

#### 3.23.4 Project Analysis Assumptions

HAZUS data is available for some, but not all, flooded habitable structures. The structures no longer flood in the 100-year storm event. Based on the BCR methodology, the project BCR is 5.2259. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM.

Easement acquisition will be required for the proposed outfall. It is anticipated that moderate maintenance of traffic and utility relocations will be required during the construction of the project. Minimal effort will be required to obtain environmental permits.

The existing neighborhood has minimal stormwater infrastructure. The infrastructure that does exist is not large enough to be included in the current model. As a result, conservative assumptions are made to determine the extent of the curb, gutter, and ditch improvements needed to convey stormwater runoff to the proposed trunk line. Additional analysis in the design phase is recommended to confirm the extent and cost of improvements.

3.23.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

3.23.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.23.7 Project Analysis Summary

Table 25 below provides a summary of the East Bay Shore Drive at Cavalier Drive project analysis. Refer to Appendix B-23 for project exhibits and supporting documentation.

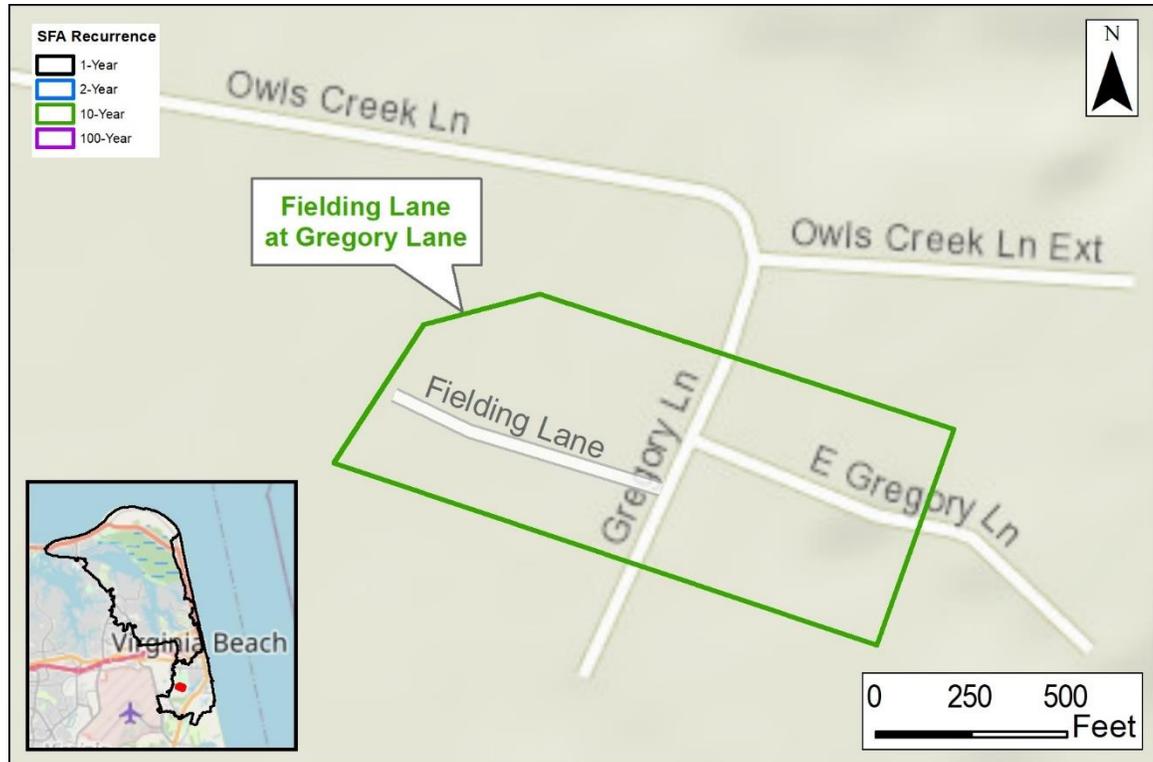
**Table 25. East Bay Shore Drive at Cavalier Drive Project Summary**

<b>SFA Recurrence</b>	1-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	5.24/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	7.2/14.4
<b>BR</b>	1.0
<b>BCR</b>	5.2259
<b>Project Cost</b>	\$2,490,000

### 3.24 Fielding Lane at Gregory Lane

#### 3.24.1 SFA Description

Fielding Lane at Gregory Lane is located west of Lake Rudee and east of South Birdneck Road. Fielding Lane and East Gregory Lane experience flooding due to inadequate stormwater infrastructure and a tidally influenced outfall into Lake Rudee. Streets, private property, and habitable structures experience flooding in the area. The models indicate Fielding Lane at Gregory Lane begins to experience flooding in the 10-year storm event, as shown in Figure 29.



**Figure 29. Location Map of Fielding Lane at Gregory Lane SFA**

#### 3.24.2 Project Description

This project upsizes the existing drainage infrastructure along Fielding Lane and Gregory Lane. The upsized infrastructure drains south along Gregory Lane and ultimately outfalls into Lake Rudee.

#### 3.24.3 Project Benefits

The major benefits of the project include mitigating street flooding on Fielding Lane and East Gregory Lane, as well as the flooding occurring on the surrounding private property. Habitable structure flooding is mitigated for one structure on Fielding Lane. This project also resolves multiple documented flood reports and mitigates flooding in an economically disadvantaged area.

### 3.24.4 Project Analysis Assumptions

The project indicates structural flooding is resolved; however, the structural flooding is not reflected in the BCR of 1.0. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM.

Easement acquisition will be required to upsize infrastructure along Gregory Lane and Fielding Lane. Minor encroachment onto federally owned property is required to upsize two existing pipes, but utilizing the existing easement for the southern cul-de-sac of Gregory Lane will minimize the encroachment. It is anticipated that moderate utility relocation will be required for conflicts with an 8-inch sewer gravity main and a 10-inch water main. Minimal effort will likely be required to obtain environmental permits for wetland impacts at the outfall location on Gregory Lane.

### 3.24.5 Other Alternatives Scored

Another alternative, as described below, was considered, but was not scored.

### 3.24.6 Other Alternatives Not Scored

One additional alternative was considered but was not scored. This alternative proposed constructing a new BMP on federally owned land (GPIN 24175071750000). This alternative did meet the PWDSM requirements but would require significant impacts to federal property, so it was not evaluated further.

### 3.24.7 Project Analysis Summary

Table 26 below provides a summary of the Fielding Lane at Gregory Lane project analysis. Refer to Appendix B-24 for project exhibits and supporting documentation.

**Table 26. Fielding Lane at Gregory Lane Project Summary**

<b>SFA Recurrence</b>	10-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	4.86/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	5.68/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0 (no HAZUS data available)
<b>Project Cost</b>	\$1,560,000

### 3.25 First Colonial Road at Camelot Drive

#### 3.25.1 SFA Description

First Colonial Road and adjacent commercial property experience flooding due to undersized stormwater infrastructure. First Colonial Road is considered a secondary evacuation route. The models indicate First Colonial Road at Camelot Drive begins to experience flooding in the 2-year storm event, as shown in Figure 30.

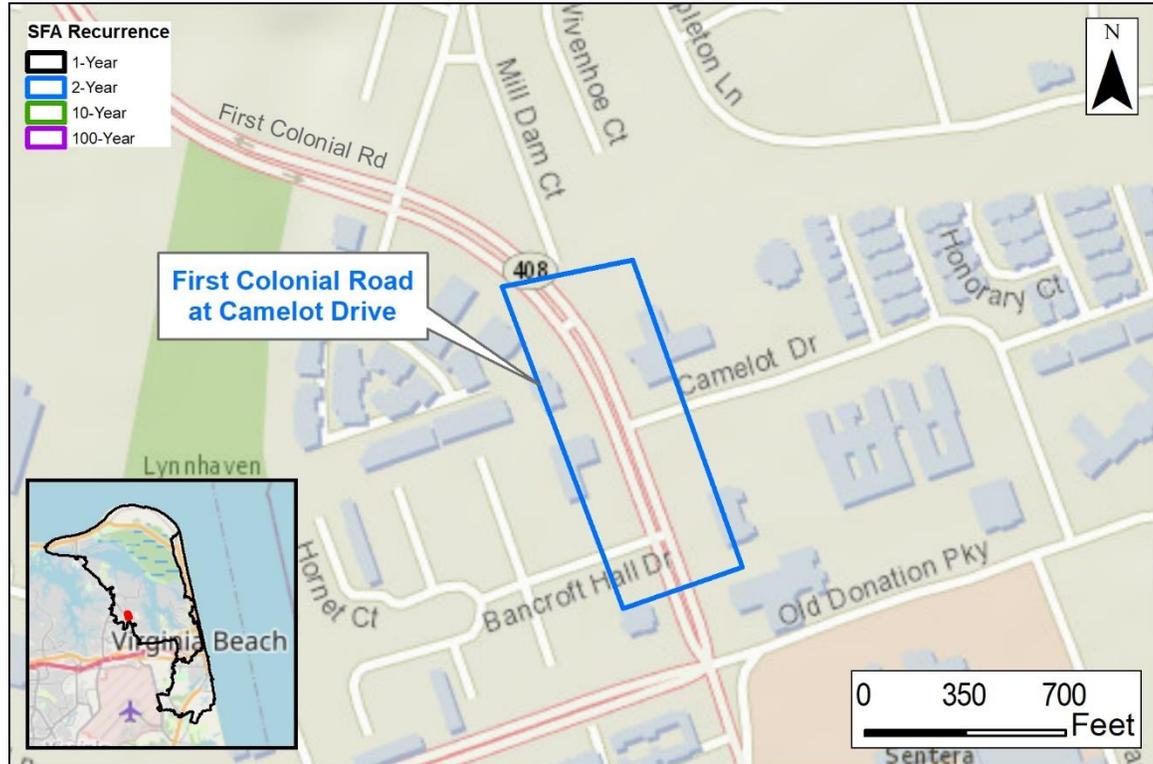


Figure 30. Location Map of First Colonial Road at Camelot Drive SFA

#### 3.25.2 Project Description

This project upsizes the existing stormwater trunkline running north on First Colonial Road. This project also proposes another outfall for the existing stormwater system along First Colonial Road by connecting to the Camelot Drive system that outfalls west of First Colonial Road near Lynnhaven Park.

#### 3.25.3 Project Benefits

The major benefits of this project include mitigating street flooding on First Colonial Road and Camelot Drive and the flooding occurring on surrounding commercial property. This project also ensures First Colonial Road can effectively serve as a secondary evacuation route and addresses several flood reports that have been documented in the area. There is a potential cost-sharing opportunity with this project through DPU for transmission main prioritization along First Colonial Road.

#### 3.25.4 Project Analysis Assumptions

No habitable structures are impacted in the 100-year storm event, so the project is given a BCR value of 1.0. The project is given a BR of 1.0 because street flooding is mitigated to meet

the PWDSM. First Colonial Road, as a secondary evacuation route, remains passable in the 10-year storm event with 3.0 feet SLR and the 100-year storm event with no SLR. Property or easement acquisition is not required as all the construction will occur within the ROW on First Colonial Road. It is anticipated that moderate maintenance of traffic and minimal utility relocations will be required during the construction of the project.

3.25.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

3.25.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.25.7 Project Analysis Summary

Table 27 below provides a summary of the First Colonial Road at Camelot Drive project analysis. Refer to Appendix B-25 for project exhibits and supporting documentation.

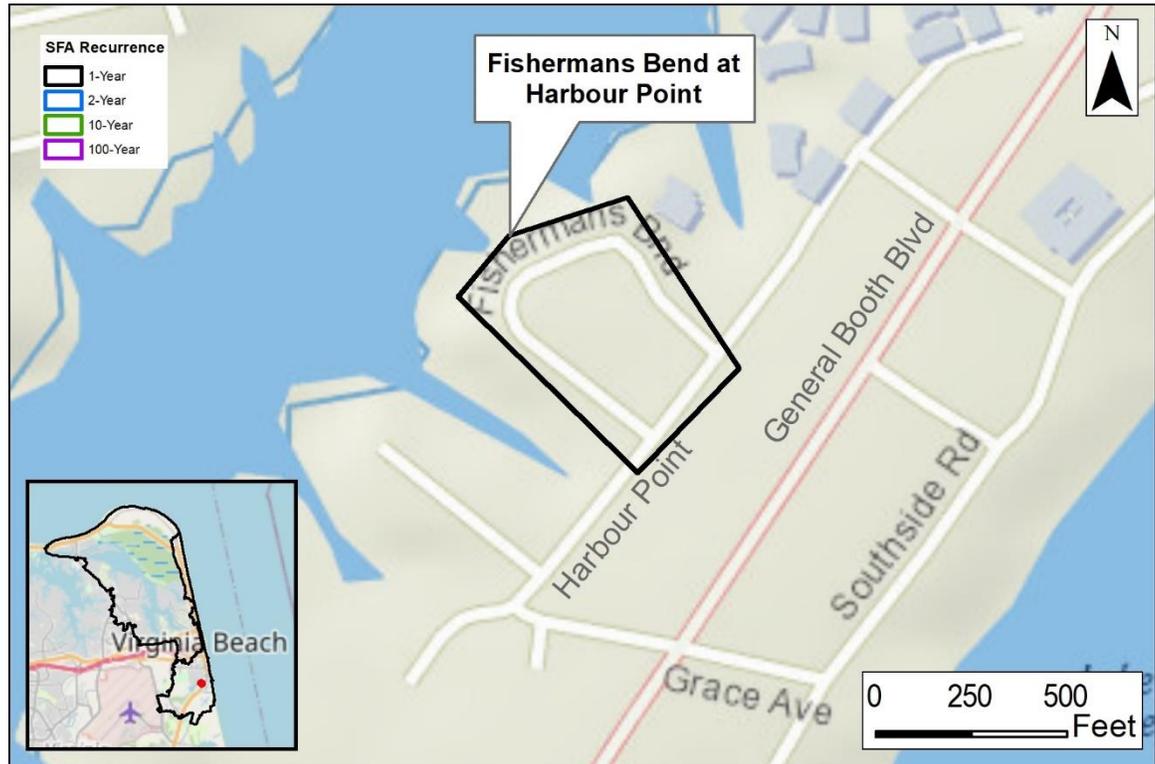
**Table 27. First Colonial Road at Camelot Drive Project Summary**

<b>SFA Recurrence</b>	2-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	6.33/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	2.7/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0 (no habitable structure flooding)
<b>Project Cost</b>	\$2,730,000

### 3.26 Fishermans Bend at Harbour Point

#### 3.26.1 SFA Description

A small portion of Fishermans Bend and Harbour Point floods due to undersized stormwater pipes. The models indicate Fishermans Bend begins to experience flooding in the 1-year storm event, as shown in Figure 31.



**Figure 31. Location Map of Fishermans Bend at Harbour Point SFA**

#### 3.26.2 Project Description

This project upsizes the existing stormwater outfall pipes in the area.

#### 3.26.3 Project Benefits

The major benefits of the project include mitigating street flooding on Fishermans Bend and Harbour Point, as well as the flooding occurring on surrounding private property.

#### 3.26.4 Project Analysis Assumptions

No habitable structures are impacted in the 100-year storm event, so the project is given a BCR value of 1.0. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM.

Easement acquisition is required to upsizes the existing outfall pipes. It is anticipated that minimal maintenance of traffic and utility relocations will be required during the construction of the project. Minimal effort will be required to obtain environmental permits.

The existing subcatchments in the area are updated to more accurately reflect the actual drainage areas for the existing pipe systems along Fishermans Bend. Additional pipes are in

the model based on available information from City GIS. These changes result in additional flooding along Harbour Point that is addressed as a part of the project.

3.26.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

3.26.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.26.7 Project Analysis Summary

Table 28 below provides a summary of the Fishermans Bend at Harbour Point project analysis. Refer to Appendix B-26 for project exhibits and supporting documentation.

**Table 28. Fishermans Bend at Harbour Point Project Summary**

<b>SFA Recurrence</b>	1-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	5.29/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	3/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0 (no habitable structure flooding)
<b>Project Cost</b>	\$1,620,000

### 3.27 Frazee Lane at South Birdneck Road

#### 3.27.1 SFA Description

Frazee Lane is a small cul-de-sac located east of South Birdneck Road. South Birdneck Road is a secondary evacuation route, but the road is not flooding in this location. Frazee Lane and the surrounding private property experience flooding due to inadequate pipes along South Birdneck Road. The models indicate Frazee Lane begins to experience flooding in the 10-year storm event, as shown in Figure 32.

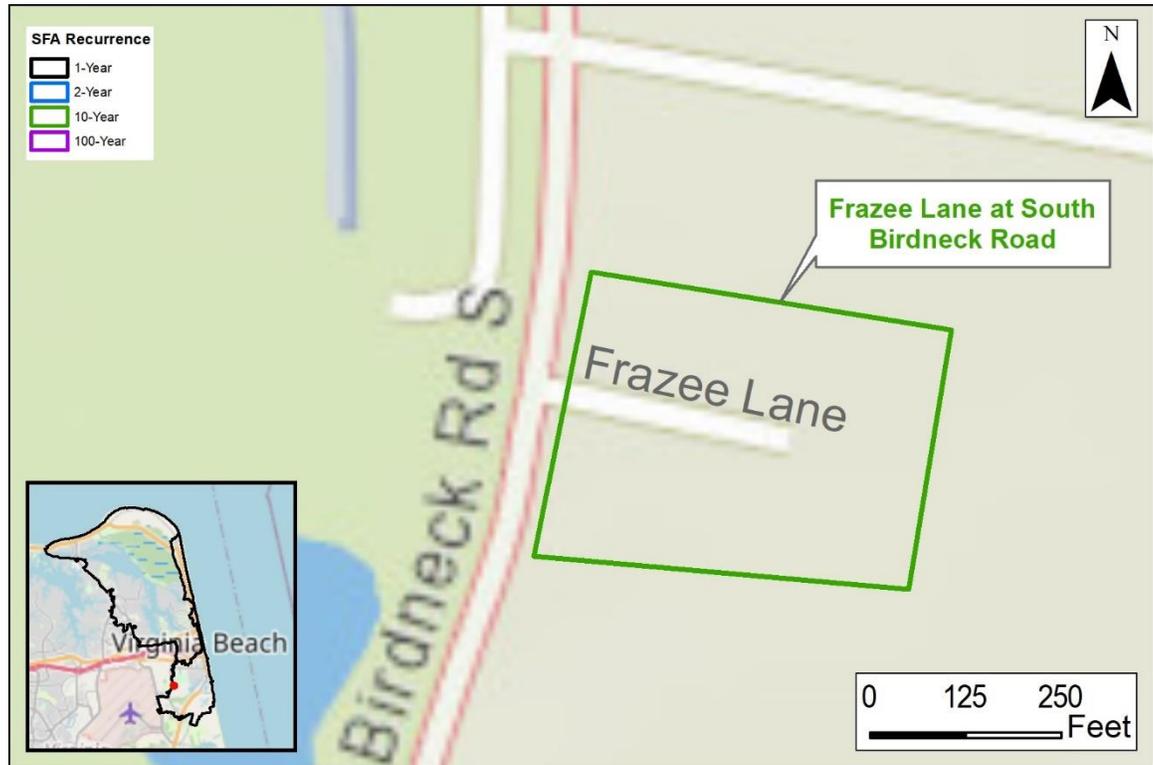


Figure 32. Location Map of Frazee Lane at South Birdneck Road SFA

#### 3.27.2 Project Description

This project upsizes the existing drainage infrastructure along Frazee Lane and South Birdneck Road to mitigate street flooding. The upsized infrastructure drains north to an existing trunkline on Owls Creek Lane, which eventually outfalls into Lake Rudee.

#### 3.27.3 Project Benefits

The major benefits of the project include mitigating street flooding on Frazee Lane, as well as the flooding on surrounding private property. The project also mitigates flooding in an economically disadvantaged area. There is a potential cost-sharing opportunity with DPU for transmission main prioritization along South Birdneck Road.

#### 3.27.4 Project Analysis Assumptions

No habitable structures are impacted in the 100-year storm event, so the project is given a BCR value of 1.0. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM.

Easement acquisition will be required at the corner of Frazee Lane and South Birdneck Road. Moderate maintenance of traffic will be required due to upsizing the existing trunkline on South Birdneck Road. It is anticipated that minimal utility relocations will be required for a conflict with an 8-inch gravity sewer line. Environmental permits will not be required.

3.27.5 Other Alternatives Scored

Other alternatives, as described below, were considered, but were not scored.

3.27.6 Other Alternatives Not Scored

A second alternative was considered but was not scored. This alternative proposed constructing a new BMP that would flow south and outfall to a proposed ditch on federal property (GPIN 24175071750000). This alternative would require significant impacts to federal property, so it was not evaluated further.

A third alternative considered a new trunkline that would flow east on Frazee Lane and then north along the property lines to connect to the existing infrastructure on Owls Creek Lane. This alternative would require coordination with the federal government, so it was not evaluated any further.

3.27.7 Project Analysis Summary

Table 29 below provides a summary of the Frazee Lane at South Birdneck Road project analysis. Refer to Appendix B-27 for project exhibits and supporting documentation.

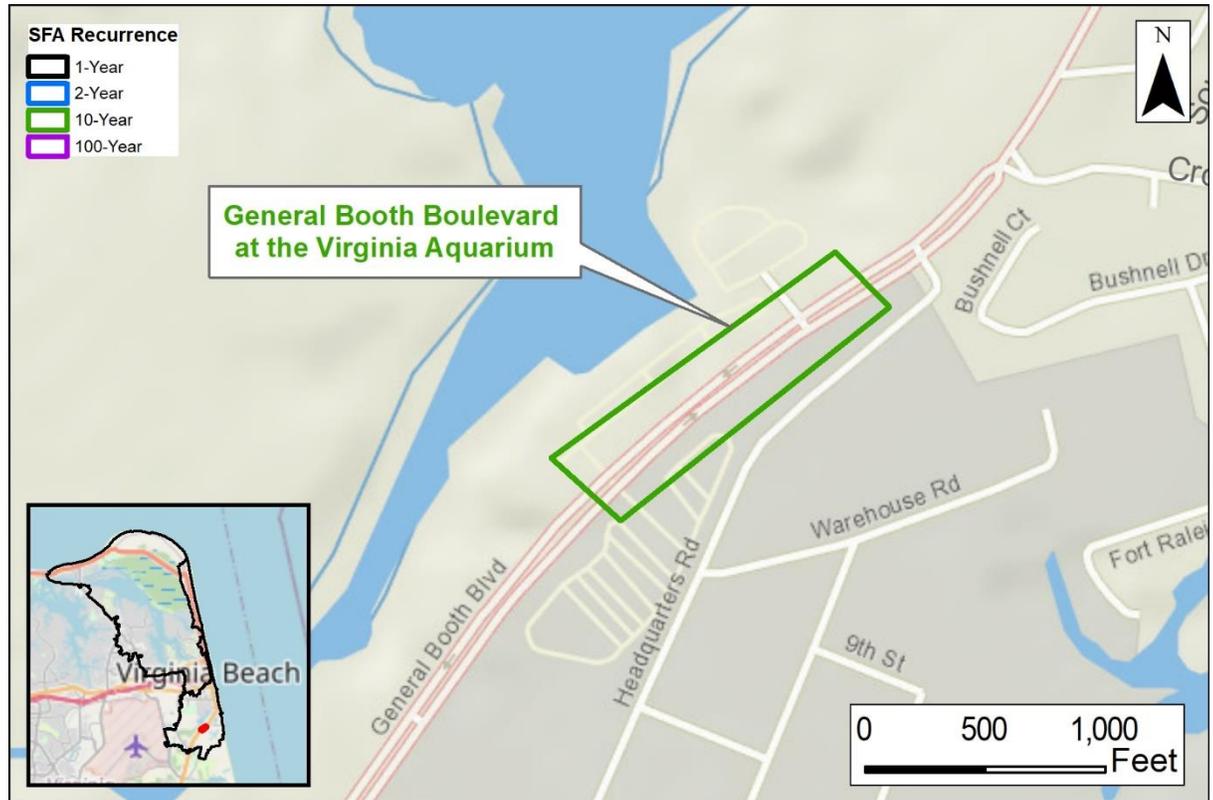
**Table 29. Frazee Lane at South Birdneck Road Project Summary**

<b>SFA Recurrence</b>	10-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	5.59/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	1.48/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0 (no habitable structure flooding)
<b>Project Cost</b>	\$960,000

### 3.28 General Booth Boulevard at the Virginia Aquarium

#### 3.28.1 SFA Description

General Booth Boulevard at the Virginia Aquarium experiences street flooding along General Booth Boulevard. The flooding is due to tailwater, inadequate stormwater infrastructure, and a lack of storage in the area. Additionally, General Booth Boulevard is a secondary evacuation route. The models indicate General Booth Boulevard at the Virginia Aquarium begins to experience flooding in the 10-year storm event, as shown in Figure 33.



**Figure 33. Location Map of General Booth Boulevard at the Virginia Aquarium SFA**

#### 3.28.2 Project Description

This project improves the stormwater infrastructure along General Booth Boulevard and within the Virginia Aquarium parking lot. Inadequate pipes are upsized, one pipe is added, and a backflow preventer is added to the outfall.

#### 3.28.3 Project Benefits

The major benefits of the project include mitigating flooding on General Booth Boulevard and ensuring that it can effectively serve as a secondary evacuation route. There is a potential cost-sharing opportunity with DPU for a transmission main prioritization along General Booth Boulevard.

#### 3.28.4 Project Analysis Assumptions

No habitable structures are impacted in the 100-year storm event, so the project is given a BCR value of 1.0. The project is given a BR of 1.0 because street flooding is mitigated to meet

the PWDSM. General Booth Boulevard, as a secondary evacuation route, remains passable in the 10-year storm event with 3.0 feet SLR and the 100-year storm event with no SLR.

Property or easement acquisition is not required as all the construction will occur within the ROW or City property. It is anticipated that moderate maintenance of traffic and utility relocations will be required during the construction of the project along General Booth Boulevard. There are possible conflicts with a 16-inch sewer force main and a 16-inch water line.

The existing pipes crossing General Booth Boulevard, southwest of the proposed improvements, are assumed to be constructed around an existing HRSD force main due to a drastic change in slope and invert elevations. As a result, improvements to these pipes are not proposed to minimize potential utility conflicts. Instead, a connection is proposed within the median from this system to the northern system that is being improved as part of the project. These pipes have a more consistent slope, so it is assumed that a conflict with the HRSD force main is less likely. The project upsizes the northern pipes to elliptical pipes to further avoid potential conflict while providing more capacity. Minimal effort will be required to obtain environmental permits to modify an existing outfall in tidal wetlands.

3.28.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

3.28.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.28.7 Project Analysis Summary

Table 30 below provides a summary of the General Booth Boulevard at the Virginia Aquarium project analysis. Refer to Appendix B-28 for project exhibits and supporting documentation.

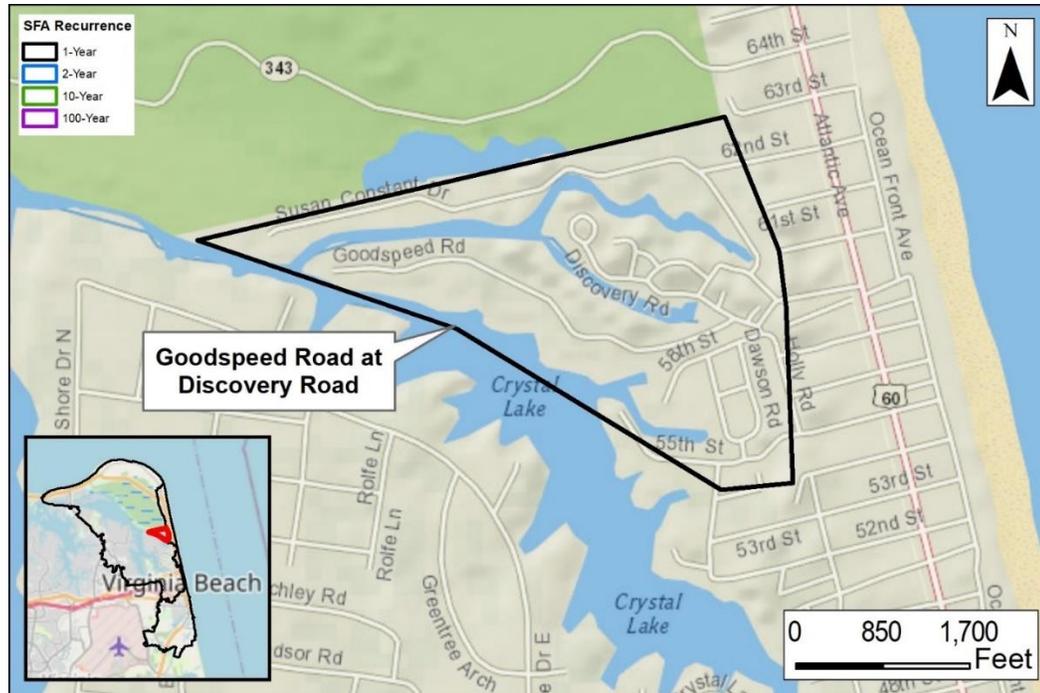
**Table 30. General Booth Boulevard at the Virginia Aquarium Project Summary**

<b>SFA Recurrence</b>	10-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	5.11/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	1.34/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0 (no habitable structure flooding)
<b>Project Cost</b>	\$2,100,000

### 3.29 Goodspeed Road at Discovery Road

#### 3.29.1 SFA Description

Goodspeed Road at Discovery Road is a residential area. The lowest street elevations range from approximately 2.5 to 4 feet. The design tailwater elevation for the 100-year storm event with no SLR is 4.3 feet in Crystal Lake. The tailwater elevation, independent of existing drainage infrastructure, floods portions of residential streets, properties, and habitable structures. The models indicate Goodspeed Road at Discovery Road begins to experience flooding in the 1-year storm event, as shown in Figure 34.



**Figure 34. Location Map of Goodspeed Road at Discovery Road SFA**

#### 3.29.2 Project Description

The downstream tailwater conditions severely limit the options for improvements to this neighborhood. The City will be evaluating this SFA with a Neighborhood Strategy in the future. Refer to Appendix B-29 for the extent of existing flooding in the area.

#### 3.29.3 Project Benefits

There is no project, and there are no benefits.

#### 3.29.4 Other Alternatives Scored

No alternatives were evaluated for this SFA.

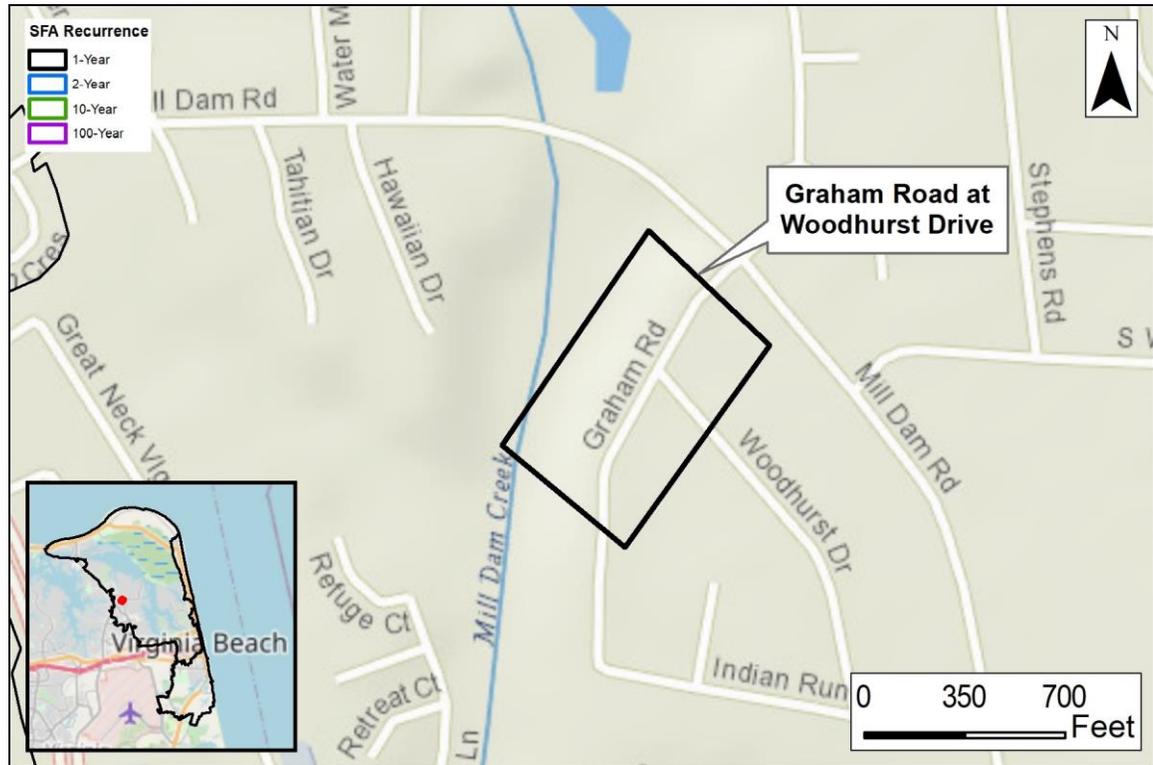
#### 3.29.5 Other Alternatives Not Scored

This neighborhood would benefit from a neighborhood solution similar to those shown in the SLR Adaptation Strategy Report. This neighborhood can be designed to resolve the flooding issues that occur from a smaller storm event. PW-SWEC will, in the future, have a neighborhood solution created to establish resiliency in this neighborhood.

### 3.30 Graham Road at Woodhurst Drive

#### 3.30.1 SFA Description

The Graham Road at Woodhurst Drive SFA experiences street, private property, and habitable structure flooding. The flooding is caused by inadequate pipes and a large amount of overland flow from Cape Henry Collegiate School. The models indicate Graham Road at Woodhurst Drive begins to experience flooding in the 1-year storm event, as shown in Figure 35.



**Figure 35. Location Map of Graham Road at Woodhurst Drive SFA**

#### 3.30.2 Project Description

This project upsizes the downstream culverts crossing Mill Dam Road to triple box culverts. The inadequate pipe draining Graham Road is upsized, and an outfall is added parallel to the upsized outfall.

#### 3.30.3 Project Benefits

The major benefits of the project include mitigating habitable structure flooding on Graham Road and street flooding along Graham Road and Woodhurst Drive. The project resolves habitable structure flooding for three structures along Graham Road. The project also addresses several flood reports that have been documented in the area.

#### 3.30.4 Project Analysis Assumptions

HAZUS data is available for the flooded habitable structures along Graham Road. The structures no longer flood in the 100-year storm event. Based on the BCR methodology, the project BCR is 1.5403. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM.

Graham Road at Woodhurst Drive and Sylvan Lake are kept separate because the Graham Road at Woodhurst Drive flooding can be mitigated without all of the Sylvan Lake improvements. However, the downstream culvert improvements under Mill Dam Road are the same in both projects. If the Sylvan Lake project is constructed first, then the downstream improvements as part of this project would not be required. Refer to Section 3.60 for a description of the Sylvan Lake project.

Easement acquisition will be required to upsize the existing outfall and establish a new outfall west of Graham Road. Acquisition will be limited by making downstream improvements. It is anticipated that moderate maintenance of traffic and utility relocations will be required during the construction of the project. Minimal effort will be required to obtain environmental permits to modify outfalls in tidal wetlands and add an outfall in nontidal wetlands.

The existing area in the neighborhood has minimal stormwater infrastructure. The infrastructure that does exist is not large enough to be included in the current model. As a result, conservative assumptions are made to determine the extent of the curb, gutter, and ditch improvements needed to convey stormwater runoff to the proposed outfalls. Additional analysis in the design phase is recommended to confirm the extent and cost of improvements.

The model shows that a large amount of flow is leaving the Cape Henry Collegiate School and flowing into the neighborhood, which is causing most of the flooding in the neighborhood. Model refinement is recommended in this area to confirm the extent of flooding and the cost of improvements needed to resolve the flooding and meet the PWDSM requirements. Model refinement will require survey of the private drainage system or a review of as-built information.

### 3.30.5 Other Alternatives Scored

Other alternatives, as described below, were considered, but were not scored.

### 3.30.6 Other Alternatives Not Scored

A second alternative considered placing additional storage on the Cape Henry Collegiate School property to reduce the runoff contributing to the neighborhood. This alternative did meet the PWDSM requirements. However, it was not preferred to place storage on private property, so this alternative was not considered further.

A third alternative considered adding an additional pipe crossing under Mill Dam Road as opposed to upsizing and proposing outfall pipes west of Graham Road. This alternative would require less property acquisition but would cause more disruption to Mill Dam Road. This alternative would also require that the pipes along Mill Dam Road be upsized. Due to the additional disruption, this alternative was not considered further.

### 3.30.7 Project Analysis Summary

Table 31 below provides a summary of the Graham Road at Woodhurst Drive project analysis. Refer to Appendix B-30 for project exhibits and supporting documentation.

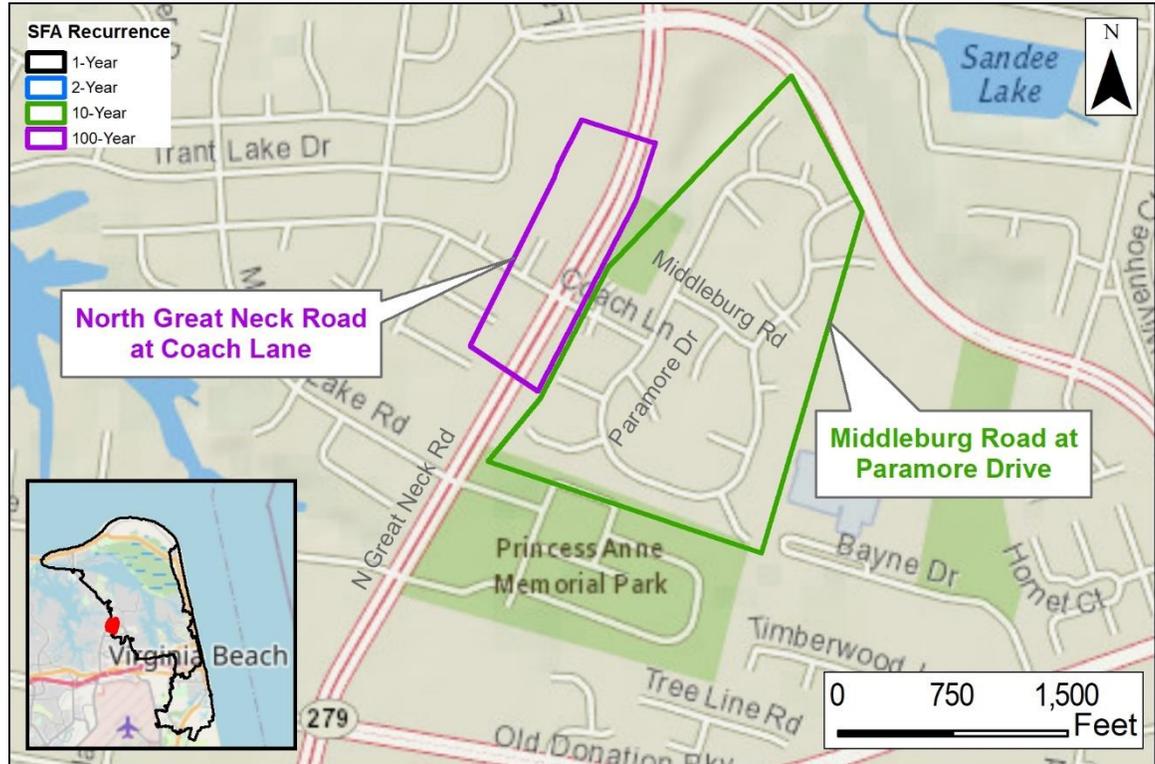
**Table 31. Graham Road at Woodhurst Drive Project Summary**

<b>SFA Recurrence</b>	1-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	4.97/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	7.7/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.5403
<b>Project Cost</b>	\$3,670,000

### 3.31 Great Neck Farms

#### 3.31.1 SFA Description

The Middleburg Road at Paramore Drive and North Great Neck Road at Coach Lane SFAs are combined into the Great Neck Farms project. Individual SFA locations are shown in Figure 36 and are further described below. Both SFAs are hydraulically connected and can be combined into one project.



**Figure 36. Location Map of Middleburg Road at Paramore Drive and North Great Neck Road at Coach Lane SFAs**

#### ***Middleburg Road at Paramore Drive SFA***

The primary cause of flooding in the Great Neck Farms neighborhood is a lack of storage. Within the SFA boundary, both private property and public streets flood. The models indicate Middleburg Road at Paramore Drive begins to experience flooding in the 10-year storm event, as shown in Figure 36.

#### ***North Great Neck Road at Coach Lane SFA***

The primary cause of flooding on North Great Neck Road is a lack of storage. Within the SFA boundary, private property and public streets flood. Additionally, North Great Neck Road is a secondary evacuation route. The models indicate North Great Neck Road begins to experience flooding in the 100-year storm event, as shown in Figure 36.

#### 3.31.2 Project Description

This project implements underground storage beneath the athletic fields of Lynnhaven Middle School and existing green space in Great Neck Farms Park. The existing infrastructure on

Middleburg Road is upsized and reversed to route most of the neighborhood runoff to the underground storage beneath the athletic fields. The existing infrastructure along North Great Neck Road is routed to the underground storage beneath Great Neck Farms Park and outfalls into an upsized ditch.

### 3.31.3 Project Benefits

The major benefits of this project include mitigating flooding for two habitable structures on Middleburg Road, one on Belvidere Road, and one on Paramore Drive. Flooding on Middleburg Road, Paramore Drive, and various side streets in the Great Neck Farms neighborhood is also mitigated. This project addresses several flood reports that have been documented in the area. There is a potential cost-sharing opportunity with DPU for transmission main prioritization along North Great Neck Road. As a secondary evacuation route, North Great Neck Road is passable in the 10-year storm event with 3.0 feet SLR and the 100-year storm event with no SLR.

### 3.31.4 Project Analysis Assumptions

A 50-year LOS is achieved for this project. Pipe improvements and storage have been maximized within the neighborhood, and there are not any more adjacent open spaces to add storage to the system. Flood depths are less than 3 inches above the crown of the road, are summarized on the 100-year flood map, and will require approval for a reduced LOS from the City Engineer.

HAZUS data is available for the flooded habitable structures on Middleburg Road, Belvidere Road, and Paramore Drive. The structures no longer flood in the 100-year storm event. Based on the BCR methodology, the project BCR is 1.0060. There is a decrease in street flooding in the 100-year storm event, but it is not completely mitigated. Therefore, the project is given a BR of 0.98. Easement acquisition will be required from multiple private landowners. Coordination will be required with the City of Virginia Beach Public Schools and Parks and Recreation for the proposed BMPs on City property. It is anticipated that moderate utility relocations and moderate maintenance of traffic will be required for the construction of the project. Due to the project location and the extent of proposed improvements, minimal effort will likely be required to obtain environmental permits.

### 3.31.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

### 3.31.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

### 3.31.7 Project Analysis Summary

Table 32 below provides a summary of the Great Neck Farms project analysis. Refer to Appendix B-31 for project exhibits and supporting documentation.

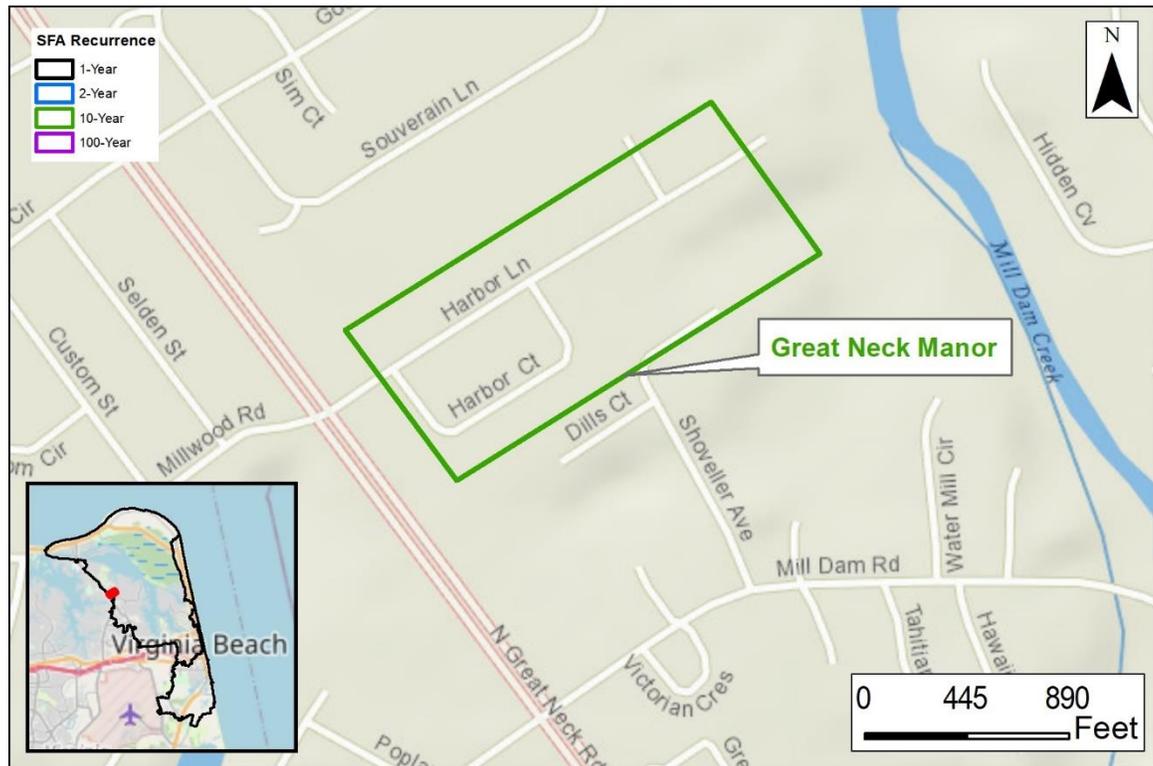
**Table 32. Great Neck Farms Project Summary**

<b>SFA Recurrence</b>	10-year (no SLR)
<b>Project LOS</b>	50-year (1.5 feet SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	4.8/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	6.05/14.4
<b>BR</b>	0.98
<b>BCR</b>	1.0060
<b>Project Cost</b>	\$13,870,000

### 3.32 Great Neck Manor

#### 3.32.1 SFA Description

The Great Neck Manor neighborhood floods due to undersized stormwater infrastructure. One habitable structure floods along with streets and private property. The models indicate Great Neck Manor begins to experience flooding in the 10-year storm event, as shown in Figure 37.



**Figure 37. Location Map of Great Neck Manor SFA**

#### 3.32.2 Project Description

This project adds stormwater infrastructure to the neighborhood. A new pipe is proposed on Harbor Lane and an existing outfall is upsized within the Godfrey Farm Road ROW.

#### 3.32.3 Project Benefits

The major benefits of the project include mitigating flooding for one habitable structure on Harbor Court and street flooding along Harbor Court, Harbor Lane, and Godfrey Farm Road. The project also addresses several flood reports that have been documented in the area.

#### 3.32.4 Project Analysis Assumptions

HAZUS data is available for the flooded habitable structure on Harbor Court. The structure no longer floods in the 100-year storm event. Based on the BCR methodology, the project BCR is 1.0484. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM.

Property or easement acquisition is not required as all the construction will occur within the ROW. It is anticipated that minimal maintenance of traffic and utility relocations will be

required during the construction of the project. Minimal effort is likely to be required to obtain environmental permits.

The existing model included an overland flow from the adjacent drainage basin, Eastern Lynnhaven River. Minimizing or eliminating this overland flow is required to meet PWDSM requirements for Great Neck Manor and will need to be confirmed as part of the Eastern Lynnhaven River SWMP.

3.32.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

3.32.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.32.7 Project Analysis Summary

Table 33 below provides a summary of the Great Neck Manor project analysis. Refer to Appendix B-32 for project exhibits and supporting documentation.

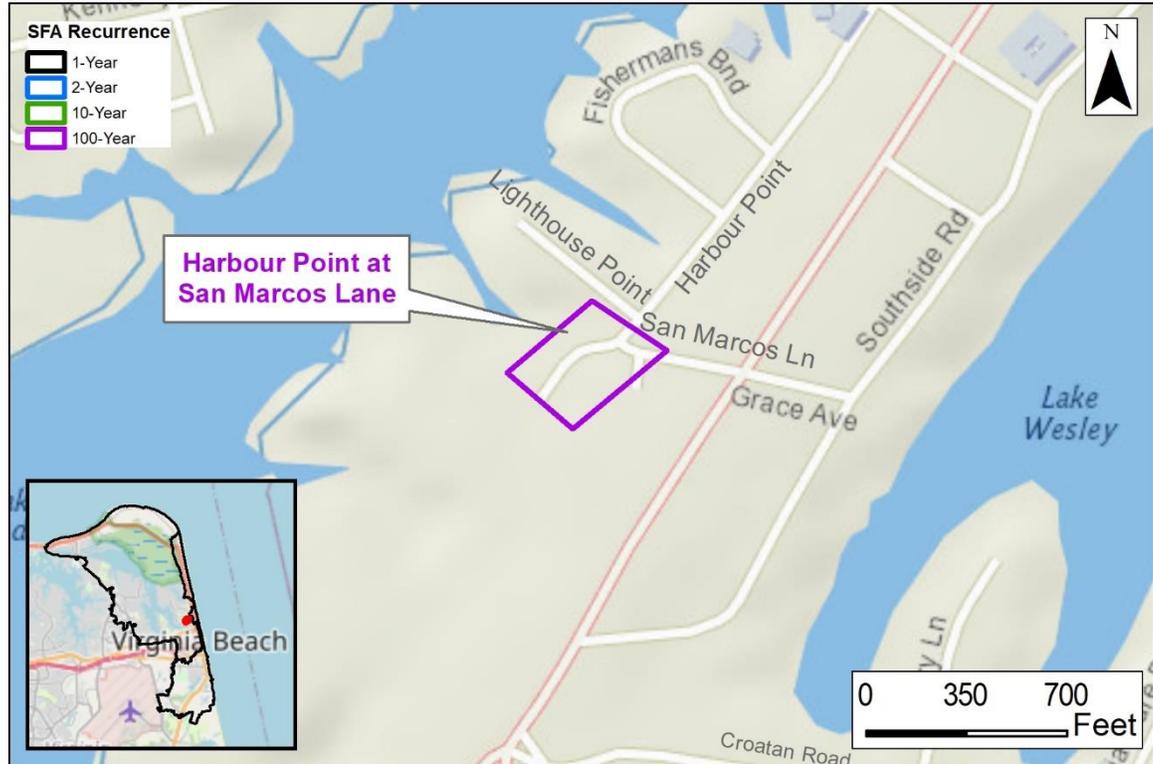
**Table 33. Great Neck Manor Project Summary**

<b>SFA Recurrence</b>	10-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	5.84/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	5.38/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0484
<b>Project Cost</b>	\$2,030,000

### 3.33 Harbour Point at San Marcos Lane

#### 3.33.1 SFA Description

Harbour Point is a small residential street west of General Booth Boulevard. It floods due to undersized pipes and tailwater influence from the adjacent Lake Rudee. The models indicate Harbour Point begins to experience flooding in the 100-year storm event, as shown in Figure 38.



**Figure 38. Location Map of Harbour Point at San Marcos Lane SFA**

#### 3.33.2 Project Description

This project raises approximately 100 feet of Harbour Point by 6 inches to meet the PWDSM requirements.

#### 3.33.3 Project Benefits

The major benefits of the project include mitigating street flooding on Harbour Point. The project also addresses a flood report that has been documented in the area. There is also potential for cost-sharing with DPU for transmission main prioritization along Harbour Point.

#### 3.33.4 Project Analysis Assumptions

No habitable structures are impacted in the 100-year storm event, so the project is given a BCR value of 1.0. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM.

Property or easement acquisition is not required for this project as all the construction will occur within the ROW. It is anticipated that minimal maintenance of traffic will be required

during the construction of the project. A CLOMR or LOMR will likely be required for raising the road in a FEMA floodplain.

3.33.5 Other Alternatives Scored

One additional alternative was scored as part of this analysis. Alternative 1 involved upsizing the existing 30-inch outfall to Lake Rudee to a dual 30-inch outfall with backflow prevention. While this alternative met the PWDSM requirements, it did not score as high because it would require easement acquisition.

3.33.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.33.7 Project Analysis Summary

Table 34 below provides a summary of the Harbour Point at San Marcos Lane project analysis. Refer to Appendix B-33 for project exhibits and supporting documentation.

**Table 34. Harbour Point at San Marcos Lane Project Summary**

<b>SFA Recurrence</b>	100-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 2
<b>ASC Score</b>	6.11/10
<b>Other ASC Score(s)</b>	Alternative 1 - 5.69
<b>PPC Score</b>	0.47/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0 (no habitable structure flooding)
<b>Project Cost</b>	\$500,000

### 3.34 Haversham Key and Middlemost Key

#### 3.34.1 SFA Description

The Haversham Key and Middlemost Key SFAs are combined into the Haversham Key and Middlemost Key project. Individual SFA locations are shown in Figure 39 and are further described below. Both SFAs are hydraulically connected and can be combined into one project.

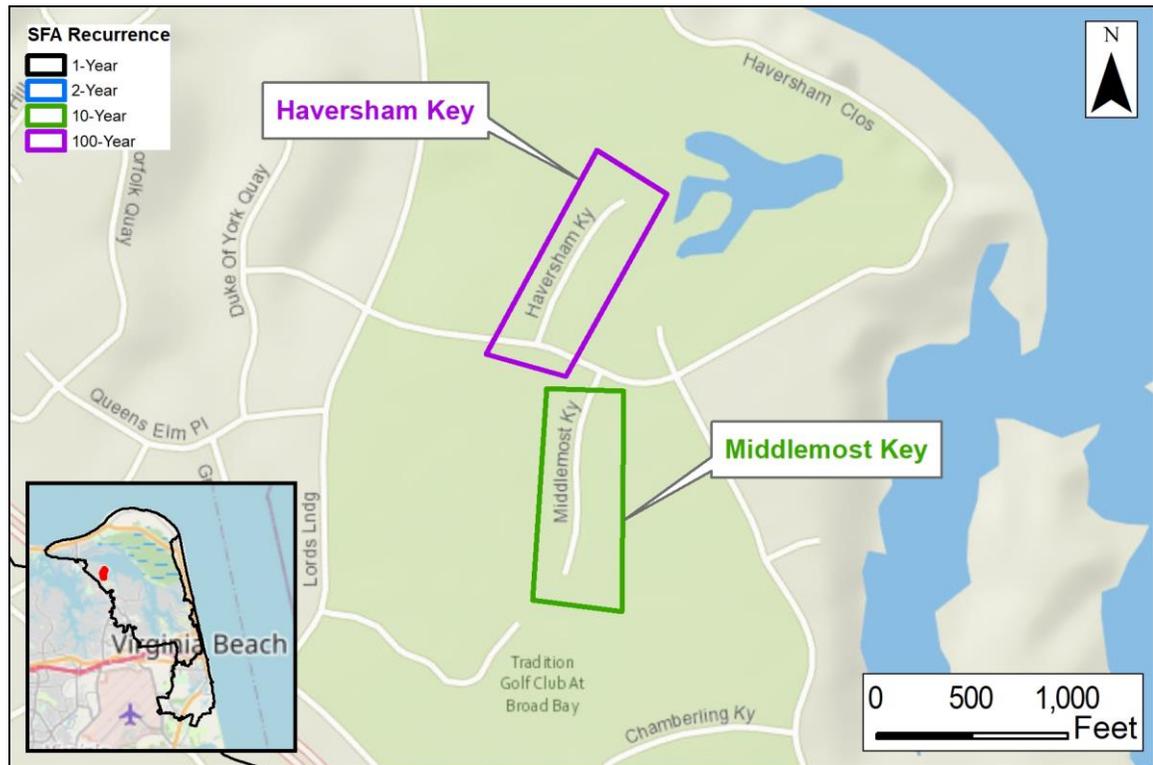


Figure 39. Location Map of Haversham Key and Middlemost Key SFAs

#### ***Haversham Key SFA***

Haversham Key floods due to undersized pipes and stormwater infrastructure. The models indicate Haversham Key begins to experience flooding in the 100-year storm event, as shown in Figure 39.

#### ***Middlemost Key SFA***

Middlemost Key floods due to undersized pipes and stormwater infrastructure. The models indicate Middlemost Key begins to experience flooding in the 10-year storm event, as shown in Figure 39.

#### 3.34.2 Project Description

This project creates a new outfall on Haversham Close parallel to the existing outfall. Pipes are upsized along Haversham Close and Middlemost Key and directed towards the new outfall.

3.34.3 Project Benefits

The major benefits of the project include mitigating street flooding on Haversham Key and Middlemost Key, as well as the flooding occurring on surrounding private property. The project also addresses one flood report that has been documented in the area.

3.34.4 Project Analysis Assumptions

No habitable structures are impacted in the 100-year storm event, so the project is given a BCR value of 1.0. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM.

Easement acquisition is required as a part of this project through historical property. However, this location is preferred because it minimizes impacts to the property as well as adjacent residential properties.

It is anticipated that moderate maintenance of traffic and utility relocations will be required during the construction of the project. Extensive effort will be required to obtain environmental permits to alter a site listed on the historical register. Coordination with the Virginia Department of Historic Resources will be required as they will need to review and approve the proposed design. While restoration of a brick wall will also be required within the historic property and along Haversham Close, the wall itself was constructed in the 1980s and is not assumed to be historic.

3.34.5 Other Alternatives Scored

Another alternative, as described below, was considered, but was not scored.

3.34.6 Other Alternatives Not Scored

Another alternative considered a different pipe alignment to Broad Bay between residential property. However, the size of pipe needed would likely have required property acquisition. This alternative was not considered any further since open space for a new pipe alignment was available on historical property.

3.34.7 Project Analysis Summary

Table 35 below provides a summary of the Haversham Key and Middlemost Key project analysis. Refer to Appendix B-34 for project exhibits and supporting documentation.

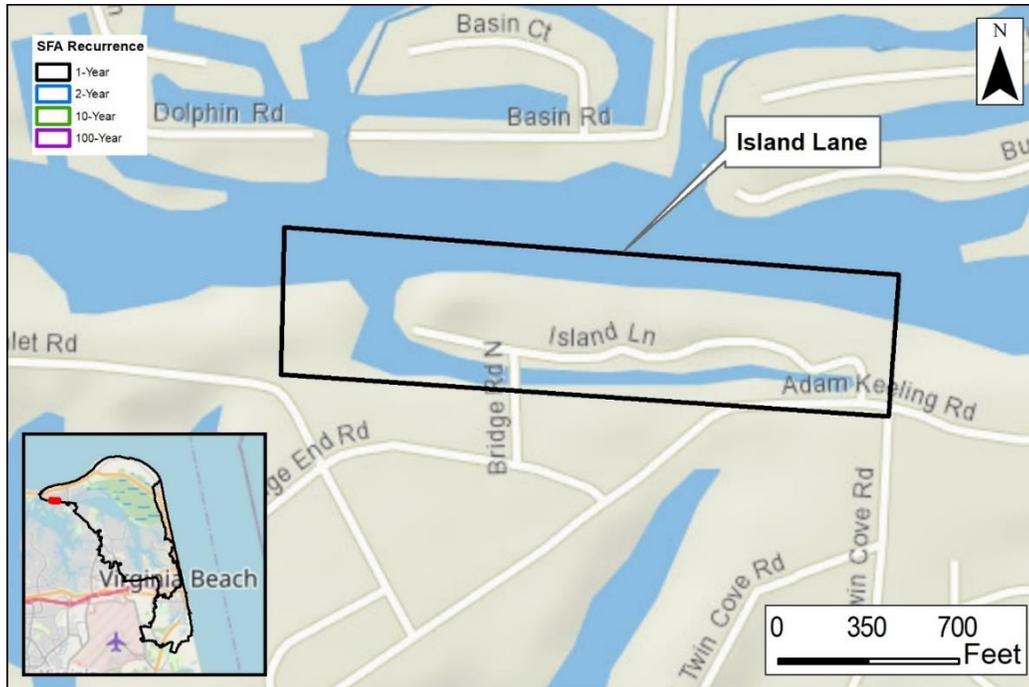
**Table 35. Haversham Key and Middlemost Key Project Summary**

<b>SFA Recurrence</b>	10-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	3.68/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	2.08/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0 (no habitable structure flooding)
<b>Project Cost</b>	\$3,850,000

### 3.35 Island Lane

#### 3.35.1 SFA Description

Island Lane experiences street, private property, and habitable structure flooding. Island Lane ranges in elevation from approximately 3 to 4 feet. The design tailwater elevation for the 100-year storm event with no SLR is 4.3 feet in the existing condition. The tailwater elevation, independent of existing drainage infrastructure, floods the street as well as habitable structures. The models indicate Island Lane begins to experience flooding in the 1-year storm event, as shown in Figure 40.



**Figure 40. Location Map of Island Lane SFA**

#### 3.35.2 Project Description

The downstream tailwater conditions severely limit the options for improvements to this neighborhood. The City will be evaluating this SFA with a Neighborhood Strategy in the future. Refer to Appendix B-35 for the extent of existing flooding in the area.

#### 3.35.3 Project Benefits

There is no project and there are no benefits.

#### 3.35.4 Other Alternatives Scored

No alternatives were evaluated for this SFA.

#### 3.35.5 Other Alternatives Not Scored

This neighborhood would benefit from a neighborhood solution, similar to those shown in the SLR Adaptation Strategy Report. This neighborhood can be designed to resolve the flooding issues that occur from a smaller storm event. PW-SWEC will, in the future, have a neighborhood solution created to establish resiliency in this neighborhood.

### 3.36 Lakeside Avenue at 52<sup>nd</sup> Street

#### 3.36.1 SFA Description

Lakeside Avenue at 52nd Street is a residential street in the North End neighborhood. The lowest street elevations are approximately 4 feet. The design tailwater elevation for the 100-year storm event with no SLR is 4.3 feet in Crystal Lake. The tailwater elevation, independent of existing drainage infrastructure, floods a portion of the street. The models indicate Lakeside Avenue at 52nd Street begins to experience flooding in the 1-year storm event, as shown in Figure 41.



**Figure 41. Location Map of Lakeside Avenue at 52<sup>nd</sup> Street SFA**

#### 3.36.2 Project Description

The downstream tailwater conditions severely limit the options for improvements to this neighborhood. The City will be evaluating this SFA with a Neighborhood Strategy in the future. Refer to Appendix B-36 for the extent of existing flooding in the area.

#### 3.36.3 Project Benefits

There is no project, and there are no benefits.

#### 3.36.4 Other Alternatives Scored

No alternatives were evaluated for this SFA.

#### 3.36.5 Other Alternatives Not Scored

This neighborhood would benefit from a neighborhood solution similar to those shown in the SLR Adaptation Strategy Report. This neighborhood can be designed to resolve the flooding issues that occur from a smaller storm event. PW-SWEC will, in the future, have a neighborhood solution created to establish resiliency in this neighborhood.

### 3.37 Laskin Road at Little Neck Creek

#### 3.37.1 SFA Description

The 33rd Street at Arctic Avenue, Laskin Road Roundabout, and 30<sup>th</sup> and 1/2 Street at Pacific Avenue SFAs are combined into the Laskin Road at Little Neck Creek project. Individual SFA locations are shown in Figure 42 and are further described below. All three SFAs are hydraulically connected and can be combined into one project.



**Figure 42. Location Map of 33<sup>rd</sup> Street at Arctic Avenue, Laskin Road Roundabout, and 30<sup>th</sup> and 1/2 Street at Pacific Avenue SFAs**

#### ***33<sup>rd</sup> Street at Arctic Avenue SFA***

The 33<sup>rd</sup> Street at Arctic Avenue SFA experiences street, private property, and habitable structure flooding. The flooding is due to inadequate storage and conveyance in the existing stormwater system, and the downstream system is also influenced by tailwater. The models indicate 33rd Street at Arctic Avenue begins to experience flooding in the 1-year storm event, as shown in Figure 42.

#### ***Laskin Road Roundabout SFA***

The Laskin Road Roundabout SFA experiences street and private property flooding due to inadequate storage and conveyance in the existing stormwater system. The downstream system is also influenced by tailwater. Laskin Road serves as a secondary evacuation route. The models indicate the Laskin Road Roundabout begins to experience flooding in the 1-year storm event, as shown in Figure 42.

### **30<sup>th</sup> and ½ Street at Pacific Avenue SFA**

The 30<sup>th</sup> and ½ Street at Pacific Avenue SFA experiences street and private property flooding due to inadequate storage and conveyance in the existing stormwater system. The downstream system is also influenced by tailwater. The models indicate 30<sup>th</sup> and ½ Street at Pacific Avenue begins to experience flooding in the 1-year storm event, as shown in Figure 42.

#### **3.37.2 Project Description**

This project adds a 120 cfs stormwater lift station on City property (GPINs 24188290740000 and 24188198650000). Inadequate pipes are upsized, and outfalls are added to Little Neck Creek.

#### **3.37.3 Project Benefits**

The major benefits of the project include mitigating habitable structure flooding for 10 structures on Pacific Avenue, 33<sup>rd</sup> Street, and 34<sup>th</sup> Street. Flooding along 32<sup>nd</sup> Street, 33<sup>rd</sup> Street, 33<sup>rd</sup> and ½ Street, 34<sup>th</sup> Street, and Laskin Road is also mitigated. The project addresses several flood reports that have been documented in the area and relieves flooding within an SGA. There is a potential cost-sharing opportunity with DPU for transmission line prioritization and water leak prioritization along Laskin Road.

#### **3.37.4 Project Analysis Assumptions**

HAZUS data is available for some, but not all, flooded habitable structures. The structures no longer flood in the 100-year storm event. Based on the BCR methodology, the project BCR is 2.1852. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM. As a secondary evacuation route, Laskin Road is passable in the 10-year storm event with 3.0 feet SLR and the 100-year storm event with no SLR.

Easement acquisition is required for select pipe improvements. The amount of easement acquisition was limited by maintaining most improvements within the ROW or City property. It is anticipated that moderate maintenance of traffic and utility relocations will be required during the construction of the project. Moderate efforts will be required to obtain environmental permits for the proposed outfalls into tidal wetlands. The underground storage being removed near the Laskin Road roundabout is assumed to have no water quality treatment associated with it. Coordination with the City's VSMP Permit Coordinator is required for the removal of underground storage since it will impact the TMDL requirements for Little Neck Creek.

#### **3.37.5 Other Alternatives Scored**

One additional alternative was scored as part of this analysis. Alternative 2 was similar to the selected project because it proposed a lift station and rerouted stormwater to the pump station. The lift station in this alternative was larger since 32<sup>nd</sup>, 33<sup>rd</sup>, 33<sup>rd</sup> and ½, and 34<sup>th</sup> Streets were routed to the lift station as well. The pipes along 32<sup>nd</sup> Street were upsized to convey stormwater to the pump station. This alternative did meet the PWDSM requirements; however, due to the significant disturbance that would be required to resolve significant utility conflicts along 32<sup>nd</sup> Street, it received a lower score.

#### **3.37.6 Other Alternatives Not Scored**

No additional alternatives were evaluated for this SFA.

3.37.7 Project Analysis Summary

Table 36 below provides a summary of the Laskin Road at Little Neck Creek project analysis. Refer to Appendix B-37 for project exhibits and supporting documentation.

**Table 36. Laskin Road at Little Neck Creek Project Summary**

<b>SFA Recurrence</b>	1-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	4.02/10
<b>Other ASC Score(s)</b>	Alternative 2 –3.8/10
<b>PPC Score</b>	9.1/14.4
<b>BR</b>	1.0
<b>BCR</b>	2.1852
<b>Project Cost</b>	\$26,490,000

### 3.38 Longstreet Avenue at Hughes Avenue

#### 3.38.1 SFA Description

The Longstreet Avenue at Burford Avenue and Longstreet Avenue at Bishop Thoroughgood Avenue SFAs are combined into the Longstreet Avenue at Hughes Avenue project. Individual SFA locations are shown in Figure 43 and are further described below. The two SFAs are hydraulically connected and can be combined into one project.



**Figure 43. Location Map of Longstreet Avenue at Burford Avenue and Longstreet Avenue at Bishop Thoroughgood Avenue SFAs**

#### ***Longstreet Avenue at Burford Avenue SFA***

Longstreet Avenue and Burford Avenue experience street flooding due to inadequate stormwater infrastructure. The models indicate Longstreet Avenue and Burford Avenue begin to experience flooding in the 2-year storm event, as shown in Figure 43.

#### ***Longstreet Avenue at Bishop Thoroughgood Avenue SFA***

Longstreet Avenue at Bishop Thoroughgood Avenue SFA experiences flooding due to inadequate pipes, a lack of storage in the area, and an inadequate outfall. Private property and streets experience flooding. The models indicate Longstreet Avenue at Bishop Thoroughgood Avenue begins to experience flooding in the 1-year storm event, as shown in Figure 43.

### 3.38.2 Project Description

This project improves the stormwater infrastructure along Longstreet Avenue by upsizing inadequate pipes. A new outfall is created by connecting to upsized pipes along Blue Pete Road. The downstream ditch is lowered to ensure that there is adequate cover for the system. Underground storage is added to an undeveloped parcel along Longstreet Avenue that connects to the proposed upsized system.

### 3.38.3 Project Benefits

The major benefits of the project include mitigating street flooding on Longstreet Avenue, Burford Avenue, and Hughes Avenue, as well as the flooding occurring on surrounding private property. Habitable structure flooding is resolved for one structure on Longstreet Avenue. The project also addresses several flood reports that have been documented in the area and mitigates flooding in an economically disadvantaged area.

### 3.38.4 Project Analysis Assumptions

HAZUS data is available for the flooded habitable structure on Longstreet Avenue. The structure no longer floods in the 100-year storm event. Based on the BCR methodology, the project BCR is 1.0037. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM.

Property acquisition of an undeveloped parcel will be required for the proposed underground storage from one private property owner. The extent of property acquisition is limited by making downstream improvements to the system and by creating a new outfall for the system. It is anticipated that moderate maintenance of traffic will be required during the construction of the project. Maintenance of traffic will be required along Marshview Drive, Blue Pete Road, and Longstreet Avenue, which are neighborhood streets that serve as the only route for entry and exit to the neighborhoods. Moderate utility relocations will be required for potential conflicts with an 8-inch gravity sewer line and an 8-inch water line. Minimal effort is likely required to obtain environmental permits to lower a non-tidal ditch.

### 3.38.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

### 3.38.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.38.7 Project Analysis Summary

Table 37 below provides a summary of the Longstreet Avenue at Hughes Avenue project analysis. Refer to Appendix B-38 for project exhibits and supporting documentation.

**Table 37. Longstreet Avenue at Hughes Avenue Project Summary**

<b>SFA Recurrence</b>	1-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	3.82/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	7.5/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0037
<b>Project Cost</b>	\$6,480,000

### 3.39 Mill Dam Road at Brighton on the Bay Neighborhood

#### 3.39.1 SFA Description

The Mill Dam Forest, Wivenhoe Way at Templeton Lane, and Starr Way at Valhalla Archway SFAs are combined into the Mill Dam Road at Brighton on the Bay Neighborhood project. Individual SFA locations are shown in Figure 44 and are further described below. All three SFAs are hydraulically connected and can be combined into one project.

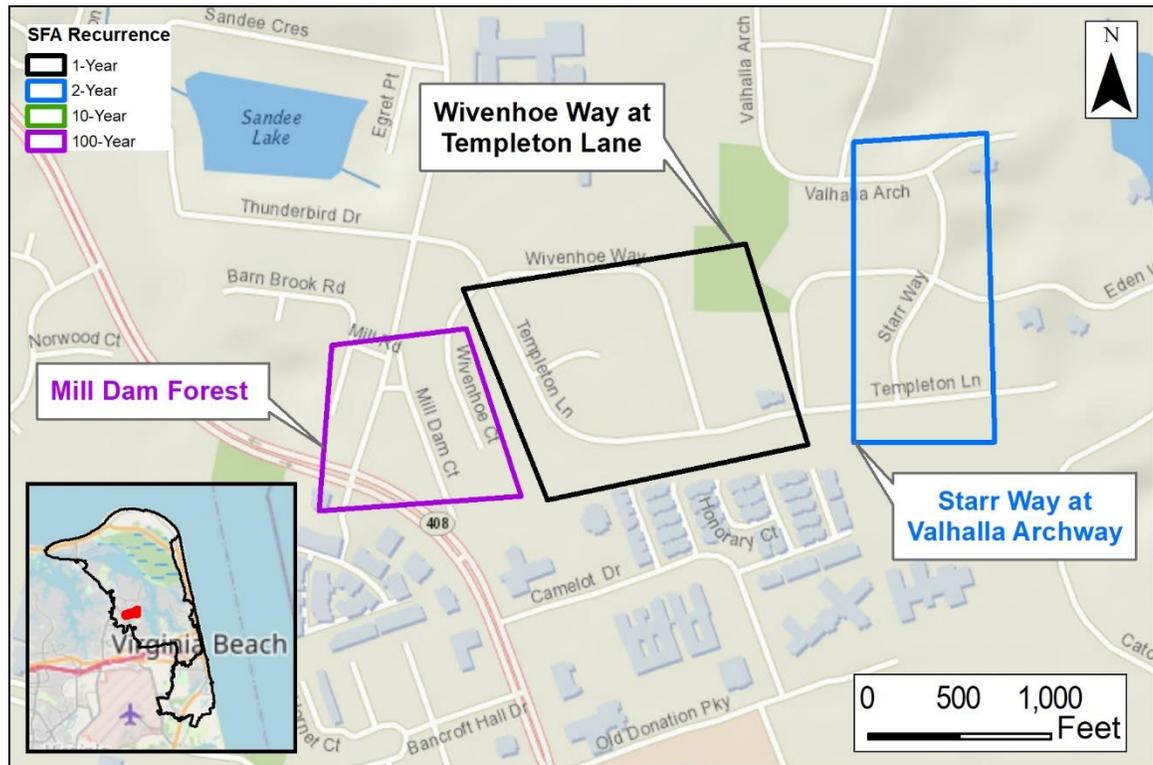


Figure 44. Location Map of Mill Dam Forest, Wivenhoe Way at Templeton Lane, and Starr Way at Valhalla Archway SFAs

#### **Mill Dam Forest SFA**

The Mill Dam Forest SFA floods due to undersized pipes crossing Mill Dam Road and an undersized outfall, which impacts public streets, habitable structures, and private property. The models indicate Mill Dam Forest begins to experience flooding in the 100-year storm event, as shown in Figure 44.

#### **Wivenhoe Way at Templeton Lane SFA**

The Wivenhoe Way at Templeton Lane SFA floods due to a lack of storage in the area, which impacts public streets and private property. The models indicate Wivenhoe Way at Templeton Lane begins to experience flooding in the 1-year storm event, as shown in Figure 44.

### ***Starr Way at Valhalla Archway SFA***

The Starr Way at Valhalla Archway SFA floods due to undersized pipes on Starr Way, which impacts residential streets. The models indicate Starr Way at Valhalla Archway begins to experience flooding in the 2-year storm event, as shown in Figure 44.

#### 3.39.2 Project Description

This project adds an underground storage BMP beneath Brighton on the Bay/Linkhorn Cove Park, which is City Property (GPIN 24086652700000). Two new proposed trunklines direct stormwater runoff from Starr Way and Wivenhoe Way into the underground storage and then to an upsized outfall on Starr Way. Stormwater infrastructure trunklines on Templeton Lane and Mill Dam Road are upsized, and outfall improvements west of Mill Dam Road are proposed.

#### 3.39.3 Project Benefits

The major benefits of the project include mitigating street and private property flooding on Mill Dam Road, Wivenhoe Court, Templeton Court, Templeton Lane, Wivenhoe Way, and Starr Way. This project also mitigates habitable structure flooding for two structures located on Barn Brook Road. This project addresses one flood report that has been documented in the area.

#### 3.39.4 Project Analysis Assumptions

A 50-year LOS is achieved for this project. Pipe improvements and storage have been maximized within the neighborhood, and there are not any more adjacent open spaces to add storage to the system. Flood depths are less than 3 inches above the crown of the road, are summarized on the 100-year flood map, and will require approval for a reduced LOS from the City Engineer.

The project indicates structural flooding is resolved; however, the structural flooding is not reflected in the BCR of 1.0. There is a decrease in street flooding in the 100-year storm event, but it is not completely mitigated. Thirty feet of Templeton Lane is inundated with 2 inches above the crown for less than 4 minutes. Therefore, the project is given a BR of 0.99.

Easement acquisition is required to create one new drainage easement on Wivenhoe Way and is also required along Templeton Lane. Easement acquisition for this project is minimized by staying primarily in the ROW and utilizing City Park property for underground storage. Coordination with Parks and Recreation will be required. The underground storage will ensure the park still maintains existing functionality. Moderate maintenance of traffic and extensive utility relocations will be required during the construction of the project. It is also anticipated that minimal effort will be required to obtain environmental permits for modifying outfalls into existing ditches.

The existing model includes minimal existing infrastructure and no existing storage within the property limits of First Colonial High School. Prior to beginning detailed design for this project, it is recommended to include the existing stormwater infrastructure within the limits of First Colonial High School. The additional model refinement may reduce the extent of the proposed improvements to the area.

#### 3.39.5 Other Alternatives Scored

An additional alternative was scored as part of this analysis. Alternative 2 is similar to the selected project because it reroutes stormwater from Starr Way and Wivenhoe Way to an

underground storage BMP below Brighton on the Bay/Linkhorn Cove Park. It also upsizes existing infrastructure along Mill Dam Road. Alternative 2 proposes a new trunkline north on Mill Dam Road that outfalls on Thunderbird Drive instead of the improvements along Barn Brook Road proposed in Alternative 1. This trunkline requires additional easement acquisition for a drainage easement, giving Alternative 2 a lower score than Alternative 1.

3.39.6 Other Alternatives Not Scored

One additional alternative was considered but was not scored. An underground storage BMP was proposed beneath the parking lot at First Colonial High School was considered to retain the significant runoff entering the existing system from the school property. The underground storage was sized to comply with PWDSM standards. With the proposed underground storage, no proposed improvements are necessary west of Mill Dam Road. Due to the significant cost of the underground detention system and the disruption required to the school property, this alternative was not considered further.

3.39.7 Project Analysis Summary

Table 38 below provides a summary of the Mill Dam Road at Brighton on the Bay Neighborhood project analysis. Refer to Appendix B-39 for project exhibits and supporting documentation.

**Table 38. Mill Dam Road at Brighton on the Bay Neighborhood Project Summary**

<b>SFA Recurrence</b>	1-year (no SLR)
<b>Project LOS</b>	50-year (1.5 feet SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	4.46/10
<b>Other ASC Score(s)</b>	Alternative 2 – 4.18/10
<b>PPC Score</b>	7.44/14.4
<b>BR</b>	0.99
<b>BCR</b>	1.0 (no HAZUS data available)
<b>Project Cost</b>	\$14,010,000

### 3.40 North Great Neck Road at First Colonial Road

#### 3.40.1 SFA Description

North Great Neck Road experiences flooding due to inadequate pipes along First Colonial Road. North Great Neck Road serves as a secondary evacuation route. The models indicate North Great Neck Road at First Colonial Road begins to experience flooding in the 100-year storm event, as shown in Figure 45.

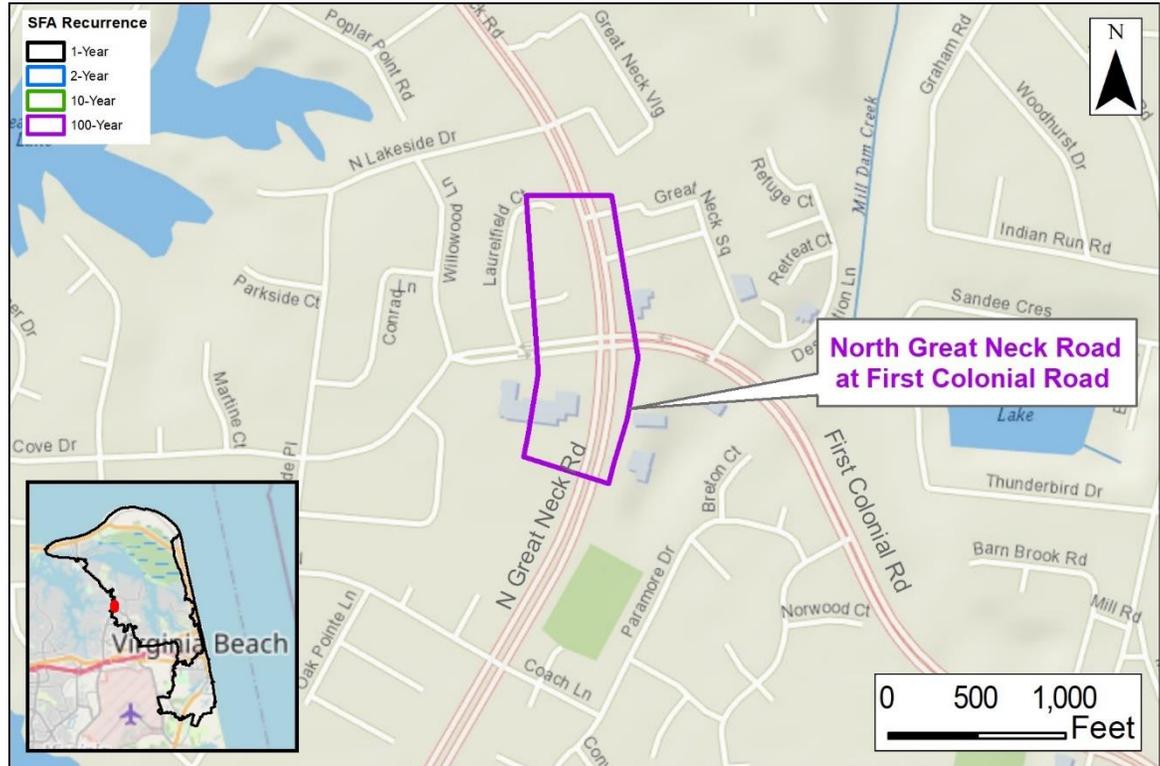


Figure 45. Location Map of North Great Neck Road at First Colonial Road SFA

#### 3.40.2 Project Description

This project upsizes the inadequate stormwater infrastructure along First Colonial Road.

#### 3.40.3 Project Benefits

The major benefits of the project include mitigating street flooding on North Great Neck Road and Laurel Cove Drive, as well as the flooding occurring on surrounding private property. The project also ensures North Great Neck Road can effectively serve as a secondary evacuation route. There is a potential cost-sharing opportunity with DPU for transmission main prioritization along First Colonial Road.

#### 3.40.4 Project Analysis Assumptions

No habitable structures are impacted in the 100-year storm event, so the project is given a BCR value of 1.0. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM. As a secondary evacuation route, North Great Neck Road is passable in the 10-year storm event with 3.0 feet SLR and the 100-year storm event with no SLR.

Easement acquisition will be required to upsize a pipe along First Colonial Road, but acquisition is limited by keeping the remaining improvements within the ROW. It is anticipated that moderate maintenance of traffic will be required during the construction of the project along First Colonial Road. Minimal utility relocations are likely required, but there is a potential for conflicts with an 8-inch gravity sewer, sewer force main, and water line along First Colonial Road.

3.40.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

3.40.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.40.7 Project Analysis Summary

Table 39 below provides a summary of the North Great Neck Road at First Colonial Road project analysis. Refer to Appendix B-40 for project exhibits and supporting documentation.

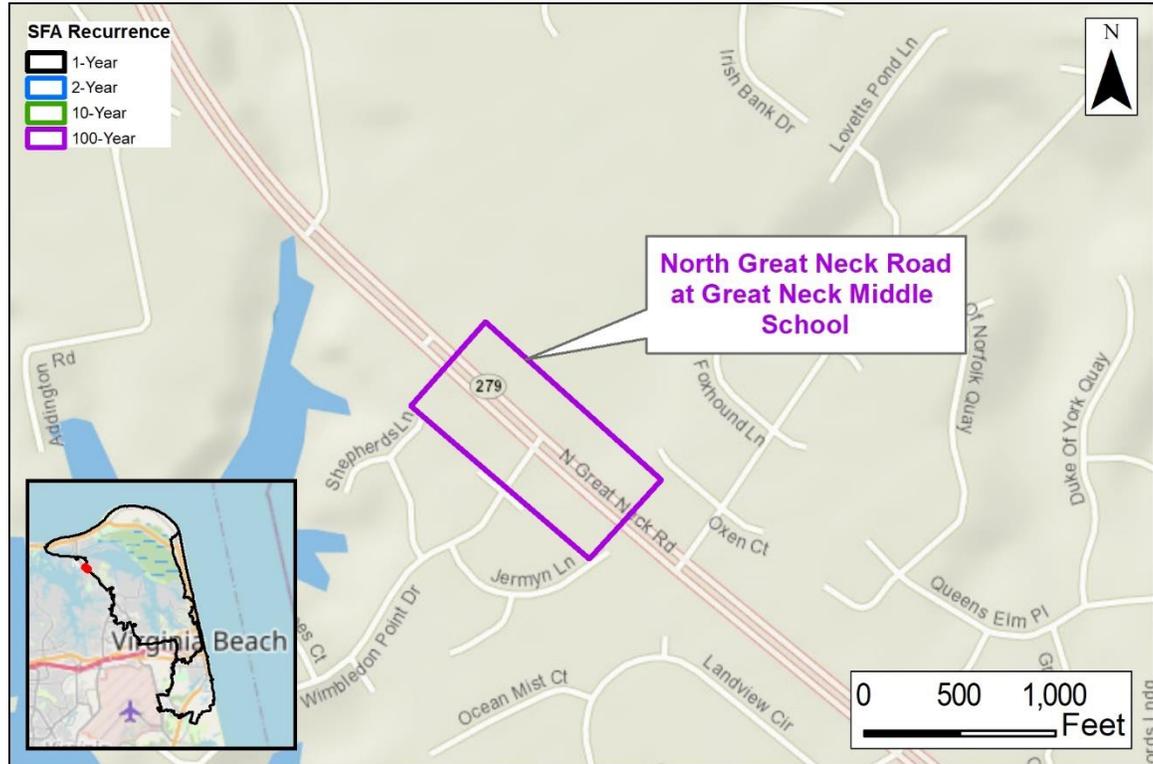
**Table 39. North Great Neck Road at First Colonial Road Project Summary**

<b>SFA Recurrence</b>	100-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	5.91/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	0.5/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0 (no habitable structure flooding)
<b>Project Cost</b>	\$2,490,000

### 3.41 North Great Neck Road at Great Neck Middle School

#### 3.41.1 SFA Description

A portion of North Great Neck Road near Great Neck Middle School floods due to undersized pipes. North Great Neck Road is a secondary evacuation route. The models indicate North Great Neck Road at Great Neck Middle School begins to experience flooding in the 100-year storm event, as shown in Figure 46.



**Figure 46. Location Map of North Great Neck Road at Great Neck Middle School SFA**

#### 3.41.2 Project Description

This project upsizes two pipes underneath North Great Neck Road to mitigate flooding.

#### 3.41.3 Project Benefits

The major benefits of the project include mitigating street flooding on North Great Neck Road and the flooding occurring on surrounding private property. This project also ensures that North Great Neck Road can effectively serve as a secondary evacuation route.

#### 3.41.4 Project Analysis Assumptions

No habitable structures are impacted in the 100-year storm event, so the project is given a BCR value of 1.0. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM. As a secondary evacuation route, North Great Neck Road is passable in the 10-year storm event with 3.0 feet SLR and the 100-year storm event with no SLR.

Property and easement acquisition is not required as all the construction will occur within the ROW. It is anticipated that extensive maintenance of traffic will be required for a short duration, and moderate utility relocations are also expected. Environmental permits are likely

not required for this project as the NWI map does not indicate that the downstream ditch is jurisdictional.

3.41.5 Other Alternatives Scored

Another alternative, as described below, was considered, but was not scored.

3.41.6 Other Alternatives Not Scored

One additional alternative was considered but was not scored. Partial removal of the median on North Great Neck Road was considered to allow for a passable lane in the 100-year storm event and minimize disturbance to the surrounding community. This alternative did not mitigate flooding for Wimbledon Point Drive, the single point of access for the Wimbledon on the Bay neighborhood, so it was not considered further.

3.41.7 Project Analysis Summary

Table 40 below provides a summary of the North Great Neck Road at Great Neck Middle School project analysis. Refer to Appendix B-41 for project exhibits and supporting documentation.

**Table 40. North Great Neck Road at Great Neck Middle School Project Summary**

<b>SFA Recurrence</b>	100-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	6.3/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	0.5/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0 (no habitable structure flooding)
<b>Project Cost</b>	\$680,000

### 3.42 North Virginia Beach

Atlantic Avenue at Shore Drive, Atlantic Avenue at 61<sup>st</sup> Street, Atlantic Avenue at 49<sup>th</sup> Street, and Bay Colony Drive at Myrtle Drive SFAs, shown below in Figure 47 and further described below, are combined into the North Virginia Beach project. Meeting the PWDSM requirements for the upstream SFAs is dependent on the improvements proposed for the downstream SFAs. A phased project is proposed considering the extent of improvements that are required to accomplish the objective of the SWMP to develop “standalone” solutions that are not dependent on downstream improvements. Project phases are defined by the individual SFA boundaries and begin with the most downstream improvements. Future refinements to the proposed project phasing may be required. Refer to Appendix B-42-1 through B-42-2 for detailed project phase maps.

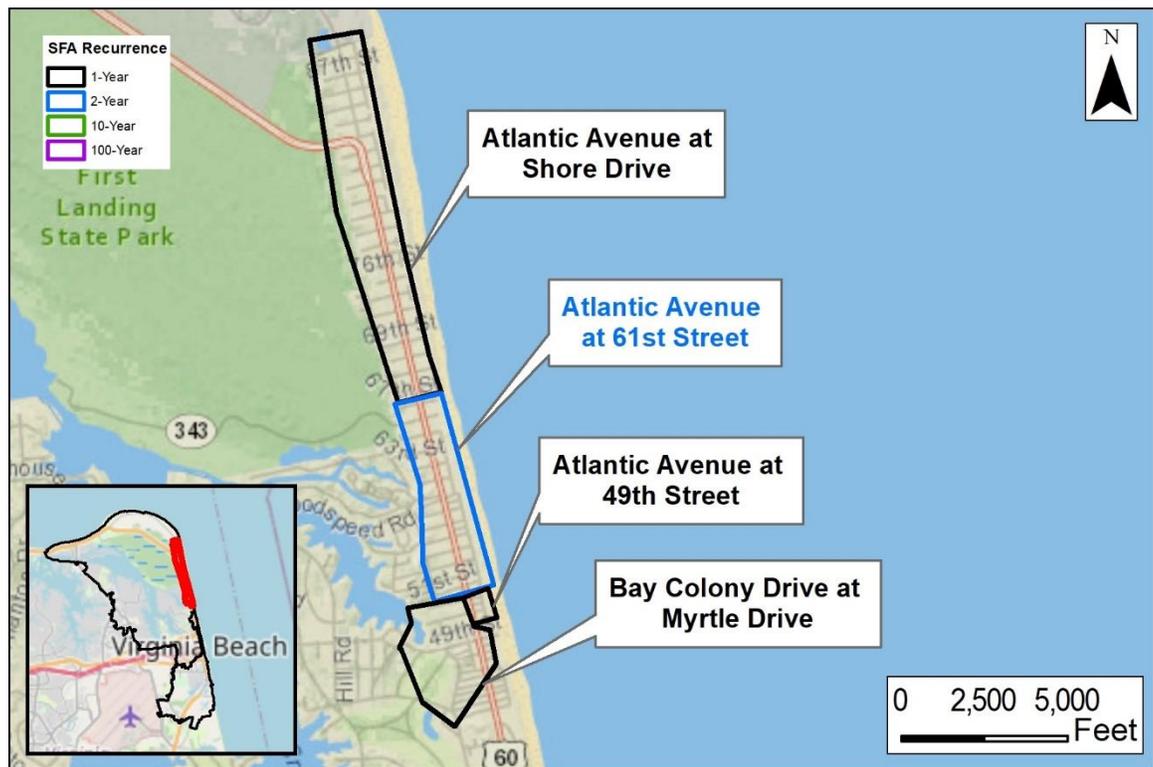


Figure 47. Location Map of Atlantic Avenue at Shore Drive, Atlantic Avenue at 61<sup>st</sup> Street, Atlantic Avenue at 49<sup>th</sup> Street, and Bay Colony Drive at Myrtle Drive SFAs

#### 3.42.1 ***Phase 1: Atlantic Avenue at 70th Street***

##### 3.42.1.1 SFA Description

The Atlantic Avenue at Shore Drive, Atlantic Avenue at 61<sup>st</sup> Street, and Atlantic Avenue at 49<sup>th</sup> Street SFAs are combined into the Atlantic Avenue at 70<sup>th</sup> Street project. Individual SFA locations are shown in Figure 47 and are further described below. All three SFAs are hydraulically connected and can be combined into one project.

##### ***Atlantic Avenue at Shore Drive SFA***

Atlantic Avenue at Shore Drive experiences street, private property, and significant habitable structure flooding. Additionally, Atlantic Avenue is a secondary evacuation route. The area

experiences flooding due to inadequate stormwater infrastructure and an inadequate lift station at 79th Street. The models indicate Atlantic Avenue at Shore Drive begins to experience flooding in the 1-year storm event, as shown in Figure 47.

#### ***Atlantic Avenue at 61st Street SFA***

Atlantic Avenue at 61st Street experiences street, private property, and significant habitable structure flooding. Additionally, Atlantic Avenue is a secondary evacuation route. The area experiences flooding due to inadequate stormwater infrastructure and an inadequate lift station at 61st Street. The models indicate Atlantic Avenue at 61<sup>st</sup> Street begins to experience flooding in the 2-year storm event, as shown in Figure 47.

#### ***Atlantic Avenue at 49<sup>th</sup> Street SFA***

Atlantic Avenue at 49<sup>th</sup> Street experiences street, private property, and habitable structure flooding. Additionally, Atlantic Avenue is a secondary evacuation route. The area experiences flooding due to inadequate stormwater infrastructure. The models indicate Atlantic Avenue at 49th Street begins to experience flooding in the 1-year storm event, as shown in Figure 47.

#### 3.42.1.2 Project Description

This project improves the existing stormwater infrastructure and proposes additional infrastructure to mitigate flooding. The existing pump station at 61st Street is upgraded from 150 cfs to 700 cfs. The existing pump station at 79th Street is upgraded from 25 cfs to 500 cfs. Two additional pump stations are added at 69th Street (700 cfs) and 89th Street (250 cfs). Pipes along Atlantic Avenue and the side streets are upsized to adequately convey runoff to the pump stations. Underground storage is added at the end of most side streets from 57th to 89th Street in the public beach access.

#### 3.42.1.3 Project Benefits

The major benefits of the project include mitigating habitable structure flooding for numerous structures on Atlantic Avenue as well as along the side streets. Private property and street flooding is also mitigated. The project also addresses several flood reports that have been documented in the area. There is a potential cost-sharing opportunity with DPU for transmission main prioritization along Atlantic Avenue and the side streets.

#### 3.42.1.4 Project Analysis Assumptions

HAZUS data is available for some, but not all, flooded habitable structures. The structures no longer flood in the 100-year storm event. Based on the BCR methodology, the project BCR is 1.7657. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM. As a secondary evacuation route, Atlantic Avenue is passable in the 10-year storm event with 3.0 feet SLR and the 100-year storm event with no SLR.

Property acquisition will be required for the proposed pump stations. The amount of property acquisition was limited by placing the pump stations in central locations and adding improvements within the City ROW. Some easement acquisition is required where pipe improvements are required outside the ROW. It is anticipated that extensive maintenance of traffic and utility relocations will be required along Atlantic Avenue. Extensive coordination with the USACE will be required to construct multiple pressurized outfalls directly into the Atlantic Ocean and to add underground storage near the sand dunes. Restoration of beach access areas will be required at the end of each street where underground storage will be placed.

The underground storage at the end of each block is assumed to provide overflow storage for the main trunkline along Atlantic Avenue. To be conservative, the underground storages were modeled without infiltration during any storm event. In detailed design, the amount of underground storage can be refined with site-specific infiltration information. Further model refinement will also be required to determine the extent of improvements along the side streets.

The existing neighborhoods have minimal stormwater infrastructure. Much of the infrastructure that does exist is not large enough to be included in the current existing model. As a result, conservative assumptions are made to determine the extent of the curb, gutter, and ditch improvements needed to convey stormwater runoff to the proposed drainage system. Additional analysis in the design phase is recommended to confirm the extent and cost of improvements.

3.42.1.5 Other Alternatives Scored

Other alternatives, as described below, were considered, but were not scored.

3.42.1.6 Other Alternatives Not Scored

It was considered to use either underground storage or additional pump stations to resolve the SFAs at a lower cost and cause less disruption to the surrounding community. However, neither of the proposed solutions met the PWDSM requirements, so they were not considered further.

It was also considered to utilize First Landing State Park for additional storage or for additional outfalls. Due to extensive environmental permitting and the required HUC boundary change and subsequent adjustments to the total maximum daily load (TMDL) requirement in the Chesapeake Bay, this alternative was not considered further.

3.42.1.7 Project Analysis Summary

Table 41 below provides a summary of the Atlantic Avenue at 70<sup>th</sup> Street project analysis. Refer to Appendix B-42-1 for project exhibits and supporting documentation.

**Table 41. Atlantic Avenue at 70<sup>th</sup> Street Project Summary**

<b>SFA Recurrence</b>	1-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	2.43/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	8.9/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.7657
<b>Project Cost</b>	\$716,290,000

3.42.2 **Phase 2: Bay Colony Drive at Myrtle Drive**

3.42.2.1 SFA Description

Bay Colony Drive at Myrtle Drive SFA experiences street, private property, and habitable structure flooding due to inadequate stormwater infrastructure and a lack of storage in the area. Additionally, tailwater influences the downstream pipes. The models indicate Bay Colony

Drive at Myrtle Drive begins to experience flooding in the 1-year storm event, as shown in Figure 47.

#### 3.42.2.2 Project Description

This project proposes a 400 cfs lift station to add more storage and conveyance capacity to the stormwater system. Inadequate pipes are upsized, and new pipes are proposed to direct stormwater to the proposed lift station and an additional outfall. One underground storage facility is added in the beach access area on 46th Street. Road profile adjustments are required in select locations. North Virginia Beach Phase 2: Bay Colony Drive at Myrtle Drive is dependent on North Virginia Beach Phase 1: Atlantic Avenue at 70<sup>th</sup> Street.

#### 3.42.2.3 Project Benefits

The major benefits of the project include mitigating habitable structure flooding for numerous structures within the neighborhood. Street flooding is mitigated along Bay Colony Drive, Myrtle Drive, and surrounding streets. The project also addresses several flood reports that have been documented in the area and relieves flooding in an economically disadvantaged area. There is a potential cost sharing opportunity with DPU for a transmission line prioritization along Atlantic Avenue.

#### 3.42.2.4 Project Analysis Assumptions

HAZUS data is available for some, but not all, flooded habitable structures. The structures no longer flood in the 100-year storm event. Based on the BCR methodology, the project BCR is 1.7108. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM. As a secondary evacuation route, Atlantic Avenue is passable in the 10-year storm event with 3.0 feet SLR and the 100-year storm event with no SLR.

Property acquisition will be required for the proposed lift station. Property acquisition is minimized by maintaining most improvements within the City ROW. It is anticipated that moderate maintenance of traffic and relocation of utilities will be required. Moderate effort will likely be required to obtain environmental permits to add additional outfalls for the lift station.

The existing neighborhoods have minimal stormwater infrastructure. Much of the infrastructure that does exist is not large enough to be included in the current existing model. As a result, conservative assumptions are made to determine the extent of the curb, gutter, and ditch improvements needed to convey stormwater runoff to the proposed drainage system. Additional analysis in the design phase is recommended to confirm the extent and cost of improvements.

#### 3.42.2.5 Other Alternatives Scored

No additional alternatives were considered for this SFA.

#### 3.42.2.6 Other Alternatives Not Scored

No additional alternatives were considered for this SFA.

#### 3.42.2.7 Project Analysis Summary

Table 42 below provides a summary of the Bay Colony Drive at Myrtle Drive project analysis. Refer to Appendix B-42-2 for project exhibits and supporting documentation.

**Table 42. Bay Colony Drive at Myrtle Drive Project Summary**

<b>SFA Recurrence</b>	1-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	3.02/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	8.7/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.7108
<b>Project Cost</b>	\$85,730,000

3.42.3 **North Virginia Beach Combined Summary**

Table 43 below provides a summary of the North Virginia Beach Project analysis. Refer to Appendix B-42-1 through B-42-2 for project exhibits and supporting documentation.

**Table 43. North Virginia Beach Project Summary**

	<b>Phase 1: Atlantic Avenue at 70<sup>th</sup> Street</b>	<b>Phase 2: Bay Colony Drive at Myrtle Drive</b>
<b>SFA Recurrence</b>	1-year (no SLR)	1-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1	Alternative 1
<b>ASC Score</b>	2.43/10	3.02/10
<b>Other ASC Score(s)</b>	N/A	N/A
<b>PPC Score</b>	8.9/14.4	8.7/14.4
<b>BR</b>	1.0	1.0
<b>BCR</b>	1.7657	1.7108
<b>Individual Project Cost</b>	\$716,290,000	\$85,730,000
<b>Total Project Cost</b>	\$802,020,000	

### 3.43 Ocean Hills Road at Oakridge Circle

#### 3.43.1 SFA Description

Ocean Hills Road at Oakridge Circle floods due to a lack of storage in the area and undersized stormwater infrastructure. One habitable structure floods in existing conditions. The models indicate Ocean Hills Road at Oakridge Circle begins to experience flooding in the 10-year storm event, as shown in Figure 48.

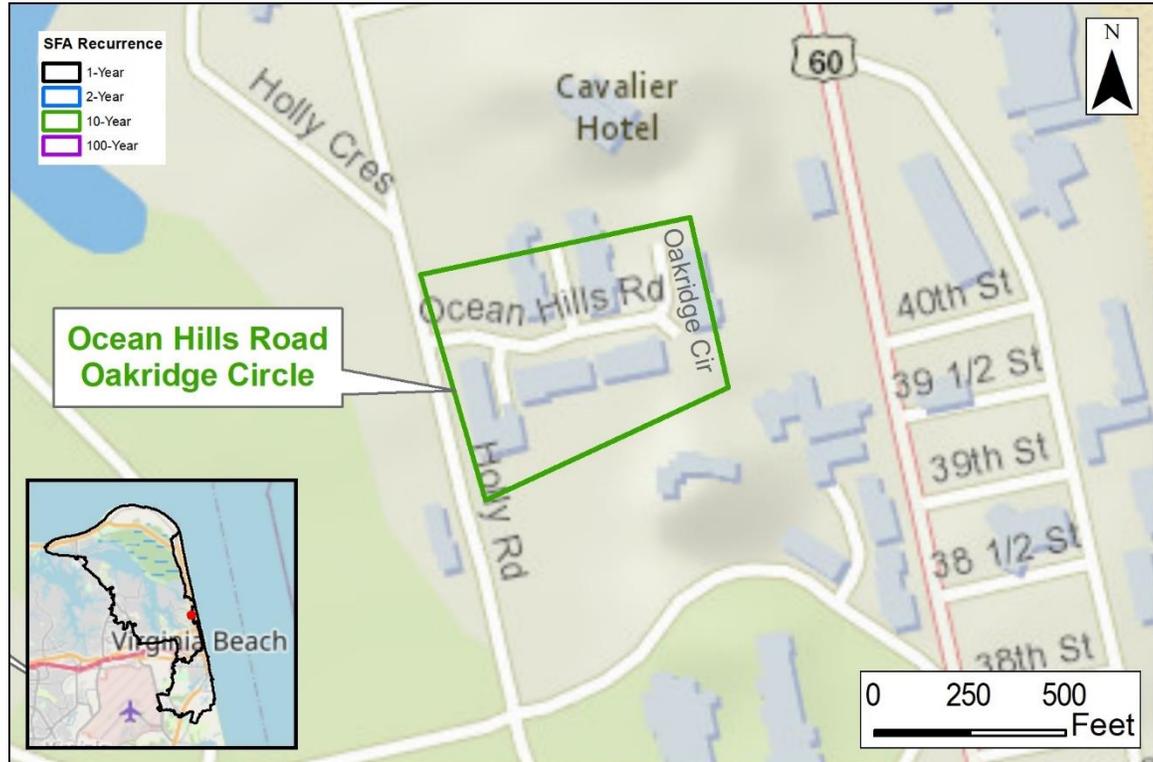


Figure 48. Location Map of Ocean Hills Road at Oakridge Circle SFA

#### 3.43.2 Project Description

This project upsizes stormwater pipes along 40th Street to add storage and capacity to the system. One pipe along Atlantic Avenue is also upsized.

#### 3.43.3 Project Benefits

The major benefits of the project include mitigating flooding for one habitable structure north of Oakridge Circle and street flooding on Ocean Hills Road and Oakridge Circle. Flooding occurring on surrounding private property is resolved, as well. There is a potential cost-sharing opportunity with DPU for transmission main and water leak prioritization.

#### 3.43.4 Project Analysis Assumptions

HAZUS data is available for the flooded habitable structure north of Oakridge Circle. The structure no longer floods in the 100-year storm event. Based on the BCR methodology, the project BCR is 1.1705.

Easement acquisition is required for this project, but it will be limited to two private property owners. It is anticipated that significant maintenance of traffic and utility relocations will be

required during the construction of the project. Environmental permits will not be required. Restoration of the landscaping and fencing in a small neighborhood park will be required on the corner of Ocean Hills Road and Oakridge Circle. Additionally, restoration of the 40<sup>th</sup> Street boardwalk access will also be required.

This project is dependent on minor improvements to the operational settings of the 42<sup>nd</sup> Street stormwater pump station. The existing station has four pumps that turn on incrementally, based on the water elevation in the wet well. For this project, it is assumed that the pump station has modified settings during the 100-year storm event. The first pump turns on at an elevation of -1.5 instead of -2, and the three subsequent pumps turn on at 0.25-foot increments instead of 0.5 to 1.5-foot increments. This increases the utilization of all four pumps during the 100-year storm event, lowering the system’s tailwater. These assumptions are based on the review of as-built information of the 42<sup>nd</sup> Street pump station and preliminary discussions with Public Works Operations personnel. It is further assumed that the operational changes can be made without any upgrades to the infrastructure associated with the 42<sup>nd</sup> Street pump station.

3.43.5 Other Alternatives Scored

Another alternative, as described below, was considered, but was not scored.

3.43.6 Other Alternatives Not Scored

One additional alternative was considered but not scored. Underground storage was proposed underneath the parking lot of Galilee Church adjacent to Ocean Hills Road and Oakridge Circle and near the intersection of Pacific Avenue and 40<sup>th</sup> Street to minimize the extent of pipe improvements along 40<sup>th</sup> Street. The use of private property for storage of public drainage would require significant easement acquisition and was not preferred. This alternative was not considered any further.

3.43.7 Project Analysis Summary

Table 44 below provides a summary of the Ocean Hills Road at Oakridge Circle project analysis. Refer to Appendix B-43 for project exhibits and supporting documentation.

**Table 44. Ocean Hills Road at Oakridge Circle Project Summary**

<b>SFA Recurrence</b>	10-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	4.96/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	4.98/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.1705
<b>Project Cost</b>	\$5,440,000

### 3.44 Old Dominion Lane and Seward Lane

#### 3.44.1 SFA Description

The Dendron Drive at Old Dominion Lane and Seward Lane at Bailey Lane SFAs are combined into the Old Dominion Lane and Seward Lane project. Individual SFA locations are shown in Figure 49 and are further described below. The two SFAs are located within the same neighborhood, so they are combined into one project.

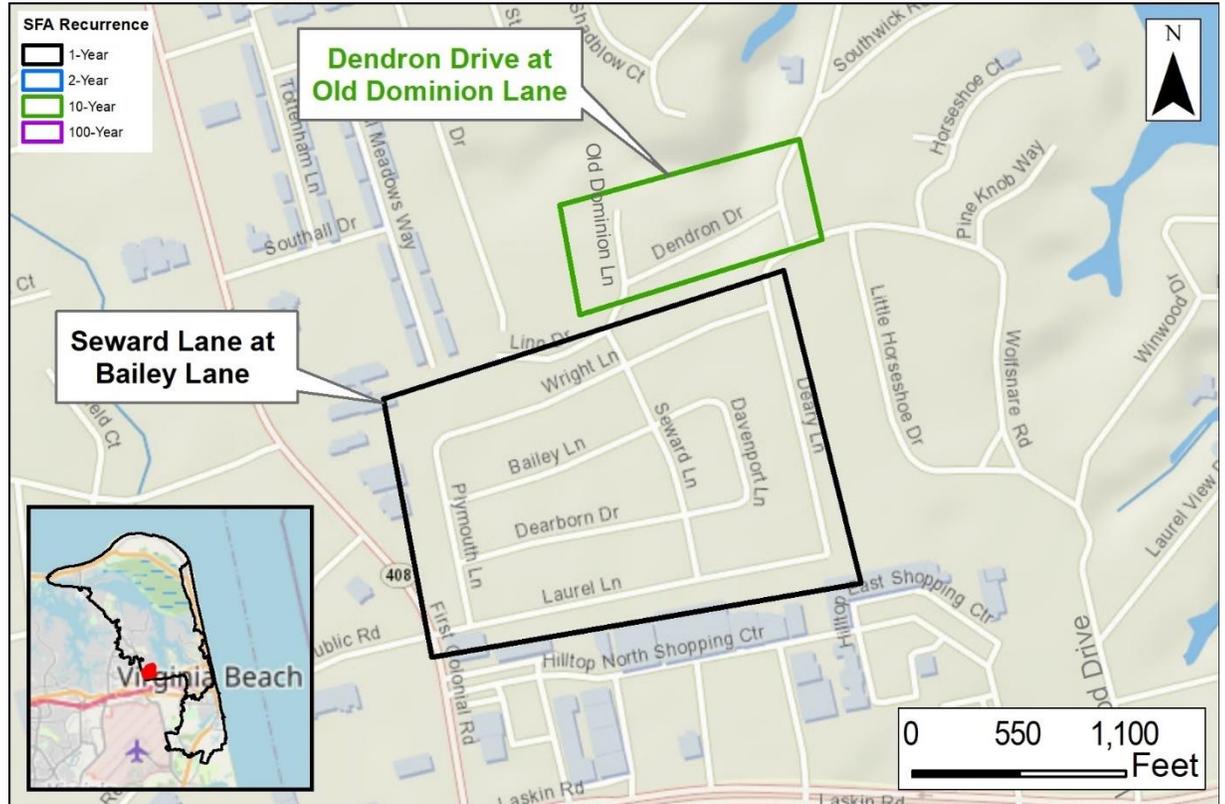


Figure 49. Location Map of Dendron Drive at Old Dominion Lane and Seward Lane at Bailey Lane SFAs

#### ***Dendron Drive at Old Dominion Lane SFA***

Dendron Drive at Old Dominion Lane experiences private property and street flooding due to inadequate pipes. The models indicate Dendron Drive at Old Dominion Lane begins to experience flooding in the 10-year storm event, as shown in Figure 49.

#### ***Seward Lane at Bailey Lane SFA***

Habitable structures, private property, and streets experience flooding along Wright Lane, Bailey Lane and Seward Lane. The flooding is caused by inadequate pipes, and a lack of stormwater infrastructure. The models indicate Seward Lane at Bailey Lane begins to experience flooding in the 1-year storm event, as shown in Figure 49.

3.44.2 Project Description

This project creates a new trunkline along Seward Lane. Pipes along Bailey Lane, Wright Lane, and Dendron Drive are directed to the new trunkline. The system outfalls into an existing ditch at the end of Old Dominion Lane.

3.44.3 Project Benefits

The major benefits of the project include mitigating habitable structure flooding for 10 structures on Wright Lane, Seward Lane, and Bailey Lane. Street flooding along Dendron Drive, Old Dominion Lane, Wright Lane, Deary Lane, Bailey Lane, Davenport Lane, and Seward Lane is mitigated, as well. The project also addresses several flood reports that have been documented in the area. There is a potential cost-sharing opportunity with DPU for water leak prioritization along Old Dominion Lane, Dendron Drive, and Seward Lane.

3.44.4 Project Analysis Assumptions

HAZUS data is available for the flooded habitable structures along Wright Lane. The structures no longer flood in the 100-year event. Based on the BCR methodology, the project BCR is 1.8992. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM.

Easement acquisition from private landowners will be required for a drainage easement at the end of Old Dominion Lane. Establishing a parallel outfall as opposed to upsizing the existing outfall is preferred due to the limited distance between the existing residential structures along the existing outfall. Easement acquisition would be required in either scenario but is limited by keeping most improvements within the ROW. It is anticipated that moderate maintenance of traffic will be required during the construction of the project along Old Dominion Lane, Dendron Drive, Seward Lane, Wright Lane, and Bailey Lane. Moderate utility relocations will likely be required during the construction of the project with 6-inch water lines and 6-inch and 8-inch gravity sewer lines. Minimal effort will be required to obtain environmental permits to add an outfall into a tidal ditch.

3.44.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

3.44.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.44.7 Project Analysis Summary

Table 45 below provides a summary of the Old Dominion Lane and Seward Lane project analysis. Refer to Appendix B-44 for project exhibits and supporting documentation.

**Table 45. Old Dominion Lane and Seward Lane Project Summary**

<b>SFA Recurrence</b>	1-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	5.36/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	7.7/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.8992
<b>Project Cost</b>	\$4,320,000

### 3.45 Old Donation Parkway and First Colonial Road at Hilltop

#### 3.45.1 SFA Description

The Forest Park and Great Neck Pines, Old Donation Parkway at Calypso Lane, Old Donation Parkway at First Colonial Road, and Country Mill Road at First General Parkway SFAs are combined into the Old Donation Parkway and First Colonial Road at Hilltop project. Individual SFA locations are shown in Figure 50 and are further described below. All four SFAs are hydraulically connected and can be combined into one project.

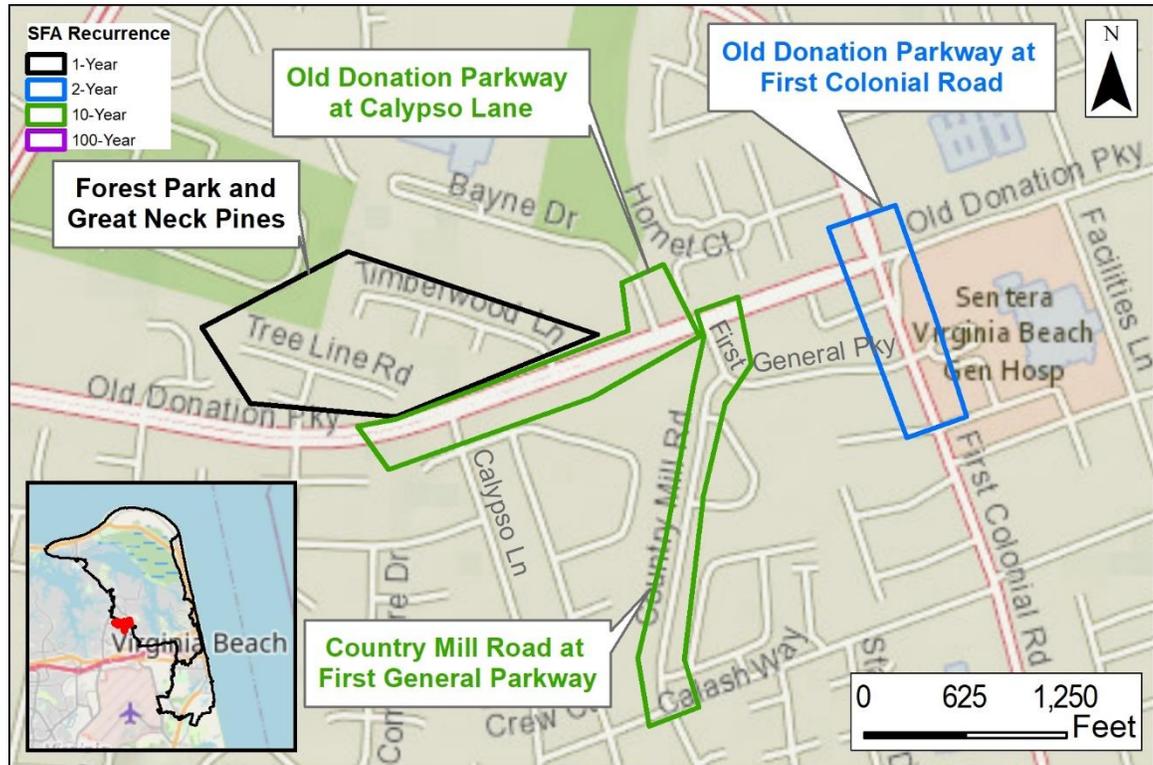


Figure 50. Location Map of Forest Park and Great Neck Pines, Old Donation Parkway at Calypso Lane, Old Donation Parkway at First Colonial Road, and Country Mill Road at First General Parkway SFAs

#### **Forest Park and Great Neck Pines SFA**

The existing stormwater infrastructure on Old Donation Parkway is undersized, and the area lacks available storage for runoff which overwhelms the existing outfall pipes. The models indicate the Forest Park and Great Neck Pines SFA begins to experience flooding in the 1-year storm event, as shown in Figure 50.

#### **Old Donation Parkway at Calypso Lane SFA**

The existing stormwater infrastructure on Old Donation Parkway is undersized, and the area lacks available storage for runoff which overwhelms the existing outfall pipes. The models indicate Old Donation Parkway at Calypso Lane begins to experience flooding in the 10-year storm event, as shown in Figure 50.

### ***Old Donation Parkway at First Colonial Road SFA***

The existing stormwater infrastructure on First Colonial Road is undersized, and the area lacks available storage for runoff which overwhelms the existing outfall pipes. The models indicate Old Donation Parkway at First Colonial Road begins to experience flooding in the 2-year storm event, as shown in Figure 50.

### ***Country Mill Road at First General Parkway SFA***

The existing stormwater infrastructure on Country Mill Road is undersized, and the area lacks available storage for runoff which overwhelms the existing outfall pipes. The models indicate Country Mill Road at First General Parkway begins to experience flooding in the 10-year storm event, as shown in Figure 50.

#### 3.45.2 Project Description

This project adds a BMP on two currently undeveloped private parcels (24085346870000 and 24085306610000). Upsized and reversed pipes on First Colonial Road and Country Mill Road outfall into the proposed BMP. This alternative also proposes upsizing the existing trunkline and proposing a parallel stormwater trunkline along Old Donation Parkway. The improvements ultimately outfall into the existing ditch within Lynnhaven Park that is widened to create additional floodplain for large storm events.

#### 3.45.3 Project Benefits

The major benefits of the project include mitigating street flooding on multiple neighborhood streets, Old Donation Parkway, and First Colonial Road so that it can effectively serve as a secondary evacuation route. The project mitigates flooding for six habitable structures on Timberwood Lane, three structures on Timber Court, three structures on Tree Line Road, and two on Country Mill Road for a total of 14 structures. The project addresses several flood reports that have been documented in the area. There is an opportunity for potential cost-sharing with DPU for transmission main prioritization for this project and with the Public Works Stormwater Regulatory Division for TMDL assistance or nutrient credits for other City projects.

#### 3.45.4 Project Analysis Assumptions

A 50-year LOS is achieved for this project. Pipe improvements and storage have been maximized within the area, and there are not any more adjacent open spaces to add storage to the system. Flood depths are less than 3 inches above the crown of the road, are summarized on the 100-year flood map, and will require approval for a reduced LOS from the City Engineer.

HAZUS data is available for some, but not all, flooded habitable structures. The structures no longer flood in the 100-year storm event, so the project BCR is 1.2912. Most street flooding is mitigated in the 100-year storm event, but the crown of Timberwood Lane is not completely visible with a depth of 1.7 inches for approximately 30 feet. Therefore, the project is given a BR of 0.99. As a secondary evacuation route, First Colonial Road remains passable in the 10-year storm event with 3.0 feet SLR and the 100-year storm event with no SLR.

Significant property acquisition of private, undeveloped land is required to construct the BMP, and some easement acquisition will be required for drainage easements. It is anticipated that moderate maintenance of traffic will be required on Old Donation Parkway during the construction of the project. Moderate utility relocations will also be required within the neighborhoods and along the main corridors such as Old Donation Parkway and First Colonial

Road. The existing stream within Lynnhaven Park will be widened in this project, likely requiring extensive effort to obtain environmental permits from USACE and DEQ. Coordination with FEMA is anticipated for the LOMR/CLOMR process. Additionally, coordination will be required with City of Virginia Beach Public Schools to widen the floodplain near their recreational facilities.

This project is located near the Broad Bay drainage basin boundary. The existing model included three overland flows from the adjacent drainage basin, Wolfsnare Creek, connecting the Great Neck Meadows and Wellington Woods North Neighborhoods to the project area. The current project was modeled and is contingent upon the elimination of these overland flows from the adjacent drainage basin. The elimination of these overland flows will need to be confirmed as part of the Wolfsnare Creek SWMP.

3.45.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

3.45.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.45.7 Project Analysis Summary

Table 46 below provides a summary of the Old Donation Parkway and First Colonial Road at Hilltop project analysis. Refer to Appendix B-45 for project exhibits and supporting documentation.

**Table 46. Old Donation Parkway and First Colonial Road at Hilltop Project Summary**

<b>SFA Recurrence</b>	1-year (no SLR)
<b>Project LOS</b>	50-year (1.5 feet SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	4.33/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	8.52/14.4
<b>BR</b>	0.99
<b>BCR</b>	1.2912
<b>Project Cost</b>	\$23,570,000

### 3.46 Oriole Drive North

#### 3.46.1 SFA Description

Oriole Drive is a residential street that provides access to both private residences and the Cavalier Golf Course and Yacht Club. The street ranges in elevation from approximately 4 to 6 feet at its lowest point. The design tailwater elevation for the 100-year storm event with no SLR is 4.3 feet in Little Neck Creek. The tailwater elevation, independent of existing drainage infrastructure, floods portions of the residential street. The models indicate Oriole Drive North begins to experience flooding in the 1-year storm event, as shown in Figure 51.



**Figure 51. Location Map of Oriole Drive North SFA**

#### 3.46.2 Project Description

This project proposes raising the road approximately 8 inches in one location along Oriole Drive, allowing the road to remain passible during the 100-year storm event. Additionally, a pipe is upsized, and a backflow preventer is added to another location on Oriole Drive to resolve flooding.

#### 3.46.3 Project Benefits

The major benefit of the project is mitigating street flooding on Oriole Drive, as well as flooding occurring on surrounding private property. The project also addresses one flood report that has been documented in the area.

#### 3.46.4 Project Analysis Assumptions

No habitable structures are impacted in the 100-year storm event, so the project is given a BCR value of 1.0. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM.

Easement acquisition will be required to upsize the pipe underneath Oriole Drive. It is anticipated that minimal maintenance of traffic and utility relocations will be required during the construction of the project. Minimal effort will likely be required to obtain environmental permits to modify the outfall into Little Neck Creek.

Oriole Drive is located directly adjacent to Little Neck Creek, making it highly susceptible to tailwater influence. The approximate low point on the roadway in existing conditions is 4 feet. This alternative raises the road to the maximum extent possible. In proposed conditions, the low point on the road is 4.7 feet, matching the tailwater in the 10-year storm event with 1.5 feet SLR of 4.7 feet. Additional analysis for a CLOMR or LOMR will likely be required for raising the road in a FEMA floodplain.

3.46.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

3.46.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.46.7 Project Analysis Summary

Table 47 below provides a summary of the Oriole Drive North project analysis. Refer to Appendix B-46 for project exhibits and supporting documentation.

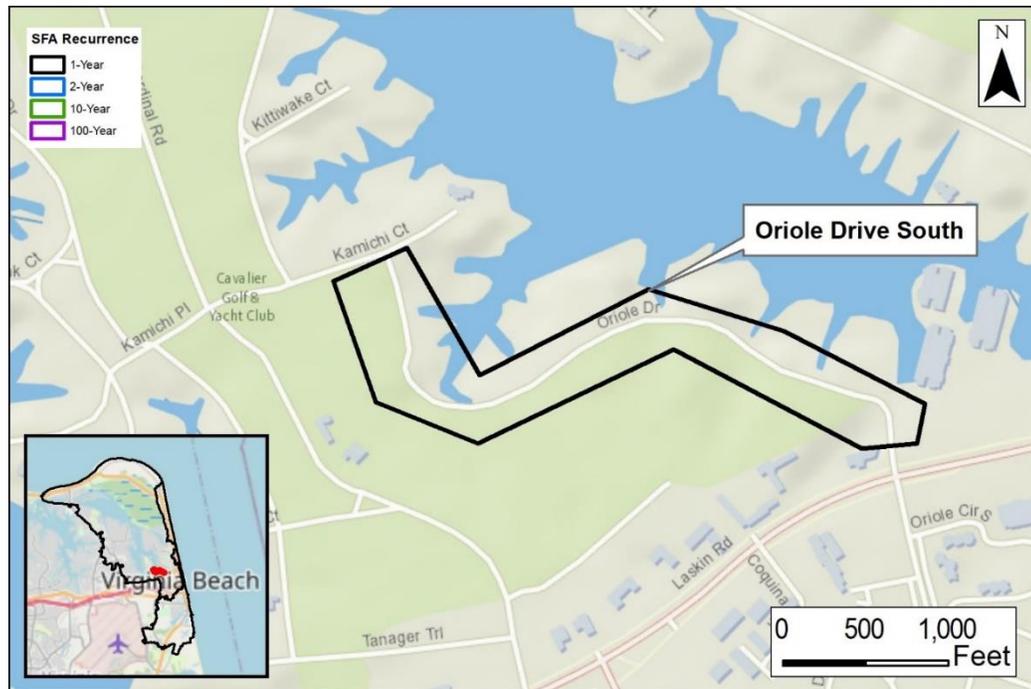
**Table 47. Oriole Drive North Project Summary**

<b>SFA Recurrence</b>	1-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	5.32/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	3.4/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0 (no habitable structure flooding)
<b>Project Cost</b>	\$670,000

### 3.47 Oriole Drive South

#### 3.47.1 SFA Description

Oriole Drive South is a residential street that provides access to both private residences and the Cavalier Golf Course and Yacht Club. The street ranges in elevation from approximately 1 foot to 3 feet at its lowest point. The design tailwater elevation for the 100-year storm event with no SLR is 4.3 feet in Little Neck Creek. The tailwater elevation, independent of existing drainage infrastructure, floods portions of the street as well as habitable structures. The models indicate Oriole Drive South begins to experience flooding in the 1-year storm event, as shown in Figure 52.



**Figure 52. Location Map of Oriole Drive South SFA**

#### 3.47.2 Project Description

The downstream tailwater conditions severely limit the options for improvements to this neighborhood. The City will be evaluating this SFA with a Neighborhood Strategy in the future. Refer to Appendix B-47 for the extent of existing flooding in the area.

#### 3.47.3 Project Benefits

There is no project, and there are no benefits.

#### 3.47.4 Other Alternatives Scored

No alternatives were evaluated for this SFA.

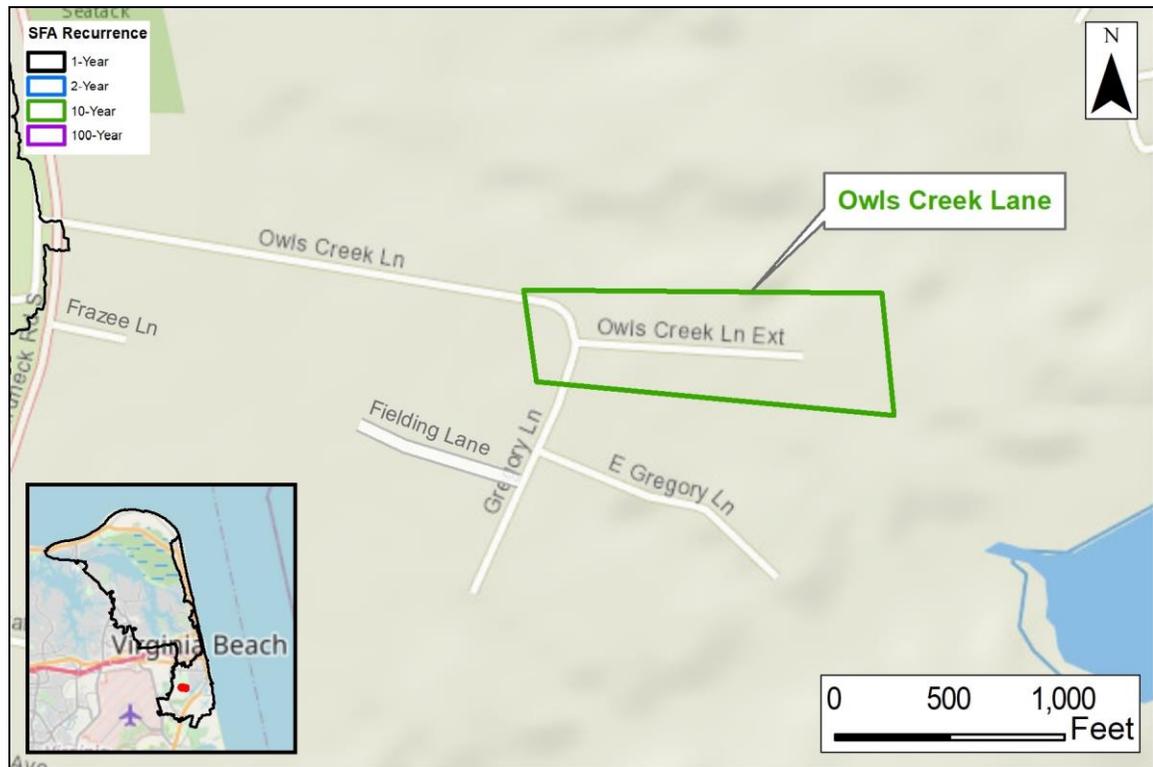
#### 3.47.5 Other Alternatives Not Scored

This neighborhood would benefit from a neighborhood solution similar to those shown in the SLR Adaptation Strategy Report. This neighborhood can be designed to resolve the flooding issues that occur from a smaller storm event. PW-SWEC will, in the future, have a neighborhood solution created to establish resiliency in this neighborhood.

### 3.48 Owls Creek Lane

#### 3.48.1 SFA Description

Owls Creek Lane is located west of Lake Rudee and east of South Birdneck Road. Owls Creek Lane experiences flooding due to an inadequate outfall pipe. Streets and private property flood at the intersection of Owls Creek Lane and Gregory Lane. The models indicate Owls Creek Lane begins to experience flooding in the 10-year storm event, as shown in Figure 53.



**Figure 53. Location Map of Owls Creek Lane SFA**

#### 3.48.2 Project Description

This project upsizes an existing outfall pipe on Owls Creek Lane. This project mitigates street flooding at the intersection of Owls Creek Lane and Gregory Lane.

#### 3.48.3 Project Benefits

The major benefits of this project include mitigating street flooding on Owls Creek Lane, as well as the flooding occurring on surrounding private property. This project also mitigates flooding in an area that is economically disadvantaged.

#### 3.48.4 Project Analysis Assumptions

No habitable structures are impacted in the 100-year storm event, so the project is given a BCR value of 1.0. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM. The proposed improvements are located within an existing drainage easement, so no easement acquisition is required. The City's Owls Creek sanitary sewer pump station is shown within the limits of existing flooding. While the proposed improvements were not designed to mitigate this flooding, the project does eliminate it. Maintenance of traffic, utility

relocations, and environmental permitting will not be required during the construction of the project.

3.48.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

3.48.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.48.7 Project Analysis Summary

Table 48 below provides a summary of the Owls Creek Lane project analysis. Refer to Appendix B-48 for project exhibits and supporting documentation.

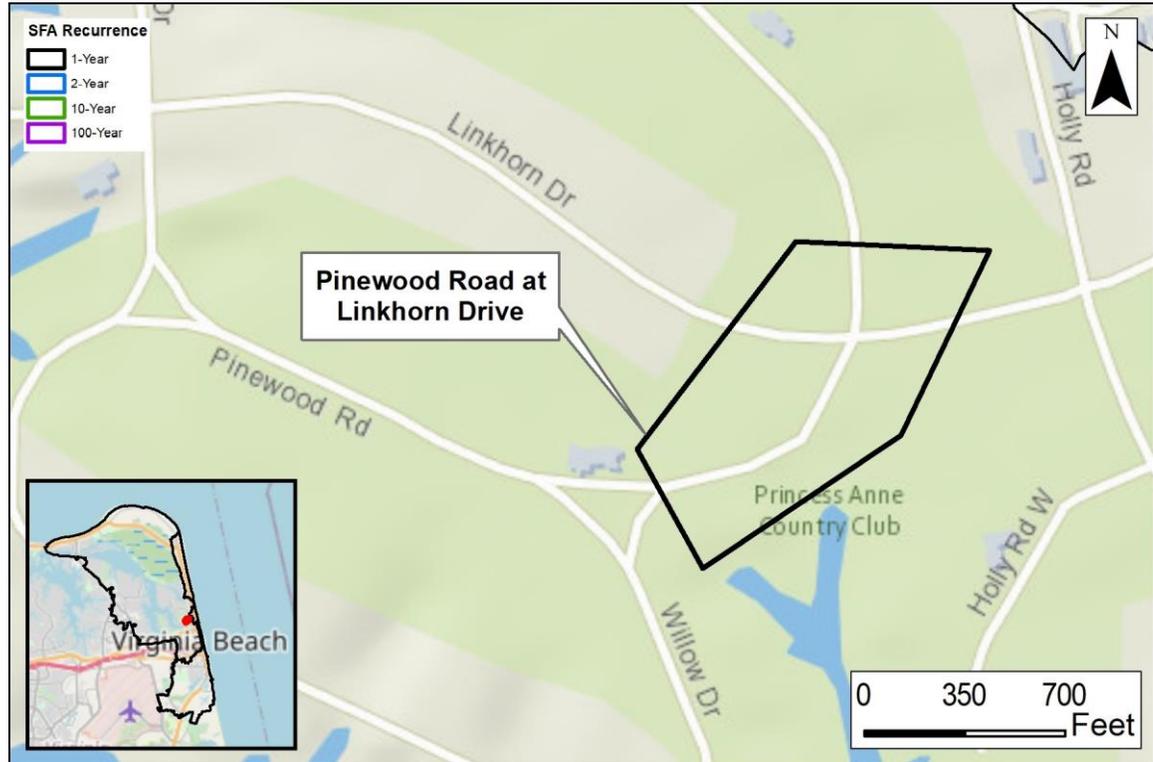
**Table 48. Owls Creek Lane Project Summary**

<b>SFA Recurrence</b>	10-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	6.45/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	1.48/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0 (no habitable structure flooding)
<b>Project Cost</b>	\$410,000

### 3.49 Pinewood Road at Linkhorn Drive

#### 3.49.1 SFA Description

Pinewood Road experiences flooding due to the roadway being lower than the downstream tailwater condition. Flooding occurs on streets and private properties. The models indicate Pinewood Road at Linkhorn Drive begins to experience flooding in the 1-year storm event, as shown in Figure 54.



**Figure 54. Location Map of Pinewood Road at Linkhorn Drive SFA**

#### 3.49.2 Project Description

This project raises Pinewood Road by 1 foot to meet the PWDSM requirements. Multiple driveways are modified to tie into the new roadway profile.

#### 3.49.3 Project Benefits

The major benefits of the project include mitigating street flooding on Pinewood Road. The project also addresses multiple flood reports that have been documented in the area.

#### 3.49.4 Project Analysis Assumptions

No habitable structures are impacted in the 100-year storm event, so the project is given a BCR value of 1.0. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM.

Additional ROW acquisition along either side of the road will be necessary. It is anticipated that moderate maintenance of traffic will be required during the construction of the project along Pinewood Drive. Utility relocations and obtaining environmental permits will likely require minimal effort for this project.

3.49.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

3.49.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.49.7 Project Analysis Summary

Table 49 below provides a summary of the Pinewood Road at Linkhorn Drive project analysis. Refer to Appendix B-49 for project exhibits and supporting documentation.

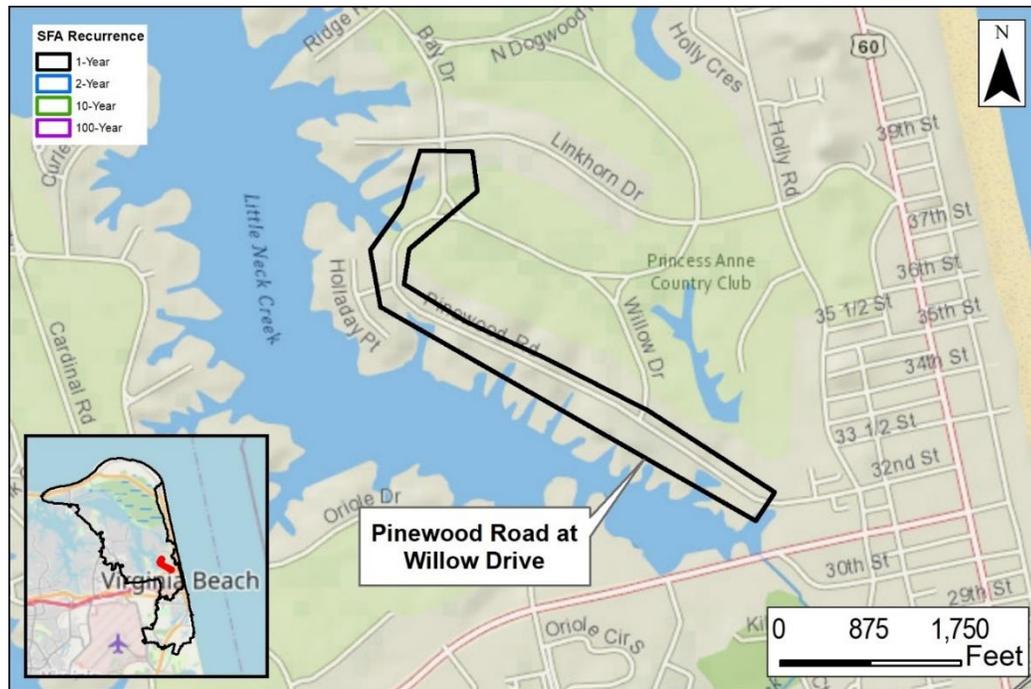
**Table 49. Pinewood Road at Linkhorn Drive Project Summary**

<b>SFA Recurrence</b>	1-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	5.51/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	3/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0 (no habitable structure flooding)
<b>Project Cost</b>	\$640,000

### 3.50 Pinewood Road at Willow Drive

#### 3.50.1 SFA Description

Pinewood Road is a public street that runs parallel to Little Neck Creek and serves both single-family homes and the Princess Anne Country Club. The road's low point elevations range from approximately 0 to 2 feet. The design tailwater elevation for the 100-year storm event with no SLR is 4.3 feet in the existing condition. The tailwater elevation, independent of existing drainage infrastructure, floods portions of the street as well as habitable structures. The models indicate Pinewood Road at Willow Drive begins to experience flooding in the 1-year storm event, as shown in Figure 55.



**Figure 55. Location Map of Pinewood Road at Willow Drive SFA**

#### 3.50.2 Project Description

The downstream tailwater conditions severely limit the options for improvements to this neighborhood. The City will be evaluating this SFA with a Neighborhood Strategy in the future. Refer to Appendix B-50 for the extent of existing flooding in the area.

#### 3.50.3 Project Benefits

There is no project, and there are no benefits.

#### 3.50.4 Other Alternatives Scored

No alternatives were evaluated for this SFA.

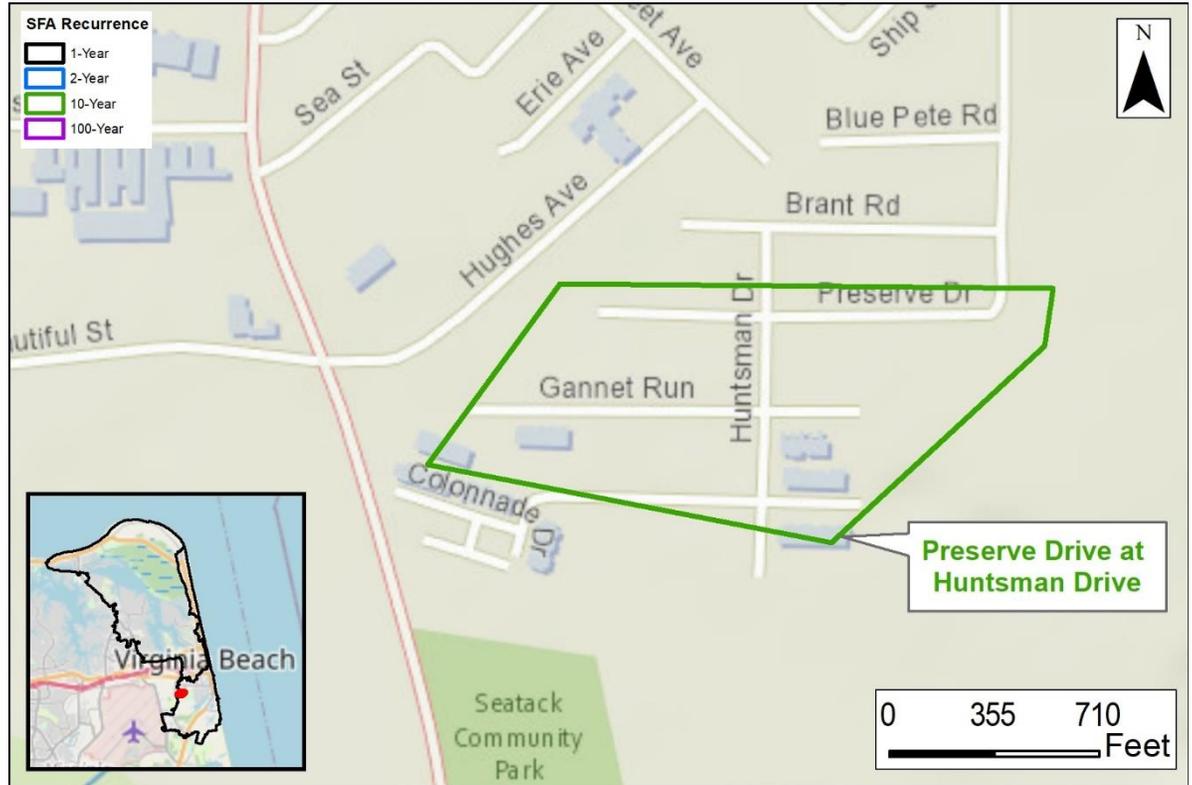
#### 3.50.5 Other Alternatives Not Scored

This neighborhood would benefit from a neighborhood solution similar to those shown in the SLR Adaptation Strategy Report. This neighborhood can be designed to resolve the flooding issues that occur from a smaller storm event. PW-SWEC will, in the future, have a neighborhood solution created to establish resiliency in this neighborhood.

### 3.51 Preserve Drive at Huntsman Drive

#### 3.51.1 SFA Description

Preserve Drive at Huntsman Drive experiences flooding due to inadequate stormwater infrastructure. Streets, private properties, and habitable structures experience flooding. The models indicate Preserve Drive at Huntsman Drive begins to experience flooding in the 10-year storm event, as shown in Figure 56.



**Figure 56. Location Map of Preserve Drive at Huntsman Drive SFA**

#### 3.51.2 Project Description

This project upsizes existing stormwater infrastructure along Preserve Drive and Gannet Run. The improved stormwater infrastructure outfalls east into an existing ditch, which will be lowered two to three feet.

#### 3.51.3 Project Benefits

The major benefits of the project include mitigating street flooding on Preserve Drive, Huntsman Drive, and Gannet Run, as well as the flooding occurring on surrounding private property. Habitable structure flooding is resolved for six structures along Preserve Drive, two structures on Brant Road, and one structure on Gannet Run for a total of nine structures. The project also addresses several flood reports in the area and mitigates flooding in an economically disadvantaged area.

#### 3.51.4 Project Analysis Assumptions

HAZUS data is available for some, but not all, flooded habitable structures. The structures no longer flood in the 100-year storm event. Based on the BCR methodology, the project BCR is

1.1684. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM.

Property or easement acquisition is not required as all the construction will occur within the ROW. Moderate maintenance of traffic will be required for Preserve Drive and Gannet Run, which are neighborhood roads that serve as the only route for entry and exit into the neighborhood. Moderate utility relocations will likely be required during the construction of the project for potential conflicts with an 8-inch gravity sewer line and an 8-inch water line along Huntsman Drive. Moderate effort will be required to obtain environmental permits to upsize outfalls in a nontidal ditch and modify approximately 1,450 feet of a nontidal ditch.

3.51.5 Other Alternatives Scored

One additional alternative was scored as part of this analysis. Alternative 2 also improved the inadequate stormwater infrastructure within the neighborhood. The existing pipes along Preserve Drive were upsized and an additional outfall is proposed along Huntsman Drive. This alternative did not score as high since there would be a larger residential community disruption and require additional maintenance.

3.51.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.51.7 Project Analysis Summary

Table 50 below provides a summary of the Preserve Drive at Huntsman Drive project analysis. Refer to Appendix B-51 for project exhibits and supporting documentation.

**Table 50. Preserve Drive at Huntsman Drive Project Summary**

<b>SFA Recurrence</b>	10-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	5.58/10
<b>Other ASC Score(s)</b>	Alternative 2 – 5.31/10
<b>PPC Score</b>	5.68/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.1684
<b>Project Cost</b>	\$3,040,000

### 3.52 Quail Point Road at Covey Street

#### 3.52.1 SFA Description

Streets and private property experience flooding along Covey Street, Quail Point Road, Star Grass Road, and Quail Pointe Cove. Habitable structures flood at Fenrose Court and Wildwood Drive. The flooding is caused by inadequate stormwater infrastructure throughout the neighborhood. The models indicate Quail Point Road at Covey Street begins to experience flooding in the 1-year storm event, as shown in Figure 57.

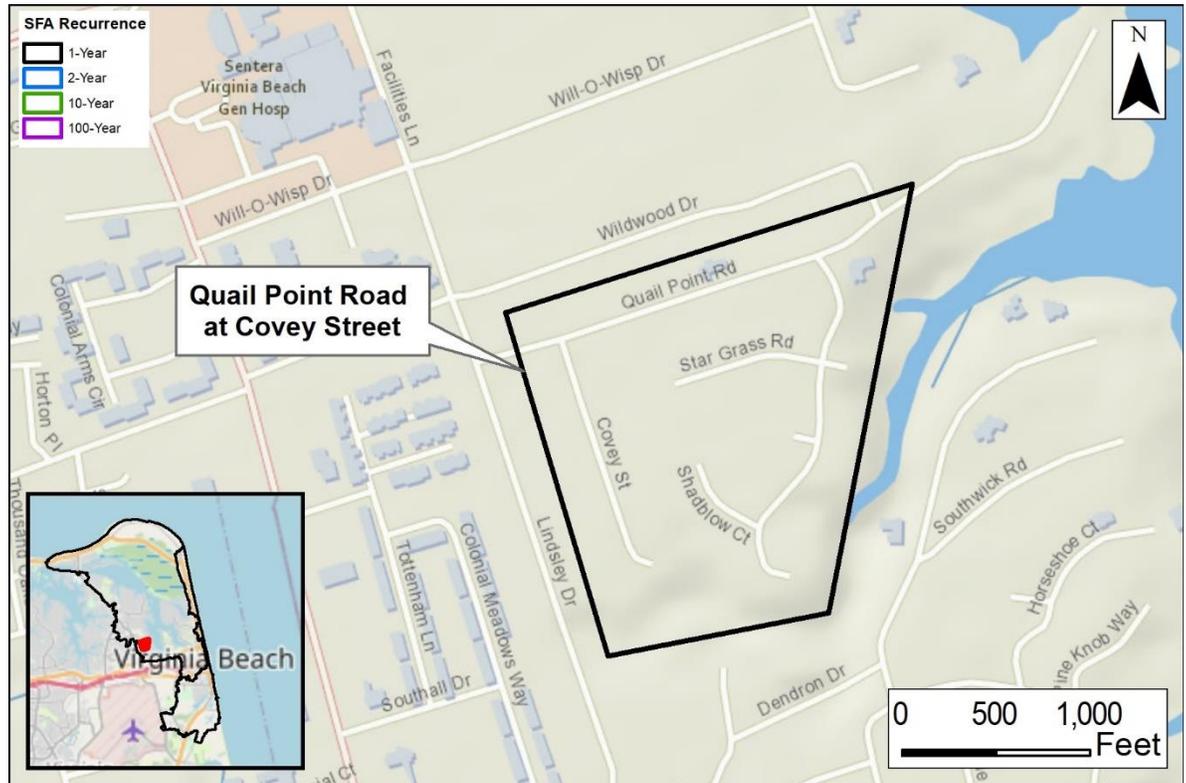


Figure 57. Location Map of Quail Point Road at Covey Street SFA

#### 3.52.2 Project Description

This project upsizes the inadequate pipes within the neighborhood. Pipes are added along Covey Street that outfall into the existing ditch. Pipes are also added along Quail Point Road that outfall directly into Linkhorn Bay.

#### 3.52.3 Project Benefits

The major benefits of the project include mitigating habitable structure flooding for two structures on Fenrose Court and one structure on Wildwood Drive. Street flooding along Fenrose Court, Quail Pointe Cove, Covey Street, Star Grass Road, and Quail Point Road is also mitigated. The project addresses several flood reports that have been documented in the area.

#### 3.52.4 Project Analysis Assumptions

HAZUS data is available for the flooded habitable structures on Fenrose Court and Wildwood Drive. The structures no longer flood in the 100-year event. Based on the BCR methodology,

the project BCR is 1.1092. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM.

Easement acquisition will be required from two private landowners at the end of Covey Street, but acquisition is limited by maintaining improvements within the ROW and existing easements when possible. It is anticipated that moderate maintenance of traffic will be required during the construction of the project. Moderate utility relocations will likely be required for potential conflicts with 8-inch water lines, 8-inch gravity sewer lines, and an 8-inch force main. Minimal effort is likely required to obtain environmental permits to add new outfalls into the tidal ditch south of Covey Street and Linkhorn Bay.

An assumption was made that there are no existing storm pipes located, within existing easements, that are not shown in City GIS. Project design will need to confirm, via topographic survey, this assumption and may require revision of the proposed improvements.

3.52.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

3.52.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.52.7 Project Analysis Summary

Table 51 below provides a summary of the Quail Point Road at Covey Street project analysis. Refer to Appendix B-52 for project exhibits and supporting documentation.

**Table 51. Quail Point Road at Covey Street Project Summary**

<b>SFA Recurrence</b>	1-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	5.12/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	7.2/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.1092
<b>Project Cost</b>	\$6,540,000

### 3.53 Sea Pines Road at Pacific Avenue

#### 3.53.1 SFA Description

Sea Pines Road, 36<sup>th</sup> Street, and Pacific Avenue experience flooding due to a lack of conveyance capacity within the existing stormwater system. Pacific Avenue is a secondary evacuation route. The models indicate this area begins to experience flooding in the 1-year storm event, as shown in Figure 58.



**Figure 58. Location Map of Sea Pines Road at Pacific Avenue SFA**

#### 3.53.2 Project Description

This project improves the existing stormwater system by upsizing pipes and rerouting stormwater along 36<sup>th</sup> Street to drain toward the boardwalk rather than draining down Pacific Avenue, which currently overwhelms the system along 38<sup>th</sup> Street. Additionally, pipes along Sea Pines Road and 38<sup>th</sup> Street are upsized and the outfall into the boardwalk is reconfigured to minimize impacts to the Navy Seal Monument.

#### 3.53.3 Project Benefits

The major benefits of the project include mitigating street flooding on Sea Pines Road, 36<sup>th</sup> Street, and Pacific Avenue as well as the flooding occurring on surrounding private property. The project ensures that Pacific Avenue can serve as a secondary evacuation route and addresses multiple flood reports that have been documented in the area.

#### 3.53.4 Project Analysis Assumptions

No habitable structures are impacted in the 100-year storm event, so the project is given a BCR value of 1.0. The habitable structure shown as flooding has a finished floor elevation above the flood depth elevation and, therefore, is not flooding. The project is given a BR of 1.0

because street flooding is mitigated to meet the PWDSM. As a secondary evacuation route, Pacific Avenue remains passable in the 10-year storm event with 3.0 feet SLR and the 100-year storm event with no SLR.

Easement acquisition will be required from private property to upsize the existing stormwater system. Easement acquisition was limited by improving pipes within the ROW. It is anticipated that moderate maintenance of traffic will be required during the construction of the project along Sea Pines Road, 36<sup>th</sup> Street, and Pacific Avenue. Significant utility relocations will be required during the construction of this project, and environmental permits will not be required. Coordination with the USACE will likely be required to modify existing connections into the pipes underneath the boardwalk. Restoration of aesthetic features such as brick pavers and landscaping areas will be required at the 36<sup>th</sup> Street and 38<sup>th</sup> Street access to the boardwalk. The project proposes to avoid conflicts with the Navy Seal Monument at 38<sup>th</sup> Street by installing proposed pipes around the monument.

3.53.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

3.53.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.53.7 Project Analysis Summary

Table 52 below provides a summary of the Sea Pines Road at Pacific Avenue project analysis. Refer to Appendix B-53 for project exhibits and supporting documentation.

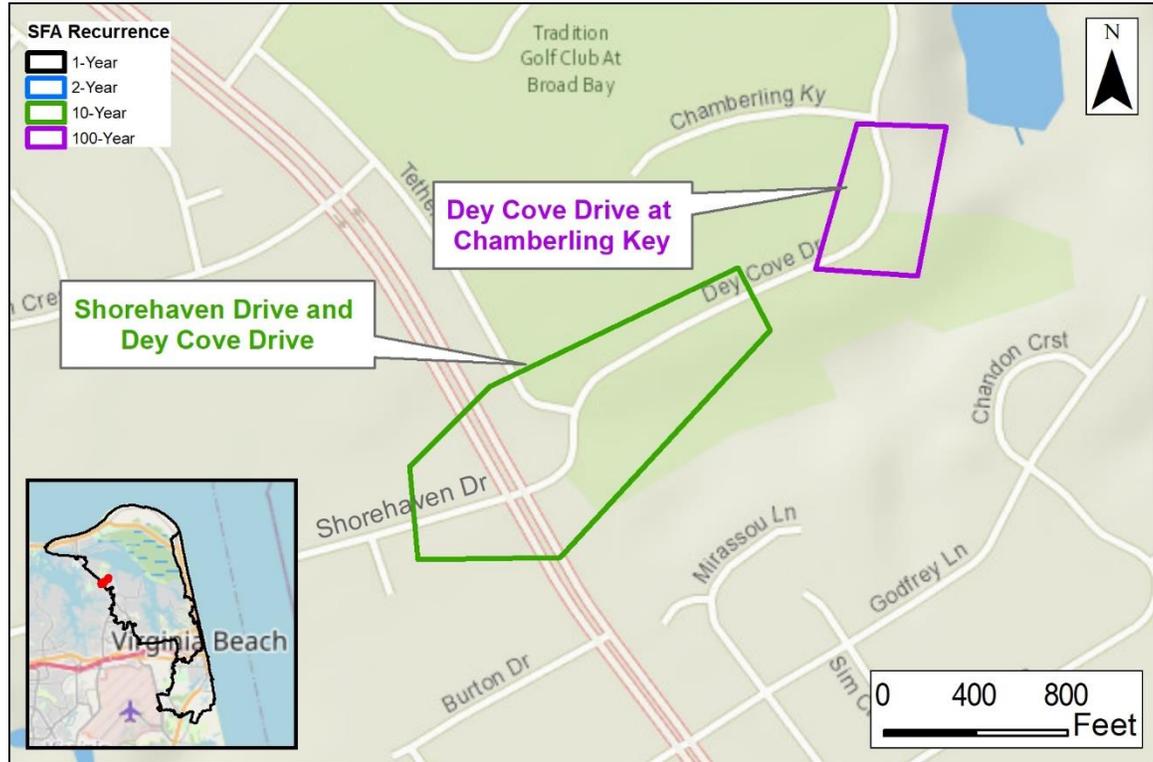
**Table 52. Sea Pines Road at Pacific Avenue Project Summary**

<b>SFA Recurrence</b>	1-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	4.59/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	4.9/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0 (no HAZUS data available)
<b>Project Cost</b>	\$7,530,000

### 3.54 Shorehaven Drive and Dey Cove Drive

#### 3.54.1 SFA Description

The Shorehaven Drive and Dey Cove Drive SFA, and Dey Cove Drive at Chamberling Key SFA are combined into the Shorehaven Drive at Dey Cove Drive project. Individual SFA locations are shown in Figure 59 and are further described below. Both SFAs are hydraulically connected and can be combined into one project.



**Figure 59. Location Map of Shorehaven Drive and Dey Cove Drive and Dey Cove Drive at Chamberling Key SFAs**

#### ***Shorehaven Drive and Dey Cove Drive SFA***

The eastern end of Shorehaven Drive and a small portion of North Great Neck Road flood due to a lack of storage and undersized pipes. North Great Neck Road is a secondary evacuation route. Portions of Dey Cove Drive flood due to undersized stormwater pipes. The models indicate the Shorehaven Drive and Dey Cove Drive SFA begins to experience flooding in the 10-year storm event, as shown in Figure 59.

#### ***Dey Cove Drive at Chamberling Key SFA***

A small portion of Dey Cove Drive near Chamberling Key floods due to undersized pipes. The models indicate Dey Cove Drive at Chamberling Key begins to experience flooding in the 100-year storm event, as shown in Figure 59.

#### 3.54.2 Project Description

This project proposes an extended detention pond on Cox High School property near the intersection of Shorehaven Drive and North Great Neck Road. Stormwater from North Great

Neck Road and a portion of Shorehaven Drive is directed into the extended detention pond that outfalls into pipes along North Great Neck Road. Outfall pipes south of Dey Cove are upsized to mitigate flooding along the road.

#### 3.54.3 Project Benefits

The major benefits of the project include mitigating street flooding on Shorehaven Drive and Dey Cove Drive, as well as the flooding occurring on surrounding private property. This project also ensures that North Great Neck Road can effectively serve as a secondary evacuation route. There is a potential cost-sharing opportunity with DPU for transmission main prioritization along Shorehaven Drive and Public Works Stormwater Regulatory Division for TMDL assistance or nutrient credits for other City projects.

#### 3.54.4 Project Analysis Assumptions

No habitable structures are impacted in the 100-year storm event, so the project is given a BCR value of 1.0. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM. As secondary evacuation route, North Great Neck Road is passable in the 10-year storm event with 3.0 feet SLR and the 100-year storm event with no SLR.

Easement acquisition is required for this project but is minimized by upsizing pipes within existing drainage easements and proposing storage on City property. It is anticipated that moderate maintenance of traffic and utility relocations will be required during the construction of the project. Minimal effort is likely required to obtain environmental permits.

It is assumed that a portion of the Cox High School parking lot will drain into the extended detention pond to generate nutrient credits. Coordination will be required with the City of Virginia Beach Public Schools for the proposed BMP on school property.

#### 3.54.5 Other Alternatives Scored

One additional alternative was scored as a part of this analysis. Alternative 2 involved upsizing pipes along Dey Cove Drive and under North Great Neck Road. The goal of this alternative was to create a solution that only involved upsizing pipes. The improvements under North Great Neck Road would require extensive maintenance of traffic. Additionally, since stormwater storage was not needed in this alternative, water quality treatment was also not provided.

#### 3.54.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

#### 3.54.7 Project Analysis Summary

Table 53 below provides a summary of the Shorehaven Drive at Dey Cove Drive project analysis. Refer to Appendix B-54 for project exhibits and supporting documentation.

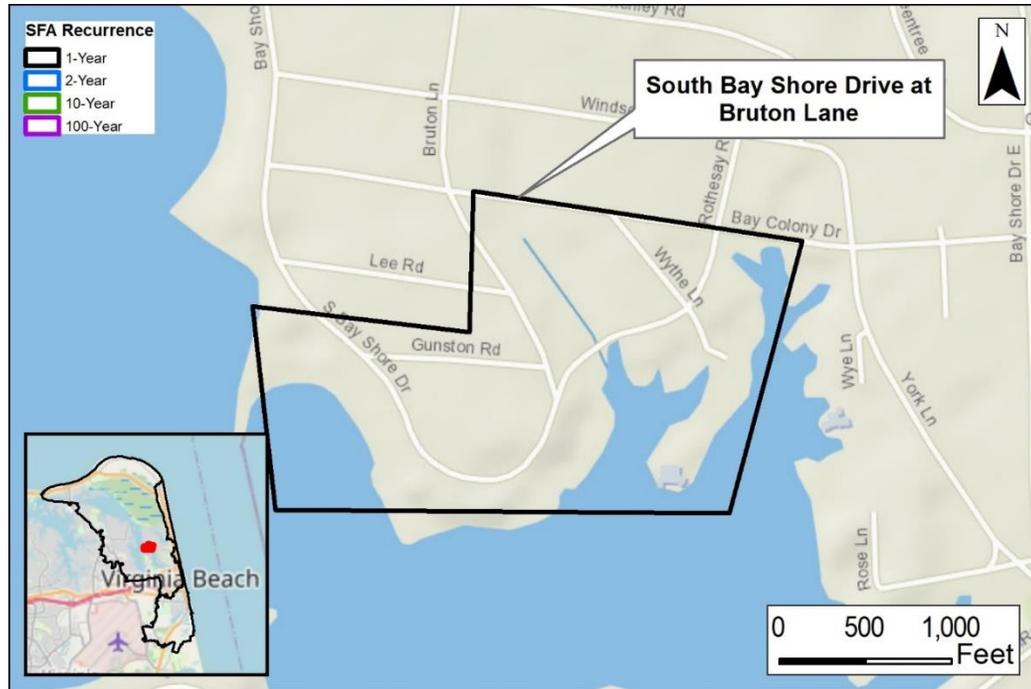
**Table 53. Shorehaven Drive at Dey Cove Drive Project Summary**

<b>SFA Recurrence</b>	10-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	5.86/10
<b>Other ASC Score(s)</b>	Alternative 2 – 5.19/10
<b>PPC Score</b>	2.04/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0 (no habitable structure flooding)
<b>Project Cost</b>	\$2,910,000

### 3.55 South Bay Shore Drive at Bruton Lane

#### 3.55.1 SFA Description

South Bay Shore Drive and Bruton Lane are residential streets in the Bay Colony neighborhood. The lowest street elevations range from approximately 2 to 4 feet. The design tailwater elevation for the 100-year storm event with no SLR is 4.3 feet in Little Neck Creek. The tailwater elevation, independent of existing drainage infrastructure, floods portions of the residential streets. The models indicate South Bay Shore Drive at Bruton Lane begins to experience flooding in the 1-year storm event, as shown in Figure 60.



**Figure 60. Location Map of South Bay Shore Drive at Bruton Lane SFA**

#### 3.55.2 Project Description

The downstream tailwater conditions severely limit the options for improvements to this neighborhood. The City will be evaluating this SFA with a Neighborhood Strategy in the future. Refer to Appendix B-55 for the extent of existing flooding in the area.

#### 3.55.3 Project Benefits

There is no project, and there are no benefits.

#### 3.55.4 Other Alternatives Scored

No alternatives were evaluated for this SFA.

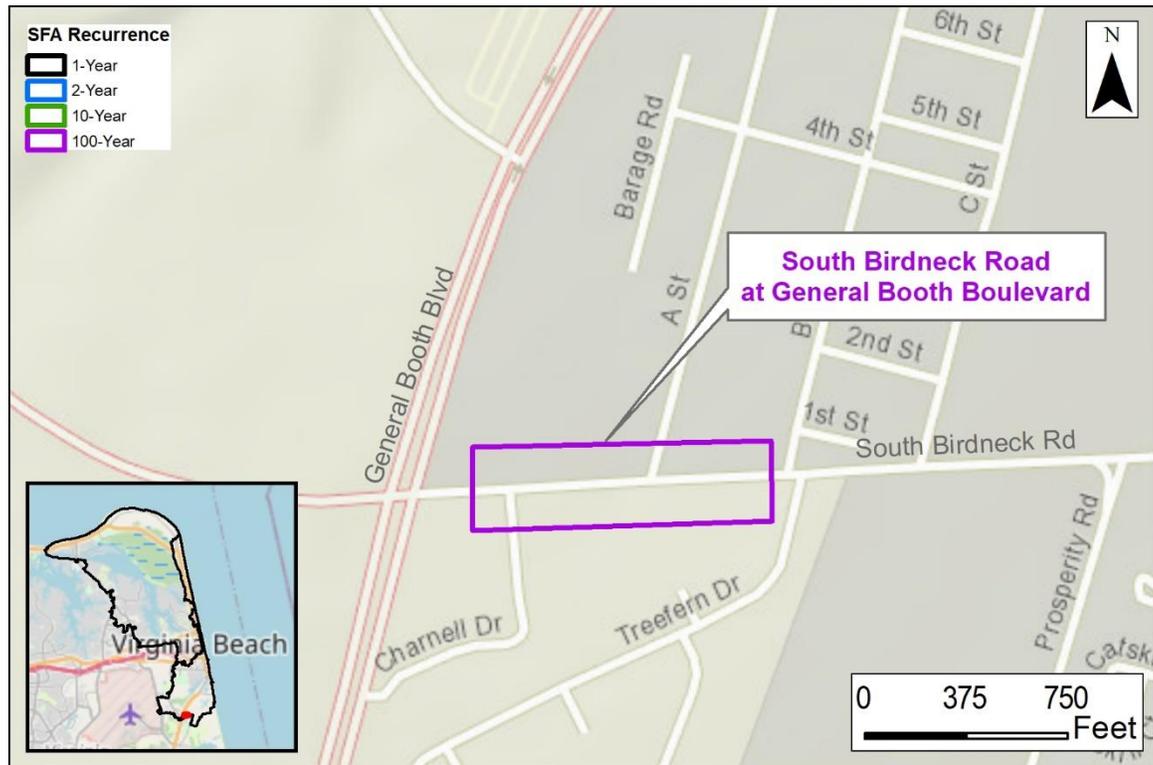
#### 3.55.5 Other Alternatives Not Scored

This neighborhood would benefit from a neighborhood solution similar to those shown in the SLR Adaptation Strategy Report. This neighborhood can be designed to resolve the flooding issues that occur from a smaller storm event. PW-SWEC will, in the future, have a neighborhood solution created to establish resiliency in this neighborhood.

### 3.56 South Birdneck Road at General Booth Boulevard

#### 3.56.1 SFA Description

A portion of South Birdneck Road east of General Booth Boulevard floods due to undersized pipes and a lack of storage. South Birdneck Road is a secondary evacuation route. The models indicate South Birdneck Road at General Booth Boulevard begins to experience flooding in the 100-year storm event, as shown in Figure 61.



**Figure 61. Location Map of South Birdneck Road at General Booth Boulevard SFA**

#### 3.56.2 Project Description

This project proposes a box culvert to connect the pipes on South Birdneck Road to General Booth Boulevard. A proposed box culvert crosses General Booth Boulevard and continues north underneath an existing ditch on City property. The box culvert outfalls into Lake Rudee at Ocean Breeze Parkway.

#### 3.56.3 Project Benefits

The major benefits of the project include mitigating street flooding on South Birdneck Road and the flooding occurring on surrounding private property. Additionally, South Birdneck Road provides access to Camp Pendleton and can effectively serve as a secondary evacuation route. The project also addresses a flood report that has been documented in the area and mitigates flooding in an economically disadvantaged area. There is a potential cost-sharing opportunity with DPU for transmission main prioritization.

3.56.4 Project Analysis Assumptions

Box culverts are proposed in this project west of General Booth Boulevard to limit permanent impacts to the recent parking lot improvements at the Virginia Aquarium and Marine Science Center.

No habitable structures are impacted in the 100-year storm event, so the project is given a BCR value of 1.0. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM. As a secondary evacuation route, South Birdneck Road is passable in the 10-year storm event with 3.0 feet SLR and the 100-year storm event with no SLR.

Property acquisition is not required as all the construction will occur within the ROW or City property. Additionally, impacts to federal property are avoided. It is anticipated that extensive maintenance of traffic and utility relocations will be required during the construction of the project. Multiple water and sewer lines, including a 16-inch sewer force main and 16-inch waterline, are located underneath General Booth Boulevard and South Birdneck Road. Minimal effort will likely be required to obtain environmental permits.

3.56.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

3.56.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.56.7 Project Analysis Summary

Table 54 below provides a summary of the South Birdneck Road at General Booth Boulevard project analysis. Refer to Appendix B-56 for project exhibits and supporting documentation.

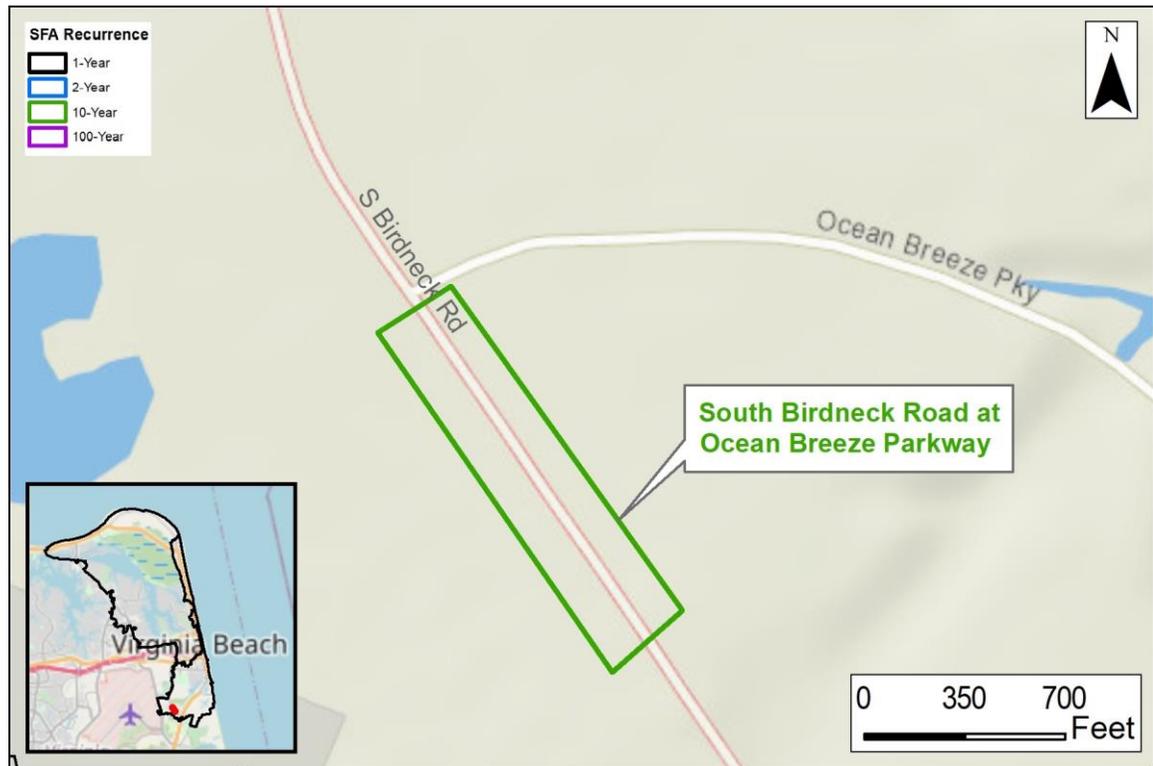
**Table 54. South Birdneck Road at General Booth Boulevard Project Summary**

<b>SFA Recurrence</b>	100-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	5.89/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	1.31/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0 (no habitable structure flooding)
<b>Project Cost</b>	\$8,820,000

### 3.57 South Birdneck Road at Ocean Breeze Parkway

#### 3.57.1 SFA Description

A section of South Birdneck Road floods due to undersized pipes and lack of storage. The models indicate South Birdneck Road at Ocean Breeze Parkway begins to experience flooding in the 10-year storm event, as shown in Figure 62.



**Figure 62. Location Map of South Birdneck Road at Ocean Breeze Parkway SFA**

#### 3.57.2 Project Description

This project adds a stormwater BMP on City property south of Ocean Breeze Parkway (GPIN 24166535280000). Existing pipes along the South Birdneck Road are directed into the proposed BMP. The proposed BMP outfalls into an existing ditch. Part of the existing ditch near South Birdneck Road is filled to direct stormwater into the BMP.

#### 3.57.3 Project Benefits

The major benefits of the project include mitigating street flooding on South Birdneck Road, as well as the flooding occurring on surrounding private property. There is a potential cost-sharing opportunity with DPU for transmission main prioritization.

#### 3.57.4 Project Analysis Assumptions

No habitable structures are impacted in the 100-year storm event, so the project is given a BCR value of 1.0. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM. South Birdneck Road, a secondary evacuation route, remains passable in the 10-year storm event with 3.0 feet SLR and the 100-year storm event with no SLR.

Property acquisition is not required as all the construction will occur within the ROW or City property. It is anticipated that minimal maintenance of traffic and utility relocations will be required during the construction of the project. Based on NWI, the existing ditch that is being removed is not anticipated to be jurisdictional, so minimal effort is assumed to be required to obtain environmental permits.

While changes to the original design function of the existing BMP west of South Birdneck Road are anticipated, they are assumed to be offset with the construction of the new BMP. Coordination with the City’s Virginia Stormwater Management Program (VSMP) Coordinator is required.

3.57.5 Other Alternatives Scored

One additional alternative was scored as a part of this analysis. Alternative 1 upsized pipes underneath South Birdneck Road and lowered and widened the downstream ditch to the east. This alternative required easement acquisition and more significant disturbance to South Birdneck Road and adjacent businesses.

3.57.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.57.7 Project Analysis Summary

Table 55 below provides a summary of the South Birdneck Road at Ocean Breeze Parkway project analysis. Refer to Appendix B-57 for project exhibits and supporting documentation.

**Table 55. South Birdneck Road at Ocean Breeze Parkway Project Summary**

<b>SFA Recurrence</b>	10-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 2
<b>ASC Score</b>	6.36/10
<b>Other ASC Score(s)</b>	Alternative 1 – 6.25/10
<b>PPC Score</b>	2.04/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0 (no habitable structure flooding)
<b>Project Cost</b>	\$1,570,000

### 3.58 South Birdneck Road at Olds Lane

#### 3.58.1 SFA Description

The Olds Lane and South Birdneck Road and Bells Road SFAs are combined into the South Birdneck Road at Olds Lane project. Individual SFA locations are shown in Figure 63 and are further described below. Both SFAs are hydraulically connected and can be combined into one project.

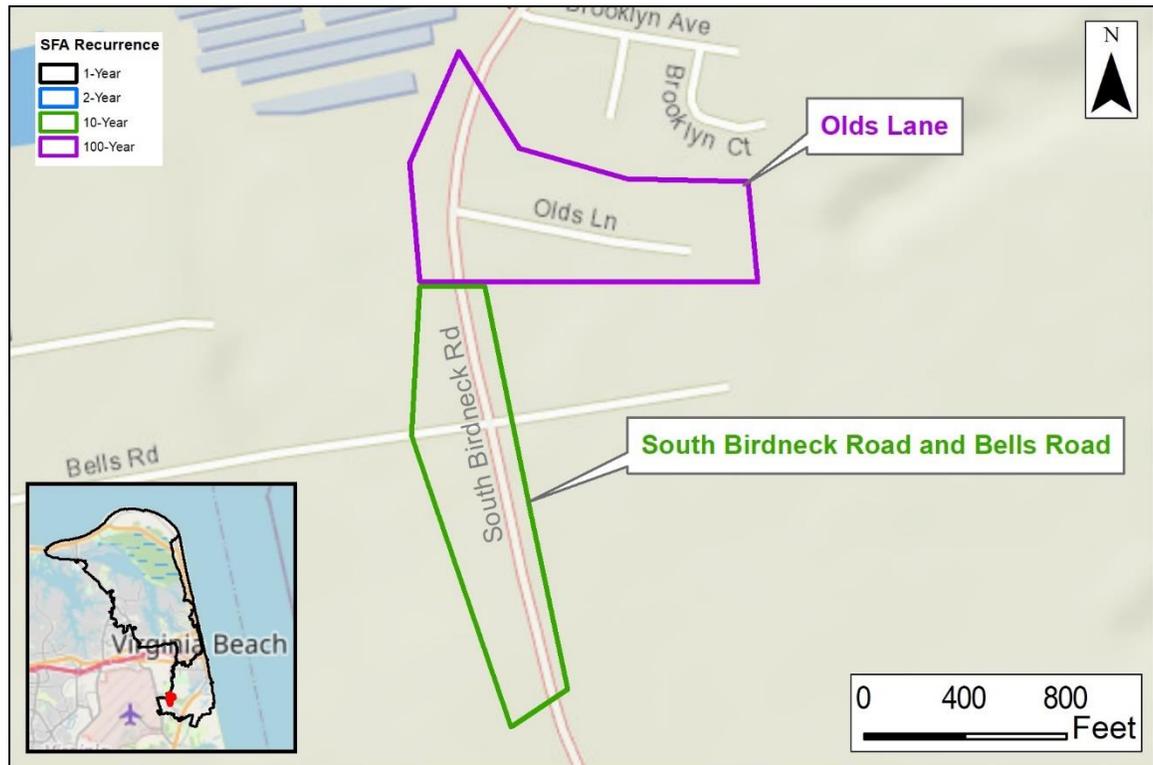


Figure 63. Location Map of Olds Lane and South Birdneck Road at Bells Road SFAs

#### ***Olds Lane SFA***

Olds Lane and portions of South Birdneck Road flood due to inadequately sized pipes. South Birdneck Road serves as a secondary evacuation route. In the existing condition, South Birdneck Road, habitable structures, and private property experience flooding. The models indicate Olds Lane begins to experience flooding in the 100-year storm event, as shown in Figure 63.

#### ***South Birdneck Road and Bells Road SFA***

South Birdneck Road and the adjacent private property flood due to inadequate storage. South Birdneck Road serves as a secondary evacuation route. The models indicate South Birdneck Road at Bells Road begins to experience flooding in the 10-year storm event, as shown in Figure 63.

#### 3.58.2 Project Description

This project increases the conveyance capacity of the existing stormwater infrastructure within the ROW along South Birdneck Road and Olds Lane. A BMP is proposed on undeveloped

property (GPIN 24165811620000) and stores redirected runoff from Bells Road that outfalls to Olds Lane. The outfall ditch east of Olds Lane is lowered by two feet to provide positive drainage for the upsized outfall pipe.

3.58.3 Project Benefits

The major benefits of this project include mitigating flooding on streets, private property, and habitable structures. Street flooding is mitigated on Olds Lane and South Birdneck Road, a secondary evacuation route. Habitable structure flooding is mitigated for four structures on Olds Lane, two structures on South Birdneck Road, and two structures on Bells Road for eight total structures. The project also addresses one documented flood report and mitigates flooding in an economically disadvantaged area. There is a potential cost-sharing opportunity with DPU for transmission main prioritization along South Birdneck Road.

3.58.4 Project Analysis Assumptions

HAZUS data is available for some, but not all, flooded habitable structures. The structures no longer flood in the 100-year storm event. Based on the BCR methodology, the project BCR is 1.0929. This project is given a BR of 1.0 because all street flooding is mitigated. As a secondary evacuation route, South Birdneck Road is passable in the 10-year storm event with 3.0 feet SLR and the 100-year storm event with no SLR.

Property acquisition of an undeveloped parcel on Bells Road is required to construct the wet pond BMP. Additional easement acquisition will be required from multiple private property owners along Olds Lane to upsize the existing infrastructure and to add a new proposed trunkline for the proposed BMP. Moderate maintenance of traffic and utility relocations will be required during the project's construction due to the extent of construction on South Birdneck Road. Moderate effort will be required to obtain environmental permits.

3.58.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

3.58.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.58.7 Project Analysis Summary

Table 56 below provides a summary of the South Birdneck Road at Olds Lane project analysis. Refer to Appendix B-58 for project exhibits and supporting documentation.

**Table 56. South Birdneck Road at Olds Lane Project Summary**

<b>SFA Recurrence</b>	10-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	5.1/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	6.54/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0929
<b>Project Cost</b>	\$8,050,000

### 3.59 Stratem Court and Brooklyn Avenue

#### 3.59.1 SFA Description

The Stratem Court and Brooklyn Avenue SFAs are combined into the Stratem Court and Brooklyn Avenue Project. Individual SFA locations are shown in Figure 64 and are further described below. Both SFAs are hydraulically connected and can be combined into one project.

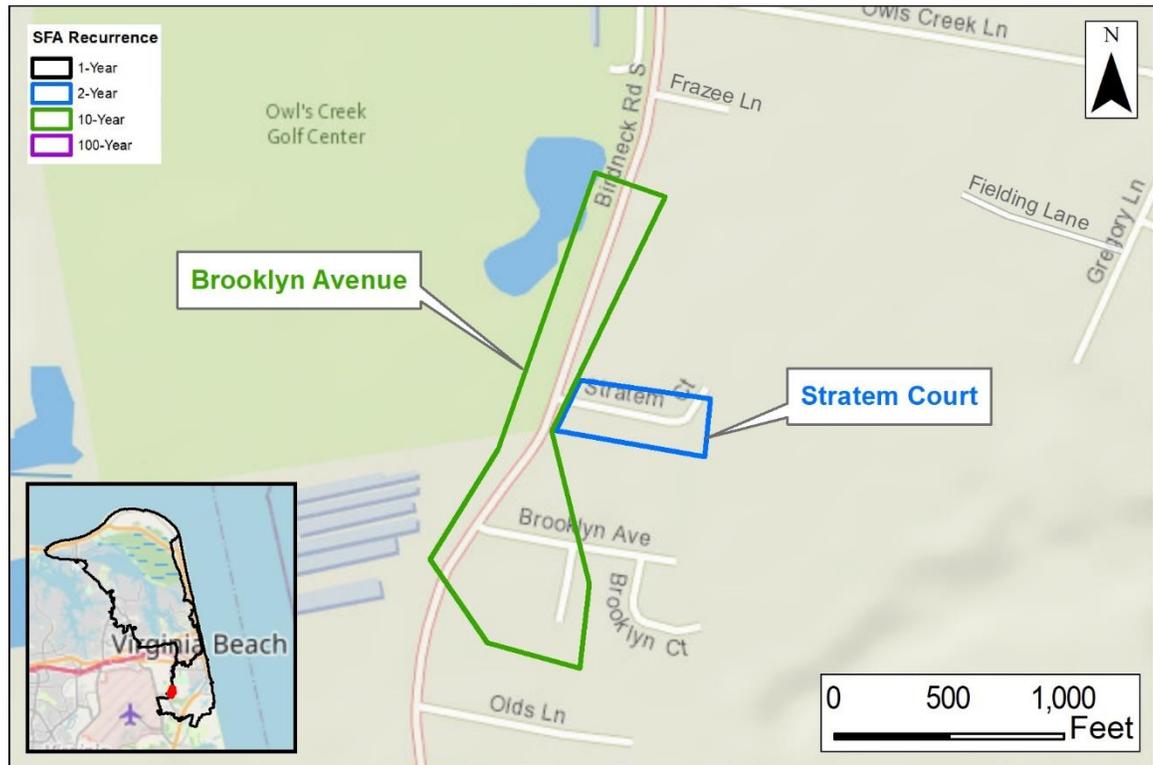


Figure 64. Location Map of Stratem Court and Brooklyn Avenue SFAs

#### **Stratem Court SFA**

Stratem Court experiences street flooding due to inadequate stormwater pipes. The surrounding private property floods due to an inadequate BMP north of Stratem Court. The models indicate that Stratem Court begins to experience flooding in the 2-year storm event, as shown in Figure 64.

#### **Brooklyn Avenue SFA**

Brooklyn Avenue, Thrush Court, and South Birdneck Road experience street flooding due to inadequate stormwater pipes and a lack of storage in the system. Several habitable structures, as well as private property, flood along those streets. South Birdneck Road serves as a secondary evacuation route. The models indicate that Brooklyn Avenue begins to experience flooding in the 10-year storm event, as shown in Figure 64.

#### 3.59.2 Project Description

This project proposes diverting runoff during larger storm events from the existing BMP north of Stratem Court to flow south where it connects to existing infrastructure on South Birdneck

Road. A BMP west of South Birdneck Road is proposed within the parcel previously used as the Owls Creek Golf Course and is currently being re-developed (GPIN 24164936880000) to provide more storage along South Birdneck Road. The proposed BMP outfalls into existing pipes on South Birdneck Road that are upsized. The existing infrastructure on Brooklyn Avenue and Thrush Court is also upsized.

### 3.59.3 Project Benefits

The major benefits of this project include mitigating street flooding on Stratem Court, South Birdneck Road, Brooklyn Avenue, and Thrush Court as well as the flooding occurring on the surrounding private property. Six habitable structures flood along South Birdneck Road, Brooklyn Avenue, and Thrush Court and are mitigated in the proposed condition. The project also addresses several flood reports that have been documented in the area and mitigates flooding in an economically disadvantaged area. There is a potential cost sharing opportunity with DPU for a transmission main prioritization along South Birdneck Road.

### 3.59.4 Project Analysis Assumptions

HAZUS data is available for some, but not all, flooded habitable structures. The structures no longer flood in the 100-year event. Based on the BCR methodology, the project BCR is 1.1263. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM. South Birdneck Road, a secondary evacuation route, remains passable in the 10-year storm event with 3.0 feet SLR and 100-year storm event with no SLR.

Stormwater runoff from Stratem Court that will be diverted to existing infrastructure on South Birdneck Road will bypass the existing BMP north of Stratem Court (SU2416590000) only during larger storm events. As a result, significant changes to the original design function of the existing BMP are not anticipated. Additional nutrient credit will be added by treating previously untreated portions of South Birdneck Road with the proposed BMP located west of South Birdneck Road.

Easement acquisition will be required for the proposed BMP, but the amount of acquisition is minimized by upsizing the downstream pipe network on Brooklyn Avenue. It is anticipated that extensive maintenance of traffic will be required on South Birdneck Road. Utility conflicts are expected along South Birdneck Road with an 8-inch gravity sewer mainline. Environmental permits will not be required.

### 3.59.5 Other Alternatives Scored

Another alternative, as described below, was considered, but was not scored.

### 3.59.6 Other Alternatives Not Scored

One additional alternative was considered but was not scored. This alternative proposed constructing a new BMP on a federally owned parcel (GPIN 24166848110000). Two proposed trunklines would divert flow between houses on Stratem Court to the BMP as well as from the east side of South Birdneck Road through a private parcel (GPIN 24165922970000) to the BMP. The BMP would outfall through a new pipe system into the upsized infrastructure on Brooklyn Avenue. Given the significant impact to federal property, this alternative was not evaluated further. This alternative did meet the PWDSM requirements.

### 3.59.7 Project Analysis Summary

Table 57 below provides a summary of the Stratem Court and Brooklyn Avenue project analysis. Refer to Appendix B-59 for project exhibits and supporting documentation.

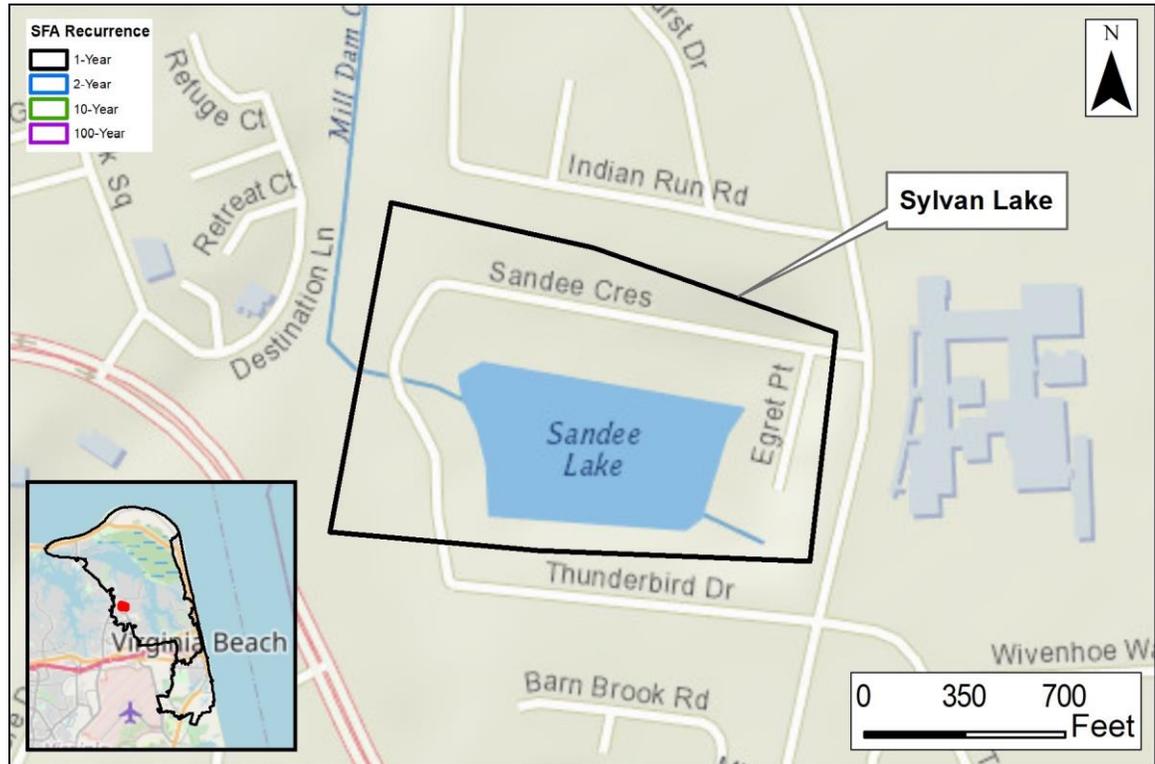
**Table 57. Stratem Court and Brooklyn Avenue Project Summary**

<b>SFA Recurrence</b>	2-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	5.33/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	7.3/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.1263
<b>Project Cost</b>	\$4,550,000

### 3.60 Sylvan Lake

#### 3.60.1 SFA Description

Sylvan Lake experiences street, private property, and habitable structure flooding that is caused by an inadequate outfall for the existing lake. The models indicate Sylvan Lake begins to experience flooding in the 1-year storm event, as shown in Figure 65.



**Figure 65. Location Map of Sylvan Lake SFA**

#### 3.60.2 Project Description

This project improves the downstream condition by upsizing the culverts crossing Mill Dam Road and expanding the existing ditch downstream of the neighborhood. The existing pipes in the neighborhood are upsized to elliptical pipes, due to cover constraints. One additional outfall is added to the pond.

#### 3.60.3 Project Benefits

The major benefits of the project include mitigating habitable structure flooding for 21 structures in the 100-year storm event. Habitable structure flooding is resolved for 17 structures on Sandee Crescent and four structures on Egret Point. Additionally, flooding on streets and private properties is reduced in the 100-year and 10-year storm events along Sandee Crescent and Egret Point. The project also addresses several flood reports that have been documented in the area.

#### 3.60.4 Project Analysis Assumptions

Given the proximity of the neighborhood to the FEMA floodway and the associated tailwater influence on the 100-year design of drainage improvements, a 10-year LOS is achieved for this project. This is necessary as the peak HGLs in Mill Dam Creek are higher than the lowest

point of some of the neighborhood streets. Flood depths are less than 6 inches above the crown of the road, are summarized on the 100-year flood map, and will require approval for a reduced LOS from the City Engineer.

Achieving the 10-year LOS requires eliminating the hydraulic connection between Mill Dam Creek and the neighborhood that currently exists through the low-lying vacant parcel (GPIN 24083784640000). It is assumed that upon development of this parcel in the future, the lot will be filled to a minimum elevation of 8 feet to provide the minimum finished floor elevation of 10 feet (2 feet above the 100-year peak HGL or base flood elevation). A lot elevation of 8 feet will eliminate the connection between Mill Dam Creek and the neighborhood.

HAZUS data is available for some, but not all, flooded habitable structures. The structures no longer flood in the 100-year storm event. Based on the BCR methodology, the project BCR is 2.3436. There is a decrease in street flooding in the 100-year storm event, but it is not completely mitigated. Therefore, the project is given a BR of 0.63.

Easement acquisition will be required from multiple private landowners. The amount of easement acquisition will be limited by making downstream improvements and making improvements in the ROW and existing easements when possible. It is anticipated that moderate maintenance of traffic and utility relocations will be required during the construction of the project. Moderate effort is likely to be required to obtain environmental permits to expand a nontidal ditch and add a new outfall as well as upsize an existing culvert that outfalls into tidal wetlands.

Sylvan Lake and Graham Road at Woodhurst Drive projects were kept separate because the Sylvan Lake flooding can be resolved without all the Graham Road at Woodhurst Drive improvements. However, the downstream culvert improvements under Mill Dam Road are the same in both projects. If the Graham Road at Woodhurst Drive project is constructed first, then the downstream improvements as part of this project would not be required. Refer to Section 3.30 for a description of the Graham Road at Woodhurst Drive project.

#### 3.60.5 Other Alternatives Scored

Another alternative, as described below, was considered, but was not scored.

#### 3.60.6 Other Alternatives Not Scored

One additional alternative was considered for this SFA. This alternative would add a 200 cfs lift station to Sylvan Lake that would outfall into the downstream ditch. This alternative did meet the PWDSM requirements and met the 100-year LOS. However, it would require that multiple private properties be acquired for the lift station and its outfall. Due to the extensive property acquisition required, this alternative was not considered further.

#### 3.60.7 Project Analysis Summary

Table 58 below provides a summary of the Sylvan Lake project analysis. Refer to Appendix B-60 for project exhibits and supporting documentation.

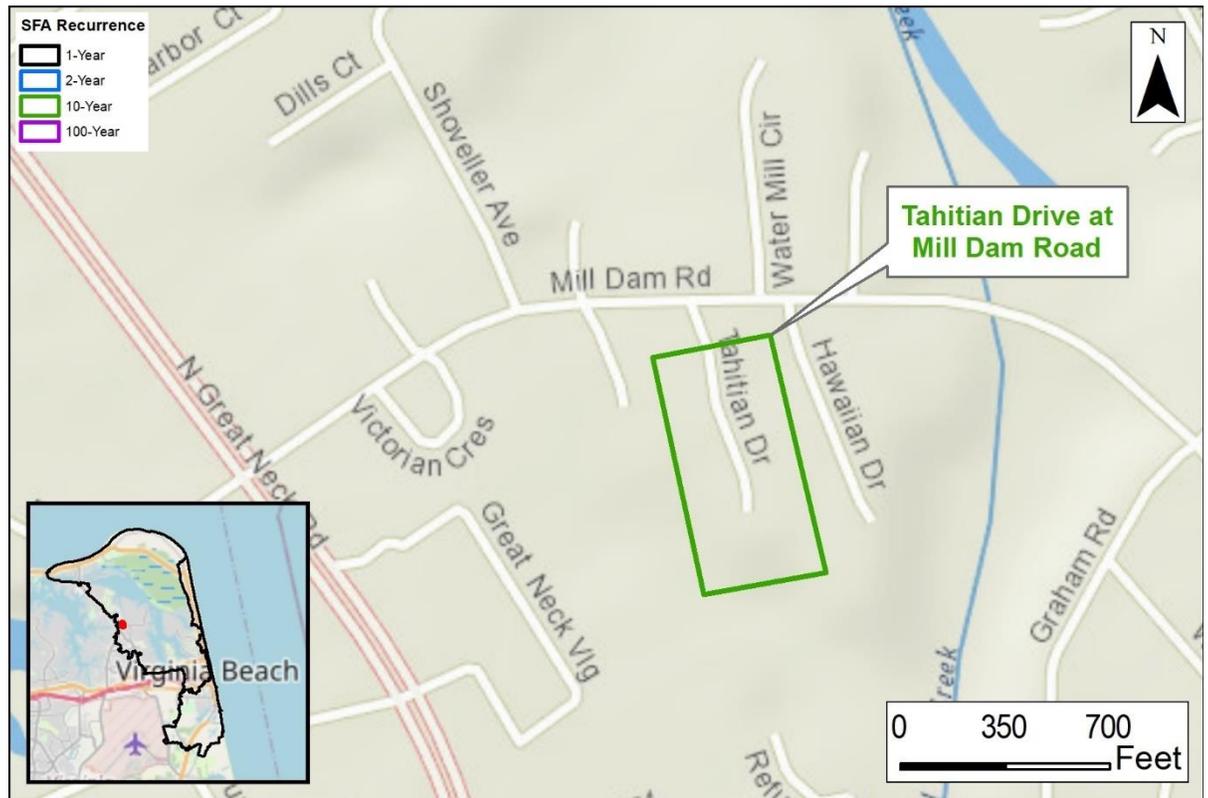
**Table 58. Sylvan Lake Project Summary**

<b>SFA Recurrence</b>	1-year (no SLR)
<b>Project LOS</b>	10-year (1.5 feet SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	4.25/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	6.92/14.4
<b>BR</b>	0.63
<b>BCR</b>	2.3436
<b>Project Cost</b>	\$6,260,000

### 3.61 Tahitian Drive at Mill Dam Road

#### 3.61.1 SFA Description

Tahitian Drive experiences street flooding due to a lack of storage and an inadequate outfall pipe within an existing dry detention BMP. The models indicate Tahitian Drive at Mill Dam Road begins to experience flooding in the 10-year storm event, as shown in Figure 66.



**Figure 66. Location Map of Tahitian Drive at Mill Dam Road SFA**

#### 3.61.2 Project Description

This project upsizes the inadequate outfall pipe within the BMP at the end of Tahitian Drive.

#### 3.61.3 Project Benefits

The major benefits of the project include mitigating street flooding on Tahitian Drive. The project also addresses several flood reports that have been documented in the area.

#### 3.61.4 Project Analysis Assumptions

No habitable structures are impacted in the 100-year storm event, so the project is given a BCR value of 1.0. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM.

Property acquisition is not required as all the construction will occur within existing easements. Utility conflicts are not anticipated and minimal effort will likely be required to obtain environmental permits to modify the existing outfall pipe in a nontidal ditch.

Changes to the original design function of the BMP are likely required, so coordination with the City’s VSMP Coordinator is required. The existing BMP is not currently included in available City GIS information, so it is unknown whether it is a volume control facility (only) or if the BMP was designed to provide water quality treatment. Existing homes along Tahitian Drive were built in the late 1990s. Upsizing the outfall pipe is preferred to expanding the BMP footprint to avoid easement or property acquisition.

3.61.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

3.61.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.61.7 Project Analysis Summary

Table 59 below provides a summary of the Tahitian Drive at Mill Dam Road project analysis. Refer to Appendix B-61 for project exhibits and supporting documentation.

**Table 59. Tahitian Drive at Mill Dam Road Project Summary**

<b>SFA Recurrence</b>	10-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	6.16/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	1.18/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0 (no habitable structure flooding)
<b>Project Cost</b>	\$300,000

### 3.62 The Reserve at Great Neck

#### 3.62.1 SFA Description

The Reserve at Great Neck neighborhood floods due to undersized stormwater infrastructure. The models indicate the Reserve at Great Neck begins to experience flooding in the 1-year storm event, as shown in Figure 67.

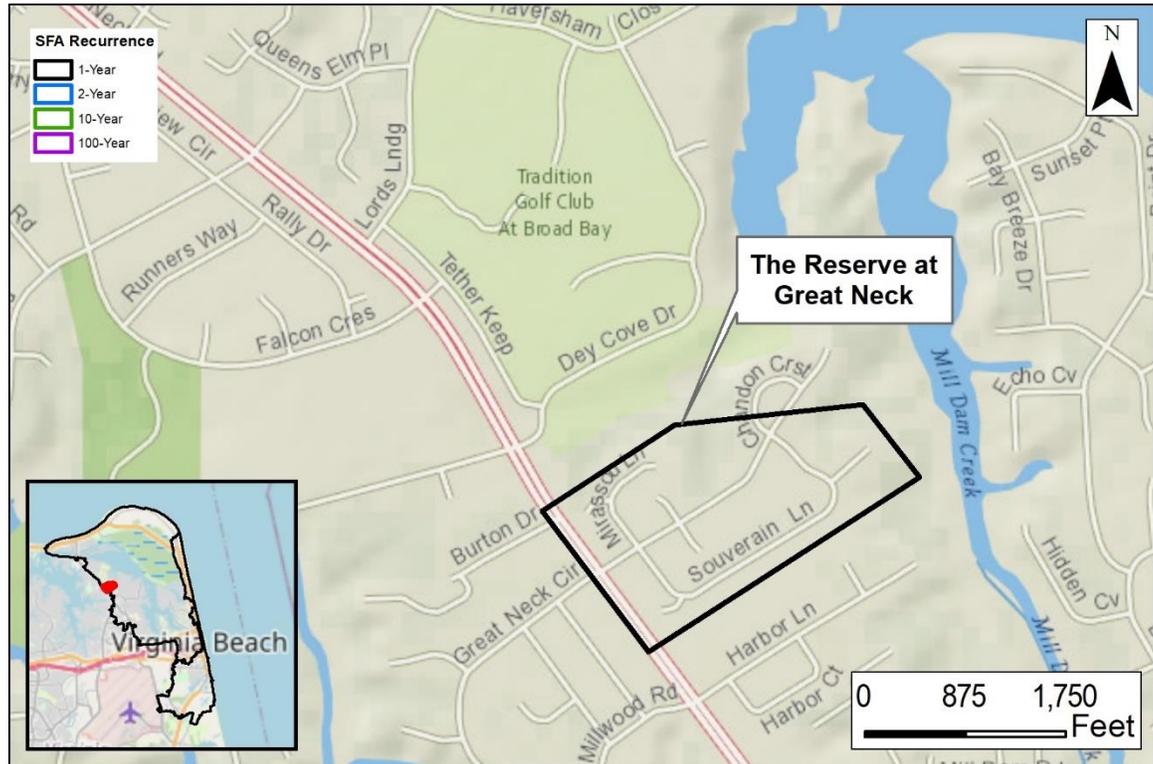


Figure 67. Location Map of The Reserve at Great Neck SFA

#### 3.62.2 Project Description

The project proposes two new outfalls to bypass the undersized stormwater BMP in the center of the neighborhood. The first new outfall is located along Godfrey Lane to the northeast of Beringer Place. The second outfall is located at the end of Mirassou Lane. New and upsized pipes are directed towards the new outfalls. Additionally, new and upsized pipes are proposed along Souverain Lane to direct stormwater to an existing outfall. It is anticipated that the water quality storm or “first flush” can be diverted to the existing BMP. In large storm events, higher flows bypass the BMP to the new outfalls.

#### 3.62.3 Project Benefits

The major benefits of the project include reducing street flooding throughout the neighborhood, as well as the flooding occurring on surrounding private property. The project also addresses several flood reports that have been documented in the area. There is a potential cost-sharing opportunity with DPU for transmission main prioritization.

#### 3.62.4 Project Analysis Assumptions

A 50-year LOS is achieved for this project. Pipe improvements have been maximized within the neighborhood, and there are not any adjacent open spaces to add storage to the system.

Flood depths are less than 3 inches above the crown of the road, are summarized on the 100-year flood map, and will require approval for a reduced LOS from the City Engineer.

No habitable structures are impacted in the 100-year storm event, so the project is given a BCR value of 1.0. There is a decrease in street flooding in the 100-year storm event, but it is not completely mitigated. Therefore, the project is given a BR of 0.98.

Easements are required for this project but are minimized by limiting improvements with the existing ROW or easement boundaries where possible. It is anticipated that moderate maintenance of traffic and utility relocations will be required during the construction of the project. Moderate effort will likely be required to obtain environmental permits for impacts to nontidal wetlands.

Coordination with the City’s VSMP Coordinator is required since flow is being redirected from the existing BMP in the center of the neighborhood (BMP ID: SU2409100000).

3.62.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

3.62.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.62.7 Project Analysis Summary

Table 60 below provides a summary of The Reserve at Great Neck project analysis. Refer to Appendix B-62 for project exhibits and supporting documentation.

**Table 60. The Reserve at Great Neck Project Summary**

<b>SFA Recurrence</b>	1-year (no SLR)
<b>Project LOS</b>	50-year (1.5 feet SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	4.95/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	3.14/14.4
<b>BR</b>	0.98
<b>BCR</b>	1.0 (no habitable structure flooding)
<b>Project Cost</b>	\$6,850,000

### 3.63 Thomas Bishop Lane at Thomas Bishop Court

#### 3.63.1 SFA Description

Thomas Bishop Lane, Thomas Bishop Court, and the surrounding private property floods due to undersized stormwater outfalls. Habitable structures on Thomas Bishop Court also experience flooding. The models indicate Thomas Bishop Lane at Thomas Bishop Court begins to experience flooding in the 10-year storm event, as shown in Figure 68.



**Figure 68. Location Map of Thomas Bishop Lane at Thomas Bishop Court SFA**

#### 3.63.2 Project Description

This project connects the two existing stormwater systems on Thomas Bishop Lane to mitigate the flooding on Thomas Bishop Lane and Thomas Bishop Court. The system collecting runoff from Thomas Bishop Court is connected to the system collecting runoff on Irish Bank Drive through a proposed 24-inch trunkline. This pipe system drains through the existing eastern outfall north of Thomas Bishop Lane and into Broad Bay. This project requires raising the roadway elevation by approximately 8 inches on Thomas Bishop Lane.

#### 3.63.3 Project Benefits

The major benefits of the project include mitigating street flooding on Thomas Bishop Lane and Thomas Bishop Court, as well as the flooding occurring on the surrounding property. The project mitigates habitable structure flooding for two structures on Thomas Bishop Court and addresses several flood reports that have been documented within the project area.

#### 3.63.4 Project Analysis Assumptions

HAZUS data is available for the flooded habitable structures along Thomas Bishop Court. The structures no longer flood in the 100-year storm event. Based on the BCR methodology, the

project BCR is 1.0797. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM. Property or easement acquisition is not required as all the construction will occur within the ROW. It is anticipated that minimal maintenance of traffic and utility relocations will be required for the project. Environmental permits will not be required.

The project considers existing stormwater infrastructure on Thomas Bishop Court that was not included in the original model. Existing pipe inverts are not available in City GIS data, so pipe and structure inverts are assumed using Virginia Department of Transportation (VDOT) minimum cover requirements based on the pipe sizes that were available in GIS data.

3.63.5 Other Alternatives Scored

One additional alternative was scored as part of this analysis. Alternative 2 was similar to Alternative 1 because it diverted stormwater away from the existing outfall near Thomas Bishop Court towards Irish Bank Drive. Instead of raising Thomas Bishop Lane, Alternative 2 upsized the existing pipe outfalls along residential property lines. This would require significant impacts to residential bulkhead structures and more extensive environmental permitting. Therefore, Alternative 2 scored lower than Alternative 1.

3.63.6 Other Alternatives Not Scored

Another alternative was considered but not scored. Minor pipe size increases were considered for the existing pipe outfalls to determine if the extent of improvements to Thomas Bishop Lane could be reduced while also minimizing the impacts to the existing bulkhead structures. Upsizing the 24-inch outfall to a 36-inch outfall did not meet the PWDSM standards. Larger outfalls were not considered further due to the potential damage to the bulkheads and property.

3.63.7 Project Analysis Summary

Table 61 below provides a summary of the Thomas Bishop Lane at Thomas Bishop Court project analysis. Refer to Appendix B-63 for project exhibits and supporting documentation.

**Table 61. Thomas Bishop Lane at Thomas Bishop Court Project Summary**

<b>SFA Recurrence</b>	10-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	6.18/10
<b>Other ASC Score(s)</b>	Alternative 2 – 5.89
<b>PPC Score</b>	5.38/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.0797
<b>Project Cost</b>	\$1,420,000

### 3.64 Tottenham Lane at Southall Drive

#### 3.64.1 SFA Description

Habitable structures, private property, and streets experience flooding along Tottenham Lane and Southall Drive due to inadequate pipes in the neighborhood and a lack of storage. The models indicate Tottenham Lane at Southall Drive begins to experience flooding in the 10-year storm event, as shown in Figure 69.

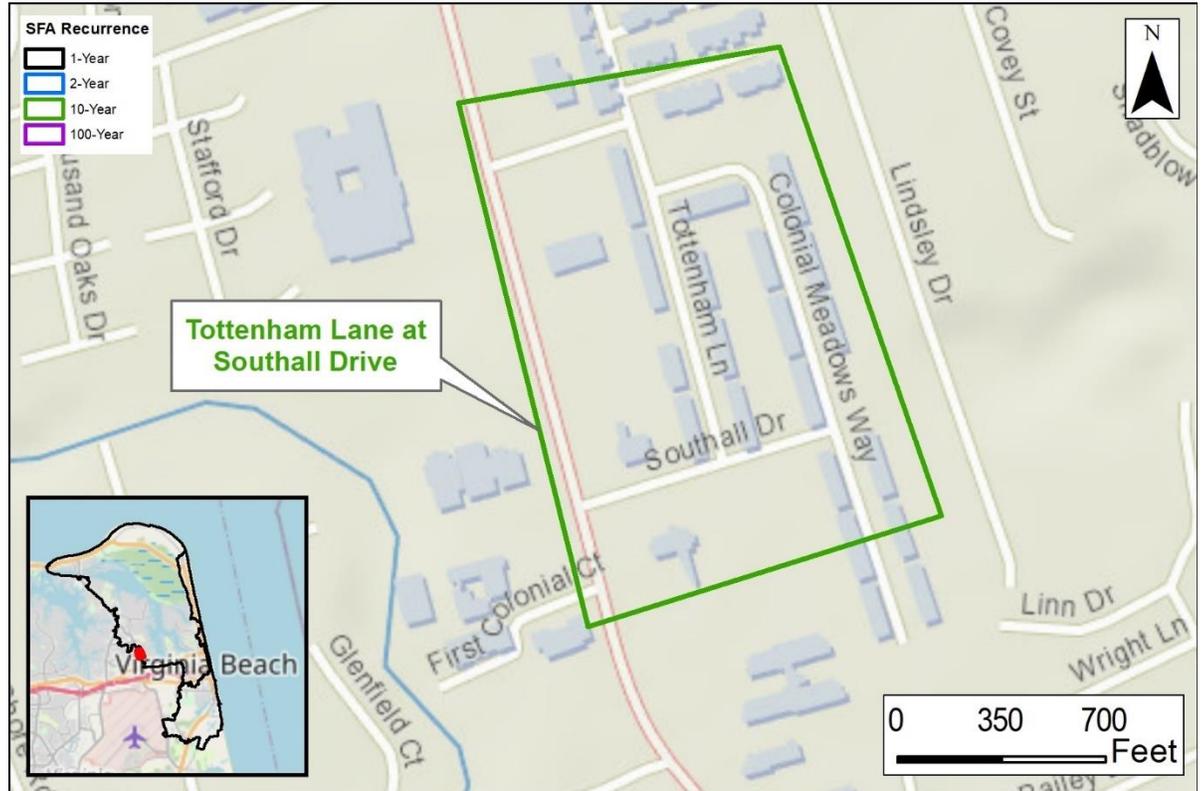


Figure 69. Location Map of Tottenham Lane at Southall Drive SFA

#### 3.64.2 Project Description

This project improves the existing stormwater infrastructure in the neighborhood by upsizing inadequate pipes and adding pipes to increase conveyance capacity. Underground storage is added on City park property (Southall Quarter Park, GPIN 24087120710000) to increase the storage capacity within the neighborhood and pipes are rerouted to the proposed storage.

#### 3.64.3 Project Benefits

The major benefits of the project include mitigating habitable structure flooding for four structures on Tottenham Lane, one structure on Colonial Meadows Way, and one structure on First Colonial Road for a total of six structures. Street flooding is mitigated along Tottenham Lane, Colonial Meadows Way, and Southall Drive. The project also addresses several flood reports that have been documented in the area. There is a potential cost-sharing opportunity with DPU for the water leak prioritization along Lindsley Drive and Colonial Meadows Way.

3.64.4 Project Analysis Assumptions

HAZUS data is available for the flooded habitable structures along Tottenham Lane, Colonial Meadows Way, and First Colonial Road. The structures no longer flood in the 100-year event. Based on the BCR methodology, the project BCR is 1.1932. The project is given a BR of 1.0 because street flooding is mitigated to meet the PWDSM.

Easement acquisition will be required from private landowners for drainage easements. The amount of easement acquisition is limited by adding underground storage on City park property, but coordination will be required with Parks and Recreation. Moderate maintenance of traffic will be required along Lindsley Drive, Colonial Meadows Way, and Southall Drive. It is anticipated that moderate utility relocations will be required during the construction of the project with gravity sewer lines and water lines. Moderate effort will likely be required to obtain environmental permits to lower the outfall ditch.

While changes to the original design function of the existing BMP east of Lindsley Drive are not anticipated, coordination with the City's VSMP Coordinator is required. It is assumed that the existing BMP is not a likely candidate for enhancements to create nutrient credits to meet VSMP and TMDL requirements based on the small size of the existing BMP relative to the watershed that drains to it.

3.64.5 Other Alternatives Scored

No additional alternatives were evaluated for this SFA.

3.64.6 Other Alternatives Not Scored

No additional alternatives were evaluated for this SFA.

3.64.7 Project Analysis Summary

Table 62 below provides a summary of the Tottenham Lane at Southall Drive project analysis. Refer to Appendix B-64 for project exhibits and supporting documentation.

**Table 62. Tottenham Lane at Southall Drive Project Summary**

<b>SFA Recurrence</b>	10-year (no SLR)
<b>Project LOS</b>	100-year (no SLR)
<b>Selected Alternative</b>	Alternative 1
<b>ASC Score</b>	4.5/10
<b>Other ASC Score(s)</b>	N/A
<b>PPC Score</b>	5.38/14.4
<b>BR</b>	1.0
<b>BCR</b>	1.1932
<b>Project Cost</b>	\$9,620,000

# Conclusion



## 4 Conclusion

The Broad Bay and Oceanfront Drainage Basins contain densely developed areas, especially at the Oceanfront, the tourism hub of Virginia Beach. Due to the high-density development throughout the area, runoff storage options (BMPs) were typically found to be infeasible due to site constraints. In areas where runoff storage was not available, pump stations were proposed, many of which outfall to the Atlantic Ocean. The highly developed areas are also subject to more existing habitable structure flooding. Therefore, the projects in the Broad Bay and Oceanfront SWMP had higher BCRs compared to the previous Linkhorn Bay and Upper West Neck Creek SWMPs.

During the development of the Broad Bay and Oceanfront SWMP, PW-SWEC made the decision to implement all Sea Level Wise City-wide solutions for all SWMPs documented in the *Virginia Beach Sea Level Wise Adaptation Strategy Report*. While City-wide alignments will eliminate SLR influence for the 100-year storm event, they will not be closed for more frequent storms. Full solutions were still conceptualized for the 10-year storm event with SLR for each SFA, except as noted below.

Broad Bay and Oceanfront SWMP projects identified for the SFAs can generally be placed into two categories:

### 1) SFAs that are not driven by tailwater influences.

- i) Fifty-three projects meet the PWDSM requirements.
- ii) Of the projects that meet the PWDSM requirements, eleven projects are phased projects. A phased project is proposed considering the extent of improvements that are required and to accomplish the objective of the SWMP to develop “standalone” solutions that are not dependent on downstream improvements. Project phases are defined by the individual SFA boundaries and begin with the most downstream improvements. Future refinements to the project phasing proposed may be required.

### 2) SFAs that are highly sensitive to tailwater.

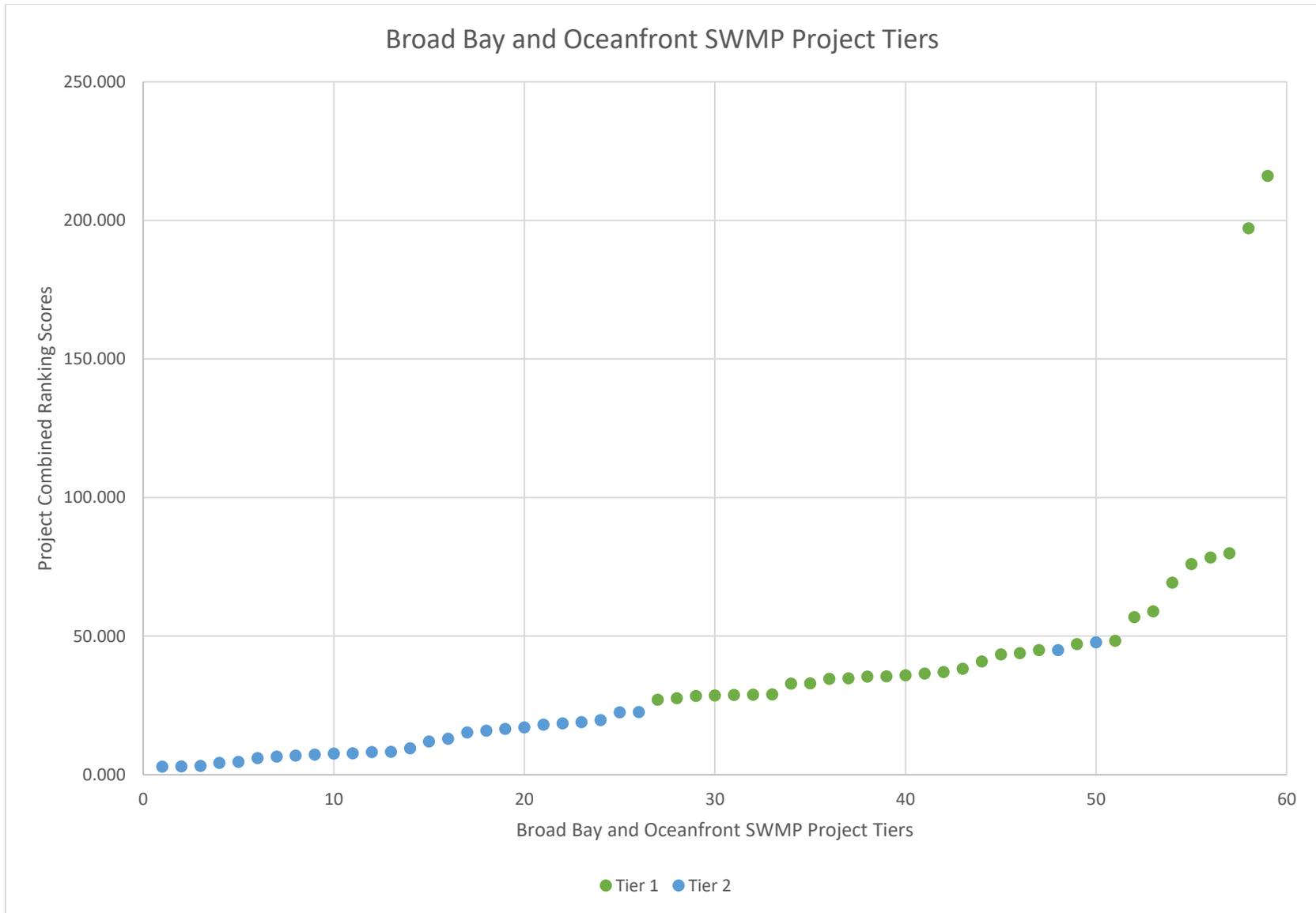
- i) One project has a reduced 10-year LOS (Sylvan Lake).
  - a) Given the proximity of the neighborhood to the 100-year floodplain and floodway, and the associated tailwater influence on the 100-year design of drainage improvements, a 10-year LOS is preferred for this project.
  - b) The BR for this project is 0.63.
  - c) The 10-year LOS maintains the HGL in the system in the 10-year storm event with 1.5 feet SLR. Habitable structure flooding is resolved, and there is less than 6 inches of flooding above the crown of the road in the 100-year storm event with no SLR. Approval of a reduced LOS by the City Engineer will be required for this project.
- ii) Five projects have a reduced 50-year LOS (Atlantis Drive and Norfolk Avenue Phase 2: Atlantis Avenue, Great Neck Farms, Mill Dam Road at Brighton on the Bay Neighborhood, Old Donation Parkway and First Colonial Road at Hilltop, and The Reserve at Great Neck).
  - a) Generally, these projects are not located as close to the 100-year floodplain as the 10-year LOS projects, but are still sensitive to tailwater influences. Typically, site constraints prohibit additional storage or conveyance improvements from achieving the 100-year LOS.
  - b) The BRs for these projects range from 0.96 to 0.99.

- c) A 50-year LOS maintains the HGL in the system for the 10-year storm event with 1.5 feet SLR. Habitable structure flooding is resolved, and there is less than 3 inches of flooding above the crown of the road in the 100-year storm event with no SLR.  
Approval of a reduced LOS by the City Engineer will be required for these projects.
- iii) Thirteen projects are set aside as it was determined that only a neighborhood solution would mitigate the flooding. All of these SFAs are within the FEMA Floodplain AE.
  - a) These are areas that would benefit from a neighborhood solution, similar to those shown in the SLW Adaptation Strategy Report. These neighborhoods can be designed to resolve the flooding issues that occur from a smaller storm event. PW-SWEC will, in the future, have a neighborhood solution created to establish resiliency in these neighborhoods.

Thirty projects include a BCR greater than 1.0 using available HAZUS AAL data. Some projects indicated that structural flooding was resolved, but the structural flooding is not reflected in the BCR.

### *Project Tiers*

The combined ranking score calculated for each project will provide guidance to the City in the future as projects are prioritized for implementation. The project's combined ranking score is the product of the selected ASC, PPC, BCR, and BR. Based on the results, the projects are separated into two tiers, as can be seen below. The highest scoring projects are placed in Tier 1, while the lower scoring projects are placed in Tier 2, as shown in Figure 70.



**Figure 70. Broad Bay and Oceanfront SWMP Tier 1 and Tier 2 Projects**

It is to be noted that the combined ranking score is necessary to separate projects into their respective tiers. It is not recommended that this score be used to determine the priority for project implementation. For this reason, projects are listed alphabetically in their respective tiers instead of descending order of the combined ranking score. Tier 1 consists of the 31 highest scoring projects. Two additional projects have Tier 1 scores, but they are part of phased projects contingent on the completion of an earlier phased Tier 2 project, and are therefore included in Tier 2. These projects are shown as Tier 2 in the graph and included in the Tier 2 table below. A total of 28 projects are placed in Tier 2. Tier 1 and Tier 2 projects are summarized in Table 63 and Table 64, respectively.

**Table 63. Broad Bay and Oceanfront SWMP Tier 1 Projects**

<b>Project Name</b>	<b>Drainage Basin</b>	<b>City District</b>	<b>Cost (in 2021 dollars)</b>
<b>Alanton Estates and Baycliff</b>	Broad Bay/ Oceanfront	6	\$8,500,000
<b>Alanton Neighborhood</b>	Broad Bay/ Oceanfront	6	\$20,050,000
<b>Atlantic Avenue at 24th Street Park*</b>	Broad Bay/ Oceanfront	6	\$1,010,000
<b>Atlantic Avenue at 33rd Street*</b>	Broad Bay/ Oceanfront	6	\$3,610,000
<b>Atlantis Drive and Norfolk Avenue Phase 1: Norfolk Avenue at Marshview Drive*</b>	Broad Bay/ Oceanfront	6	\$3,400,000
<b>Bay Colony</b>	Broad Bay/ Oceanfront	6	\$31,820,000
<b>Chelsea and Green Hill Farms Neighborhood</b>	Broad Bay/ Oceanfront	8	\$9,810,000
<b>Croatan Beach Neighborhood Phase 1B: South Maryland Avenue</b>	Broad Bay/ Oceanfront	5	\$2,070,000
<b>Croatan Beach Neighborhood Phase 1C: Virginia Dare Drive at Croatan Hills Drive</b>	Broad Bay/ Oceanfront	5	\$1,590,000
<b>Croatan Beach Park*</b>	Broad Bay/ Oceanfront	5	\$2,000,000
<b>Duke of Norfolk Quay at Green Hill Road</b>	Broad Bay/ Oceanfront	8	\$1,780,000
<b>East Bay Shore Drive at Cavalier Drive</b>	Broad Bay/ Oceanfront	6	\$2,490,000
<b>Fielding Lane at Gregory Lane*</b>	Broad Bay/ Oceanfront	6	\$1,560,000
<b>Graham Road at Woodhurst Drive</b>	Broad Bay/ Oceanfront	6/8	\$3,670,000
<b>Great Neck Farms</b>	Broad Bay/ Oceanfront	8	\$13,870,000
<b>Great Neck Manor</b>	Broad Bay/ Oceanfront	8	\$2,030,000
<b>Laskin Road at Little Neck Creek</b>	Broad Bay/ Oceanfront	6	\$26,490,000

Project Name	Drainage Basin	City District	Cost (in 2021 dollars)
Longstreet Avenue at Hughes Avenue*	Broad Bay/Oceanfront	6	\$6,480,000
Mill Dam Road at Brighton on the Bay Neighborhood	Broad Bay/Oceanfront	6	\$14,010,000
North Virginia Beach Phase 1: Atlantic Avenue at 70th Street	Broad Bay/Oceanfront	6	\$716,290,000
North Virginia Beach Phase 2: Bay Colony Drive at Myrtle Drive	Broad Bay/Oceanfront	6	\$85,730,000
Ocean Hills Road at Oakridge Circle*	Broad Bay/Oceanfront	6	\$5,440,000
Old Dominion Lane and Seward Lane	Broad Bay/Oceanfront	6	\$4,320,000
Old Donation Parkway and First Colonial Road at Hilltop	Broad Bay/Oceanfront	8	\$23,570,000
Preserve Drive at Huntsman Drive*	Broad Bay/Oceanfront	6	\$3,040,000
Quail Point Road at Covey Street*	Broad Bay/Oceanfront	6	\$6,540,000
South Birdneck Road at Olds Lane	Broad Bay/Oceanfront	6	\$8,050,000
Stratem Court and Brooklyn Avenue*	Broad Bay/Oceanfront	6	\$4,550,000
Sylvan Lake	Broad Bay/Oceanfront	6/8	\$6,260,000
Thomas Bishop Lane at Thomas Bishop Court	Broad Bay/Oceanfront	8	\$1,420,000
Tottenham Lane at Southall Drive*	Broad Bay/Oceanfront	6	\$9,620,000

\*Projects were initially designed with 1.5 feet SLR in the 100-year storm event. Refer to Section 2.2.1 for more information.

Table 64. Broad Bay and Oceanfront SWMP Tier 2 Projects

Project Name	Drainage Basin	City District	Cost (in 2021 dollars)
Alanton Drive at Valhalla Arch*	Broad Bay/Oceanfront	6	\$1,290,000
Atlantic Avenue at 28th Street*	Broad Bay/Oceanfront	6	\$7,140,000
Atlantis Drive and Norfolk Avenue Phase 2: Atlantis Drive	Broad Bay/Oceanfront	6	\$20,960,000
Bay Breeze Drive at Sunset Point	Broad Bay/Oceanfront	6	\$1,450,000
Brant Road at Huntsman Drive*	Broad Bay/Oceanfront	6	\$1,020,000

<b>Project Name</b>	<b>Drainage Basin</b>	<b>City District</b>	<b>Cost (in 2021 dollars)</b>
<b>Caton Drive at Will O Wisp Drive*</b>	Broad Bay/ Oceanfront	6	\$1,280,000
<b>Croatan Beach Neighborhood Phase 1A: Kerry Lane at Croatan Road</b>	Broad Bay/ Oceanfront	5	\$550,000
<b>Croatan Beach Neighborhood Phase 1D: Croatan Lot Pump Station at Croatan Beach</b>	Broad Bay/ Oceanfront	5	\$127,870,000
<b>Croatan Beach Neighborhood Phase 2A: Christine Drive at Croatan Road</b>	Broad Bay/ Oceanfront	5	\$7,840,000
<b>Croatan Beach Neighborhood Phase 2B: Twilight Lane at Vanderbilt Avenue</b>	Broad Bay/ Oceanfront	5	\$3,860,000
<b>Croatan Beach Neighborhood Phase 3: Surfside Avenue at Virginia Dare Drive</b>	Broad Bay/ Oceanfront	5	\$4,950,000
<b>First Colonial Road at Camelot Drive</b>	Broad Bay/ Oceanfront	6/8	\$2,730,000
<b>Fishermans Bend at Harbour Point</b>	Broad Bay/ Oceanfront	5	\$1,620,000
<b>Frazee Lane at South Birdneck Road*</b>	Broad Bay/ Oceanfront	6	\$960,000
<b>General Booth Boulevard at the Virginia Aquarium*</b>	Broad Bay/ Oceanfront	5/6	\$2,100,000
<b>Harbour Point at San Marcos Lane</b>	Broad Bay/ Oceanfront	5	\$500,000
<b>Haversham Key and Middlemost Key</b>	Broad Bay/ Oceanfront	8	\$3,850,000
<b>North Great Neck Road at First Colonial Road</b>	Broad Bay/ Oceanfront	6/8	\$2,490,000
<b>North Great Neck Road at Great Neck Middle School</b>	Broad Bay/ Oceanfront	8	\$680,000
<b>Oriole Drive North</b>	Broad Bay/ Oceanfront	6	\$670,000
<b>Owls Creek Lane*</b>	Broad Bay/ Oceanfront	6	\$410,000
<b>Pinewood Road at Linkhorn Drive</b>	Broad Bay/ Oceanfront	6	\$640,000
<b>Sea Pines Road at Pacific Avenue</b>	Broad Bay/ Oceanfront	6	\$7,530,000
<b>Shorehaven Drive and Dey Cove Drive</b>	Broad Bay/ Oceanfront	8	\$2,910,000
<b>South Birdneck Road at General Booth Boulevard</b>	Broad Bay/ Oceanfront	5/6	\$8,820,000
<b>South Birdneck Road at Ocean Breeze Parkway</b>	Broad Bay/ Oceanfront	6	\$1,570,000
<b>Tahitian Drive at Mill Dam Road</b>	Broad Bay/ Oceanfront	6	\$300,000

Project Name	Drainage Basin	City District	Cost (in 2021 dollars)
<b>The Reserve at Great Neck</b>	Broad Bay/ Oceanfront	8	\$6,850,000

*\*Projects were initially designed with 1.5 feet SLR in the 100-year storm event. Refer to Section 2.2.1 for more information*

Tier 3 is reserved for those projects highly influenced by existing tailwater conditions and the future impacts of SLR, especially for storms more frequent than the 100-year event, where the most practical solutions are limited to neighborhood flood protection measures. Thirteen projects are in Tier 3, as summarized in Table 65 below.

**Table 65. Broad Bay and Oceanfront SWMP Tier 3 Projects**

Project Name	Drainage Basin	City District
<b>Bay Drive at Linkhorn Drive</b>	Broad Bay/ Oceanfront	6
<b>Bay Island</b>	Broad Bay/ Oceanfront	8
<b>Bobolink Drive North</b>	Broad Bay/ Oceanfront	6
<b>Bobolink Drive South</b>	Broad Bay/ Oceanfront	6
<b>Broad Bay Colony</b>	Broad Bay/ Oceanfront	8
<b>Crystal Lake Circle</b>	Broad Bay/ Oceanfront	6
<b>Curlew Place</b>	Broad Bay/ Oceanfront	6
<b>Goodspeed Road at Discovery Road</b>	Broad Bay/ Oceanfront	6
<b>Island Lane</b>	Broad Bay/ Oceanfront	8
<b>Lakeside Avenue at 52nd Street</b>	Broad Bay/ Oceanfront	6
<b>Oriole Drive South</b>	Broad Bay/ Oceanfront	6
<b>Pinewood Road at Willow Drive</b>	Broad Bay/ Oceanfront	6
<b>South Bay Shore Drive at Bruton Lane</b>	Broad Bay/ Oceanfront	6

## List of Appendices

A	Benefit-Cost Analysis (BCA) Methodology
B-1	Alanton Drive at Valhalla Arch
B-2	Alanton Estates and Baycliff
B-3	Alanton Neighborhood
B-4	Atlantic Avenue at 24 <sup>th</sup> Street Park
B-5	Atlantic Avenue at 28 <sup>th</sup> Street
B-6	Atlantic Avenue at 33 <sup>rd</sup> Street
B-7	Atlantis Drive and Norfolk Avenue
B-7-1	Phase 1: Norfolk Avenue at Marshview Drive
B-7-2	Phase 2: Atlantis Drive
B-8	Bay Breeze Drive at Sunset Point
B-9	Bay Colony
B-10	Bay Drive at Linkhorn Drive
B-11	Bay Island
B-12	Bobolink Drive North
B-13	Bobolink Drive South
B-14	Brant Road at Huntsman Drive
B-15	Broad Bay Colony
B-16	Caton Drive at Will O Wisp Drive
B-17	Chelsea and Green Hill Farms Neighborhood
B-18	Croatan Beach Neighborhood
B-18-1	Phase 1A: Kerry Lane at Croatan Road
B-18-2	Phase 1B: South Maryland Avenue
B-18-3	Phase 1C: Virginia Dare Drive at Croatan Hills Drive
B-18-4	Phase 1D: Croatan Lot Pump Station at Croatan Beach
B-18-5	Phase 2A: Christine Drive at Croatan Road
B-18-6	Phase 2B: Twilight Lane at Vanderbilt Avenue
B-18-7	Phase 3: Surfside Avenue at Virginia Dare Drive
B-19	Croatan Beach Park
B-20	Crystal Lake Circle
B-21	Curlew Place
B-22	Duke of Norfolk Quay at Green Hill Road
B-23	East Bayshore Drive at Cavalier Drive
B-24	Fielding Lane at Gregory Lane
B-25	First Colonial Road at Camelot Drive
B-26	Fishermans Bend at Harbour Point
B-27	Fraze Lane at South Birdneck Road
B-28	General Booth Boulevard at the Virginia Aquarium
B-29	Goodspeed Road at Discovery Road
B-30	Graham Road at Woodhurst Drive
B-31	Great Neck Farms
B-32	Great Neck Manor
B-33	Harbour Point at San Marcos Lane
B-34	Haversham Key and Middlemost Key
B-35	Island Lane
B-36	Lakeside Avenue at 52 <sup>nd</sup> Street
B-37	Laskin Road at Little Neck Creek
B-38	Longstreet Avenue at Hughes Avenue
B-39	Mill Dam Road at Brighton on the Bay Neighborhood
B-40	North Great Neck Road at First Colonial Road
B-41	North Great Neck Road at Great Neck Middle School
B-42	North Virginia Beach
B-42-1	Phase 1: Atlantic Avenue at 70 <sup>th</sup> Street
B-42-2	Phase 2: Bay Colony Drive at Myrtle Street

B-43 Ocean Hills Road at Oakridge Circle  
B-44 Old Dominion Lane and Seward Lane  
B-45 Old Donation Parkway and First Colonial Road at Hilltop  
B-46 Oriole Drive North  
B-47 Oriole Drive South  
B-48 Owl's Creek Lane  
B-49 Pinewood Road at Linkhorn Drive  
B-50 Pinewood Road at Willow Drive  
B-51 Preserve Drive at Huntsman Drive  
B-52 Quail Point Road at Covey Street  
B-53 Sea Pines Road at Pacific Avenue  
B-54 Shorehaven Drive and Dey Cove Drive  
B-55 South Bay Shore Drive at Bruton Lane  
B-56 South Birdneck Road at General Booth Boulevard  
B-57 South Birdneck Road at Ocean Breeze Parkway  
B-58 South Birdneck Road at Olds Lane  
B-59 Stratem Court and Brooklyn Avenue  
B-60 Sylvan Lake  
B-61 Tahitian Drive at Mill Dam Road  
B-62 The Reserve at Great Neck  
B-63 Thomas Bishop Lane at Thomas Bishop Court  
B-64 Tottenham Lane at Southall Drive