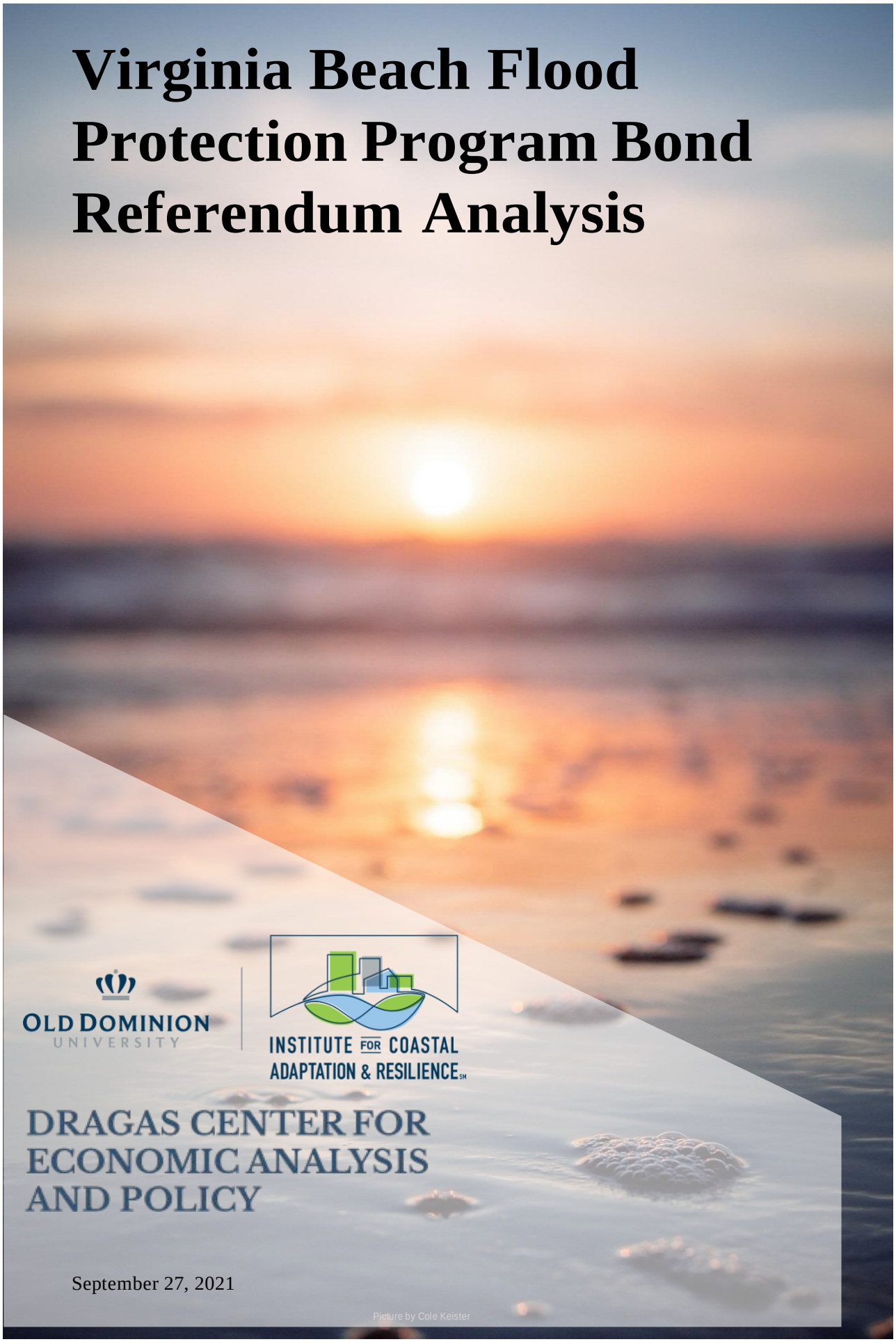
Virginia Beach Flood Protection Program Bond Referendum Analysis



OLD DOMINION UNIVERSITY

INSTITUTE FOR COASTAL ADAPTATION & RESILIENCE

DRAGAS CENTER FOR ECONOMIC ANALYSIS AND POLICY

September 27, 2021

Picture by Cole Keister

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Authors:

Dr. Robert McNab
Professor, Department of Economics
Director, Dragas Center for Economic Analysis and Policy
Old Dominion University

Dr. Juita-Elena (Wie) Yusuf
Professor, School of Public Service,
Assistant Director for Education, Institute for Coastal Adaptation & Resilience
Old Dominion University

Dr. Afi Anuar
Scientist
Consultant

Dr. Jessica Whitehead
Executive Director, Institute for Coastal Adaptation & Resilience,
Old Dominion University

Contributors:

Carol Considine
Director of Applied Projects, Commonwealth Center for Recurrent Flooding Resiliency
Institute for Coastal Adaptation & Resilience
Old Dominion University

Dr. Tom Allen
Department of Political Science & Geography
Program Head for Sea Level Rise & Geography,
Institute for Coastal Adaptation & Resilience,
Old Dominion University

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Executive Summary

On November 2, 2021, voters in the City of Virginia Beach will vote on a referendum that determines whether or not the City Council should increase real estate taxes to fund a Flood Protection Program. The proposal accelerates the construction of six flood mitigation projects already in the Virginia Beach Capital Improvement Plan by 3 years, and funds design and construction of 15 additional projects that would also be completed by 2031. This report, jointly produced by Old Dominion University's Institute for Coastal Adaptation and Resilience (ICAR) and the Dragas Center for Economic Analysis and Policy, combines a technical economic "pay now or pay later" analysis that this bond referendum would have if passed with a synthesis of past social science and participatory mapping work on flooding in Virginia Beach. It also provides an updated state of the research on options available to finance infrastructure that reduces the impact of flooding. The report takes no position on whether the bond referendum should pass.

The impact of flooding is economically and socially significant. Recurrent flooding is the type of flooding that occurs due to smaller flood events and chronic sea level rise. Unlike flooding from large disasters like hurricanes or nor'easters, recurrent flooding is unlikely to meet thresholds to qualify for federal disaster assistance, meaning that its costs will be borne locally by residents and businesses and grow over time. If Virginia Beach takes no action to reduce the effects of projected recurrent flooding, our analysis calculates that average annualized losses from floods will rise from $74.7 million (2021 to 2039) to $99.9 million (2040 to 2059) to $349.1 million (2060 to 2069). In addition to these direct losses, floods also lead to lost economic output. We estimate the average annualized loss in economic output increases from $106.8 million (2021 to 2039), $142.7 million (2040 – 2059), and $495.5 million (2060 – 2069).

Next, our report calculates the economic impact that construction of the projects in the referendum will have. We estimate that the construction of the currently approved slate of projects will lift economic output in Virginia Beach by $53.7 million and create over 470 jobs. If the referendum is passed and the schedule for the currently approved projects accelerated, economic output will increase by $67.7 million and employment by almost 600 jobs. The construction of the projects that are conditional on the passage of the referendum would raise economic output by $371.5 million and create approximately 3,300 jobs. These economic impacts are largely transitory as the impacts are closely tied to the construction of the approved and planned projects. If Virginia Beach continues to develop and construct additional projects as part of their flood protection program, beyond which is detailed in this report, the construction-related impacts would undoubtedly increase. As we do not have information on projects beyond those approved or conditional on the referendum, our analysis is focused on the impacts associated with these projects.

To estimate the flood mitigation impacts of the currently approved slate of projects and projects whose construction is dependent upon referendum passage, we calculated the net present value of the projects and the economic impacts of the projects. If one does not account for the economic impacts of mitigating flood related losses to existing capital stock, the benefit-cost ratio ranges from 13.4 to 14.1. Using economic output as a measure of benefits, we estimate the benefit-cost ratio ranges from 19.1 to 20.1 Additionally, we determined how sensitive the resulting estimates were to multiple assumptions about discount rate, inflation rate, leakage of expenditures outside the local economy, and the effectiveness of the projects in reducing flood damages. Even if one assumes that the proposed projects only mitigate 25% of projected flood losses, the estimated benefit-cost ratios are 3.3 (ignoring economic impacts) and 4.8 (inclusive of economic impacts).

Several quantitative surveys and qualitative focus groups and participatory mapping efforts have been conducted in Hampton Roads since 2010. There are surveys with relevance to Virginia Beach, two of which were conducted by the ASERT (Action-oriented Stakeholder Engagement for a Resilient Tomorrow) team at Old Dominion University. In May-June 2016, 22% of the 1,633 respondents to the Hampton Roads Residents Perceptions of Sea Level Rise and Flooding Adaptation survey lived in Virginia Beach. The ASERT team also gathered public perception data from Virginia Beach residents (185 in-person participants, 81 online participants) at ASERT community meetings Phase 1 in December 2017 and January 2018, held in the 7 sub-watersheds of the City. ASERT Community Meetings Phase 2 in May-August 2019 were attended by 186 in-person participants and 59 online participants.

These ASERT-led efforts were conducted with different methodologies and using different questions than the telephone survey conducted in June and July 2021 by Issues & Answers as part of the Stormwater/Flood Protection Program Awareness and Attitudes Study, so the results of these ASERT efforts represent additional studies to compare and build a picture of public perception. They cannot be used to demonstrate a change in public perception over time. Together, these efforts produce a consistent picture that Virginia Beach residents recognize the need to plan for a future with more flooding. Residents also consistently prefer infrastructure solutions to reducing flooding impacts, including public preference and support for green infrastructure and natural and nature-based solutions.

Both the ASERT Community Meetings Phase 2 (2019) and the Stormwater/Flood Protection Program Awareness and Attitudes Study (2021) asked questions specifically about public perceptions of how to pay for flood protection projects. In the Stormwater/Flood Protection Program Awareness and Attitudes Study (2021), more than half of residents surveyed either strongly agreed or somewhat agreed that existing revenue sources for stormwater and flood protection is not sufficient to meet all the City's long term flood preparedness needs. The Phase 2 ASERT Community Meetings (2019) found that overall, there is support for different approaches to financing resilience infrastructure, with the highest levels of participant support for conventional bonds (such as general obligation bonds or revenue bonds). To repay the debt associated with infrastructure projects, of those ASERT participants, 73% of residents supported reallocating existing revenues, 71% supported creating new revenue sources associated with the flood risk reduction, and 64% supported dedicating revenue from fees and taxes associated with the infrastructure projects.

The questions in the Stormwater/Flood Protection Program Awareness and Attitudes Study (2021) were phrased to provide a more nuanced understanding. In that study, when asked about the effects of sea level rise nearly 7 out of 10 residents surveyed agree that the city should not have to increase their taxes to pay for flood protection projects. However, when asked about the proposed flood protection projects in particular, 65% of Virginia Beach residents agree that they are willing to pay at least 1 cent more in taxes for flood protection projects, with 40% of residents surveyed willing to pay at least 5 cents more. While less than 8% of the ASERT Community Meetings Phase 2 (2019) participants indicated that social vulnerability impact was the most important criteria for evaluating adaptation solutions, 46% of respondents to the Stormwater/Flood Protection Program Awareness and Attitudes Study (2021) indicated that they were most concerned about the damaging effects of flooding on vulnerable populations.

Our team also analyzed the locations of the proposed projects accelerated by or made possible by the bond referendum in comparison to maps created by ASERT Community Meetings Phase 1 (2018). The ASERT Phase 1 meetings included a participatory mapping component, where residents used weTable technology to map locations of observed flooding. For several projects and communities in Virginia Beach, there is a strong correspondence between project locations with community flooding concerns. Specifically, Linkhorn Bay master plan (Seatack and First Colonial & Oceana) and Central Beach district, Eastern Shore Drive and Lake Bradford/Chubb Lake/Church Point area, and Windsor Woods/Princess Anne Plaza/The Lakes (**Figure 5**) project locations have a strong correlation with the

community flooding concerns identified during ASERT. It is important to note that not all flooding concerns identified on the ASERT community map are addressed by the prioritized stormwater projects in the bond referendum.

The bond referendum asks voters to approve the City of Virginia Beach to issue general obligation bonds in the maximum amount of $567,500,000 for the design and construction of flood mitigation measures as part of a Citywide Flood Protection Program. To provide information on how this approach compares with the current state of knowledge on how to fund flood protection projects, this report reviews the current state of financing and revenue options for resilience infrastructure. About 90% of state and local capital infrastructure spending in the United States is paid for through debt financing. Primarily, local governments use general obligation (G.O.) bonds to finance projects like drainage improvements, roads, and other government facilities that do not produce revenues.

Recently, some local governments across the country are developing innovative debt instruments such as green bonds, sustainability bonds, climate bonds, social impact bonds, environmental impact bonds, catastrophe bonds, and resilience bonds. Green, sustainability, and climate bonds are specific types of G.O. bonds that have an environmental bottom line with additional reporting and monitoring. They sometimes attract lower interest rates than traditional bonds, but not always. Impact bonds do not have a fixed rate of return and the repayment of principal and interest is contingent on the project meeting agreed-upon goals and outcomes. The City of Hampton, Virginia, issued $12 million in environmental impact bonds to pay for nature-based projects with low borrowing costs due to strong investor demand and the bond being oversubscribed. The City of Hampton developed outcomes in collaboration with Quantified Ventures and the Chesapeake Bay Foundation and will predict, measure, and report on the stormwater storage capacity these projects produce. Catastrophe bonds are risk management tools which pay out during a disaster and are not applicable to Virginia Beach's need for stormwater projects, because they cannot be used to finance infrastructure. Finally, resilience bonds are still in the stage of concept development and require complex modeling of risks and risk reduction.

In Virginia, payment of G.O. bonds requires the issuing locality to levy ad valorem taxes (i.e., taxes based on the assessed value of the taxed item) such as the real estate property tax. Both the Virginia Beach City Charter and Virginia Public Finance Act provide the authority for the city to levy ad valorem taxes upon taxable property within the city for bond payment. The bond referendum as proposed will use an increase in real estate tax as the revenue stream that secures the bond. Alternative approaches could include local option taxes (though this option is limited by jurisdiction eligibility and currently authorized in the Hampton Roads region for funds allocated to roads and transit), user fees, impact fees, tax increment financing, and special assessment districts. We describe the advantages and disadvantages of each of these options; however, economic analysis to determine how any of these options might compare to the mechanism proposed in the bond referendum was outside the scope of our economic analysis.

Background and Introduction

The City of Virginia Beach has included a bond referendum for a Flood Protection Program on the November 2, 2021, ballot to determine whether City Council should increase real estate taxes to fund flood protection projects. This report includes an analysis of the economic impact of the proposed stormwater projects included in the referendum, public perceptions and preferences for flood adaptation, community identified flooding challenges and available options for paying for flood resilience infrastructure.

The bond referendum specifically includes the design and construction of flood mitigation measures as part of a comprehensive flood protection program that includes 21 projects. Six of the projects (Eastern Shore Drive - Elevate Lynnhaven Drive, Princess Anne Plaza North London/Bridge Creek Tide Gate, Pungo Ferry Road Improvements, The Lakes Holland Road Gate, Windsor Woods - Thalia Creek/Lake Trashmore Improvements, and Windsor Woods Pump Station) are approved in the current Virginia Beach Capital Improvement Plan with completion dates that extend from June of 2028 to June of 2031. As part of the comprehensive flood protection program, these six projects will be accelerated with all projects completed by June of 2028. In addition to the acceleration of those six projects the bond referendum includes 15 additional projects that are not currently approved as part of the Virginia Beach Capital Improvement plan (Central Resort District - 24th Street Culvert, Central Resort Drainage Improvements, Chubb Lake / Lake Bradford Outfall, Church Point / Thoroughgood BMP and Conveyance Improvements, Eastern Shore Drive - Phase I - Section 1F Improvements, Eastern Shore Drive - Phase I - Section 1G Improvements, Eastern Shore Drive - Poinciana Pump Station, First Colonial Road and Oceana Boulevard Drainage Improvements, Princess Anne Plaza North London Bridge Creek Pump Station Princess Anne Plaza North London Bridge Creek Barriers, Sandbridge/New Bridge Intersection Improvements, Seatack Neighborhood Drainage Improvements, Stormwater Green Infrastructure - Marsh Restoration, The Lakes Drainage Improvements - Flood Barriers, West Neck Creek Bridge City-Wide SLR Strategy, Windsor Woods Drainage - Flood Barriers, Princess Anne Plaza Golf Course Conversion). These additional projects will also be accelerated to be completed by June of 2031.

The City of Virginia Beach reached out to Old Dominion University to request a technical analysis of the Virginia Beach Flood Protection Program Bond Referendum that synthesizes work done at Old Dominion University on flood adaptation and resilience since 2010 with economic analysis of the projects in the proposed flood protection program. This analysis also leverages work previously done on recurrent flooding in Virginia Beach on the Sea Level Wise Adaptation Strategy. Importantly, this report takes no position on whether the bond referendum should pass. Instead, it seeks to provide a “pay now or pay later” analysis for the City of Virginia Beach on the costs, benefits, and limits of the proposed referendum, a synthesis of the prior social science work done on flooding perceptions, and context from public policy research on the types of financing options that can potentially be used for flood resilience infrastructure projects. The analysis of the Virginia Beach Flood Protection Program Bond Referendum has been completed by a multidisciplinary team from Old Dominion University and is a partnership between the Institute for Coastal Adaptation and Resilience (ICAR) and Dragas Center for Economic Analysis and Policy.

Economic Cost and Impact of the Flood Protection Program

The City of Virginia Beach, Virginia is proposing to fund a set of infrastructure projects through a public referendum to mitigate current and projected losses associated with recurrent flooding. While a small number of projects are approved in the current Capital Improvement Program (CIP), a larger set of projects is conditional on the passage of the referendum. We estimate that if no action is taken beyond what is approved in the current CIP, the net present value of annualized losses due to recurrent flooding from 2021 to 2069 range from $4.6 billion to $5.9 billion in 2021 dollars. Accounting for the associated economic impacts due to the loss of capital stock, the net present value of losses in terms of economic output would likely range from $6.5 billion to $8.4 billion in 2021 dollars. annual declines in economic activity would reduce annual employment in Virginia Beach by 700 from 2021 to 2039, over 900 from 2040 to 2059, and approximately 3,050 from 2060 to 2070.

The benefit-cost ratio is a useful guide to the public return on investment in infrastructure projects and is equal to the ratio of the net present value of mitigated losses and the net present value of real expenditures. If one does not account for the economic impacts of mitigating flood related losses to existing capital stock, the benefit-cost ratio of the proposed projects ranges from 13.4 to 14.1. Using economic output as a measure of benefits, we estimate the benefit-cost ratio of the proposed projects ranges from 19.1 to 20.1. The benefit-cost ratio remains significant even if one adopts non-standard assumptions on the discount rate, inflation rate, and the effectiveness of the flood mitigation projects. Even if the current and proposed projects mitigate only 25% of projected flooding losses from 2021 to 2069, the benefit-cost ratio ranges from 3.3 to 4.8. We argue that our estimates serve as a lower-bound as population growth, increases in economic activity, or an acceleration of sea level rise would increase the projected losses in the future. Given the severity of losses increases over time, current action would yield sufficient benefits to taxpayers, businesses, and residents in the future. These results support the conclusion that the passage of the referendum would generate benefits to the taxpayers of Virginia Beach well in excess of the costs associated with the projects in question.

Introduction

Virginia Beach is proposing to fund a slate of infrastructure projects with the express intent of mitigating current and future losses associated with recurrent flooding. While some projects are included in the approved Capital Improvement Program (CIP), not all approved projects are currently funded. A larger set of proposed infrastructure projects is dependent upon the passage of a bond referendum in November 2021. The purpose of this report is to estimate the net present value and associated economic impacts of the current slate of projects and the projects conditional on the passage of the referendum.

If no action is taken to mitigate projected recurrent flooding in Virginia Beach, estimates of annual expected losses rise significantly over the study period. Average annualized losses rise from $74.7 million (2021 to 2039) to $99.9 million (2040 to 2059) to $349.1 million (2060 to 2069). We estimate the average annualized loss in economic output increases from $106.8 million (2021 to 2039), $142.7 million (2040 – 2059), and $495.5 million (2060 – 2069).

We estimate that the net present value of annualized losses from flooding ranges from $4.6 billion to $5.9 billion in 2021 dollars. These losses would ripple through the Virginia Beach economy, lowering economic output and employment. 1 We estimate the net present value of declines in economic output range from $6.5 billion to $8.4 billion in 2021 dollars. These losses are equivalent to approximately one-quarter of Virginia Beach's 2019 real Gross Domestic Product. Unlike a natural disaster that occurs in a discrete time period and typically results in the injection of public and private insurance and recovery funds, damages from recurrent flooding occur and accumulate over time. As recurrent flooding increases, insurers are likely to increase premiums and restrict coverages before leaving the Virginia Beach market altogether as losses accumulate. We can reasonably expect that, over time, a greater proportion of costs will be borne by residents and businesses, further depressing economic activity.

To estimate the economic impacts of the slate of current and proposed projects, we examine the impacts associated with construction separately from the impacts associated with flood mitigation. We use estimates of average annual expected losses from flooding to estimate the net present value of these projects and associated impacts on economic output and employment. We examine the sensitivity of our results to changes in the underlying assumptions and variations in loss mitigation.

We estimate that the construction of the currently approved slate of projects will lift economic output in Virginia Beach by $53.7 million and create over 470 jobs. If the referendum is passed and the schedule for the currently approved projects accelerated, economic output will increase by $67.7 million and employment by almost 600 jobs. The construction of the projects that are conditional on the passage of the referendum would raise economic output by $371.5 million and create approximately 3,300 jobs. These economic impacts are largely transitory as the impacts are closely tied to the construction of the approved and planned projects. If Virginia Beach continues to develop and construct additional projects as part of their flood protection program, beyond which is detailed in this report, the construction-related impacts

[1] We adhere to standard practice in defining employment as total jobs in the study area, where total jobs are equal to the sum of full-time, part-time, and seasonal employment (Bureau of Economic Analysis, 2018).

would undoubtedly increase. As we do not have information on projects beyond those approved or conditional on the referendum, our analysis is focused on the impacts associated with these projects.

We estimate the flood mitigation impacts of the currently approved slate of projects and projects conditional on the passage of the referendum. We calculate the net present value of the projects and the economic impacts of the projects. We test the sensitivity of the estimates to variations in the discount rate, inflation rate, and leakages of expenditures out of the local economy. We also explore how variations in the effectiveness of flood mitigation would impact the estimates.

We calculate the benefit-cost ratio to provide a gauge of the return to public investment. The benefit-cost ratio is equal to the ratio of the net present value of mitigated losses and the net present value of real expenditures. If one does not account for the economic impacts of mitigating flood related losses to existing capital stock, the benefit-cost ratio ranges from 13.4 to 14.1. Using economic output as a measure of benefits, we estimate the benefit-cost ratio ranges from 19.1 to 20.1.

To test the sensitivity of the estimates, we explore the possibility that the proposed projects do not completely mitigate projected damages. Even if one assumes that the proposed projects only mitigate 25% of projected flood losses, the estimated benefit-cost ratios are 3.3 (ignoring economic impacts) and 4.8 (inclusive of economic impacts). Acceptable variations in the underlying assumptions do not yield a benefit-cost ratio below 1. We must make non-standard assumptions about discount rates, inflation, economic leakages, and the ineffectiveness of flood mitigation efforts to produce benefit-cost ratios below 1.

Our analysis provides insight into the benefits and costs associated with the currently approved and contingent projects. We estimate, if the referendum is passed and projects are constructed according to the announced schedule, that each dollar of public investment will generate 13 to 20 dollars of benefits, depending on the prevailing assumptions. The returns on investment remain robust even when assumptions are altered to heavily discount future benefits and diminish the effectiveness of flood mitigation efforts. Given the relatively high return on the proposed public investments, we conclude that the proposed projects funded by the referendum would yield significant net benefits to the taxpayers of Virginia Beach.

A Brief Primer on Economic Impact Analysis

When considering the economic impact of a policy, economists focus on two broad effects: displacement and additionality. Changes in public policy may cause economic agents (consumers and businesses) to alter their behavior. The question is whether the policy change results in spending that is additional or whether it displaces economic activity from one sector to another. Economic impact analysis focuses on the incremental changes in economic activity and employment and should not be confused with the overall level of activity and jobs in the economy.

Additionality occurs when a policy change causes economic agents to engage in behavior that they would not have taken in absence of the policy. Economic agents do not shift expenditures from elsewhere in this case. If Virginia Beach passes a referendum to fund the construction of a flood mitigation project, then the expenditures associated with the project and consequent economic activity are additional to the local economy.

Displacement, on the other hand, occurs when a policy change causes economic agents to shift their behavior such that they reduce spending in one area to increase spending in another area. The additional spending because of the updated policy must be balanced against the reductions in spending elsewhere to determine the economic impact. For example, if Virginia Beach cancels the construction of a recreational facility to fund the construction of a flood mitigation project, the city is merely moving spending from one type of capital spending to another. If we ignored the decline in planned expenditures on the recreational facility, we would overstate the economic impact of the flood mitigation project.

The timing of spending is also important and may mix the concepts of additionality and displacement. If spending is accelerated or delayed, then one must account for the impacts associated with the original schedule and altered schedule. The net impact will be the incremental changes in output and employment associated with the schedule change, not the net impacts associated with the original schedule or the altered schedule.

To understand our approach, it is helpful to imagine a pebble dropped into a puddle of water to visualize how the economy reacts to a change in investment or employment. The impact represents the initial round of economic activity on output, earnings, and employment. The initial round of economic activity ripples through the rest of the economy like the waves moving through the puddle. These ripples represent the indirect and induced impacts that come about through the interconnectedness of the local economy. The indirect economic impact comes from economic activity by companies frequented by employees or companies that provide services to the project or individuals or establishments in the project. The induced impact accounts for additional spending due to additional income generated by industries directly and indirectly affected by the project in Virginia Beach. These spillovers create a total economic impact that is generally larger than the direct impact.

The notion of an economic multiplier summarizes the total economic impact of a change in economic activity. If a firm invests $10,000,000 (direct impact) that generates $3,000,000 in indirect economic impacts and $2,000,000 in induced economic impacts, then the economic impact multiplier is ($10,000,000 + $3,000,000 + $2,000,000) / $10,000,000 = 1.5. In other words, for this sector, every $1 of new spending yields a $1.5 increase in economic output, where output is the measure of the total value of goods produced in the sector.

The expenditure of funds also may create an incremental change in employment (jobs). The direct, indirect, and induced impacts on jobs are dependent upon the relationship between changes in output and changes in employment. Labor intensive sectors, for example, will likely observe more significant direct employment impacts than capital intensive sectors. Continuing the example, assume that $10 million in direct spending generates 40 jobs, $3 million in indirect spending generates 1.5 jobs, and $2 million in

induced spending yields 0.5 jobs. The jobs multiplier is thus (40+1.5+0.5)/($10,000,000/$1,000,000) = 4.2. In other words, a $1 million increase in direct spending generates 4.2 new jobs.

We must also consider whether spending 'leaks' from the local economy. The higher the proportion of spending that occurs outside the study region, the lower the direct expenditure and economic impacts on the area of interest. Assume that in the previous example, the firm invested $10 million in a local facility, but 50% of this expenditure was on materials and labor from outside the study area. In this case, direct spending would be $5 million, not $10 million, because of the leakage of $5 million outside the study area. The overall economic impact of the firm's investment would be $7.5 million, not the $10 million associated with the overall spending on the project.

Overview of Existing and Proposed Projects

To estimate the economic impact of the slate of projects funded by the proposed referendum, it is necessary to first establish the baseline against which comparisons can be made. The baseline consists of a set of projects in the approved CIP that are either funded or there exists high confidence that these projects will be funded by the scheduled start date. The six baseline projects, schedules, and budgeted amounts are displayed in **Table 1**.

Table 1.
Projects Approved in the Current Capital Improvement Plan

Project Name	Start Date	End Date	Total Budget
Eastern Shore Drive - Elevate Lynnhaven Drive	07/01/23	11/30/29	$3,600,000
Princess Anne Plaza North London/Bridge Creek Tide Gate	07/01/20	06/30/31	$11,322,000
Pungo Ferry Road Improvements	07/01/24	01/01/30	$11,500,000
The Lakes Holland Road Gate	07/01/24	06/30/30	$8,507,000
Windsor Woods - Thalia Creek/Lake Trashmore Improvements	07/01/23	06/30/28	$5,200,000
Windsor Woods Pump Station	07/01/22	06/30/30	$40,250,000
Total			**$80,379,000**

If the referendum passes, the projects highlighted in **Table 1** will be accelerated relative to the existing baseline. As **Table 2** illustrates, the funding levels of these projects remain constant in nominal (budget) dollars, however, the acceleration shifts these projects forward in time. The acceleration of these projects

means that the spending and benefits accrue earlier than the baseline. To avoid double-counting, we estimate the incremental benefit of acceleration for this set of projects.

Table 2.
Projects Approved in the Current Capital Improvement Plan - Accelerated

Project Name	Start Date	End Date	Total Budget
Eastern Shore Drive - Elevate Lynnhaven Drive	07/01/22	06/30/28	$3,600,000
Princess Anne Plaza North London/Bridge Creek Tide Gate	07/01/20	06/30/25	$11,322,000
Pungo Ferry Road Improvements	07/01/22	12/31/27	$11,500,000
The Lakes Holland Road Gate	07/01/22	06/30/27	$8,507,000
Windsor Woods - Thalia Creek/Lake Trashmore Improvements	07/01/22	06/30/25	$5,200,000
Windsor Woods Pump Station	07/01/22	06/30/27	$40,250,000
Total			**$80,379,000**

The passage of the referendum will also fund the design and construction of a large slate of new projects. As these projects are conditional on the passage of the referendum, there are no economic impacts associated with these projects in the baseline scenario. **Table 3** illustrates the group of new projects. For convenience, we treat one project that consists of three phases (the Princess Anne Golf Course Conversion project) as three distinct projects.

Table 3.
New Projects Funded by Referendum Passage

Project Name	Start Date	End Date	Total Budget
Central Resort District - 24th Street Culvert	07/01/22	06/30/26	$5,200,000
Central Resort Drainage Improvements	07/01/22	12/31/30	$92,800,000
Chubb Lake / Lake Bradford Outfall	07/01/22	06/30/29	$78,200,000
Church Point / Thoroughgood BMP and Conveyance Improvements	07/01/23	06/30/30	$35,900,000
Eastern Shore Drive - Phase I - Section 1F Improvements	07/01/22	12/31/25	$1,560,000
Eastern Shore Drive - Phase I - Section 1G Improvements	07/01/22	12/31/25	$940,000
Eastern Shore Drive - Poinciana Pump Station	07/01/22	12/31/26	$8,200,000
First Colonial Road and Oceana Boulevard Drainage Improvements	07/01/22	12/31/25	$2,325,000
Princess Anne Plaza North London Bridge Creek Pump Station	07/01/22	06/30/27	$55,452,000
Princess Anne Plaza North London Bridge Creek Barriers	07/01/22	06/30/26	$2,126,000
Sandbridge/New Bridge Intersection Improvements	07/01/22	12/31/27	$7,990,000
Seatack Neighborhood Drainage Improvements	07/01/22	12/31/25	$2,400,000
Stormwater Green Infrastructure - Marsh Restoration	07/01/23	06/30/26	$40,000,000
The Lakes Drainage Improvements - Flood Barriers	07/01/22	06/30/26	$3,600,000
West Neck Creek Bridge City-Wide SLR Strategy	07/01/22	06/30/31	$69,000,000
Windsor Woods Drainage - Flood Barriers	07/01/22	06/30/26	$14,000,000
Princess Anne Plaza Golf Course Conversion (Phase 1)	07/01/20	06/30/25	$33,975,434
Princess Anne Plaza Golf Course Conversion (Phase 2)	07/01/23	06/30/28	$31,290,133
Princess Anne Plaza Golf Course Conversion (Phase 3)	07/01/26	06/30/31	$18,334,433
Total			**$503,293,000**

Methodology for Present Value Expenditure Estimates

To estimate the economic impact of the baseline and alternative scenarios, we first estimate nominal expenditures by project by category by year. Using the projected start and completion dates of each product and category, we determine the total number of months that each project *i* is active in category *j*. We explicitly assume that category expenditures are evenly distributed across active months and estimate average monthly category nominal expenditures in **Equation (1).**

Equation (1)

$$\text{Average } Expenditures_{i,j} = \frac{Budget_{i,i}}{Months_{i,j}}$$

Using the projected start and completion dates, we then determine the total number of months that each project is active in each category by year *t*. The product of the number of months active by year in each category and average expenditures by category yields the estimate of annual expenditures by category by project by year as shown in **Equation (2).**

Equation (2)

$$\text{Nominal Expenditures}_{i,j,t} = \text{Months}_{i,j,t} \times \text{Average Expenditures}_{i,j}$$

The Office of Management and Budget's Circular A-94 (OMB A-94) provides guidelines for benefit-cost analysis for the analysis of federal programs (Office of Management and Budget, 2012). As noted in OMB Circular A-94, economic analyses are commonly conducted using real or constant-dollar values.[2] Given the potential costs of flooding are expressed as annualized losses in 2021 dollars, we convert estimated nominal expenditures into constant price 2021 dollars using the GDP Price Index. **Equation (3)** illustrates the conversion of nominal expenditures to constant price expenditures.

Equation (3)

$$\text{Real Expenditures}_{i,j,t} = \frac{\text{Nominal Expenditures}_{i,j,t}}{\text{GDP } Index_t}$$

[2] It is commonly understood that one should not mix nominal and real values in economic analysis

Table 4 contains the assumptions for the baseline and alternate scenarios. For the baseline scenario, we adopt the Congressional Budget Office's forecasts of the Gross Domestic Product (GDP) Price Index (Congressional Budget Office, 2021). We convert the base year of the index from 2012 to 2021 for conformity with the annualized loss estimates and formation of the budget expenditure projections. The CBO's July 2021 forecast is that the growth in the GDP price index will moderate from 2.8% in 2021 to 2.1% in 2022 and remain constant at 2.1% over the study period. For our alternate scenario, we assume a higher rate of growth in the GDP Price Index than the CBO baseline to test the sensitivity of our analysis. We assume that the GDP price index will increase 3% in 2021, 2.8% in 2022, 2.6% in 2023, and will then average 2.5% over the remainder of the study period.

Table 4.
Baseline and Alternate Scenario Assumptions

	Primary Analysis	Sensitivity Analysis
Real Discount Rate	7.0%	2.5%
Inflation Rate		
2021 Inflation Rate	2.8%	3.0%
2022 Inflation Rate	2.1%	2.8%
2023 Inflation Rate	2.1%	2.6%
2024 Inflation Rate	2.1%	2.5%
2025 Inflation Rate	2.1%	2.5%
2026 Inflation Rate	2.1%	2.5%
2027 Inflation Rate	2.1%	2.5%
2028 Inflation Rate	2.1%	2.5%
2029 Inflation Rate	2.1%	2.5%
2030 Inflation Rate	2.0%	2.5%
2031 Inflation Rate	2.0%	2.5%
Leakages		
Design	10%	10%
Site Acquisition	10%	25%
Private Utility Adjustments	50%	50%
Construction	25%	35%
Contingencies	25%	30%

To compute the present value of the baseline and alternative scenarios, it is necessary to discount future benefits and costs. Discounting reflects the time value of money as future costs and benefits are worth less contemporaneously the farther out these costs and benefits occur in the future. We use a real discount rate to discount constant-dollar expenditures. As noted in OMB A-94, constant-dollar cost benefit analyses of proposed investments should utilize a real discount rate of 7 percent. However, the Congressional Research Service (CRS) noted the Water Resources Development Act of 1974 (WRDA 1974) required the executive branch to use an annually adjusted water planning discount rate for project planning purposes (Congressional Research Service, 2016). For 2021, the WRDA 1974 discount rate was set at 2.5 percent (Natural Resources Conservation Service, 2021). We use a real discount rate of 7 percent following OMB guidance and test the sensitivity of our results using the 2.5 percent discount rate.

We estimate the present value of constant-dollar expenditures by category and year for the slate of projects in the primary and alternative scenarios. **Equation (4)** illustrates the calculation of the discount factor given the discount rate *r*. We determine the number of periods, *n*, as equal to the year distance (positive or negative) from 2021.

Equation (4)

$$\text{Discount Factor}_t = \frac{1}{(1+r)^n}$$

Using the discount factor in **Equation (4)** and **Equation (5),** we estimate the present value of real expenditures for each project category in year *t*.

Equation (5)

$$\text{Present Value of Real Expenditures}_{i,j,t} = \text{Nominal Expenditures}_{i,j,t} \times \text{discount factor}_t$$

Tables 5 and **6** present the real present value of the current slate of CIP projects as currently scheduled and as accelerated if the referendum passes. In the baseline scenario, the present value of real expenditures increases from $46.9 million to $59.2 million if the referendum is passed, an increase of $12.2 million. In the alternative scenario, acceleration increases the present value of real expenditures from $60.5 million to $68.4 million, an increase of $7.9 million. The larger increase in the baseline scenario is largely due to the higher discount rate relative to the alternative scenario; acceleration moves expenditures closer to the present, increasing their present value.

Table 5.
Present Value of Real Expenditures Projects Approved in the Current Capital Improvement Plan Baseline Scenario

Project Name	Total Budget	Current Schedule	Accelerated Schedule
Eastern Shore Drive - Elevate Lynnhaven Drive	$3,600,000	$2,130,051	$2,364,074
Princess Anne Plaza North London/Bridge Creek Tide Gate	$11,322,000	$6,751,973	$9,577,611
Pungo Ferry Road Improvements	$11,500,000	$6,355,549	$7,660,616
The Lakes Holland Road Gate	$8,507,000	$4,532,340	$6,180,178
Windsor Woods - Thalia Creek/Lake Trashmore Improvements	$5,200,000	$3,411,271	$4,133,209
Windsor Woods Pump Station	$40,250,000	$23,729,146	$29,229,643
Total	**$80,379,000**	**$46,910,329**	**$59,145,330**

Notes: *The baseline scenario employs a real discount rate of 7% and the Congressional Budget Office's GDP Price Index forecast of July 2021.*

Table 6.
Present Value of Real Expenditures Projects Approved in the Current Capital Improvement Plan – Accelerated Alternative Scenario

Project Name	Total Budget	Current Schedule	Accelerated Schedule
Eastern Shore Drive - Elevate Lynnhaven Drive	$3,600,000	$2,736,483	$2,888,155
Princess Anne Plaza North London/Bridge Creek Tide Gate	$11,322,000	$8,605,286	$10,365,272
Pungo Ferry Road Improvements	$11,500,000	$8,448,521	$9,302,311
The Lakes Holland Road Gate	$8,507,000	$6,128,615	$7,193,726
Windsor Woods - Thalia Creek/Lake Trashmore Improvements	$5,200,000	$4,172,506	$4,613,120
Windsor Woods Pump Station	$40,250,000	$30,424,999	$34,037,543
Total	**$80,379,000**	**$60,516,411**	**$68,400,127**

Notes: *The alternative scenario employs a real discount rate of 2.5% and the alternative GDP Price Index forecast contained in* ***Table 1****.*

Table 7 contains estimates of the real present value of the projects that are conditional on the passage of the referendum. The real present value of these projects is $328.7 million in the baseline scenario and $401.2 million in the alternative scenario. These estimates highlight the conservative nature of adopting the 7 percent discount rate in the baseline scenario given that it more significantly discounts future costs and benefits than the 2.5 percent discount rate in the alternative scenario.

Table 7.
Present Value of Real Expenditures New Projects Funded by Referendum Passage

Project Name	Total Budget	Baseline Scenario	Alternative Scenario
Central Resort District - 24th Street Culvert	$5,200,000	$3,738,219	$4,378,467
Central Resort Drainage Improvements	$92,800,000	$54,013,864	$69,741,476
Chubb Lake / Lake Bradford Outfall	$78,200,000	$49,485,880	$61,463,655
Church Point / Thoroughgood BMP and Conveyance Improvements	$35,900,000	$20,796,336	$26,959,312
Eastern Shore Drive - Phase I - Section 1F Improvements	$1,560,000	$1,166,866	$1,341,196
Eastern Shore Drive - Phase I - Section 1G Improvements	$940,000	$712,591	$813,670
Eastern Shore Drive - Poinciana Pump Station	$8,200,000	$5,886,385	$6,898,080
First Colonial Road and Oceana Boulevard Drainage Improvements	$2,325,000	$1,760,613	$2,011,280
Princess Anne Plaza North London Bridge Creek Pump Station	$55,452,000	$42,029,036	$47,867,623
Princess Anne Plaza North London Bridge Creek Barriers	$2,126,000	$1,555,078	$1,806,104
Sandbridge/New Bridge Intersection Improvements	$7,990,000	$5,298,922	$6,443,645
Seatack Neighborhood Drainage Improvements	$2,400,000	$1,820,690	$2,078,121
Stormwater Green Infrastructure - Marsh Restoration	$40,000,000	$30,659,916	$34,805,603
The Lakes Drainage Improvements - Flood Barriers	$3,600,000	$2,673,938	$3,082,096
West Neck Creek Bridge City-Wide SLR Strategy	$69,000,000	$38,373,686	$50,617,676

Windsor Woods Drainage - Flood Barriers	$14,000,000	$10,315,767	$11,937,690
Princess Anne Plaza Golf Course Conversion (Phase 1)	$33,975,434	$28,990,165	$31,242,083
Princess Anne Plaza Golf Course Conversion (Phase 2)	$31,290,133	$20,203,455	$24,906,923
Princess Anne Plaza Golf Course Conversion (Phase 3)	$18,334,433	$9,215,697	$12,825,971
Total	**$503,293,000**	**$328,697,102**	**$401,220,672**

Notes: *The baseline scenario employs a real discount rate of 7% and the Congressional Budget Office's GDP Price Index forecast of July 2021. The alternative scenario employs a real discount rate of 2.5% and the alternative GDP Price Index forecast contained in* ***Table 1****.*

An economic leakage occurs when spending occurs outside a study area. If the spending that flows to individuals and businesses outside the study area is included in the economic impact analysis, the impact of the proposed projects would be overstated. If, for example, 10% of the real present value design expenditures leak from Virginia Beach, then the present value of real direct design expenditures in Virginia Beach will be equal to 90% of the present value of real design expenditures (the total spending in the design category for the project in a given year). **Equation (6)** shows the estimation of the present value of direct real expenditures by project, spending category, and time. The present value of real direct expenditures by project is the input for the economic impact estimates as it captures only the spending that occurs within Virginia Beach.

Equation (6)

$$\text{Present Value of Direct Real Expenditures}_{i,j,t} = \frac{\text{Nominal Expenditures}_{i,j,t}}{\text{GDP } Index_t} \times \text{discount factor}_t \times (1 - \text{leakage}_j)$$

Construction Economic Impacts

To determine the economic impact of the construction, we ascertain the impact of the approved slate of projects. As shown in **Table 8**, the real present value of the approved projects on the current schedule is $46.9 million. After accounting for leakages in the baseline scenario (**Table 4**), the real present value of direct spending in Virginia Beach will be $36.3 million. If construction proceeded as currently scheduled, these projects would lift economic output by $53.7 million. In the alternative scenario, economic output increases by $61.5 million. **Graph 1** illustrates the real present value of direct spending and the real present value of economic output in the baseline and alternative scenarios.

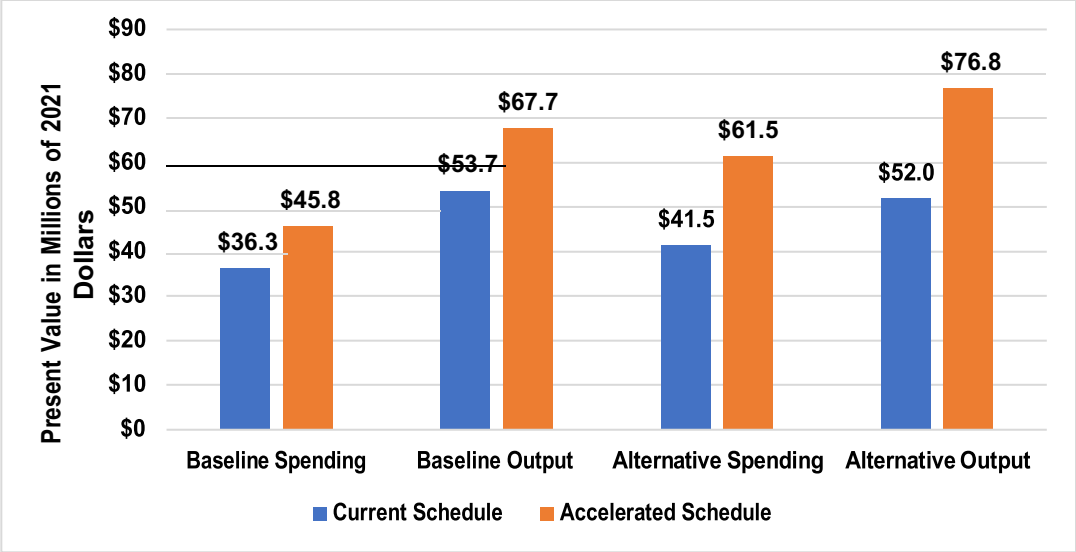
Table 8.
Construction Economic Impacts in the Baseline Scenario Projects Approved in the Current Capital Improvement Plan

Project Name	Planned Budget Expenditure	Present Value of Real Expenditures	Present Value of Real Direct Expenditures in Virginia Beach	Total Estimated Impact on Real Output	Total Employment
Eastern Shore Drive - Elevate Lynnhaven Drive	$3,600,000	$2,130,051	$1,654,304	$2,411,542	21.3
Princess Anne Plaza North London/Bridge Creek Tide Gate	$11,322,000	$6,751,973	$5,122,165	$7,466,208	65.2
Pungo Ferry Road Improvements	$11,500,000	$6,355,549	$4,935,551	$7,155,266	63.5
The Lakes Holland Road Gate	$8,507,000	$4,532,340	$3,526,049	$5,217,013	46.3
Windsor Woods - Thalia Creek/Lake Trashmore Impr	$5,200,000	$3,411,271	$2,673,491	$3,969,188	35.0
Windsor Woods Pump Station	$40,250,000	$23,729,146	$18,379,205	$27,434,898	242.6
Totals	**$80,379,000**	**$46,910,329**	**$36,290,765**	**$53,654,115**	**474**

Graph 2 presents the impact on employment for the currently approved projects. In the baseline scenario, currently scheduled construction would create 474 jobs. If the referendum were passed, the acceleration of these projects would raise job creation to 599 jobs (**Table 9**). In the alternative scenario, 543 and 677 jobs are created under the current and accelerated schedules, respectively.

Graph 3 displays the real present value of spending and economic output in Virginia Beach for the slate of new projects that would be funded by the passage of the referendum. In the baseline scenario, these projects would result in approximately $254.5 million in real direct spending in the city, increasing total economic output by about $371.5 million (**Table 10**). In the alternative scenario, the projects would increase direct spending by approximately $273.1 million and economic output by $398.9 million. In the baseline scenario, the new projects would create approximately 3,310 jobs while 3,545 jobs would be added in the alternative scenario. These jobs include the jobs directly related to the construction of the projects and the indirect and induced jobs created by the construction spending and employment.

Graph 1.
Real Present Value of Currently Approved Projects Baseline and Alternative Scenarios



Graph 2.
Impact on Employment – Construction of Currently Approved Projects Baseline and Alternative Scenarios

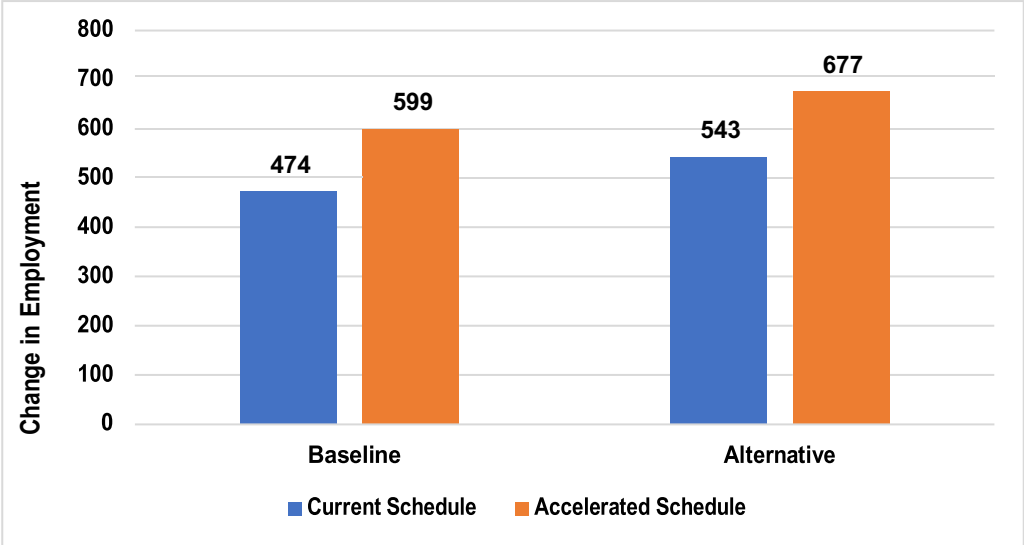


Table 9.
Construction Economic Impacts in the Baseline Scenario Projects Approved in the Current Capital Improvement Plan - Accelerated

Project Name	Planned Budget Expenditure	Present Value of Real Expenditures	Present Value of Real Direct Expenditures in Virginia Beach	Total Estimated Impact on Real Output	Total Employment
Eastern Shore Drive - Elevate Lynnhaven Drive	$3,600,000	$2,364,074	$1,835,978	$2,678,061	23.6
Princess Anne Plaza North London/Bridge Creek Tide Gate	$11,322,000	$9,577,611	$7,269,482	$10,600,463	92.5
Pungo Ferry Road Improvements	$11,500,000	$7,660,616	$5,953,296	$8,638,715	76.6
The Lakes Holland Road Gate	$8,507,000	$6,180,178	$4,825,010	$7,164,445	63.7
Windsor Woods - Thalia Creek/Lake Trashmore Impr	$5,200,000	$4,133,209	$3,231,282	$4,784,669	42.1
Windsor Woods Pump Station	$40,250,000	$29,229,643	$22,647,314	$33,875,891	299.9
Totals	**$80,379,000**	**$59,145,330**	**$45,762,363**	**$67,742,244**	**599**

Graph 3.
Real Present Value of Direct Spending and Economic Output Baseline and Alternative Scenarios

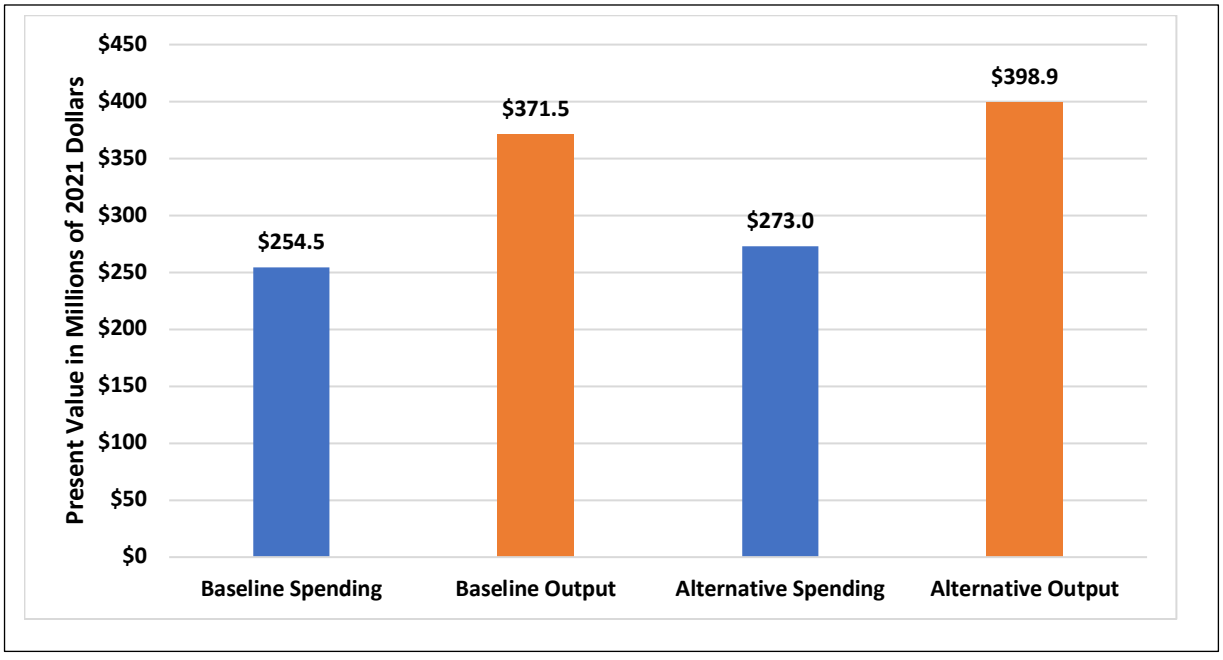
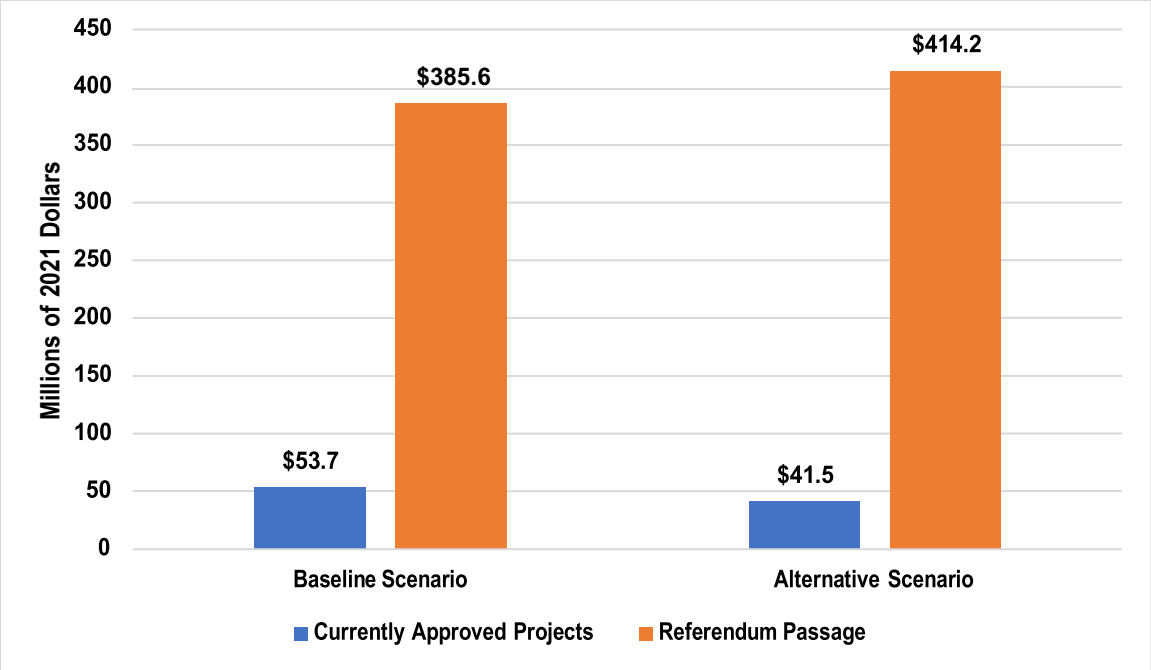


Table 10.
Construction Economic Impacts in the Baseline Scenario
New Projects

Project Name	Planned Budget Expenditure	Present Value of Real Expenditures	Present Value of Real Direct Expenditures in Virginia Beach	Total Estimated Impact on Real Output	Total Employment
Central Resort District – 24th Street Culvert	$5,200,000	$3,738,219	$2,821,569	$3,970,374	35.7
Central Resort Drainage Improvements	$92,800,000	$54,013,864	$41,629,892	$61,143,411	549.5
Chubb Lake / Lake Bradford Outfall	$78,200,000	$49,485,880	$38,429,461	$56,331,091	503.2
Church Point / Thoroughgood BMP and Conveyance Improvements	$35,900,000	$20,796,336	$16,149,481	$23,671,762	211.5
Eastern Shore Drive - Phase I – Section 1F Improvements	$1,560,000	$1,166,866	$900,302	$1,291,388	11.4
Eastern Shore Drive - Phase I – Section 1G Improvements	$940,000	$712,591	$559,596	$809,743	7.3
Eastern Shore Drive – Poinciana Pump Station	$8,200,000	$5,886,385	$4,521,689	$6,568,502	57.2
First Colonial Road and Oceana Boulevard Drainage Improvements	$2,325,000	$1,760,613	$1,344,853	$1,966,315	17.2
Princess Anne Plaza North London Bridge Creek Pump Station	$55,452,000	$42,029,036	$32,757,725	$47,349,681	431.9
Princess Anne Plaza North London Bridge Creek Barriers	$2,126,000	$1,555,078	$1,204,038	$1,764,346	15.4
Sandbridge/New Bridge Intersection Improvements	$7,990,000	$5,298,922	$4,068,970	$5,898,187	52.9
Seatack Neighborhood Drainage Improvements	$2,400,000	$1,820,690	$1,374,892	$2,008,907	17.6
Stormwater Green Infrastructure – Marsh Restoration	$40,000,000	$30,659,916	$23,435,634	$33,731,826	293.7
The Lakes Drainage Improvements – Flood Barriers	$3,600,000	$2,673,938	$2,097,992	$3,050,014	27.4
West Neck Creek Bridge City-Wide SLR Strategy	$69,000,000	$38,373,686	$29,822,159	$43,876,751	387.9
Windsor Woods Drainage – Flood Barriers	$14,000,000	$10,315,767	$8,063,814	$11,938,936	105.0
Princess Anne Plaza Golf Course Conversion (Phase 1)	$33,975,434	$28,990,165	$22,703,941	$33,056,343	295.9
Princess Anne Plaza Golf Course Conversion (Phase 2)	$31,290,133	$20,203,455	$15,533,367	$22,587,126	196.7
Princess Anne Plaza Golf Course Conversion (Phase 3)	$18,334,433	$9,215,697	$7,107,436	$10,498,084	92.3
Totals	**$503,293,000**	**$328,697,102**	**$254,526,810**	**$371,512,786**	**3,310**

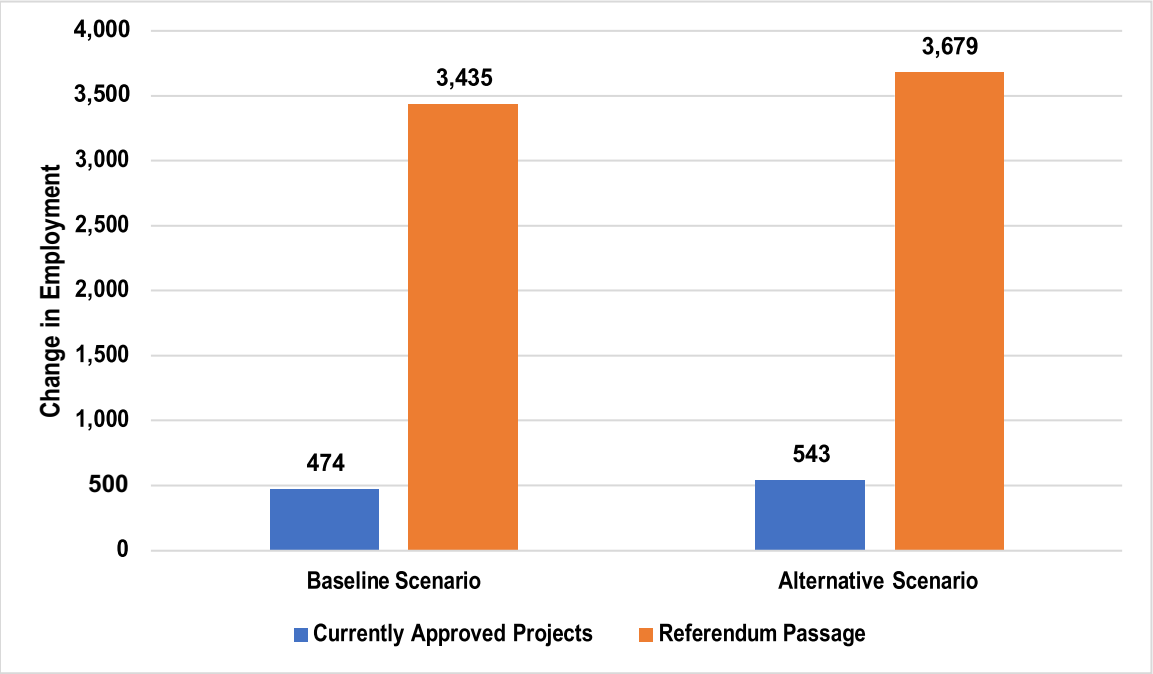
The referendum, as previously noted, would have two discernable effects: acceleration of currently approved projects and funding of new projects. **Graph 4** illustrates the changes in economic output if the referendum is successful. In the baseline scenario, the impact on economic output increases from $53.7 million to $385.6 million. In the alternative scenario, the impact on economic output increases from $61.5 million to $414.2 million. With regards to employment, the passage of the referendum increases jobs by 3,435 and 3,679 in the baseline and alternative scenarios, respectively (**Graph 5**).

Graph 4.
Impact on Economic Output – Construction Baseline and Alternative Scenarios



Note: *Currently approved projects only include projects in the approved CIP and on current schedule. Referendum passage includes the impact of the acceleration of currently approved projects and the construction of projects conditional on the passage of the referendum.*

Graph 5.
Impact on Employment – Construction Baseline and Alternative Scenarios



Note: *Currently approved projects only include projects in the approved CIP and on current schedule. Referendum passage includes the impact of the acceleration of currently approved projects and the construction of projects conditional on the passage of the referendum.*

We note that these economic impacts are solely related to the construction of these projects in question and do not account for the mitigation of losses associated with these projects. We also note that the construction impacts are associated with the current and proposed slate of projects. If additional projects are constructed in the future, the economic impacts of the current and proposed projects would increase. However, our focus is on the projects that would be affected by the referendum. For these reasons, we estimate the impacts of construction and acceleration separately from the impacts of mitigation.

Net Present Value of Mitigation

To estimate the net present value of the losses associated with the proposed projects, we employ damage estimates from HAZUS as generated by Virginia Beach Public Works Stormwater Engineering Center and Dewberry. As noted by the United States Geological Service, the federal government employs annual exceedance probabilities (AEPs). The most used definition is a '1 in 100-year flood.' This refers to a flood level that has a one in one hundred, or 1%, chance in being equaled or exceeded each year. Following standard practice, this is noted as a 1% AEP.

It should be noted that a 1% AEP does not imply that a 1 in 100-year flood will only occur once in 100 years. It refers to the likelihood of flood occurrence in any given year. Given a 50-year period, there is a 39.5% likelihood that a 1% AEP event will happen at least once during this.[3] **Table 11** provides estimates of the likelihood of experiencing a flood event during a 50-year period.

Table 11.
Probabilities of Experiencing a Given Size Flood at Least Once in 50 Years

Odds	AEP	Probability
1 in 10	10%	99.5%
1 in 25	4%	87.0%
1 in 50	2%	63.4%
1 in 100	1%	39.5%
1 in 500	0.2%	9.5%

Virginia Beach Public Works Stormwater Engineering Center provided the estimates of the Average Annualized Loss (AAL) for the current sea level rise scenario (current SLR), a 1.5 foot increase in sea level scenario (1.5 feet SLR), and a 3 foot increase in sea level scenario (3 feet SLR). HAZUS damage estimates were generated for a 1 in 10-year flood (10% AEP), 1 in 25-year flood (4% AEP), 1 in 50-year flood (2% AEP), and a 1 in 100-year flood (1% AEP). Estimates for a 1 in 500-year flood (0.2% AEP) were generated for Coastal HAZUS as part of the Sea Level Wise Adaptation Strategy Report. The AALs represent the expected coastal flood loss to Virginia Beach for any given year and are a weighted average of the scenario loss estimates for the period of analysis. The weights are the incremental differences in likelihoods between adjacent scenarios. There are three periods of analysis: 2021-2039, 2040-2059, and 2060-2069 corresponding to the three sea level rise scenarios (Dewberry, 2020).

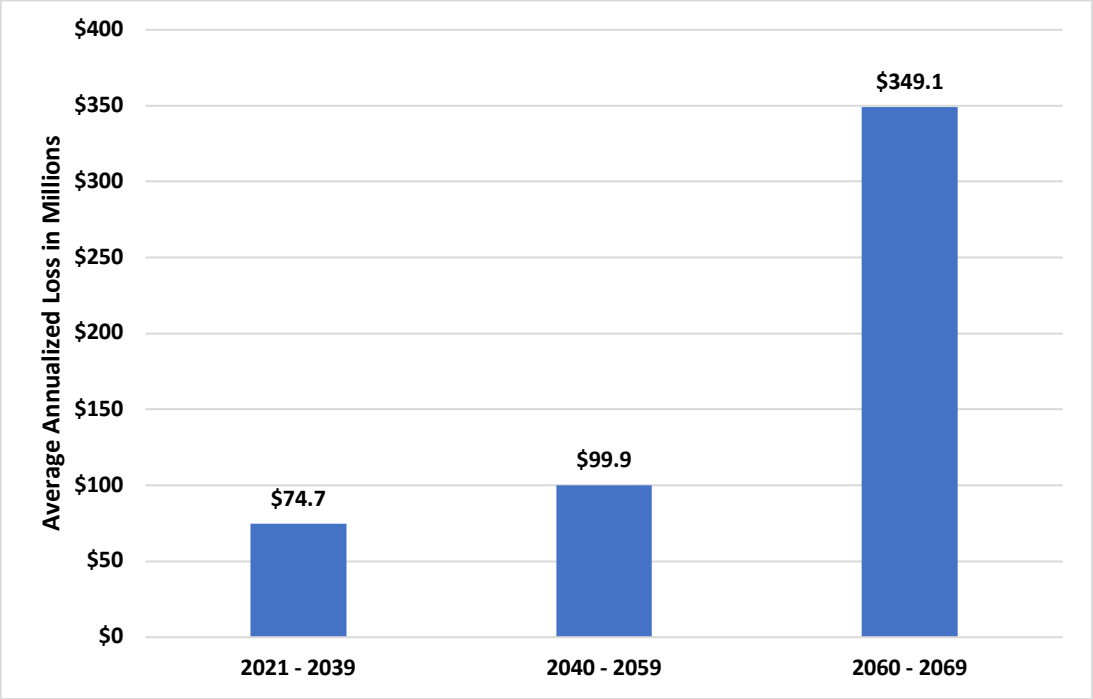
Graph 6 depicts the AALs for existing and future flood conditions in Virginia Beach if no action is taken to mitigate the damages from coastal flooding. Average expected losses rise from approximately $74.7 million to $99.9 million by 2040 as projected sea levels increase by 1.5 feet. As sea level rises from 1.5 feet in 2040 to 2059 to 3 feet in 2060 to 2069, expected losses increase by more than 3 times, from $99.9 to $349.1 million. We note that the HAZUS estimates are generated using existing building stock thus these estimates likely understate the impact of flooding given the reasonable assumption that Virginia Beach will continue to grow over time.

To estimate the net present value (NPV) of mitigation, we need to determine the NPV of specific projects for which AALs are available and the NPV of the losses. If the benefits (reducing losses) outweigh the

[3] The likelihood is equal to 1 – 0.99^(50) = 0.395.

costs (construction) of the projects, then we can estimate a benefit-cost ratio which provides an approximation of the return on investment. If, on the other hand, the NPV of costs exceeds the NPV of benefits, then the rationale for the project or projects is diminished. We have already estimated the NPV of constructing the projects in question, thus the task at hand is estimating the NPV of the losses due to coastal flooding.

Graph 6.
Average Annualized Loss from Coastal Flooding, Virginia Beach
Existing and Future Flood condition



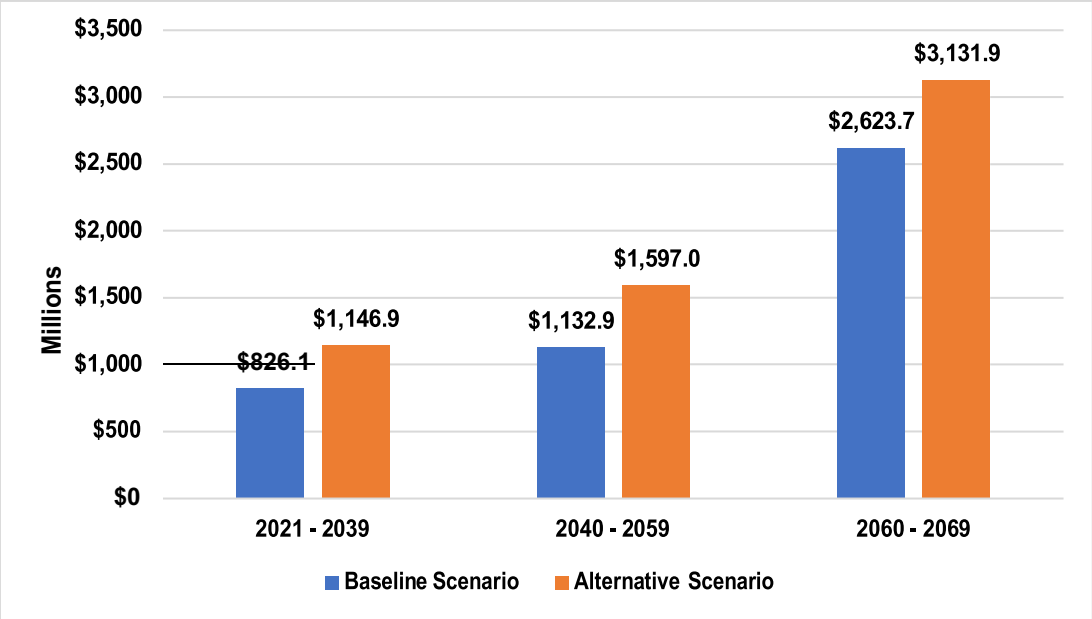
Given the AALs are fixed within each period and estimated in 2021 dollars, we assume that the losses are the analytical equivalent to an annuity, where each AAL is already expressed in present value. The opportunity cost of funds is represented by the assumed discount rate and the number of periods is equal to the time distance of each study period. **Equation (7)** illustrates the formula used to calculate the present value of losses in each study period.

Equation (7)

$$PV = AAL \times \frac{1 - \frac{1}{(1+r)^n}}{r}$$

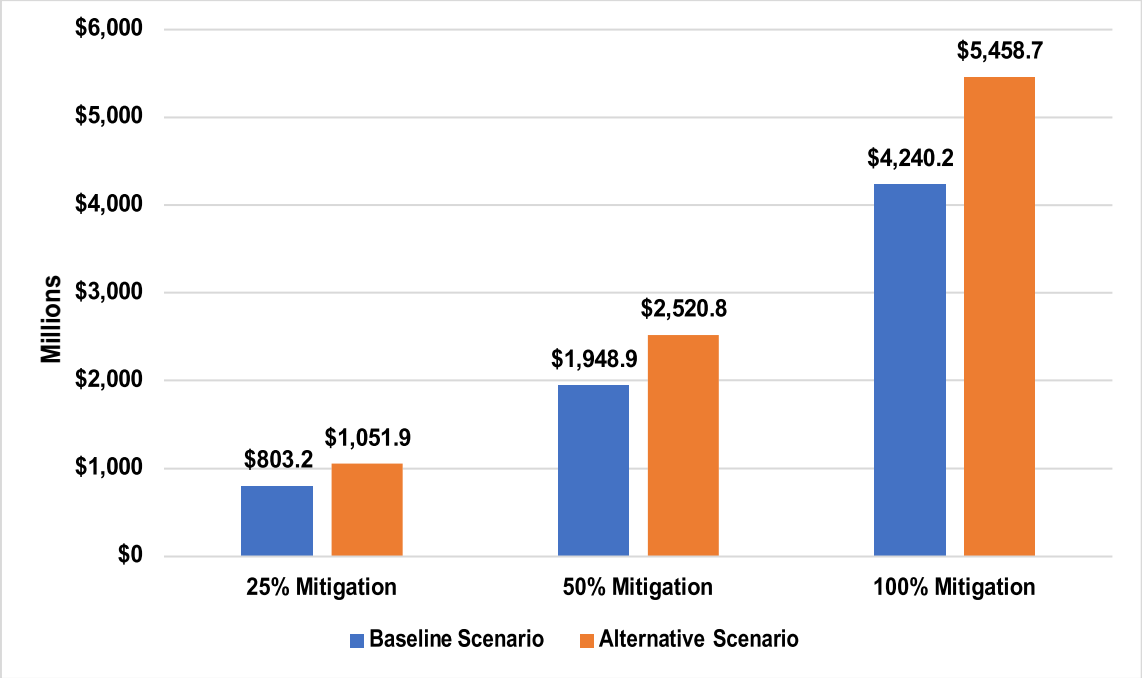
Graph 7 displays the present value of losses for each study period for the baseline and alternative scenarios. In the baseline scenario, the present value of losses increases from $826.1 million (2021 – 2039) to $1,132.9 million (2040 – 2059) to $2,623.7 million (2060 – 2069). If no action is taken, the present value of losses from 2021 to 2069 equals $4.6 billion in 2021 dollars. In the alternative scenario, the present value of losses from 2021 to 2069 equals $5.9 billion in 2021 dollars.

Graph 7.
Present Value of Losses from Coastal Flooding, Virginia Beach Existing and Future Flood Conditions Baseline and Alternative Scenarios



Using the present value of the construction costs of the projects, we can estimate the net present value for the proposed referendum. **Graph 8** presents the estimates for three mitigation scenarios: 25% loss mitigation, 50% loss mitigation, and 100% loss mitigation. We present these loss mitigation scenarios to explore the sensitivity of our estimates. We find that if the projects only mitigate 25% of the expected losses, that the net present value of the proposed slate of projects is $803 million in 2021 dollars in the baseline scenario and $1.05 billion in the alternative scenario. If the proposed projects mitigate 50% of expected losses, the net present value rises to $1.95 billion and $2.52 billion for the baseline and alternative scenarios, respectively. Finally, if the projects mitigate expected damages entirely, then the net present value of the proposed projects climbs to $4.24 billion and $5.46 billion in the baseline and alternative scenarios. **Tables 12** and **13** provide the more fulsome estimates for the interested reader.

Graph 8.
Net Present Value of Losses from Coastal Flooding, Virginia Beach Existing and Future Flood Conditions Baseline and Alternative Scenarios



The benefit-cost ratio provides insight into the return on investment. In the baseline scenario, each dollar expended in present value generates approximately 13.4 dollars of benefits, assuming complete mitigation (**Graph 9**). Even if only 25% of losses are mitigated, the benefit-cost ratio in the baseline scenario is 3.3. With respect to the alternative scenario, the lower discount rate and higher inflation rate leads to a benefit-cost ratio of 3.5 if only 25% of losses are mitigated by the proposed projects. However, as mitigation rises in the alternative scenario, the benefit-cost ratio increases to 7.0 (50% mitigation) and 14.1 (100%) mitigation. These estimates illustrate that highly conservative assumptions on loss mitigation and the time value of money produce benefit-cost ratios greater than 1.

Table 12.
Net Present Value of Referendum Projects, Virginia Beach Baseline Scenario

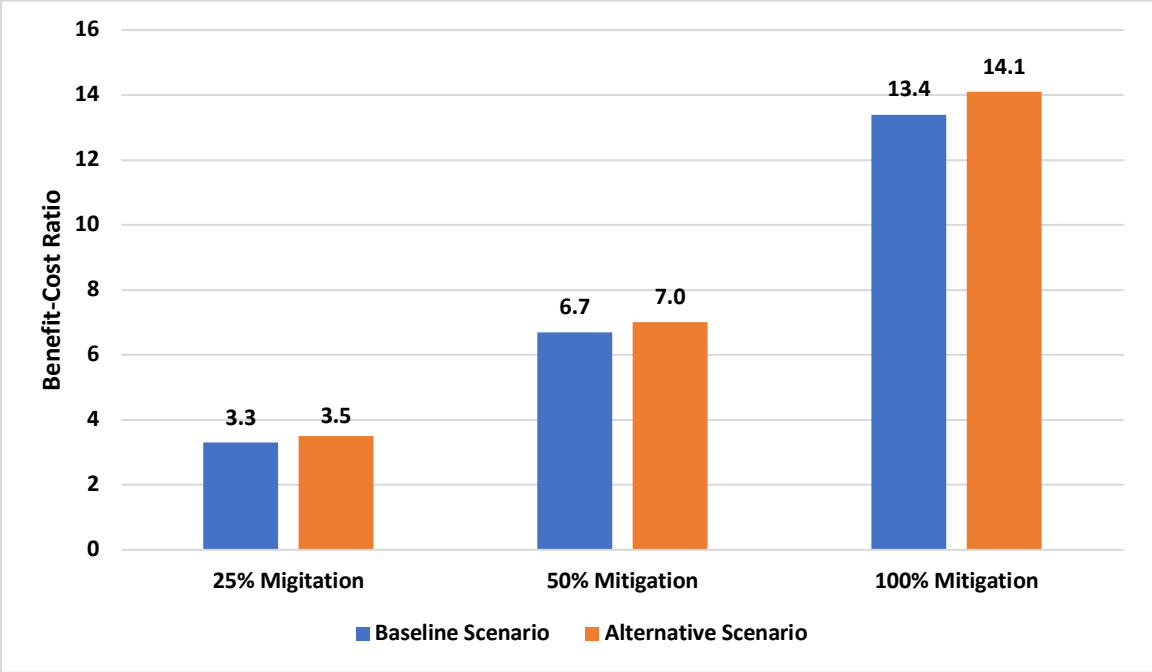
Project	Planned Nominal Expenditures	Net Present Value of Real Planned Expenditures	NPV of Annualized Losses	NPV of Proposed Project	Benefit-Cost Ratio
West Neck Creek Bridge City-Wide SLW Strategy	$69,000,000	$38,373,686	$323,912,273	$285,538,587	8.4
Chubb Lake / Lake Bradford Outfall	$114,100,000	$70,282,216	$112,850,507	$42,568,291	1.6
Eastern Shore Drive Drainage Improvements	$14,300,000	$10,129,915	$59,941,954	$49,812,039	5.9
Windsor Woods Drainage Improvements	$59,450,000	$43,678,618	$735,680,188	$692,001,570	16.8
Princess Anne Plaza and the Lakes Drainage Improvements	$164,607,000	$120,425,159	$1,404,097,825	$1,283,672,666	11.7
Central Beach Drainage Improvements	$98,000,000	$57,752,082	$1,946,220,660	$1,888,468,578	33.7
Seatack Neighborhood Drainage Improvements	$2,400,000	$1,820,690	$1,497	-$1,819,193	0.0
Virginia Beach (Excluding Road Projects)	**$521,857,000**	**$342,462,367**	**$4,582,704,904**	**$4,240,242,538**	**13.4**

Notes: *The distribution of losses and groupings of project provided by Virginia Beach Stormwater. Results for Virginia Beach use AALs derived from HAZUS outputs.*

Table 13.
Net Present Value of Referendum Projects, Virginia Beach Alternative Scenario

Project	Planned Nominal Expenditures	Net Present Value of Real Planned Expenditures	NPV of Annualized Losses	NPV of Proposed Project	Benefit-Cost Ratio
West Neck Creek Bridge City-Wide SLW Strategy	$69,000,000	$50,617,676	$400,396,364	$349,778,688	7.9
Chubb Lake / Lake Bradford Outfall	$114,100,000	$88,422,968	$149,576,621	$61,153,653	1.7
Eastern Shore Drive Drainage Improvements	$14,300,000	$11,941,101	$83,217,595	$71,276,495	7.0
Windsor Woods Drainage Improvements	$59,450,000	$50,588,353	$934,197,173	$883,608,820	18.5
Princess Anne Plaza and the Lakes Drainage Improvements	$164,607,000	$139,289,798	$1,763,314,306	$1,624,024,508	12.7
Central Beach Drainage Improvements	$98,000,000	$74,119,943	$2,545,024,124	$2,470,904,181	34.3
Seatack Neighborhood Drainage Improvements	$2,400,000	$2,078,121	$1,836	-$2,076,286	0.0
Virginia Beach (Excluding Road Projects)	**$521,857,000**	**$417,057,961**	**$5,875,728,019**	**$5,458,670,058**	**14.1**

Graph 9.
Benefit – Cost Ratios of Proposed Projects Existing and Future Flood Conditions Baseline and Alternative Scenarios



Economic Impacts of Mitigation

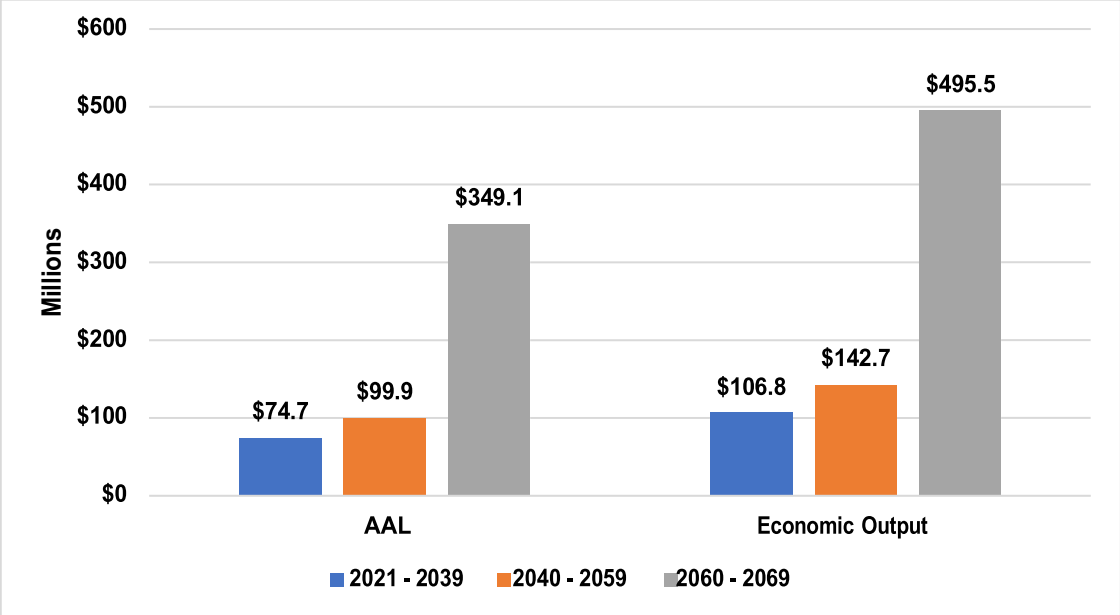
We estimate the impact of flooding on economic output and employment. We first disaggregate the AALs by broad economic sector. To do this, we employ HAZUS outputs by economic sector for 4 of 5 sea-level rise scenarios as the 0.2% AEP damages are not available by economic sector. We use the distribution of AALs by economic sector for each of the three scenarios to distribute the aggregate AALs by economic sector to ensure consistency with the overall estimated annualized losses.[4] We note that in each of the HAZUS outputs that the preponderance of losses comes from the household sector and the proportion of losses from the household sector rises as the probability of the event declines. In the current SLR scenario, for example, households make up 64.2% (10% AEP) to 72.1% (1% AEP) of damages from flooding. In the 3 foot SLR scenario, household damages are between 75% and 75% of all damages across the AEPs. Using the distribution of losses from the weighted average of losses provides a more reasonable distribution than any given HAZUS run.

[4] We have total losses by sector for all but the 1 in 500 year events. Coastal HAZUS generated the estimates for the 0.2% AEP events.

Using the AALs by economic sector, we first estimate the annualized impact on economic output and employment in Virginia Beach. We use multipliers from JOBSEQ and treat the losses as declines in capital stock in each sector. As shown in **Graph 10**, the real present value annualized losses in economic output increase from 106.8 million (2021 to 2039) to $142.7 million (2040 to 2059) to $495.5 million (2060 to 2069). If no action is taken to mitigate flooding, the annualized loss in employment will be 700 jobs (2021 to 2039), 922 jobs (2040 to 2059), and 3,056 jobs (2060 to 2069).

Graph 10.

Average Annualized Losses and Losses in Economic Output
Existing and Future Flood Conditions



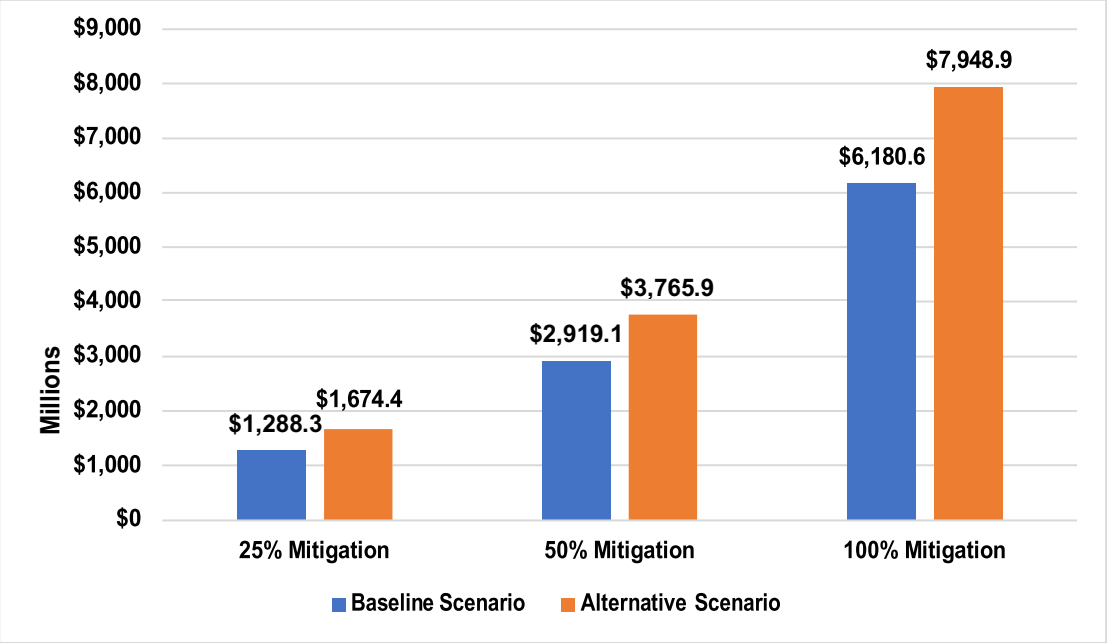
We utilize the same methodology to estimate the present value of economic output as we used to determine the present value of annualized losses. The net present value of economic output losses is $6.2 billion in the baseline scenario and $8.0 billion in the alternative scenario (**Table 14**). We examine the differences between mitigating 25%, 50%, and 100% of projected flood losses (**Graph 11**). The net present value of economic output ranges from $1.3 billion (25% flood mitigation) to $6.2 billion (100% flood mitigation) in the baseline scenario. In the alternative scenario, net present value ranges from $1.7 billion (25% flood mitigation) to $8.0 billion (100% flood mitigation).

Table 14.
Net Present Value of Projects and Economic Output
Baseline and Alternative Scenarios

	Planned Nominal Expenditures	Net Present Value of Real Planned Expenditures	NPV of Annualized Output	NPV of Output Minus Expenditures	Benefit-Cost Ratio
Baseline Scenario	$521,857,000	$342,462,367	$6,523,142,855	$6,180,680,488	19.0
Alternative Scenario	$521,857,000	$417,057,961	$8,365,859,851	$7,948,801,890	20.1

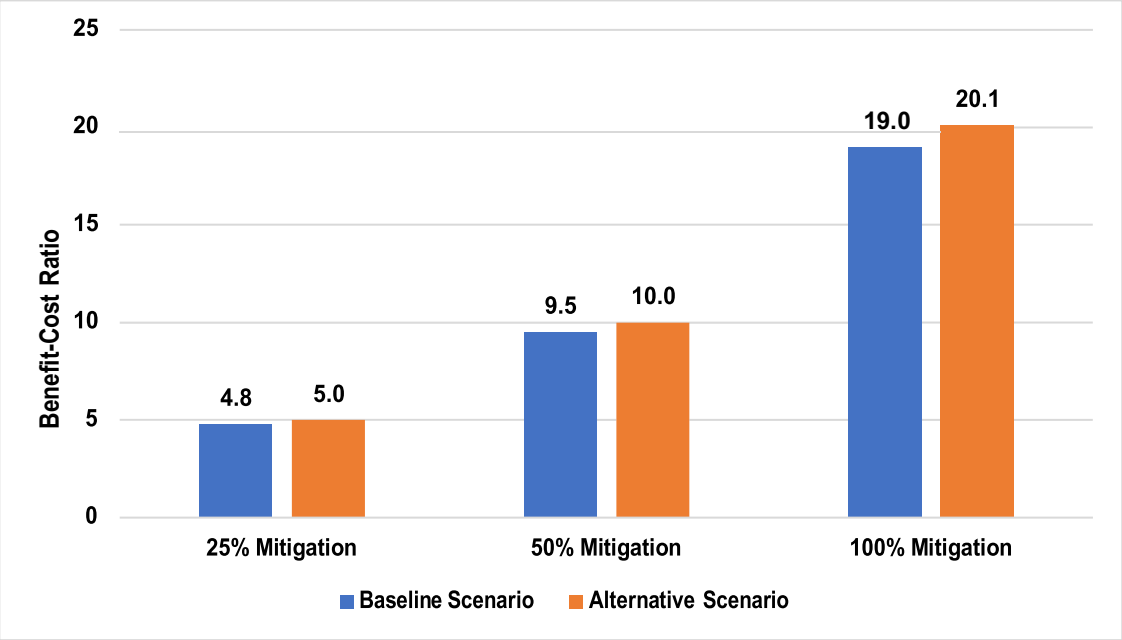
Notes: *The distribution of losses and groupings of project provided by Virginia Beach Stormwater. Results for Virginia Beach use AALs derived from HAZUS outputs.*

Graph 11.
Net Present Value of Losses in Economic Output from Coastal Flooding, Virginia Beach Existing and Future Flood Conditions Baseline and Alternative Scenarios



Given these estimates, it should be no surprise that the benefit-cost ratios, where benefits are measured in terms of economic output, rise relative to the previous estimates. As shown in **Graph 12**, benefit-cost ratios range from 4.8 (25% flood mitigation) to 19.0 (100% flood mitigation) in the baseline scenario. In the alternative scenario, the benefit-cost ratio ranges from 5.0 (25% flood mitigation) to 20.1 (100% flood mitigation).

Graph 12.
Benefit – Cost Ratios of Economic Output for Proposed Projects Existing and Future Flood Conditions Baseline and Alternative Scenarios



We find that to obtain benefit-cost ratios below requires significant variations from standard practice regarding discount rates, inflation rates, or the effectiveness of the proposed projects in mitigating future losses. Simply put, one would have to assume that the proposed projects were almost completely ineffective at mitigating future flood losses to arrive at a result where the net present value of constructing the projects was greater than the net present value of flood mitigation. For example, if one assumed that the proposed projects mitigated only 8% of projected losses, the net present value of the projects remains positive. Only when mitigation effectiveness declines to approximately 7% does net present value become negative. We argue that these assumptions are significantly out of range with respect to the effectiveness of flood mitigation efforts.

Conclusion

We note our results do not capture the potential impact of insurance payments and government assistance for flood damages for residents and businesses in Virginia Beach. However, we also note that recurrent flooding is not a distinct event that generates significant losses in a short period of time but a process that generates losses that accumulate and grow over time. If a hurricane, for example, made landfall in Virginia Beach, we could reasonably expect that private and public insurance payments and public disaster payments would inject significant resources into the economy in a relatively short period of time. These payments would rebuild business and residential properties and public infrastructure and would likely offset some (if not all) of the losses in economic output and employment associated with the hurricane.

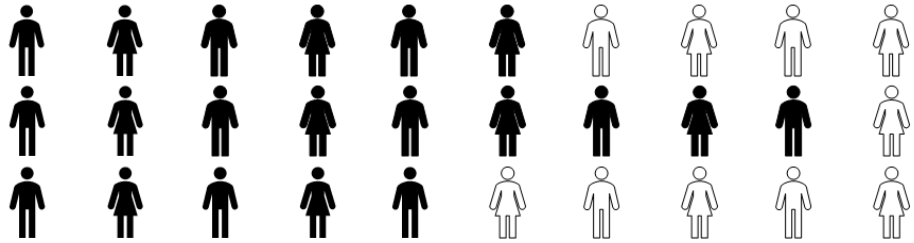
Recurrent flooding, on the other hand, generates increasing losses over time. We would expect that private insurance firms would increase premiums, restrict coverages, and, in the limit, exit the Virginia Beach market completely. The National Flood Insurance Program is already strained by flooding claims and it is an open question whether the federal government would continue to subsidize the program for individuals residing in an area subject to recurrent flooding. As insurance options dwindle and become more costly and the likelihood of public assistance also becomes more uncertain, damages from recurrent flooding will accumulate and accelerate. Unlike the economic shock of a hurricane, recurrent flooding that is not mitigated would be, to paraphrase a popular saying, more equivalent to economic decline by thousands of small damages to local properties.

Our analysis provides insight into the benefits and costs associated with the currently approved and contingent projects. We estimate that, if the referendum is passed and projects are constructed according to the announced schedule, that each dollar of public investment will generate approximately 13 to 20 dollars of benefits in terms of projected loss mitigation, depending on the prevailing assumptions. The returns on investment remain robust even when assumptions are altered to heavily discount future benefits and diminish flood mitigation.

Public Perceptions and Preferences for Flood Adaptation

Highlights

A need for plans and solutions to protect against flooding and reduce flood risks



6 out of 10 – the City should plan for a future with more frequent and intense flooding

9 out of 10 – is important for the City to have plan to deal with recurrent flooding, stormwater runoff, and rising sea levels

4 out of 10 – risk reduction is the most important criteria for determining solutions

Need for infrastructure investments

5 out of 10 – the City should enhance the resilience of critical infrastructure and invest in capital improvements to reduce flood risk

5 out of 10 – improving roads, bridges and infrastructure is a top priority

9 out of 10 – Constructing public buildings and structures to better withstand flooding and storms

9 out of 10 – Use green infrastructure

Who pays and how to pay

7 out of 10 – the City should not have to increase their taxes to pay for flood protection projects

7 out of 10 – the City should not have to increase their taxes to pay for flood protection projects

5 out of 10 – are willing to pay more taxes to pay for flood protection projects

5 out of 10 – people who do not experience flooding on their properties should not have to pay for flood protection projects.

Description of Data Sources for Residents' Perceptions

Multiple surveys, studies, and reports have been conducted in Virginia Beach and Hampton Roads since 2010 that offer insights into public perceptions and preferences regarding flooding and flood adaptation and resilience. Results from four surveys are used to describe residents' perceptions regarding flooding and their preferences for flood adaptation and resilience solutions. The first three surveys, discussed next, were conducted by the ASERT (Action-oriented Stakeholder Engagement for a Resilient Tomorrow) research team at Old Dominion University.

The Hampton Roads Residents' Perceptions of Sea Level Rise and Flooding Adaptation Survey was conducted between May and June 2016. Participants were surveyed on their perceptions of flooding and sea level rise and support for different approaches to flooding adaptation. An online survey was available through Qualtrics and paper surveys were distributed at public locations (i.e., music festivals, malls, recreational centers). A total of 1,633 survey responses were usable for data analysis. Participants resided mostly in Virginia Beach (22%) and Norfolk (38%). The remaining participants were from Hampton (12%), Chesapeake (9%) and nearby cities such as Portsmouth and Newport News. Throughout this report this survey will be referenced as the Hampton Roads Residents' Perceptions of Sea Level Rise and Flooding Adaptation survey (2016).[5]

Two sources of public perception data come from the ASERT community meetings involving residents of Virginia Beach. These community meetings were part of the city's Sea Level Wise planning process. Phase 1 of the community meetings were conducted in December 2017 and January 2018 at public schools located in the seven different sub-watersheds of Virginia Beach. A community meeting was also hosted at a Virginia Beach public library in March 2018. At these meetings residents were asked to provide input on flood resilience issues such as their tolerance for flooding and support for adaptation options. Residents participating in Phase 1 community meetings also helped identify locations where travel had been disrupted due to flooding and areas or assets threatened by flooding in a community mapping process. An online survey was also available for residents to participate. There were 185 in-person participants and 81 online participants. Throughout this report we refer to this data as the Virginia Beach ASERT Community Meetings Phase 1 (2018).[6]

Phase 2 ASERT community meetings in Virginia Beach were conducted at the Virginia Aquarium and at five public schools. The meetings were held in May, July, and August 2019. Participating residents were asked about their perceptions regarding adaptations and responses to sea level rise and flooding. Online feedback was also collected from residents who were not able to participate in the community meetings. There were 186 in-person participants and 59 online participants. Throughout this report we refer to this data as the Virginia Beach ASERT Community Meetings Phase 2 (2018 – 19).[7]

[5] Summary of results from the Hampton Roads Residents' Perceptions of Sea Level Rise and Flooding Adaptation Survey can be found here: https://digitalcommons.odu.edu/odurc_ops/1/

[6] Summary of results from surveys conducted during the Virginia Beach ASERT Community Meetings Phase 1 can be found here https://digitalcommons.odu.edu/odurc-presentations/27/

[7] Summary of results from surveys conducted during the Virginia Beach ASERT Community Meetings Phase 2 can be found here: https://digitalcommons.odu.edu/odurc-presentations/26/

The most recent survey of public perceptions among Virginia Beach residents was conducted in June and July 2021. This telephone survey was conducted by Issues & Answers as part of the Stormwater/Flood Protection Program Awareness and Attitudes Study commissioned by S.E. Wells Communication LLC. Surveys were conducted between June 21, 2021 and July 8, 2021 and averaged 19 minutes in length. The sample size for the telephone survey was 400 residents with responses spread across Virginia Beach to insure a representative sample of neighborhoods. The focus of the survey was to understand: (1) levels of agreement among Virginia Beach residents on the importance of the issue of storm water and flood management programs, (2) residents' willingness to fund mitigation programs and the level to which funding is accepted, and (3) determine residents' concerns regarding the impact of recurrent flooding and sea level rise. This survey is referred to as the Stormwater/Flood Protection Program Awareness and Attitudes Study (2021).

Preference for Improving Resilience of Public Infrastructure and Through Investment in Public Infrastructure

Over 60% of Virginia Beach residents participating in the Virginia Beach ASERT Community Meetings in Summer 2019 were supportive of the city planning for a future with more frequent and intense flooding (see **Table 1**). Furthermore, as a policy and planning approach, more than half of these participating residents support the city undertaking efforts to enhance the resilience of critical infrastructure and invest in capital improvements to reduce flood risks (see **Table 1**). Results from the Stormwater/Flood Protection Program Awareness and Attitudes Study are consistent with the recognition of the need to plan for a future with more flooding. Almost 9 out of every 10 Virginia Beach residents agreed that it is important for the city to have a plan to deal with recurrent flooding, stormwater runoff, and rising sea levels (see **Table 2**). Similarly, 83% of residents agree that the city should make investments to reduce the impact of flooding in all communities in Virginia Beach.

Table 1.
Policy and Planning Goals for the City of Virginia Beach to Implement

	% Identifying as Top 3 Policy and Planning Goals
Plan for a future with more frequent and intense flooding	63.6%
Preserve and enhance natural flood buffers and open space	63.6%
Enhance the flood resilience of critical infrastructure and invest in capital improvements to reduce flood risk	50.4%

Advocate for changes in state and federal law and policy to incentivize, support, and fund local resilience implementation	42.6%
Enhance the flood resilience of buildings and neighborhoods	29.5%
Improve City coordination and responsiveness to community flood concerns	24.8%
Protect and enhance the local economy	10.9%

n=129
Question: *Which of the following Policy Goals, identified in the Policy Response Report, do you think are the highest priority? Select the top 3 goals.*
Source: *Virginia Beach ASERT Community Meetings Phase 2 (2018-19)*

Table 2.
Agreement with Impacts Flooding

	% Somewhat Agree or Strongly Agree
It is important for Virginia Beach to have a plan to deal with recurrent flooding, stormwater runoff and rising sea levels that is updated regularly to keep up with the latest science.	88%
I want to see Virginia Beach take action to protect our communities from the risk of flooding.	86%
We should make investments to reduce the impact of flooding in all communities in Virginia Beach.	83%
Virginia Beach can take actions now that will reduce the future impacts of increased flooding, heavy rainfall, and rising sea levels.	78%
I want to see Virginia Beach take action to protect our coastal communities from the risk of rising sea levels and flooding.	78%
If we do not act, sea level rise/recurrent flooding will have a serious impact on future generations of Virginia Beach citizens.	74%

n=400
Question: *Next I am going to read a series of statements about the effects of sea level rise in Virginia Beach. Please indicate whether you strongly agree, somewhat agree, somewhat disagree or strongly disagree with each statement. If you can't rate an item, please tell me and we will move on.*
Source: *Stormwater/Flood Protection Program Awareness and Attitudes Study (2021)*

Residents of Hampton Roads tend to prefer infrastructure-oriented solutions to address flooding. First, residents express concern over the resilience of infrastructure and the need to build infrastructure to be resilient. When asked about their support for different adaptation solutions, Hampton Roads residents responding to the survey expressed overwhelming support for constructing public buildings and structures to better withstand flooding and storms – 87% were supportive of this adaptation action (see **Table 3**) – but only 13% support city investment in making roads and building more resilient by elevating them (see **Table 5**).

Second, residents also support infrastructure solutions to improve flood resilience. For example, almost half of Hampton Roads residents surveyed perceived improved drainage systems as most feasible for improving flood resilience (see **Table 4**). Almost 30% of Virginia Beach residents participating in the Phase 1 ASERT community meetings indicated a preference for the city to invest in stormwater improvements (see **Table 5***)*. While this percentage may seem low, this option had the highest levels of support among Virginia Beach residents.

Table 3.
Support for Adaptation Actions

	% Somewhat Support or Strongly Support
Constructing public buildings and structures to better withstand flooding and storms (n=1,627)	86.7%
Using green infrastructure (n=1,630)	86.3%
Changing building codes and increasing construction standards in vulnerable areas (n=1,619)	84.5%
Providing tax incentives for taking actions to reduce risks of flood damage (n=1,621)	80.2%
Reducing new building on the coast (n=1,629)	78.1%
Building sand dunes (n=1,629)	76.4%
Limiting rebuilding in locations seriously damaged by flooding or storms (n=1,628)	71.3%
Replenishing sand on beaches (n=1,627)	69.1%
Offering money to people and businesses to move inland (n=1,630)	51.5%
Building sea walls (n=1,630)	42.5%

Questions:
Do you support or oppose the government constructing public buildings and structures to withstand or accommodate rising sea level, flooding and storms?
Do you support or oppose the use of green infrastructure?
Do you support or oppose the government changing building codes and having higher construction standards for all buildings in areas vulnerable to flooding and storms?
Do you support or oppose the government providing tax incentives to property owners for taking action to reduce flooding and potential damage of sea level rise?

Do you support or oppose the government passing laws and regulations to reduce the number of new buildings that people and businesses can build on the coast?
Do you support or oppose the government building sand dunes to protect people, infrastructure, and buildings?
Do you support or oppose the government passing laws and regulations to reduce the number of new buildings that people and businesses can build on the coast?
Do you support or oppose the government replenishing sand on beaches?
Do you support or oppose the government offering money to people and businesses near the coast if they move further inland?
Do you support or oppose the government building walls like this along shores where damaging flooding is likely to increase in the future due to sea level rise?
Source: *Hampton Roads Residents' Perceptions of Sea Level Rise and Flooding Adaptation (2016)*

Table 4.
Actions Perceived to be Most Feasible for Improving Flood Resilience

	% somewhat support or strongly support
Floodplain policy and management	50%
Natural solutions	49%
Improve drainage systems	49%
Flood-proofing buildings	30%
Educate residents on SLR and/or flooding	26%
Flood warning systems and preparedness	25%
Storm surge barriers	23%
Levees/floodwalls/dikes	17%

n=1,629
Question: *Resilience refers to the ability to bounce back following an extreme event such as major flooding or a storm. Which of the following actions are most feasible for improving your community's resilience to sea level rise and/or flooding? (Please select up to 3)*
Source: *Hampton Roads Residents' Perceptions of Sea Level Rise and Flooding Adaptation (2016)*

The Issues & Answers 2021 study results are consistent with the preference for infrastructure solutions to reduce flooding impacts. As shown in **Table 7**, drainage improvements are seen as "top priority" flood mitigation options. 60% of residents responding to the telephone survey indicate that increase storm drain cleaning and maintenance is a top priority. Almost 59% of Virginia Beach residents found clearing drainage ditches a top priority. Other stormwater management options such as conducting stormwater modeling and planning and building more pump stations were in the middle range of residents' priorities.

Third, in terms of infrastructure solutions, there is public preference and support for green infrastructure and natural and nature-based solutions. 86% of Hampton Roads residents surveyed support using green infrastructure as adaptation solutions (see **Table 3**). Almost half of Hampton Roads residents perceive natural solutions as most feasible for improving flood resilience (see **Table 4**). As shown in **Table 6**, Virginia Beach residents are especially supportive of natural and nature-based solutions to increase flood resilience. More than 95% of Virginia Beach residents participating in the Phase 2 Virginia Beach ASERT

Community Meetings support using natural and nature-based solutions such as marshes and wetlands in addition to structural solutions and maintaining natural flood buffers such as marshes. 26% of Phase 2 ASERT community meeting participants were supportive of the city investing in natural solutions, reflecting the second most supported investment option (see **Table 5**). 57% of Virginia Beach residents participating in the summer 2021 Stormwater/Flood Protection Program Awareness and Attitudes Study indicated that protecting natural resources such as marshes, wetlands, and dunes – that can also be used as flood buffers – was a priority.

Table 5.
Actions for the City of Virginia to Invest In

	% Identifying as Top 3
Stormwater improvements	29.8%
Natural solutions (dunes and beaches, wetlands, oyster reefs, maritime forests)	26.3%
Elevating roads and buildings	12.7%
Storm surge barriers	15.3%
Levees or floodwalls	9.4%
Other	6.3%

n=699
Question: *Given a limited amount of public funding, which of the following options would you prefer your local government invest in? (Select up to 3)*
Source: *Virginia Beach ASERT Community Meetings Phase 1 (2018)*

Table 6.
Support for Natural and Nature – Based Solutions

	% Somewhat Support or Strongly Support
Support for adding NNBF to the structural solutions being developed (n=140)	95.0%
Support encouraging maintenance of natural flood buffers (n=141)	97.2%
Support creating incentives to encourage use of natural features (n=141)	95.8%

n=699
Questions:
Do you support adding NNBF to the structural solutions being developed by the city?
Do you support encouraging maintenance of natural flood buffers, including living shoreline approaches for managing erosion?
Do you support creating incentives to encourage use of natural features to absorb water such as trees and rain gardens?
Source: *Virginia Beach ASERT Community Meetings Phase 2 (2019)*

Table 7.
Ways to Reduce Flooding Impacts

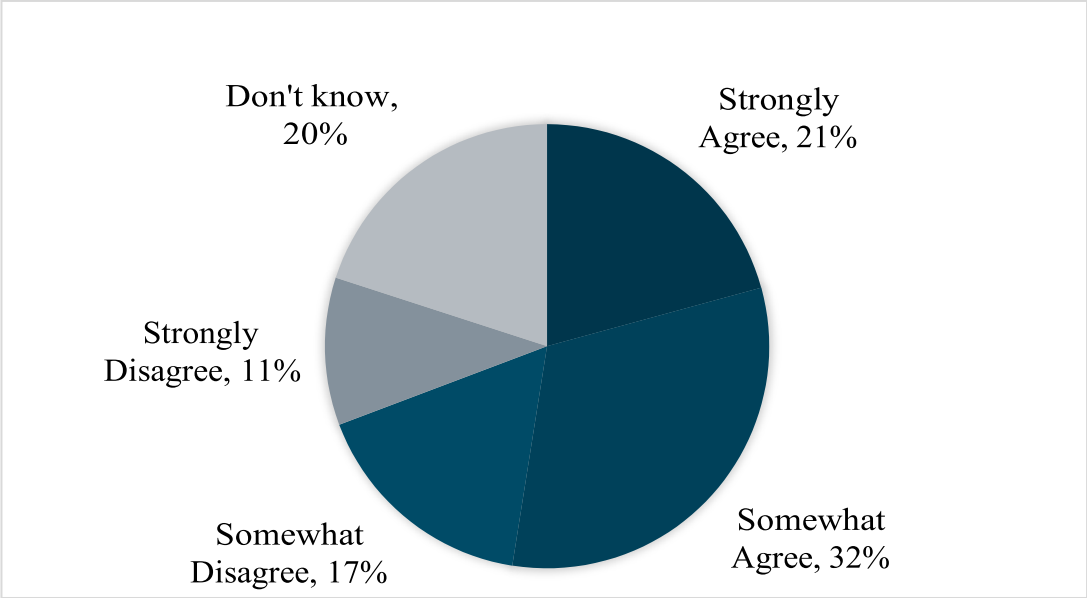
	% Indicating Top Priority	% Indicating Not a Priority or Do Not Address
Increase storm drain cleaning and maintenance	60.0%	2.4%
Clear drainage ditches	58.9%	3.3%
Protect marshes, wetlands and dunes	57.0%	7.2%
Watershed management	49.0%	4.7%
Large-scale infrastructure design	47.3%	11.6%
Stormwater modeling and planning	41.4%	5.3%
Impose more restrictions on land use and development	38.1%	15.7%
Build more pump stations	34.3%	15.9%
Build/expand retention ponds	30.0%	17.8%
Dredge canals	28.1%	16.6%
Build seawalls	22.4%	21.5%
Construct tide gates	19.3%	30.9%
Purchase, relocation of properties with recurrent flooding	15.9%	35.8%
Construct levees	15.7%	25.2%

n=400
Question: *Now I am going to read a list of ways to reduce the impacts of flooding. Please indicate the priority that each should have in Virginia Beach by saying if the mitigation process should be a top priority, an important issue but not the top priority, a lower priority or it should not be a priority at all. If you think Virginia Beach should not do anything about it, please say so.*
Source: *Stormwater/Flood Protection Program Awareness and Attitudes Study (2021)*

Preference for Issuing Bonds and Paying for Flood Adaptation

As noted earlier, residents recognize the need for the city to plan for future flooding and to undertake efforts to enhance flood resilience. The recent Stormwater/Flood Protection Program Awareness and Attitudes Study by Issues & Answers provides broad understanding of residents' perceptions regarding paying for flood protection projects. More than half of Virginia Beach residents surveyed agree that the existing revenue source for stormwater and flood protection is not sufficient to meet all of the City's long-term flood preparation needs (see **Graph 1**). In contrast, 28% of residents disagree that existing revenues sources are insufficient.

Graph 1.
Existing Revenue Source for Stormwater and Flood Protection is not Sufficient to Meet All of the City's Long-term Flood Preparedness Needs



n=400
Question: *Do you agree or disagree with the following statement: The existing revenue source for stormwater and flood protection is not sufficient to meet all of the city's long-term flood preparedness needs.*
Source: *Stormwater/Flood Protection Program Awareness and Attitudes Study (2021)*

Virginia Beach residents participating in the Phase 2 ASERT Community Meetings in Summer 2019 were asked more nuanced questions about their support for different financing and funding options to pay for flood adaptation infrastructure such as for stormwater or transportation infrastructure. As shown in **Table 8**, the debt financing (issuing bonds) options provided to participating residents received broad support. More than 71% of participating residents express support for using conventional bonds such as general obligation bonds or revenue bonds to finance infrastructure and over 70% of residents support using alternative financing mechanisms such as green bonds, resilience bonds, or environmental impact bonds. Overall, there is support for different approaches to financing resilience infrastructure but conventional bonds had the highest levels of strong support. In terms of revenue sources to repay the debt associated with infrastructure projects, 73% of residents support reallocating existing revenues, 71% support creating new revenue sources associated with the flood risk reduction, and 64% support dedicating revenue from fees and taxes associated with the infrastructure projects. However, the dedicated revenue option had the highest level of strong support.

Table 8.
Support for Financing and Funding Options for Infrastructure Solutions

	% Somewhat Support or Strongly Support	% Strongly Support
Reallocating existing revenues to pay off debt (n=115)	73.0%	25.2%
Using conventional bonds such as Revenue and/or General Obligation bonds (n=116)	71.5%	36.2%
Creating new revenue sources associated with increased value of land, property, or economic activity from reduced flood risk (n=111)	71.4%	25.0%
Using alternative financing mechanisms such as green, resilience, or environmental impact bonds (n=113)	70.8%	35.4%
Dedicating revenue from fee- or tax-generating facilities or amenities to pay off debt associated with related infrastructure investments that improve flood resilience (n=111)	64.3%	27.0%

Questions:
Do you support reallocating existing revenues to pay off the debt?
Do you support using conventional bonds such as Revenue and/or General Obligation bonds?
Do you support creating new revenue sources associated with increased value of land, property, or economic activity from reduced flood risk?
Do you support using alternative financing mechanisms such as green, resilience or environmental impact bonds?
Do you support dedicating revenue from fee- or tax-generating facilities or amenities to pay off debt associated with related infrastructure investment that improve flood resilience?
Source: *Virginia Beach ASERT Community Meetings Phase 2 (2019)*

The recent Stormwater/Flood Protection Program Awareness and Attitudes Study by Issues & Answers provides more nuanced understanding of residents' perceptions regarding paying for flood protection projects. More than half of Virginia Beach participating residents agree that the existing revenue source for stormwater and flood protection is not sufficient to meet all of the City's long-term flood preparation needs (see **Graph 1**). In contrast, 28% of residents disagree that existing revenues sources are insufficient.

Nearly 7 out of 10 residents surveyed agree that the city should not have to increase their taxes to pay for flood protection projects (see **Table 9**). Just over half of Virginia Beach residents agree that they are willing to pay more in taxes for flood protection projects. However, half of residents also agree that people who do not experience flooding on their properties should not have to pay for flood protection projects.

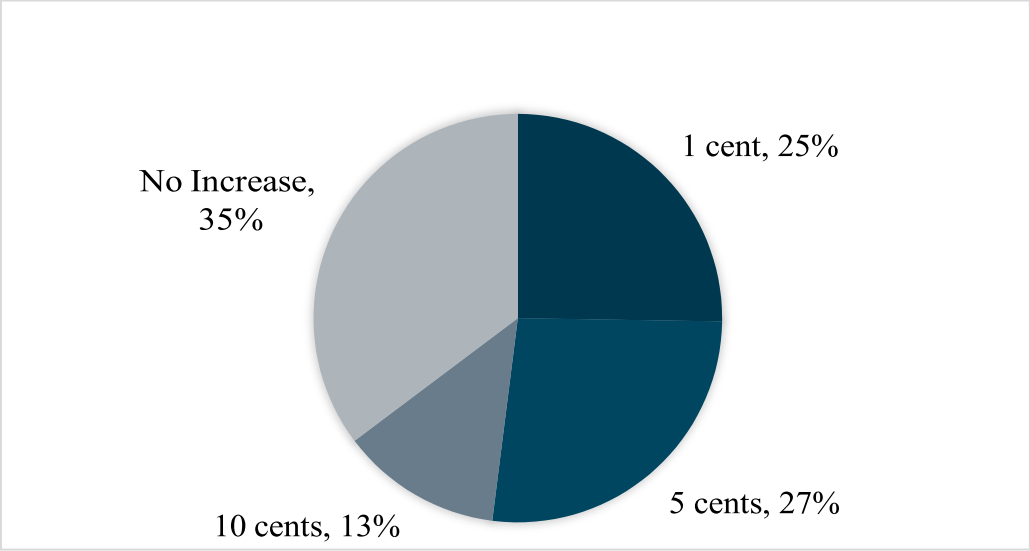
Table 9.
Agreement with Statements About Taxes and Paying for Flood Protection Projects

	% Somewhat or Strongly Agree
The city should not have to increase my taxes to pay for flood protection projects.	69%
I am willing to pay more in taxes for flood protection projects.	51%
People who do not experience flooding at their properties should not have to pay for flood protection projects.	50%

n=400
Question: *Next, I am going to read a series of statements about the effects of sea level rise in Virginia Beach. Please indicate whether you strongly agree, somewhat agree, somewhat disagree or strongly disagree with each statement. If you can't rate an item, please tell me and we will move on.*
Source: *Stormwater/Flood Protection Program Awareness and Attitudes Study (2021)*

As shown in **Graph 2**, more than a third of residents surveyed would be unwilling to pay an increase in real estate taxes to implement proposed flood protection projects. In contrast, 25% and 27% of residents would be willing to pay a 1 cent or 5 cent real estate tax rate increase. Only 13% expressed willingness to pay a real estate tax rate increase of 10 cents.

Graph 2.
Willingness to Pay for Flood Protection Projects



n=400
Question: *Funding for the proposed flood protection projects would come from an increase in real estate tax rates. Which proposal would you be willing to pay for the city to implement proposed flood protection projects?*
Source: *Stormwater/Flood Protection Program Awareness and Attitudes Study (2021)*

Important Criteria for Evaluating Adaptation Solutions

Studies of public perceptions and preferences also provide insight into criteria deemed important for determining which flood adaptation solutions to pursue. Risk reduction is the most important criteria for evaluating adaptation solutions. Participants in the Phase 2 Virginia Beach ASERT Community Meetings were asked to identify the most important criteria the city should use in evaluating sea level rise infrastructure solutions, such as risk reduction, cost effectiveness, cost, and environmental impact (see **Table 10**). Four out of ten residents indicate risk reduction is the most important criteria. More than 27% of residents identify cost effectiveness or value for money as the most important criteria.

Table 10.
Most Important Criteria for Evaluation SLR Adaptation Solutions

	% Identifying as Most Important Criteria
Risk reduction	41.7%
Cost effectiveness (value for money)	27.5%
Environmental impact	17.5%
Social vulnerability impact	7.5%
Cost	3.3%
Legal	0%

n=120
Question: *Help us prioritize criteria for evaluating sea level rise adaptation solutions. Please rank the following evaluation criteria in order of importance with #1 being the most important criteria.*
Source: *Virginia Beach ASERT Community Meetings Phase 2 (2019)*

As shown in **Table 10**, less than 8% of participating residents identify social vulnerability impacts as the most important criteria for evaluating adaptation solutions. However, the recent survey by Issues & Answers found that more residents are concerned about the effects of flooding on vulnerable populations compared to effects on military bases, the agriculture industry, or business closures (see **Table 11**). Furthermore, 72% of residents express agreement with the statement that 'Investments in flood protection is important for low-income communities and those that include people of color.' This suggests that social vulnerability should be an important consideration for the city's planning for future flooding.

Table 11.
Most Concerning Impact of Flooding

	% Identifying as Most Concerning
Effects on vulnerable populations	46.0%
Risk of closing military bases or operations	24.0%
Impact on local agriculture industry	16.0%
Businesses that close or leave Virginia Beach	14.0%

n=400
Question: *When it comes to the damaging effects of flooding, which of the following is the most concerning for you?*
Source: *Stormwater/Flood Protection Program Awareness and Attitudes Study (2021)*

Potential Competing Issues

Surveys show that flooding and its impacts are a concern for Virginia Beach residents and that there is general support for investing to increase resilience of critical infrastructure and to implement infrastructure solutions to increase flood resilience. However, localities have limited resources to address every issue of concern to residents and must prioritize competing issues. How does infrastructure investment rank as a priority issue for Virginia Beach residents? **Table 12** summarizes how Virginia Beach residents responding to the Stormwater/Flood Protection Program Awareness and Attitudes survey prioritize issues to be addressed by the City.

More than half of residents participating in the survey identify improving roads, bridges and infrastructure as a top priority; this is the highest rated priority area for Virginia Beach residents. Other top priority issues are preventing water pollution (49%), protecting wetlands (48%), addressing risk of flooding (47%), and improving the economy (47%). Some of these top priorities may not be directly related to infrastructure investment – such as preventing water pollution and protecting wetlands – but these can be addressed through green infrastructure and natural and nature-based solutions. Improving infrastructure by itself is a high priority, but infrastructure improvements can address several of the other priorities identified for City action such as addressing the risk of flooding, mitigating risk of flood damage.

Table 12.
Priority Issues for Virginia Beach Lawmakers to Address

	% Indicating Top Priority	% Indicating Not a Priority or Do Not Address
Improving roads, bridges and infrastructure for Virginia Beach citizens	52.5%	1.5%
Preventing water pollution	49.3%	3.5%
Protecting Virginia Beach wetlands because they help to reduce flood risks	47.5%	4.8%
Addressing the risk of flooding throughout Virginia Beach	47.3%	5.6%
Improving the city's economy	46.5%	4.0%
Mitigating risk of flood damage to homes and businesses throughout Virginia Beach	44.3%	5.6%
Addressing the risk of flooding along the Virginia Beach coast	41.5%	6.5%
Protecting the city's air quality	37.3%	8.0%
Addressing sea level rise	35.5%	15.8%

n=400
Question: *Next, I am going to read a list of issues facing Virginia Beach residents. Please indicate the priority that each should have for Virginia Beach lawmakers by saying if the issue should be a top priority, an important issue but not the top priority, a lower priority or it should not be a priority at all. If you think Virginia Beach lawmakers, should not do anything about it, please say so.*
Source: *Stormwater/Flood Protection Program Awareness and Attitudes Study (2021)*

Community – Identified Flooding Challenges

This section describes how the 21 flood protection projects identified by the City of Virginia Beach as part of its flood protection program align with flooding challenges identified by Virginia Beach residents. Flood protection project locations were overlayed on the ASERT community map, which identified challenges the community faces related to flooding.

Community Assets and Challenges

Our ASERT framework is designed to engage stakeholders in an effort to build coastal resilience in the community. In ASERT one approach towards understanding resiliency is to identify and map; (1) assets that exist in the community that are of particular value and (2) challenges the community faces with respect to increasing flooding. Assets are beneficial and valuable features of the community. Some examples of assets are community support, and natural assets and recreation. Challenges are physical, social and economic elements that prevent community from being resilient to flooding or SLR. Some examples of challenges are safety and environmental. This method, known as participatory mapping, is a key component of the ASERT framework. The data collected from this activity are used as a starting point for identifying vulnerabilities to flooding.

The ASERT community map was developed to allow stakeholders to identify and locate assets and challenges on a map. After identifying an asset or challenge on the ASERT community map a user selects the appropriate category, provide a description, uploads a photo (if available) on a map. The ASERT community map was made available to the public during the ASERT community meetings via an interactive weTable that afforded participants the opportunity to identify these assets and challenges. The weTable which uses Wii technology, an infrared pen and a map projection on large tables (**Figure 1** illustrates how the weTable is used). The map is also publicly available as a web community map.[8]

Figure 1.
WeTable at an ASERT Community Meeting

[8] The ASERT community map can be accessed here: https://odu-gis.maps.arcgis.com/apps/MapSeries/index.html?appid=b671f417edf146aba58210092aa06718

Overlay of Flood Challenges with Phase 1 Projects

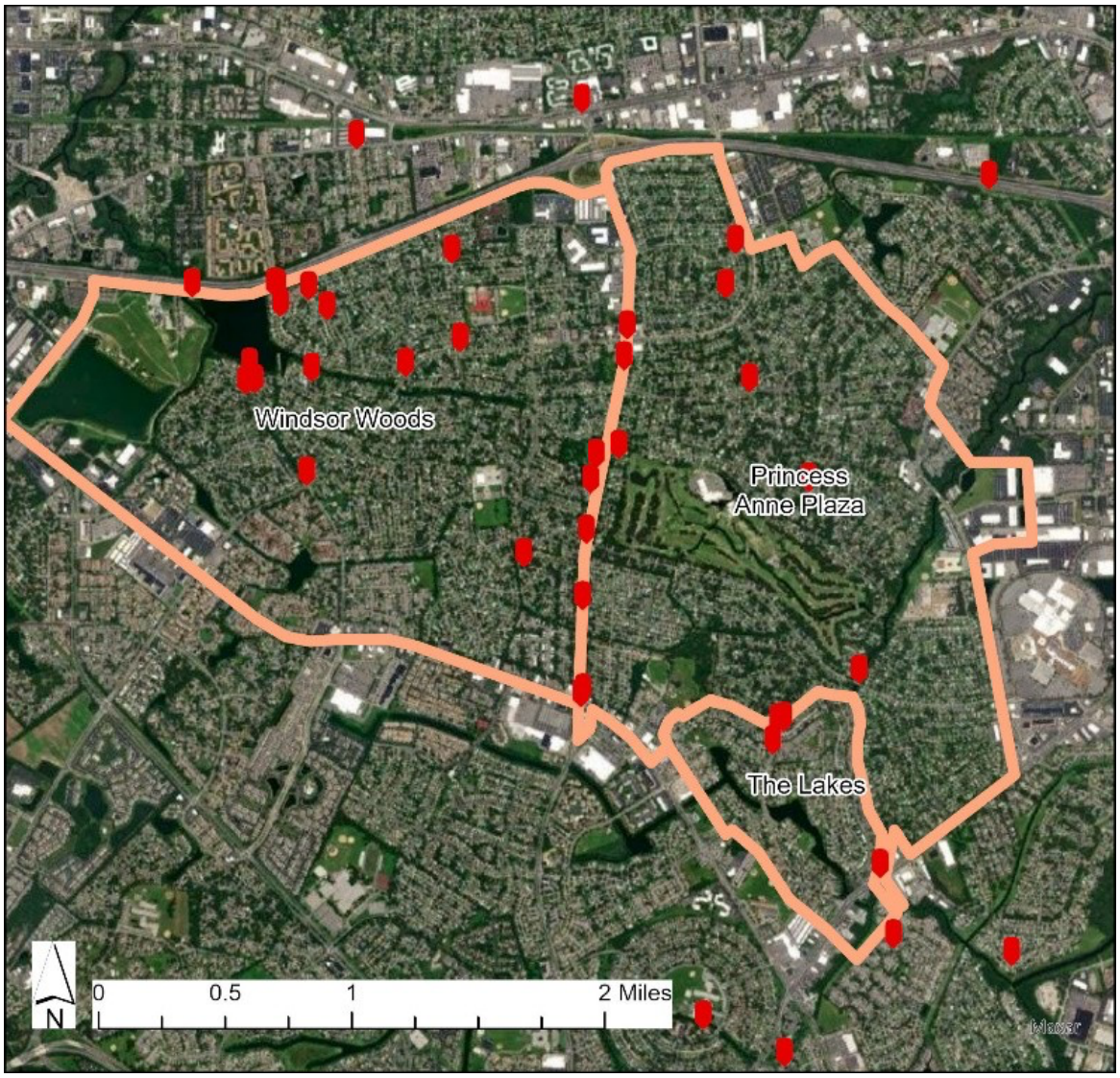
Our analysis of the proposed Phase 1 capital projects show that these projects address residents' concerns about flooding in Virginia Beach. Specifically, these projects are congruent with areas identified by Virginia Beach residents as areas of flood concerns. **Figure 2** is an overlay of several Phase 1 projects with flooding challenges as identified in the ASERT community map. In this figure it shows that for several projects and communities in Virginia Beach, there is a strong correspondence between Phase 1 projects with community flooding concerns. Specifically, Linkhorn Bay master plan (Seatack and First Colonial & Oceana) and Central Beach district (**Figure 3**), Eastern Shore Drive and Lake Bradford/Chubb Lake/Church Point area (**Figure 4**) and Windsor Woods/Princess Anne Plaza/The Lakes (**Figure 5**) project locations have a strong correlation with the community flooding concerns. It is important to note that not all flooding concerns identified on the ASERT community map are addressed by the prioritized stormwater projects, which is seen in **Figure 2**.

Figure 2.
Phase I Projects Overlay with Flooding Challenges

Figure 3.
Seatack, First Colonial, and Resort Area Projects Overlay with Flooding Challenges

Figure 4.
Eastern Shore Drive Improvement and Chubb Lake, Lake Bedford, and Church Point Projects Overlay with Flooding Challenges

Figure 5.
Windsor Woods and Princess Anne Plaza Projects Overlay with Flooding Challenges



Financing Options for Resilience Infrastructure

Introduction

For most coastal communities, the risks of flooding are immediate and felt directly by residents. Local responsibilities for stormwater and drainage systems and transportation infrastructure will continue to stress budgets as flood and storm risks increase. The local governments' ability to pay for increased infrastructure needs may be hindered by traditional approaches to capital management and budgeting. Yet, the ability to leverage funds to catalyze major projects sooner rather than later could be the difference between proactively managing flood risks and incurring significant losses from flooding – not only due to direct damages but also resulting from lower quality of life and decreased economic productivity.

How can localities like Virginia Beach pay for needed capital projects? The need for investment in public and private infrastructure to adapt to flooding is not in question. In 2016, the Virginia legislature established the **Virginia Shoreline Resiliency Fund** designed to provide low-interest loans to homeowners and businesses to help them retrofit buildings to enhance flood resilience. However, no funds were appropriated so no building retrofit projects were paid for out of the fund.

The Virginia Shoreline Resiliency Fund is a good starting point for a conversation that answers the question about how Virginia Beach can pay for capital projects that reduce flood risks and increase flood resilience. As just illustrated by the Virginia Shoreline Resiliency Fund example, it is important to differentiate between financing mechanisms and the funding or revenues streams that feed into these financing mechanisms. A locality needs to be able to finance its large scale, long-term projects, but must also find the funding or revenue streams to underpin the use of the financing instrument.

Financing refers to the use of financial instrument (such as bonds or long-term leases) that allows leveraging current and future project revenues, accelerating project implementation, and matching costs and benefits of public assets. Financing usually involves borrowing money to pay for an infrastructure project, typically through a bond, but also through loans or other debt mechanisms. Similar to a home mortgage, debt must be paid back over time with interest. A source of revenue, such as from grants, taxes, or other sources, must be secured to repay the debt. Funding refers to this revenue.
This section is intended to provide basic understanding of the traditional general obligation (G.O.) bond approach to financing infrastructure. Other financing mechanisms are briefly reviewed to provide a contrast to this traditional approach. The discussion also recognizes that the real estate (property) tax is the primary revenue option to pay for debt service payments of the interest and principal on the bonds issued to finance infrastructure. Other funding sources, such as user fees and charges, impact fees, and value capture options are reviewed. For each financing and funding option, the discussion provides an explanation of each option, the advantages and disadvantages, and in some cases, examples are provided to illustrate their application.

Basics of Infrastructure Finance

Answering the question of how to raise the initial funds needed to finance flood adaptation and resilience infrastructure is an important first step. In general, local governments utilize two methods of financing infrastructure: (1) pay-as-you-go, and (2) pay-as-you-use (also referred to as debt financing).[9] Pay-as-you-go capital financing refers to the use of cash or other current assets to pay for capital projects. This approach is most commonly used when capital projects are small, the local government has limited access to debt or are closely approaching debt limits, or there are prohibitions on using debt. The pay-as-you-use approach, on the other hand, involves issuing long-term debt such as municipal bonds.

Pay-as-you-use or debt financing is the primary approach used by localities to raise money for long-lived infrastructure assets. About 90% of state and local capital infrastructure spending in the U.S. is financed by debt.[10] For local governments, capital projects are primarily financed by municipal bonds, but can also be bank-financed through direct loans from private commercial banks, industrial loan companies, or industrial banks.

Debt financing, however, entails incurring borrowing costs and risk of default from failure to repay. On the other hand, lack of timely infrastructure investment (by waiting to invest until sufficient resources are available via a pay-as-you-go approach) can lead to slower growth and delayed efforts to address the underpinning problems. Thus, the trade-off between the two options is that between (1) higher borrowing costs and risk of using bonds, and (2) the slower pace of the pay-as-you-go method. The general consensus is that the higher risk of issuing bonds is more acceptable than slower flood adaptation and resilience response. Whether the choice is pay-as-you-go or pay-as-you-use capital financing, sources of funding generally come from local general taxes, user fees, earmarked taxes, grants, or a combination of these sources

Traditional Debt Financing via Municipal Bonds

Local governments use general obligation (G.O.) bonds and revenue bonds as their primary types of municipal bond financing. These traditional debt financing instruments are generally tax-exempt bonds where the interest earned by bondholders are exempt from taxes at the Federal level, and, in some cases, state and local levels. This interest income tax exemption enables the bonds to be issued and sold at favorable interest rates, allowing local governments access to low-cost financing. The cost of municipal bond debt service is relatively low, and the tax-exempt nature of municipal bonds help keep interest rates below those for other bonds. For the week of September 13, 2021 the Bond Buyer's 20 bond index rate was 2.15%.[11]

[9] Capital budgeting and finance: A guide for local governments, by J. Marlowe, W.C. Rivenbark & A.J. Vogt. Washington, DC, ICMA Press, 2009.
[10] Municipal bonds and infrastructure development – Past, present, and future (A policy issue white paper prepared on behalf of the ICMA Governmental Affairs and Policy Committee), by J. Marlowe, 2015.
[11] The Bond Buyer (also known as the Red Book) publishes statistics and index figures relative to the fixed income markets. The Bond Buyer's 20 Bond Index tracks the prices of a selected group of municipal bonds.

General Obligation (G.O.) Bonds

General obligation (G.O.) bonds are the long-term borrowing obligations of local governments backed by the issuer's full faith and credit, which means the issuing governments are obligated to repay bonds from their general tax revenues. The debt is secured by the ability of the issuing authority to generate revenues, primarily via property taxes at the local government level. As such G.O. bonds impose a debt obligation on future taxpayers and limit the local government's budget flexibility in future years. G.O. bonds are traditionally issued to finance projects that do not produce revenues, such as drainage improvements, road projects, public schools, libraries, and public safety facilities. G.O. bonds usually have higher credit ratings and lower interest rates. However, they are subject to debt limits imposed by local and state legal requirements. In many states, G.O. bond issuance requires voter approval.

Table 1.
G.O. Bond Example

Miami issued $400 million in G.O. bonds in November 2017. About half of the Miami Forever Bond[12] proceeds were targeted for resilience projects, and the balance were for affordable housing, road improvements, parks, and economic development. The bond referendum passed 55% to 45% shortly after Hurricane Irma caused considerable damage to the area.

Revenue Bonds

In contrast to G.O. bonds, revenue bonds are nonguaranteed debt typically used by local governments to finance capital projects that have definable users and generate revenue streams, such as utilities, toll roads and bridges, parking structures, and sports facilities (i.e., through user fees, tolls, or facility rent). These revenue bonds are secured by the pledge of these pre-defined revenue sources. Because these revenues are more uncertain, revenue bonds have higher risk and higher interest costs. However, most revenue bonds are not subject to constitutional debt limits and may not require voter approval.

[12] Miami gets $200 million to spend on sea rise as voters pass Miami Forever bond, by D. Smiley, November 7, 2017. http://www.miamiherald.com/news/politics-government/election/article183336291.html. Miami Forever Bond. https://www.miamigov.com/My-Government/Departments/Office-of-Capital-Improvements/Miami-Forever-Bond.

Table 2.
Revenue Bond Example

The City of Clovis, New Mexico, in 2012, approved the issuance of $1.65 billion industrial revenue bonds (the third-highest in the state's history)[13] to finance a power station that connects major power grids across the nation. Under the bond arrangement, the City of Clovis retains ownership of the power station and leases it back to Tres Amigas (a private company) at a rate sufficient to pay the principal and interest on the bonds. At the conclusion of the lease, the company will purchase the facility from the City. The Bond Buyer reported that the bond's interest rates would be higher than those of tax-exempt bonds.

Alternative Debt Financing Tools

Local governments may also consider alternative infrastructure financing options that supplement the traditional G.O. and revenue bonds approach. For example, recent years has seen growth in development of innovative debt instruments such as green bonds, sustainability bonds, climate bonds, social impact bonds, environmental impact bonds, catastrophe bonds, and resilience bonds.

Green Bonds, Sustainability Bonds, and Climate Bonds

Green Bonds are municipal bonds (G.O. bonds or revenue bonds) issued to finance projects identified as "green" projects that generate environmental benefits. Examples of green projects include those involving sustainable management of living natural resources, sustainable water management, and climate change adaptation.[14] Green bonds are attractive to investors who are interested in investing in environmental projects or who seek environmental benefits for their investments. These investors are also willing to accept lower interest returns to achieve environmental returns.[15] Institutional investors (such as pension funds) are also increasingly investing in green bonds. Interest by environmentally conscious investors and institutional investors suggest the potential for a larger pool of buyers for green bonds.[16]

[13] Small city in New Mexico will finance billion dollar "Renewable Energy Hub" through industrial revenue bonds, by M. Tiger, 2012. https://ced.sog.unc.edu/small-city-in-new-mexico-will-finance-billion-dollar-renewable-energy-hub-through-industrial-revenue-bonds/. $1.65B deal could make Clovis, N.M., hub of nation's power, by R. Williamson, 2012. https://www.bondbuyer.com/news/165b-deal-could-make-clovis-nm-hub-of-nations-power.
[14] Green bond principles: Voluntary process guidelines for issuing green bonds, by the International Capital Market Association, June 2021. https://www.icmagroup.org/assets/documents/Sustainable-finance/2021-updates/Green-Bond-Principles-June-2021-140621.pdf.
[15] GOING GREEN: Considerations for green bond issuers, by M.T. Kim in *Government Finance Review, 31*(6), 14-18, December 2015.
[16] Green bonds take root in the US municipal bond market, by D. Saha, October 25, 2016. https://www.brookings.edu/blog/the-avenue/2016/10/25/green-bonds-take-root-in-the-u-s-municipal-bond-market/.
A brief note on the global green bond market, by D. Wood & K. Grace, February 2011. https://iri.hks.harvard.edu/files/iri/files/iri_note_on_the_global_green_bonds_market.pdf.

Green bonds are appropriate for local governments interested in investing in projects that advance its environmental performance and enhances its reputation in the environmental and sustainability arena.[17] However, green bonds have an environmental bottom line and bond issuers are required to meet additional monitoring and reporting specific to green projects.[18] Green bonds may also incur additional issuance, administrative, and compliance costs. Investors and issuers have indicated that the environmental focus and project specificity of green bonds contribute to the attractiveness of green bonds. Given the reporting requirements, investors can get information on the green projects they are supporting and obtain evidence of the project's environmental impact. However, green bonds are primarily self-designated; the "green" label is sometimes viewed as a marketing device or greenwashing. Green bonds do not always attract lower interest rates and can involve extra costs for certification. Sustainable bonds and climate bonds are green bonds that meet specific standards as sustainability or climate focused. For example, sustainable bonds are those that fulfill the Sustainability Bond Guidelines[19] while climate bonds are those that meet the Climate Bonds Standard and certification requirements of the Climate Bonds Initiative.[20]

[17] GOING GREEN: Considerations for green bond issuers, by M.T. Kim in *Government Finance Review, 31*(6), 14-18, December 2015.
[18] Infrastructure financing: A guide for local government managers, by C. Chen & J.R. Bartle for the ICMA (International City/County Management Association) and GFOA (Government Finance Officers Association), 2017.
[19] Sustainability bond guidelines, by the International Capital Market Association, June 2021. https://www.icmagroup.org/sustainable-finance/the-principles-guidelines-and-handbooks/sustainability-bond-guidelines-sbg/.
[20] Climate bonds standard and certification scheme, by Climate Bonds Initiatives. https://www.climatebonds.net/standard.

Table 3.
Green Bond, Sustainability Bond, and Climate Bond Examples

Green Bonds
In 2014, the District of Columbia Water and Sewer Authority (DC Water) issued a $350 million 100-year green bond to finance portions of its DC Clean Rivers Project, a water quality improvement program designed to reduce combined sewer overflows[21]. Following best practices, DC Water (1) conducted a cost-benefit analysis that determined it had the systems, controls, and staff to manage the administrative component of issuing a green bond, (2) hired an independent consultant to provide assurance, via "second party" opinion on the environmental benefits of the project, and (3) committed to annual reporting on performance indicators. There was strong investor demand for the bond – there were more than $1 billion in orders for the $300 million bonds initially offered – which allowed DC Water a larger issuance at lower cost. DC Water was able to increase the issuance from $300 million to $350 million and to lower the bond yield by 0.15%.

Sustainability Bonds
In 2017 the Massachusetts Bay Transportation Authority (MBTA) issued the first tax-exempt sustainability bond in the nation. This first issuance, for $99 million, has since been followed by additional $46 million sustainability bond issuances[22]. Bond proceed have been used to pay for projects on the MBTA's capital improvement plan that have clear environmental and social benefit. The MBTA developed a Sustainability Bond Framework[23] for use in identifying projects appropriate for funding via sustainability bonds and to ensure conformance with the Sustainable Bond Guidelines administered by the International Capital Market Associate. However, the MBTA elected not to use an external reviewer to confirm the alignment of their sustainability bonds with key features of the Sustainable Bond Guidelines. The MBTA issues annual sustainability bond progress reports that detail how bond proceeds are spent and the sustainability priority areas the proceeds contributed to. The MBTA sustainability bonds had lower interest rates compared to its traditional bonds.

Climate Bonds
In 2016, the San Francisco Public Utilities Commission (SFPUC) issued $499 million in water and wastewater infrastructure green bonds to pay for sustainable storm water management and wastewater projects included in its Sewer System Improvement Program[24] and the Water System Improvement Program. These green bonds were certified as climate bonds and the first to be certified under the Water Climate Bonds Standard of the Climate Bonds Initiative. Compliance of the bonds with the requirements of the standards were verified by an independent firm. Most recently, in October 2020 the SFPUC issued a $340 million taxable water climate revenue bond.

[21] GOING GREEN: Considerations for green bond issuers, by M.T. Kim in *Government Finance Review, 31*(6), 14-18, December 2015.
[22] Sustainability Bonds, by the MBTA. https://www.mbta.com/sustainability/sustainability-bonds
[23] Massachusetts Bay Transportation Authority Sustainability Bond Framework. https://cdn.mbta.com/sites/default/files/2017-10/mbta-sustainability-bond-framework-080117.pdf
[24] San Francisco Public Utilities Commission, by the Climate Bonds Initiative. https://www.climatebonds.net/certification/sfpuc.

Impact Bonds

Impact bonds or pay-for-performance bonds are a performance-based financing tool that enables governments to pay for programs that meet specific, pre-defined outcomes.[25] Unlike traditional municipal bonds, these impact bonds do not have a fixed rate of return. Rather, the repayment of principal and interest are contingent on the success of achieving agreed-upon goals and outcomes. As such, impact bonds are debt financing tools that reward success. Impact bonds are characterized as social impact bonds or environmental impact bonds depending on the goal or outcome. In most cases, social impact bonds are used to finance social infrastructure projects such as hospitals, prisons, and affordable housing. Social impact bonds are technically not bond instruments but are investment vehicles or investment contracts. Environmental impact bonds, on the other hand, are used to finance infrastructure projects with environmental goals.

The primary advantage of impact bonds is that it transfers risks for achieving outcomes to private investors. However, the need to specify goals and outcomes and the resulting repayment structure can result in a complicated contracting process that underpin the issuance of impact bonds. Both social impact bonds and environmental impact bonds are fairly new and in the early stages.[26] Like green bonds, however, given the emphasis on achieving specific goals and outcomes, impact bonds may be attractive to investors willing to accept uncertain and potentially lower returns (that depend on program performance). If project performance can generate contractually guaranteed cash flow or cost reductions, this can help to secure financing via impact bonds. The focus on goals and outcomes imposes additional issuance, administration, monitoring, and compliance costs. But by focusing on outcomes and measuring progress along the way, impact bonds can also generate broader support for the projects and the bonds from those who are concerned about government effectiveness and accountability.[27]

[25] Social Impact Bonds: A Guide for State and Local Governments, by the Harvard Kennedy School Social Impact Bond Technical Assistance Lab, June 2013. https://hkssiblab.files.wordpress.com/2013/07/social-impact-bonds-a-guide-for-state-and-local-governments.pdf
[26] Infrastructure financing: A guide for local government managers, by C. Chen & J.R. Bartle for the ICMA (International City/County Management Association) and GFOA (Government Finance Officers Association), 2017.
[27] Why environmental impact bonds are catching on, May 22, 2018. https://www.governing.com/gov-institute/voices/col-environmental-impact-bonds-washington-dc-baltimore-atlanta.html

Table 4.
Impact Bond Examples

Social Impact Bonds
In 2016, the City of Denver developed a social impact bond initiative to provide housing and supportive case management services to at least 250 homeless individuals. Investors included philanthropic foundations and impact investment funds. The social impact bond contract detailed repayment to investors that was contingent on achieving the program's outcome targets. The outcomes were achieved and the City paid investors $9.6 million, representing the full initial investment plus an additional $1 million based on the project's outcomes.[28]

Environmental Impact Bonds
In 2020, the City of Hampton, Virginia, issued $12 million in environmental impact bonds to pay for nature-based projects that are part of the city's Resilient Hampton plan. These projects include a drainage ditch retrofit project, a revamped detention pond to improve water management, and a road elevation project to protect against flooding. Quantified Ventures and the Chesapeake Bay Foundation supported design of the environmental outcomes metric, impact measurement, and disclosure aspects of the bond, and provided technical assistance in selecting the projects to be funded. The City will predict, measure, and report on the stormwater volume storage capacity added by these projects. Because of strong investor demand and the bond being oversubscribed, the City was able to achieve lower borrowing costs.[29]

Catastrophe and Resilience Bonds

Catastrophe bonds or "cat bonds" are financial instruments designed to help manage the financial risks associated with disasters. These insurance-linked bonds are primarily used by businesses to manage risks associated with catastrophic events such as hurricanes or earthquakes but have more recently been used by government organizations. Catastrophe bonds are risk management (i.e., insurance) tools that are not used to finance infrastructure. They are a form of contingent bonds and represent a hybrid bond/insurance instrument. With cat bonds, investors receive interest payments, but risk losing a portion of their principal if a natural disaster exceeds a specified level or trigger. This built-in trigger is a defining feature of cat bonds.[30] For example, if hurricane storm surge causes damages to public infrastructure in

[28] Denver Social Impact Bond Program. https://pfs.urban.org/pfs-project-fact-sheets/content/denver-social-impact-bond-program. Denver's supportive housing social impact bond a "remarkable success," July 15, 2021. https://www.denvergov.org/Government/Agencies-Departments-Offices/Department-of-Finance/News/2021/Independent-Evaluation-Finds-Denver%E2%80%99s-Supportive-Housing-Social-Impact-a-success.
[29] Hampton, VA: An Environmental Impact Bond to Fight Flooding, by Quantified Ventures. https://www.quantifiedventures.com/hampton-eib. Paying for Stormwater Solutions, by the Chesapeake Bay Foundation. https://www.cbf.org/assets/promos/main-body-content/environmental-impact-bonds.html.
[30] Leveraging Catastrophe Bonds as a Mechanism for Resilient Infrastructure Project Finance https://www.refocuspartners.com/wp-content/uploads/2017/02/RE.bound-Program-Report-December-2015.pdf

excess of a trigger level of $200 million, the entity issuing the bond (i.e., the local government) keeps a specified portion of the bond amount to cover the losses.

The resilience bond is an extension and modification to catastrophe bonds to capture the savings from a lowered risk of insurance payouts and then use that savings as rebates to invest in resilient infrastructure projects.[31] Specifically, investing in resilience infrastructure projects such as those that improve stormwater drainage to reduce flooding allows local governments to reduce their risk of losses from disasters. This lower exposure to risk creates insurance savings that can be used to pay for the resilience infrastructure project. By linking insurance coverage through cat bonds with capital investment in resilient infrastructure, localities issuing resilience bonds can increase both protection and insurance against disasters.

Resilience bonds are still in the concept development and proposal stage. However, a key challenge is that many localities do not currently insure against large scale disasters. As such there are no insurance savings to capitalize via resilience bonds. There are also high transactions costs associated with the multiple intermediaries needed to connect resilience investments and their benefits with the insurance component. Resilience bonds also require complex and complicated modeling of risks and risk reduction from resilience infrastructure.

Table 5.
Catastrophe Bond Example

In 2013 the New York Metropolitan Transportation Authority (MTA) issued a $200 million catastrophe bond to insure against defined storm surge events. This catastrophe bond incorporated a parametric trigger that based the insurance payout on the measured strength of the catastrophe, in this case storm surge. The bond pays out the full $125 million if the trigger parameters are met, ensuring that the MTA can repair its damaged facilities and remain solvent following a disaster. The MTA suffered $5 billion damages from Hurricane Sandy in 2012, and the cat bond allows the agency to transfer risk of similar storm-related losses. This MTA example is a rare use of catastrophe bonds by a municipal agency. The MTA renewed the catastrophe bond in 2017 (at a reduced level of $125) but with the addition of earthquake coverage. In 2020 the MTA renewed the cat bond for $100 million and a binary parametric trigger (i.e., 100% payout if the trigger is reached and no payout sliding scale).[32]

[31] Leveraging Catastrophe Bonds – As a Mechanism for Resilient Infrastructure Project Finance (RE.bound Report), by S. Vajjhala & J. Rhodes, December 9, 2015. http://www.refocuspartners.com/reports/RE.bound-Program-Report-December-2015.pdf.
[32] New York MTA to renew MetroCat Re parametric cat bond. Launches $100m deal, by S. Evans, April 22, 2020. https://www.artemis.bm/news/new-york-mta-to-renew-metrocat-re-parametric-cat-bond-launches-100m-deal/

Revenues for Debt Service

Flood adaptation and resilience requires substantial upfront investment that generates benefits over decades. In this way financing with municipal bonds is an attractive option. However, these bonds need to be secured against a revenue stream, which would vary according to the type of bond. Requirements for G.O. bonds often involve obligation of general revenues such as property taxes while revenue bonds are often secured by dedicated funding streams associated with the project such as parking fees or usage fees. In Virginia, payment of G.O. bonds require the issuing locality to levy ad valorem taxes (i.e., taxes based on the assessed value of the taxed item) such as the real estate property tax. Both the Virginia Beach City Charter and Virginia Public Finance Act provide the authority for the city to levy ad valorem taxes upon taxable property within the city for bond payment. The City Charter specifies that "the city shall levy ad valorem taxes upon all taxable property within the city for the payment of such bonds or notes and the interest thereon, without limitation as to rate or amount."[33] Similarly, Virginia's Public Finance Act requires the city to levy and collect "a tax upon all taxable property within the locality, over and above all other taxes, authorized or limited by law and without limitation as to rate or amount, sufficient to pay when due the principal of and premium, if any, and interest on any general obligation bonds of the locality issued under the provisions of this chapter to the extent other funds of the locality are not lawfully available and appropriated for such purpose."[34] Real estate taxes would be considered ad valorem taxes upon all taxable property within the city that would be used to repay the bonds – the principal amount, any premiums, and interest.

The sources of revenues used has important implications for fairness and equity, in terms of the burden reflecting the benefits provided and reflecting the ability to pay.[35] Fairness and equity are often in tension. For example, the costs can be borne by property owners within a specific geographic area or spread broadly among all property owners or taxpayers within the city. Funding approaches that spread the burden more broadly can reduce the costs on an individual basis and avoid heavily burdening some groups over others. On the other hand, because the benefits from the capital projects may disproportionately benefit some residents more than others, the everybody pays approach may not be perceived as fair. A narrower approach, such as those specific to smaller geographic areas (such as the tax increment financing or special assessments district approach) allows costs to be imposed more narrowly on those who benefit more directly, but at the same time imposing higher costs on those fewer tax or fee payers. When lower income communities are disproportionately impacted by the problems and the solutions, these narrower approaches may place additional burdens on residents of these low-income neighborhoods. These fairness and equity considerations are included in the following discussion of revenue sources.

[33] Virginia Beach City Charter. Chapter 6, sections 6.01 -6.06. https://law.lis.virginia.gov/charters/virginia-beach/.
[34] Code of Virginia. Public Finance Act. https://law.lis.virginia.gov/vacodepopularnames/public-finance-act/
[35] Financing Climate Resilience: Mobilizing Resources and Incentives to Protect Boston from Climate Risks. Sustainable Solutions Lab, University of Massachusetts Boston. April 2018.
https://www.umb.edu/editor_uploads/images/centers_institutes/sustainable_solutions_lab/Financing_Climate_Resilience_April_2018.pdf

Real Estate (Property) Taxes

Property tax is a tax paid on property owned by an individual or other legal entity, such as a corporation. It is assessed by the local government where the property is located and paid by the owner of the property. The tax is usually based on the value of the owned property, including land. When real estate or property taxes are used to pay debt service, the amount paid is roughly proportional to the assessed value of property, ensuring some degree of equity. The differential between commercial and residential rates, as well as tax exemptions, can contribute to equity issues.

Other Taxes

Local governments can use more narrowly-based taxes as dedicated revenues to pay off debt incurred to finance local infrastructure. For example, select sales taxes and hotel and other occupancy taxes can be deposited into a special revenue fund and reserved for a specific project. The key advantage of earmarking specific tax revenues is that earmarking protects these infrastructure projects from competition from other uses of these funds. However, these revenue sources tend to be less stable than the property tax. Earmarking these revenues may restrict the flexibility and discretion for fiscal planning in the future.

Local Option Taxes

Local option taxes are tax options that are either authorized at the state level or approved by local voters and levied at the local level to pay for infrastructure-related purposes. The local option sales tax is the most common type of local option taxes, but some jurisdictions use local fuel taxes, local income and payroll taxes, and local vehicle taxes. Revenues from local option taxes can be earmarked for special local infrastructure projects. In Virginia, access to a special local option sales tax is limited by jurisdiction eligibility, including population thresholds. Virginia Beach is part of the Hampton Roads region that is authorized to and has adopted local option taxes with funds allocated primarily for roads and transit.

User Fees and Charges

Use fees and charges allow local governments to impose fees to cover the cost associated with funding services and infrastructure to increase the quality of life and cover administrative and regulatory processes. They play a crucial role in paying for infrastructure and can be imposed on residents and businesses for their use of utilities and other public enterprises such as transit fares, water charges, sewer charges, and parking fees.

User fees and charges such as water and sewer fees can be used as the dedicated revenue sourceto secure revenue bonds. Water and sewer services provide a useful basis for user fees because every property owner pays for their use and the fees can be made to relate to the scale of a building or facility that reflect the

benefits received or the costs imposed. Some municipalities are piloting stormwater feesthat are tied to the area of impervious surfaces that generate runoff, which provides an incentive for property owners to invest in reducing runoff.

User fees are voluntary (i.e., paid by choice) and fair in terms of those who directly consume and directly benefit. However, infrastructure projects can generate positive externalities, so others may indirectly benefit without having to incur the costs. Furthermore, reliance on certain services or over utilization of services by lower income residents may pose equity challenges for using fees. Fees based on water and sewer usage are attractive relative to property taxes because of the prevalence of property tax exemptions, and there are more legal hurdles and political sensitivities to raising property taxes.

Impact Fees

An impact fee is a one-time charge imposed on new businesses or property owners to pay for a share of the costs of new development activities. Impact fees are widely used in many local governments to fund the provision of new public infrastructure during the development process. Local governments in Virginia are authorized to use impact fees to cover costs of roads, streets, and bridges; stormwater collection, retention, detention, treatment, and disposal facilities; flood control facilities; shore protection and enhancement improvements; parks, open space, and recreation areas; and related facilities; schools, libraries and related facilities.[36]

Value Capture: Tax Increment Financing and Special Assessment Districts

Additional revenues to pay debt service for infrastructure project can come from value capture that monetizes the benefits of the infrastructure investment. These value capture options include use of tax increment financing and special assessment districts.

Tax Increment Financing

Tax increment financing (TIF) is a value capture mechanism that earmarks increases in tax revenues to pay for public infrastructure. It allocates a portion of taxes in a certain area or district to finance capital improvements for specific purposes that benefit the district. The property tax is the primary tax used in connection with tax increment financing. The public improvements, such as road or drainage improvements, are expected to cause the property value within the district to rise over time, generating an increase in property taxes. The improvements may also cause a rise in income and/or consumption,

[36] Code of Virginia. Imposition of impact fees. https://law.lis.virginia.gov/vacode/title15.2/chapter22/section15.2-2329/.

generating increased income and/or sales tax revenue. The difference between the existing tax collections in the district and the higher tax collections post-improvement (i.e., the tax increment) is used to cover the debt service for the bond used for the improvement project. In this way, the TIF structure captures previously authorized (but incremental) tax revenue rather than levying new taxes or fees. The local government does not have to impose a new tax but reallocates new revenue from the development to pay for development costs.

TIF is flexible and versatile; eligibility requirements have been broad, allowing it to be used for a wide range of development projects. TIF may be more politically feasible, as it is perceived to promote projects that "pay their own way." However, tax increment financing is a resource-intensive and complicated undertaking, requiring extensive technical, professional and legal expertise.

Special Assessment Districts

With a special assessment district (SAD), property owners within the defined geographic area pay a special property tax assessment to fund a proposed improvement from which they expect to benefit directly. A SAD is flexible in allowing for financing a wide array of infrastructure needs in new development or redevelopment areas. It can be formally established by request of local voters or property owners, generally not requiring voter approval. Special assessments promote economic efficiency and equity along several dimensions such as by matching payments with benefits within a designated geographical area. However, political feasibility may be an issue with special assessments, as they are highly visible to affected property owners. SADs also incur administration and assessment burdens.

In Missouri, cities can utilize tax infrastructure financing and special assessments (such as Neighborhood Improvement Districts or Community Improvement Districts that impose special property or sales taxes) to fund water infrastructure projects specific to that district.[37]

[37] Paying for local infrastructure in a new era of federalism: A state-by-state analysis, by the National League of Cities, 2016. https://www.nlc.org/wp-content/uploads/2016/12/NLC_2016_Infrastructure_Report.pdf

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