APPENDIX D
BENEFITS ANALYSES

TABLE OF CONTENTS

ANNEXES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

BCR	benefit-to-cost ratio
EQ	Environmental Quality
Int	Intermediate
NED	National Economic Development
OSE	Other Social Effects
RED	Regional Economic Development
SLR	sea level rise
Zone AE	Special flood hazard area subject to flooding by the 1 percent annual change flood (100 year flood)
Zone AH	Special flood hazard area subject to shallow flooding or ponding by the 1 percent annual change flood (100 year flood)
Zone AO	Special flood hazard area subject to shallow flooding by the 1 percent annual change flood (100 year flood)

D.1 Introduction

This appendix provides a Table of Effects reflecting the performance of alternatives against federal objectives, guiding principles, the four accounts (National Economic Development [NED], Regional Economic Development [RED], Environmental Quality [EQ], and Other Social Effects [OSE]), the four formulation and evaluation criteria, and the Study objectives. The federal objectives and guiding principles emphasize sustainable economic development, avoiding unwise use of floodplains, and protecting and restoring natural systems, including ecosystems. Additional guiding principles include public safety, social effects, and a watershed approach. Connections between these federal objectives and guiding principles link to study-specific planning objectives and relevant metrics. According to the U.S. Army Corps of Engineers January 5, 2021 Policy Directive, *Comprehensive Documentation of Benefits in Decision Documents*, a satisfactory array of metrics should be represented under all four accounts. Relationships among metrics become clearer through plan formulation iterations as the team advances toward a Tentatively Selected Plan.

Also included in this appendix are the following Technical Memorandums, with referenced sections:

- Section D.3, National Economic Development Benefits Technical Memorandum: Documents analysis to generate total benefits, net benefits, and benefit-to-cost ratio (BCR) using the NED economic analysis tool, based on total avoided equivalent annual damages and transportation travel time and operations savings. The HEC-FDA modeling results, which generate the total avoided equivalent annual damages, are provided in **Annex D-1**.
- Section D.4, National Economic Development Benefits Transportation Modeling Technical Memorandum, Part A: Details analysis performed using the Southeast Florida Regional Planning Model to evaluate travel time savings across the final alternatives.
- Section D.5, National Economic Development Benefits Transportation Modeling Technical Memorandum, Part B: Documents analysis using the transportation benefits analysis tool to assess travel time and operations savings from Southeast Florida Regional Planning Model results.
- Section D.6, Regional Economic Development Benefits Business Interruption Technical Memorandum: Describes analysis generating Business Interruption and Direct Output Loss for the final alternatives via the HAZUS standardized risk assessment tool.
- Section D.7, Regional Economic Development Benefits Temporary Displacement Technical Memorandum: Details calculation of total temporary displacement for the final alternatives through the temporary displacement analysis tool.
- Section D.8, Regional Economic Development Benefits IMPLAN Technical Memorandum: Documents regional economic impact analysis related to temporary displacement days, cost savings, and benefits from construction and operations of the final alternatives using IMPLAN modeling.
- Section D.9, Environmental Quality and Other Social Effects Benefits Technical Memorandum: Details analysis calculating flood values for septic tanks and cultural resource sites/buildings for the final alternatives using respective tools.

D.2 Tables of Effects

Table D.2-1 through **Table D.2-4** provide a summary of the benefits results analyses for the NED, RED, EQ, and OSE accounts.

Table D.2-1. National Economic Development Benefits Results.

Planning Objective	**Enhance C&SF Project water control structures' functionality and capacity to reduce flood damages and improve resiliency caused by inundation and changed conditions within the Study Area over the 50-year period of analysis of 2035–2085.**															
Federal Objectives & Policy Requirements of the Region	**Maximize Sustainable Economic Development**															
Guiding Principles	**Sustainable Economic Development**															
P&G Accounts	**NED**															
Formulation & Evaluation Criteria	**Effectiveness**								**Efficiency**							
Metrics	**Total Avoided Equivalent Annual Damages, January 2025 ($1,000,000)**			**Travel Time/Operations Savings NPV ($1,000,000) 2 year coastal, 25 year rainfall (0.033)**	**Total Benefits (Nominal Results, values escalated to account for inflation, Millions)**				**Net Benefits ($1,000,000)**				**BCR**			
	Low SLR	**Int SLR**	**High SLR**	**Int SLR**	**Low SLR**	**Int SLR**	**Int SLR (+ Transportation Benefits)**	**High SLR**	**Low SLR**	**Int SLR**	**Int SLR (+ Transportation Benefits)**	**High SLR**	**Low SLR**	**Int SLR**	**Int SLR (+ Transportation Benefits)**	**High SLR**
No Action Alternative	--	--	--	--	--	--		--	--	--		--	--	--		--
Alternative A	$33.6	$34.8	$66.7	$121.1	$1,815.0	$1,847.0	$2,195.0	$2,611.0	$482	$514	$863	$1,278	1.36	1.39	1.65	1.96
Alternative B	$34.8	$37.1	$74.7	$111.0	$1,855.0	$1,912.0	$2,221.0	$2,815.0	-$363)	-$307	$3	$597	0.84	0.86	1.00	1.27
Alternative C	$36.5	$38.5	$78.4	$108.1	$1,965.0	$2,014.0	$2,314.0	$2,973.0	-$1,945	-$1,896	-$1,596	-$937	0.50	0.52	0.59	0.76
Alternative RO	$35.2	$31.8	$66.5	$248.8	$1,922.0	$1,840.0	$2,630.0	$2,675.0	-$359	-$440	$350	$394	0.84	0.81	1.15	1.17

Notes for Tables D.2-1 through D.2-4: Where provided, dollar amounts are in millions, 2025 dollars. NED = National Economic Development. BCR = benefit-to-cost ratio. Int = intermediate. SLR = sea level rise. RO = Resilience Optimized

Table D.2-2. Regional Economic Development Benefits Results.

Planning Objective	**Enhance C&SF Project water control structures' functionality and capacity to reduce flood damages and improve resiliency caused by inundation and changed conditions within the Study Area over the 50-year period of analysis of 2035–2085.**
Federal Objectives & Policy Requirements of the Region	**Maximize Sustainable Economic Development**
Guiding Principles	**Sustainable Economic Development**
P&G Accounts	**RED**
Formulation & Evaluation Criteria	**Effectiveness**

Metrics	Business Interruption Annualized Direct Output Loss, 2025 (Millions)		Business Interruption Regional Economic Impacts Savings, High Sea Level Rise				Temporary Displacement, Annualized Value of Total Displacement Days (Millions)						Temporary Displacement Regional Economic Impacts, Indirect and Induced Savings (Direct and Secondary Benefits)								Construction				Operations			
			Total Jobs (Full-time Equivalent)	Total Labor Income (Millions)	Total Value Added (Millions)	Total Output (Millions)	2 year coastal, 25 year rainfall (0.033)		2 year coastal, 100 year rainfall (0.009)		100 year coastal, 100 year rainfall (0.002)		Total Job Losses (Full-time Equivalent)		Total Labor Income (Millions)		Total Value Added (Millions)		Total Output (Millions)		Total Jobs (Full-time Equivalent)	Total Labor Income (Millions)	Total Value Added (Millions)	Total Output (Millions)	Direct Jobs (Full-time Equivalent)	Total Labor Income (Millions)	Total Value Added (Millions)	Total Output (Millions)
	Int SLR	High SLR					Int SLR	High SLR	Int SLR	High SLR	Int SLR	High SLR	Int SLR	High SLR	Int SLR	High SLR	Int SLR	High SLR	Int SLR	High SLR								
No Action Alternative	$2.6	$5.9	--	--	--	--	$6.1	$8.4	$4.9	$6.6	$1.3	$2.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Alternative A	$2.3	$3.5	40	$2.6	$3.0	$4.3	$5.3	$6.2	$4.2	$5.1	$1.2	$1.8	12	32	$0.7	$2.2	$1.5	$4.5	$2.1	$6.4	739	$50.7	$84.6	$143.3	10	$0.7	$1.2	$2.3
Alternative B	$2.1	$2.9	51	$3.3	$3.8	$5.4	$5.2	$5.9	$4.2	$4.8	$1.1	$1.7	13	38	$0.9	$2.5	$1.8	$5.2	$2.6	$7.5	1,234	$84.7	$141.2	$239.0	19	$1.3	$2.3	$4.3
Alternative C	$2.0	$3.0	51	$3.2	$3.8	$5.4	$5.1	$5.6	$4.0	$4.6	$1.1	$1.6	15	41	$1.0	$2.8	$2.1	$5.8	$3.0	$8.3	2,051	$140.7	$234.8	$397.5	37	$2.5	$4.5	$8.4
Alternative RO	$2.2	$3.9	32	$2.1	$2.4	$3.3	$5.3	$6.1	$4.2	$5.1	$1.2	$1.9	32	40	$0.8	$2.2	$1.6	$4.5	$2.3	$6.5	1,274	$87.4	$145.8	$246.8	18	$1.2	$2.2	$4.1

Int = intermediate. SLR = sea level rise.

Table D.2-3. Regional Economic Development Benefits Results: National Flood Insurance Program Perspective

Metrics	National Flood Insurance Program Perspective: Structures with Flood Values, AO, AE, AH Flood Zones																	
	2 yr coastal, 25 yr rainfall (0.033)						2 yr coastal, 100 yr rainfall (0.009)						100 yr coastal, 100 yr rainfall (0.002)					
	Zone AO Int SLR	Zone AO High SLR	Zone AE Int SLR	Zone AE High SLR	Zone AH Int SLR	Zone AH High SLR	Zone AO Int SLR	Zone AO High SLR	Zone AE Int SLR	Zone AE High SLR	Zone AH Int SLR	Zone AH High SLR	Zone AO Int SLR	Zone AO High SLR	Zone AE Int SLR	Zone AE High SLR	Zone AH Int SLR	Zone AH High SLR
No Action Alternative	1	1	129	482	484	552	11	11	519	1267	1197	1435	11	11	709	2733	1250	1718
Alternative A	1	1	112	217	422	463	11	11	409	728	1074	1232	11	11	663	1768	1110	1436
Alternative B	1	1	106	187	419	460	11	11	383	638	1054	1178	11	11	453	1603	1082	1346
Alternative C	1	1	115	188	397	445	11	11	370	604	1006	1122	11	11	438	1593	1026	1214
Alternative RO	1	1	114	234	427	463	11	11	429	823	1060	1177	11	11	621	2134	1132	1360

Table D.2-3. Regional Economic Development Benefits Results: Septic Tank Flood Values and Wellfield Effects.

Metrics	T&E Species Risk	Number of Septic Tanks with Flood Values (Int/High SLR)						Headwater Stage Management with Indirect Benefits to Wellfields (Least Capacity =1, Greatest Capacity =5)
		2 year coastal, 25 year rainfall (0.033)		2 year coastal, 100 year rainfall (0.09)		100 year coastal, 100 year rainfall (0.002)		
		Int SLR	High SLR	Int SLR	High SLR	Int SLR	High SLR	
No Action Alternative	No Direct Effects	7,854	8,071	9,312	9,550	9,368	9,713	1
Alternative A	No Direct Effects	7,769	7,860	9,153	9,323	9,200	9,442	2
Alternative B	No Direct Effects	7,762	7,835	9,143	9,289	9,160	9,421	4
Alternative C	No Direct Effects	7,732	7,798	9,096	9,234	9,112	9,350	5
Alternative RO	No Direct Effects	7,761	7,856	9,152	9,282	9,232	9,449	3

Table D.2-4. Environmental Quality, Other Social Effects, and Watershed Approach Benefits Results.

Planning Objective	Enhance C&SF Project water control structures' functionality and capacity to reduce flood damages and improve resiliency caused by inundation and changed conditions within the Study Area over the 50-year period of analysis of 2035–2085.																		
Federal Objectives & Policy Requirements of the Region	**Protect and Restore the Functions of Natural Ecosystems**						**Maximize Sustainable Economic Development**						**Protect and Restore the Functions of Natural Ecosystems**						
Guiding Principles	**Healthy and Resilient Ecosystems**						**Public Safety**						**Healthy and Resilient Ecosystems**						**Watershed Approach**
P&G Accounts	**EQ**						**OSE**						**OSE**						**OSE**
Formulation & Evaluation Criteria	**Effectiveness**						**Completeness**						**Effectiveness**						**Acceptability**
	Reduction in Risk to Sanitary Sewer Overflow Occurrences						**Critical Infrastructure (Number of Flooded Structures, Int/High SLR)**						**Cultural Resources Sites with Flood Values (Int/High SLR)**						
	2 year coastal, 25 year rainfall (0.033)		**2 year coastal, 100 year rainfall (0.009)**		**100 year coastal, 100 year rainfall (0.002)**		**2 year coastal, 25 year rainfall (0.033)**		**2 year coastal, 100 year rainfall (0.009)**		**100 year coastal, 100 year rainfall (0.002)**		**2 year coastal, 25 year rainfall (0.033)**		**2 year coastal, 100 year rainfall (0.009)**		**100 year coastal, 100 year rainfall (0.002)**		
Metrics	**Int SLR**	**High SLR**	**Int SLR**	**High SLR**	**Int SLR**	**High SLR**	**Int SLR**	**High SLR**	**Int SLR**	**High SLR**	**Int SLR**	**High SLR**	**Int SLR**	**High SLR**	**Int SLR**	**High SLR**	**Int SLR**	**High SLR**	**Maintains integrity across sub basins**
No Action Alternative	--	--	--	--	--	--	4	5	10	15	12	26	104	106	116	119	116	121	Diminished conditions in upstream watersheds.
Alternative A	2%	2%	2%	3%	2%	5%	4	4	8	13	11	19	105	106	116	118	116	118	Least engineering complexity to reduce flooding in upstream watersheds; minimal tradeoffs in downstream watersheds.
Alternative B	2%	2%	2%	3%	2%	5%	4	4	8	13	10	18	104	106	116	117	117	119	Moderate engineering complexity to reduce flooding in upstream watersheds; moderate tradeoffs in upstream and downstream watersheds.
Alternative C	2%	2%	2%	4%	2%	6%	4	4	8	13	9	16	102	103	113	115	113	117	Greatest engineering complexity to reduce flooding in upstream watersheds with enhanced drawdown potential; highest potential tradeoffs in upstream and downstream watersheds.
Alternative RO	2%	2%	2%	3%	2%	5%	4	4	9	14	11	21	105	105	115	116	116	117	Moderate engineering complexity to reduce flooding in upstream watersheds; moderate tradeoffs in upstream and downstream watersheds.

EQ = Environmental Quality; OSE = Other Social Effects; Int = intermediate; SLR = sea level rise

D.3 National Economic Development Benefits Technical Memorandum

Prepared for:	South Florida Water Management District
Prepared by:	J-Tech, an Alliance between Jacobs Engineering and Tetra Tech, Inc.
Date:	October 24, 2025
Subject:	C&SF Flood Resiliency (Section 203) Study for Broward Basins NED Analysis

DRAFT

1 Purpose:

This memo outlines the national economic development (NED) analysis, carried out as part of the South Florida Water Management District's (SFWMD) Central and Southern Florida (C&SF) Flood Resiliency (Section 203) Study for Broward Basins (203 Study). The analysis was carried out in compliance with applicable U.S. federal guidelines, including the 1983 Principles and Guidelines (P&G) (42 U.S.C. 1962a-2), designed to guide the formulation and evaluation of major Federal water resources development agencies, including the U.S Army Corps of Engineers, in accordance with section 103 of the Water Resources Planning Act; and the 2013 Principles, Requirements, and Guidelines (PR&G) including the Principles and Requirements for Federal Investments in Water Resources issued by the Council on Environmental Quality and approved by the Water Resources Council, the Interagency Guidelines for implementing the Principles and Requirements, and the Corps of Engineers Agency Specific Procedures to Implement the Principles, Requirements, and Guidelines.

This Section 203 Study focuses on enhancing the resiliency of the water control structures and adjacent primary canals in Broward Basins Reach A, a reach of the ongoing USACE C&SF Section 216 Study. Broward Basins Reach A is referred to herein as the Section 203 Study Area (or Study Area).

2 Summary of Results:

The final array of alternatives that were included in the economic analysis include three alternatives (denoted as A, B, and C), as well as an optimized version of Alternative C. The three alternatives include increasingly complex infrastructure investments, including primary structure modifications, primary Central and Southern Florida (C&SF) Project Canal improvements, and storage and nature-based projects, and therefore each show increasing costs. Alternative A includes the least number of features and a lower cost, Alternative B adds complexity and project features, and Alternative C includes the most projects and is therefore expected to be most expensive. Alternative C1 builds on Alternative C to evaluate whether additional risk management measures, including nonstructural features, could enhance overall benefits and provide a cost-effective flood risk management approach. Project alternatives allow for an assessment of which drainage areas are improved most by the additional cost and complexity. Results for the three alternatives and the optimized version of Alternative C are summarized below in Table 1.

The best projects for each drainage area are carried forward into the tentatively selected plan (TSP). Economic analysis of the TSP is also added to this memo, as summarized in Table 1.

Total costs and benefits of the project alternatives were evaluated in current dollars on a net present value basis, accounting for the expected impacts of inflation. Costs were estimated to include both design and capital construction costs over an 8--year period from 2027 to 2034, and operations and maintenance costs over the 50-year evaluation period starting in 2035. Flood damage reduction estimates for structures, roadways, and vehicles in the study area are included as project benefits, based on HEC-FDA modeling results. Uncertainty around future flooding scenarios is represented in the HEC-FDA results through a low, intermediate, and high sea level rise scenario for the 2085 future condition. Transportation benefits are also included in the analysis for the intermediate sea level rise scenario only. All costs and benefits are entered into the model in 2025 dollars and adjusted for expected escalation over time. BCA results are evaluated in net present value terms for a base year 2035, the estimated first year of project operation. This analysis conforms to the methodologies set forth in the USACE Principles and Guidelines and other federal guidelines regarding benefit cost analysis. Individual assumptions and approaches are discussed in more detail in the sections that follow.

Analysis results for Alternative A, Alternative B, Alternative C, and Alternative C, Optimized are summarized in Table 1. Alternative A is found to have a benefit to cost ratio over 1, indicating cost effectiveness, under all sea level rise scenarios. Alternative B is only cost effective under the intermediate and high sea level rise scenarios. Alternative C is not cost effective under any of the sea level rise scenarios. The TSP is estimated to be cost effective under the intermediate and high sea level rise scenarios.

Table 1. Summary of NED Analysis for Final Array of Alternatives--Net Present Value Results (net present value, in millions)

		Sea Level Rise Scenario			
Alternative	**Benefit-Cost Calculation**	**Low SLR**	**Intermediate SLR**	**Intermediate SLR (including Transportation benefits)**	**High SLR**
Alternative A	Total Benefits	$1,918	$1,953	$2,324	$2,779
	Total Costs	$1,294	$1,294	$1,294	$1,294
	BCR	1.48	1.51	1.80	2.15
	Net Benefits	$624	$659	$1,030	$1,485
Alternative B	Total Benefits	$1,962	$2,022	$2,352	$2,999
	Total Costs	$2,151	$2,151	$2,151	$2,151
	BCR	0.91	0.94	1.09	1.39
	Net Benefits	-$189	-$128	$201	$848
Alternative C	Total Benefits	$2,077	$2,131	$2,449	$3,167
	Total Costs	$3,759	$3,759	$3,759	$3,759
	BCR	0.55	0.57	0.65	0.84
	Net Benefits	-$1,683	-$1,629	-$1,311	-$593
Alternative C, Optimized	Total Benefits	$2,929	$2,990	$3,308	$4,180
	Total Costs	$3,759	$3,759	$3,759	$3,759
	BCR	0.78	0.80	0.88	1.11
	Net Benefits	-$831	-$769	-$451	$421
TSP	Total Benefits	$2,031	$1,943	$2,789	$2,845
	Total Costs	$2,277	$2,277	$2,277	$2,277
	BCR	0.89	0.85	1.23	1.25
	Net Benefits	-$246	-$334	$512	$568

3 Economic Analysis

This analysis evaluates the costs and benefits of the alternative plans, Alternative A, Alternative B, and Alternative C, and an optimized version of Alternative C for resiliency improvements to the existing infrastructure of the Central and Southern Florida (C&SF) Project. These are defined as the final array of project alternatives, in addition to the TSP. The project timeline includes a 8-year design and construction period from 2027 to 2034 and a 50-year period of analysis from the beginning of 2035 to the beginning of 2085. In keeping with the nominal federal discount rate, costs and benefits are all considered in current or nominal dollars, and escalated as appropriate. The net present value of the stream of future costs and benefits is calculated using a 3.0% discount rate, determined by the Bureau of Reclamation for use by Federal agencies in the formulation and evaluation of plans for water and related land resources for the 2025 fiscal year (through September 30, 2025), as required by the Water Resources Planning Act of 1965 and the Water Resources Development Act of 1974 and announced in the Federal Register on December 12, 2024 (89 FR 100533 Federal Register :: Change in Discount Rate for Water Resources Planning).

3.1 Final Array of Alternatives

The final array of alternatives includes Alternative A, Alternative B, and Alternative C, as well as an optimized version of Alternative C. Alternatives A, B, and C increase in complexity and number of projects included. Alternative C adds additional risk management measures, including nonstructural features, assuming elevation and dry floodproofing are implemented for residential and non-residential buildings. Assumptions around the costs and benefits used to evaluate the final array of alternatives are described in the following sections. The TSP, based on the best projects for each drainage area, was also analyzed, with results presented along with the final array of alternatives.

3.1.1 Costs

3.1.1.1 Capital Costs

Project capital costs are based on rough order of magnitude (ROM) construction cost estimates completed for each of the project alternatives by water resource engineers on the JTech team. These costs are summarized below in Table 2. Construction costs are assumed to be spread evenly over the 6-year construction period from 2029 to 2034. The alternatives range in cost from less infrastructure-intensive to more infrastructure-intensive. Construction costs are escalated according to the USACE Civil Works Construction Cost Index System (CWCCIS) (USACE 2024). Although the three construction elements most closely related to the C&SF Flood Resiliency Project include channels and canals; levees and floodwalls; and floodway control and diversion structures, the composite CWCCIS index is used to estimate construction cost increases over time. The index uses an increase of 2.6% for all future years.

Table 2. Construction Costs—Final Array (1000s 2025 dollars, rounded to the nearest 100)

Cost Element	Alt A	Alt B	Alt C	Alt C, Optimized	TSP
Flood Risk Management Improvements to Coastal Structures and Non-coastal Structure S37B:					
G56 Improvements	$9,600	$77,100	$288,200	$288,200	$77,100
G57 Improvements	$45,700	$67,300	$141,600	$141,600	$67,300
S37B Improvements	$0	$42,300	$0	$0	$35,300
S37A Improvements	$292,500	$298,500	$292,500	$292,500	$285,000
S36 Improvements	$28,700	$153,000	$177,000	$177,000	$131,900
S33 Improvements	$151,900	$163,000	$198,100	$198,100	$163,000
G54 Improvements	$8,300	$51,400	$224,700	$224,700	$193,100
S13 Improvements	$197,800	$257,700	$303,600	$303,600	$267,400

Other Flood Risk Management Improvements:					
G-08 Canal	$0	$36,900	$36,900	$36,900	$36,900
C-14 Canal (in C-14 West Watershed)	$0	$5,700	$5,700	$5,700	$5,700
C-14 Canal (in C-14 East Watershed) -From DS side of S37B to 300' US of S37A	$0	$0	$48,000	$48,000	$0
C-14 Canal (in C-14 East Watershed) -From 300' DS of S37A to End of Canal Excav.	$0	$0	$19,400	$19,400	$0
C-13 Canal (in C-13 West Watershed)	$0	$0	$18,700	$18,700	$0
C-13 Canal (in C-13 East Watershed) -From End of S36 Project to NW 21st Ave	$0	$0	$4,000	$4,000	$0
C-13 Canal (in C-13 East Watershed) -From NW 21st Ave to End of Canal Excav.	$0	$0	$7,400	$7,400	$0
C-12 Canal (in C-12 West Watershed)	$0	$0	$3,200	$3,200	$0
G-15 Canal	$0	$0	$63,200	$63,200	$0
C-11 Canal (in C-11 West and East Watersheds)	$0	$37,300	$37,300	$37,300	$37,300
Stormwater storage improvements					
Stormwater Storage Capacity Improvement No. 1 (Markham Park)	$0	$36,000	$36,000	$36,000	$0
Stormwater Storage Capacity Improvement No. 2 (Hillsboro Watershed)	$0	$0	$133,400	$133,400	$0
Upstream Nonstructural Costs (elevation and dry floodproofing)	$0	$0	$0	$145,500	$0
Downstream Canal Stage Monitoring Stations (6 New Stations)	$0	$0	$0	$0	$3,300
Total Construction Costs	$734,500	$1,226,100	$2,038,900	$2,184,400	$1,303,300

Real estate costs were also considered under capital costs. Cost to acquire necessary rights-of-way, as well as temporary and permanent easements were estimated for each project alternative, as summarized in Table 3. Real estate costs are assumed to all take place in 2028. It is assumed that real estate costs escalate over time at the same rate as inflation, therefore real cost escalation is zero.

Table 3. Real Estate Costs—Final Array (1000s 2025 dollars, rounded to the nearest 100)

Cost Element	Alt A	Alt B	Alt C	Alt C, Optimized	TSP
SFWMD's Cost to Acquire Perpetual Easements:	$4,300	$3,100	$123,800	$123,800	$6,100
SFWMD's Cost to Acquire Fee Estates:	$20,100	$20,100	$20,100	$20,100	$20,100
SFWMD's Cost to Acquire Temporary Easements:	$1,000	$1,500	$1,400	$1,400	$1,700
Total Real Estate Costs	**$25,400**	**$24,700**	**$145,400**	**$145,400**	**$27,900**

Table 4 summarizes total capital costs of the project alternatives including construction, construction management, design, and real estate costs. Construction management and design costs are estimated as 7.5% and 12% of the total construction costs respectively, (not including nonstructural elements).

Table 4. Total Capital Costs—Final Array (1000s 2025 dollars, rounded to the nearest 100)

Cost Element	Alt A	Alt B	Alt C	Alt C, Optimized	TSP
Construction Costs	$734,500	$1,226,100	$2,038,900	$2,184,400	$1,303,300
Construction Management	$88,100	$147,100	$244,700	$244,700	$156,400
Design	$55,100	$92,000	$152,900	$152,900	$97,700
Real Estate Costs	$25,400	$24,700	$145,400	$145,400	$27,900
Total Capital Costs	**$903,200**	**$1,489,800**	**$2,581,900**	**$2,727,400**	**$1,585,400**

3.1.1.2 Operations and Maintenance Costs

Annual operations and maintenance costs were estimated for the future without project (FWOP) and all project alternatives based on 2010 O&M costs. Costs were escalated to 2025 dollars (Q1) using the GDP Implicit Price Deflator quarterly data (US Bureau of Economic Analysis 2025). Annual O&M costs are included in the analysis for the 50-year analysis period, assuming that operations begin in 2035. It is assumed that O&M costs will increase over the analysis period at the same rate as inflation.

Table 5. Annual Operations and Maintenance Costs—Final Array (1000s, rounded to the nearest 100)

	FWOP	Alt A	Alt B	Alt C	Alt C, Optimized	TSP
O&M Costs (2010 dollars)	$1,100	$2,100	$2,800	$4,500	$4,500	$2,800
Net O&M Costs (2010 dollars)		$900	$1,700	$3,400	$3,400	$1,700
Net O&M Costs (2025 Q1 dollars)		$1,300	$2,500	$4,800	$4,800	$2,400

3.1.2 Benefits

The main NED benefits of the project are reduced flood damages within the study area. Reduced damages to structures, roadways, and vehicles were modeled using HEC-FDA software and integrated into the NED analysis. Transportation benefits in the form of travel time savings and vehicle operating cost savings were modeled in a dedicated transportation analysis and integrated into the NED analysis for the intermediate sea level rise scenario only.

3.1.2.1 Flood Damage Reduction Benefits

Flood damage reduction benefits were estimated using HEC-FDA software. Refer to the HEC-FDA Technical Memo, Annex D-1, for detail on how that analysis was carried out. Expected annual damages avoided were calculated for 2035, the start of project operations, and for 2085, the end of the analysis period, for a low, intermediate, and high sea level rise scenario. Structure damage estimates were refined to ensure compliance with 33 U.S. Code §2318 (Floodplain Management) by excluding structures constructed after 1991 that are not compliant with the effective FEMA Base Flood Elevation. This resulted in 491 structures being omitted from the damage calculations. Structure and road damages were originally estimated in HEC-FDA in January 2021 dollars. Vehicle damages were originally estimated in January 2024 dollars. All values are converted to 2025 Q1 dollars using the GDP Implicit Price Deflator quarterly data (US Bureau of Economic Analysis 2025) for entry into the model. Expected annual damages are interpolated for the years between 2035 and 2085 using a straight-line interpolation. It is assumed that the value of avoided flood damages escalates over time at the same rate as overall inflation over the analysis period.

Table 6 summarizes expected annual avoided damages for 2035 and 2085 for all project alternatives, across the low, intermediate, and high sea level rise future conditions.

Table 6. HEC-FDA Estimates of Expected Annual Damages Avoided—Final Array (1000s real 2025 dollars, rounded to the nearest 100)

Alternative	Damage Category	2035	2085 Low SLR	2085 Intermediate SLR	2085 High SLR
Alternative A	Structures	$27,600	$26,300	$27,200	$51,900
Alternative A	Road Base	$6,100	$5,500	$6,000	$11,300
Alternative A	Vehicles	$1,700	$1,800	$1,600	$3,500

Alternative B	Structures	$27,900	$27,300	$29,000	$57,100
Alternative B	Road Base	$6,100	$5,700	$6,400	$13,500
Alternative B	Vehicles	$1,700	$1,800	$1,700	$4,100
Alternative C	Structures	$29,900	$28,600	$30,000	$60,800
Alternative C	Road Base	$6,500	$6,000	$6,700	$13,500
Alternative C	Vehicles	$1,800	$1,900	$1,800	$4,100
Alternative C, Optimized	Structures	$45,300	$43,800	$45,500	$82,200
Alternative C, Optimized	Road Base	$6,500	$6,000	$6,700	$13,500
Alternative C, Optimized	Vehicles	$1,800	$1,900	$1,800	$4,100
TSP	Structures	$29,600	$27,300	$24,500	$51,300
TSP	Road Base	$6,400	$6,000	$5,800	$11,800
TSP	Vehicles	$1,700	$1,900	$1,500	$3,400

3.1.2.2 Transportation Benefits

Transportation benefits were estimated based on a dedicated traffic analysis and results integrated into the NED analysis. Refer to the Transportation Benefits Technical Memo in Sections D.4 and D.5 for a detailed summary of that analysis. Transportation benefits were estimated based on travel time savings and vehicle operations cost savings associated with avoided flooding and evacuation of the study area. Estimates of transportation benefits were modeled based on expected flooding under future conditions in 2035 and 2085 under the intermediate sea level rise scenario. Results were interpolated for the intermediate years on a linear basis to arrive at benefits estimates for each year of the analysis period from 2035 to 2085 in real 2025 dollars. The Transportation Benefits Technical Memo in Sections D.4 and D.5 provides more details on the modeled results and interpolation of benefits estimates. It is assumed that these benefits escalate over time at the same rate as inflation over the analysis period.

Note that transportation benefits were estimated only for the intermediate sea level rise future condition.

3.1.3 Results

The net present value of the future stream of costs and benefits of the project is calculated using a 3.0% discount rate, set forth in the Federal Register for use by Federal agencies in the formulation and evaluation of plans for water and related land resources for the 2025 fiscal year (through September 30, 2025), and announced in the Federal Register on December 12, 2024 (89 FR 100533).

The net present value of project benefits are summarized in Table 7 for each alternative, sea level rise scenario and benefit category. Note that transportation benefits were only modeled for the intermediate sea level rise scenario. Transportation benefits were not calculated for the TSP.

Table 7. Summary of Project Benefits—Final Array (millions, net present value)

		Sea Level Rise Scenario		
Alternative	**Benefit Category**	**Low SLR**	**Intermediate SLR (including Transportation benefits)**	**High SLR**
Alternative A	Structures/Contents	$1,503	$1,527	$2,168
	Roads	$322	$337	$472
	Vehicles	$93	$90	$138
	Transportation		$371	
	Total Benefits	**$1,918**	**$2,324**	**$2,779**
Alternative B	Structures/Contents	$1,537	$1,581	$2,310
	Roads	$330	$348	$534
	Vehicles	$95	$94	$155
	Transportation		$329	
	Total Benefits	**$1,962**	**$2,352**	**$2,999**
Alternative C	Structures/Contents	$1,630	$1,666	$2,466
	Roads	$347	$367	$544
	Vehicles	$99	$97	$157
	Transportation		$318	
	Total Benefits	**$2,077**	**$2,449**	**$3,167**
Alternative C, Optimized	Structures/Contents	$2,482	$2,526	$3,480
	Roads	$347	$367	$544
	Vehicles	$99	$97	$157
	Transportation		$318	
	Total Benefits	**$2,929**	**$3,308**	**$4,180**
TSP	Structures/Contents	$1,588	$1,515	$2,212
	Roads	$345	$339	$495
	Vehicles	$98	$89	$138
	Transportation		$846	
	Total Benefits	**$2,031**	**$2,789**	**$2,845**

Dividing the net present value of project benefits by the net present value of project costs yields the benefit-to-cost ratio (BCR), which determines cost effectiveness of the project alternative. Subtracting the net present value of costs from the net present value of benefits yields the project alternative's net benefits.

NED analysis results show that Alternative A is estimated to be cost effective under all sea level rise scenarios. Alternative A has the greatest net benefit among project alternatives. Alternative B is cost effective only under the intermediate and high sea level rise scenarios. Alternative C is not cost effective under any of the sea level rise scenarios. The TSP has a BCR above 1 for the intermediate and high sea level rise scenarios.

Table 8 summarizes results of the NED analysis. Note that transportation benefits were only estimated for the intermediate sea level rise scenario.

Table 8. Summary of NED Analysis Net Present Value Results—Final Array (net present value, in millions)

		Sea Level Rise Scenario			
Alternative	**Benefit-Cost Calculation**	**Low SLR**	**Intermediate SLR**	**Intermediate SLR (including Transportation benefits)**	**High SLR**
Alternative A	Total Benefits	$1,918	$1,953	$2,324	$2,779
	Total Costs	$1,294	$1,294	$1,294	$1,294
	BCR	1.48	1.51	1.80	2.15
	Net Benefits	$624	$659	$1,030	$1,485
Alternative B	Total Benefits	$1,962	$2,022	$2,352	$2,999
	Total Costs	$2,151	$2,151	$2,151	$2,151
	BCR	0.91	0.94	1.09	1.39
	Net Benefits	-$189	-$128	$201	$848
Alternative C	Total Benefits	$2,077	$2,131	$2,449	$3,167
	Total Costs	$3,759	$3,759	$3,759	$3,759
	BCR	0.55	0.57	0.65	0.84
	Net Benefits	-$1,683	-$1,629	-$1,311	-$593
Alternative C, Optimized	Total Benefits	$2,929	$2,990	$3,308	$4,180
	Total Costs	$3,759	$3,759	$3,759	$3,759
	BCR	0.78	0.80	0.88	1.11
	Net Benefits	-$831	-$769	-$451	$421
TSP	Total Benefits	$2,031	$1,943	$2,789	$2,845
	Total Costs	$2,277	$2,277	$2,277	$2,277
	BCR	0.89	0.85	1.23	1.25
	Net Benefits	-$246	-$334	$512	$568

References

U.S. Army Corps of Engineers. 2024. EM 1110-2-1304. 30 September 2024. CWCCIS Indices 30 September 2024

U.S. Bureau of Economic Analysis, Gross Domestic Product: Implicit Price Deflator [GDPDEF], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/GDPDEF, August 9, 2025.

D.4 National Economic Development Benefits Transportation Benefits Technical Memorandum, Part A

Prepared for:	South Florida Water Management District
Prepared by:	J-Tech, an Alliance between Jacobs Engineering and Tetra Tech, Inc.
Date:	August 2025
Subject:	C&SF Flood Resiliency (Section 203) Study for Broward Basins, Transportation Benefits Modeling Approach

DRAFT

1 Introduction and Purpose

This analysis quantifies the impacts of roadway flooding on travel performance and associated road-user costs. Impacts are measured as changes in Vehicle-Hours Traveled (VHT)—representing additional delay—and Vehicle-Miles Traveled (VMT)—representing additional travel distance—due to flood-related roadway closures.

The methodology integrates hydrologic and topographic data with the Southeast Florida Regional Planning Model (SERPM), a Florida Department of Transportation (FDOT)-approved travel demand model, to simulate network performance under multiple sea-level rise (SLR) and storm event scenarios.

2 Regulatory and Modeling Framework

2.1 Federal Requirements

Under 23 CFR 450.324, Metropolitan Planning Organizations (MPOs) serving urbanized areas with populations over 200,000 are required to update their metropolitan transportation plans using validated, regionally coordinated data (e.g., for travel, land use, population, employment, and congestion). The plans must also include current and projected transportation demand of persons and goods—requirements that logically necessitate robust, validated travel demand modeling. These ensure credible forecasts, coordinated investment planning, and compliance with environmental justice and congestion management requirements.

2.2 Model Selection

SERPM was selected as the analytical tool. It is maintained by the Regional Transportation Technical Advisory Committee – Modeling Subcommittee (RTTAC-MS) under the Southeast Florida Transportation Council (SEFTC), comprising modeling staff from FDOT Districts 4 and 6, the Broward MPO, Miami-Dade TPO, and Palm Beach TPA. This study employed SERPM[1] version 8.543, which at the time represented the most current and reliable release of the model.[2]

[1] SERPM **8.543** (Oct-2024) as maintained under SEFTC/RTTAC-MS; CT-RAMP with five time-period assignments. FDOT Blob Storage

[2] Although SERPM version 9 was issued shortly thereafter, it was subsequently recalled due to identified issues and was therefore not considered suitable for use.

2.3 Geographic Scope

The SERPM coverage area encompasses Miami-Dade, Broward, and Palm Beach Counties, as illustrated in the regional coverage map in **Exhibit** 1. The exhibit further depicts the SERPM highway network, which extends throughout all three counties.

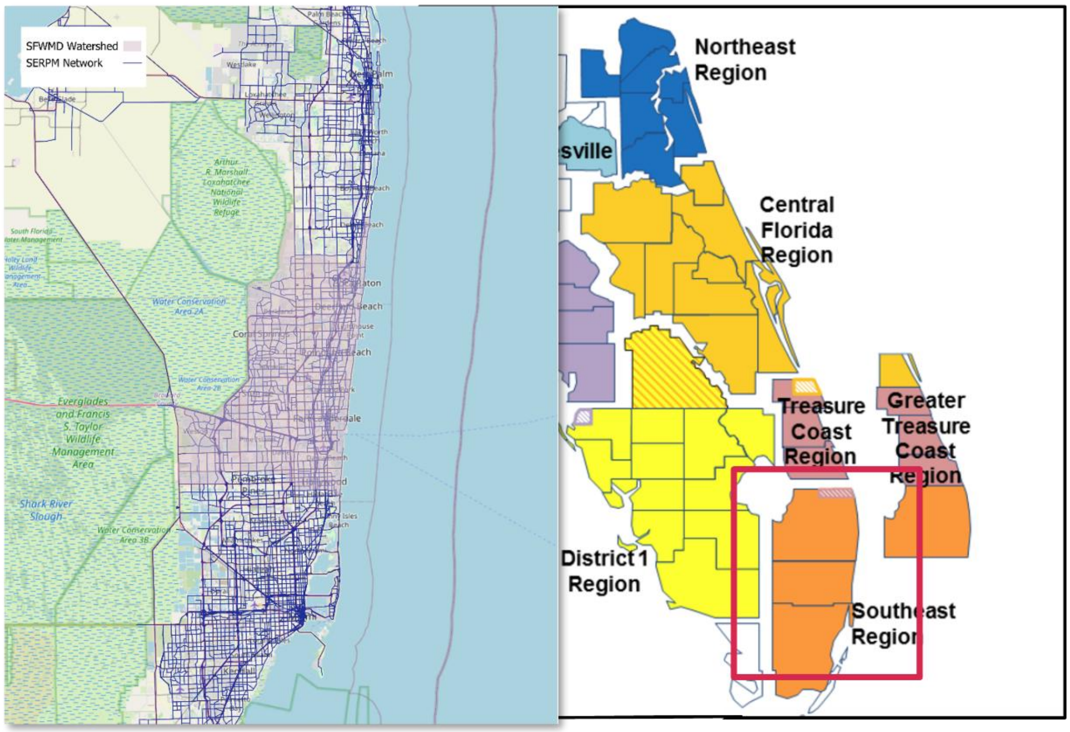


Exhibit 1: SERPM Model Geographic Scope

3 SERPM Model Overview

SERPM is an integrated passenger–freight (multi-modal) activity-based travel demand model with iterative feedback to ensure that network speeds and travel times used in trip-making decisions are consistent with the final assignment results. SERPM is implemented in Citilabs (acquired by Bentley Systems) – Cube®. The model sequence, which is depicted in **Exhibit 2**, includes:

a. Input Data

- Land Use and Other Zonal Data: Provides spatial socio-economic information (population, employment, land use patterns) for generating trips.
- Transportation Networks: Describes the roadway and transit networks, including capacities, speeds, and connectivity.

b. Freight and External Trips

- Truck, Port, EE/EI Trip Generation: Produces trip totals for freight (truck and port-related) and external trips (EE = External–External, EI = External–Internal) based on land use and network data.

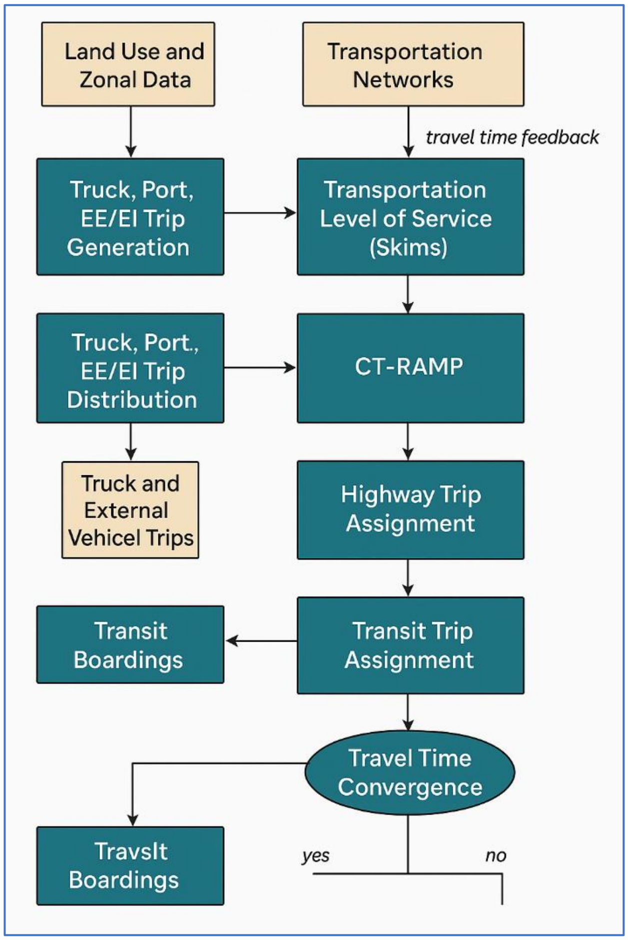
- Transportation Level of Service (Skims): Generates travel time and cost matrices for all modes and purposes, used as input for trip distribution and mode choice.
- Truck, Port, EE/EI Trip Distribution: Allocates freight and external trips between origin and destination zones using the skim data.
- Truck and External Vehicle Trips: Resulting trip tables for freight and external vehicles, which will later be assigned to the network.

c. Passenger Trips

- *Synthetic Population*: A modeled representation of the regional population, including households and individuals with socio-economic attributes.
- *CT-RAMP*: The activity-based passenger travel model (Coordinated Travel – Regional Activity Modeling Platform), which:
    - Generates daily activity patterns.
    - Produces household, person, tour, and trip files.
- *Visitor Model*: Generates trips from tourists and non-resident visitors, producing tour and trip files.

d. Network Assignment

- *Highway Trip Assignment*: Assigns truck, external, CT-RAMP-generated, and visitor trips to the highway network, resulting in highway volumes and speeds.
- *Transit Trip Assignment*: Assigns passenger transit trips to the transit network, producing Transit Boardings.



e. Feedback Loop

After the highway trip assignment, Travel Time Convergence is checked:

- *Yes* → Model run ends with final assignments.
- *No* → Updated travel times feed back into the Transportation Level of Service (Skims) step, and the process iterates until convergence is reached.

Exhibit 2: SERPM Summary Flow Chart

3.1 SERPM Outputs

SERPM 8 generates time-of-day travel demand and traffic assignments across five distinct time periods: **AM peak** (6:00–9:00 AM), **Midday** (9:00 AM–3:00 PM), **PM peak** (3:00–7:00 PM), **Evening** (7:00 PM–10:00 PM)**,** and **Night** (10:00 PM–6:00 AM). These periods represent the temporal distribution of daily travel activity and are used to allocate trips from the activity-based model into appropriately time-stamped demand matrices.

Each time period is assigned a unique set of skims and highway assignments to reflect congestion and travel conditions specific to that interval. To produce daily metrics—such as total vehicle miles traveled (VMT) and vehicle hours traveled (VHT)—the model aggregates the results across all five periods, ensuring that outputs account for diurnal variation in network performance and travel patterns.

3.2 SERPM Highway Network Characteristics

The SERPM highway network classifies all roadway links using **the Facility Type Class 1 (FTC1)** system, which provides a broad categorization of facilities consistent with standard roadway hierarchies. FTC1 identifies links as freeways, principal arterials, minor arterials, collectors, or local roads, and this classification is used in reporting, network summaries, and post-processing of model outputs such as vehicle miles traveled (VMT) and vehicle hours traveled (VHT). These categories provide an interpretable framework for understanding travel patterns and system performance at a regional scale.

In addition to FTC1, the model also employs a **Facility Type Class 2 (FTC2)** coding, which is a more detailed classification used internally during traffic assignment. FTC2 sub-divides the broad FTC1 categories to assign facility-specific capacities, volume–delay function parameters, and adjustments for features such as managed lanes, toll roads, ramps, and auxiliary lanes.

In practice, FTC1 supports communication and summary-level analysis, while FTC2 provides the operational detail necessary for accurate highway assignment and network performance modeling**.** **Exhibit 3** summarizes the differences between this facility-type attributes.

FTC1 (General Category)	FTC2 Subcategories (Detailed)	Use in SERPM
Freeway	Freeway - General Purpose, Managed/Toll Lanes, Ramps, Expressways	Broad reporting category; FTC2 used for assignment with lane, toll, and auxiliary lane adjustments
Principal Arterial	Principal Arterial - Divided, Undivided, Toll Arterials	FTC2 distinguishes major urban vs rural arterials and toll variations; used in capacity lookup
Minor Arterial	Minor Arterial - Divided, Undivided	FTC2 provides finer-grained arterial coding for speeds and capacity
Collector	Major Collector, Minor Collector	FTC2 refines collector coding for suburban vs rural conditions
Local	Local Street (Urban or Rural)	No major FTC2 subdivisions; mostly input for connectivity

Exhibit 3: Roadway Classification - Facility Types in SERPM

4 Highway Network Enhancement

The SERPM base network lacks elevation attributes for roadway links, making it inherently flat. Without correcting for this limitation, flood-depth calculations would have been inaccurate.

4.1 Elevation Data Source and Accuracy

Elevation information was retrieved from the Florida Geographic Data Library (FGDL). The two-foot contour polygon-based dataset was sourced by the Florida Division of Emergency Management, collected by LiDAR, and created by CH2M Hill in 2008, with a reported vertical accuracy of at least two feet.

4.2 SERPM Network Adaptation

Using ArcGIS, elevation data was clipped to an area extending slightly beyond the Broward County boundary to reduce file size (**Exhibit 4**). The clipped elevation dataset was then spatially joined to the unloaded SERPM future network—defined as the network containing all projects in the County's 2045 Long Range Transportation Plan (LRTP)—using the Spatial Join function.

Through this process, each network polyline was assigned the average elevation value of all intersecting contour polygons. The elevation-enhanced network (Exhibit 4) was then stored for subsequent use in flood-depth calculations.

Exhibit 4: Broward County Terrain

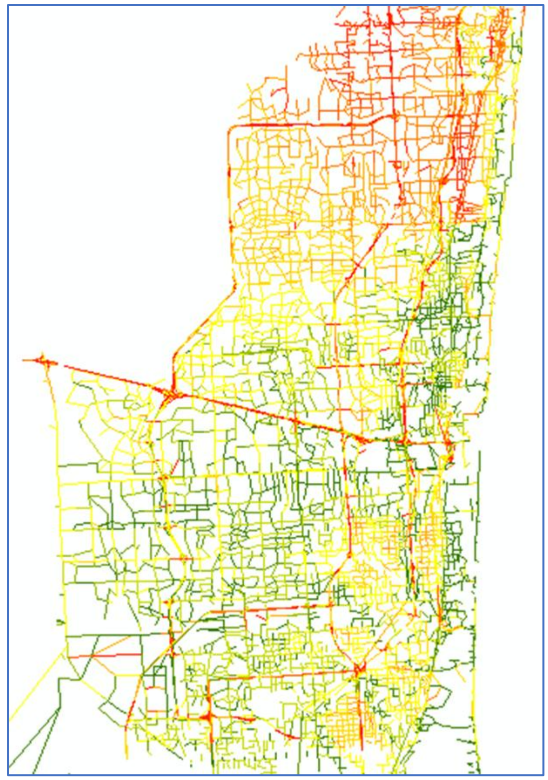


Exhibit 5: SERPM Network with Elevation

4.3 Flood Depth Calculation and Network Conditioning

Flood inundation layers for a 25-year storm under Intermediate and High SLR projections were overlaid on the elevation-enhanced network. Flood depth was calculated as:

- *Flood Depth = Inundation Surface Elevation – Roadway Crest Elevation*
- *Links with depth > 0.5 ft were closed (capacity/speed set to zero)*

5 Alternatives Analyzed

Along with the 25-year flood, we modeled two SLR scenarios: intermediate conditions for 2035 and 2085, and high conditions for 2085. The analysis included a Without Project alternative and three build alternatives (A, B, and C). These scenarios/alternatives are summarized in **Exhibit 6.**

For this project, SERPM 2045 trip tables were locked (and reused across all scenarios and alternatives) and the model was run **assignment-only** with closures. The convergence criterion is set for 200 iterations with a relative gap of 0.0001.

Year / SLR	FWOP	Alt A	Alt B	Alt C
2035 iSLR	✓	✓	✓	✓
2085 iSLR	✓	✓	✓	✓
2085 hSLR	✓	✓	✓	✓

Exhibit 6: Scenario Matrix (Year/SLR × Alternative)

6 Roadway Network Flood Impact Assessment

The analysis quantified flood impacts on the roadway network by testing the PM peak traffic period, which represents the heaviest travel demand, in combination with the most severe four-hour flood. This condition is expected to yield the greatest transportation impacts—and thus the most pronounced potential benefits of the build alternatives. If substantial effects are not observed under this condition, other periods can be reasonably assumed to exhibit minimal impacts.

Model reliability is directly dependent on input accuracy; results are only as sound as the underlying data. Accordingly, flood profiles were reviewed to confirm content, identify the worst-case condition, and ensure consistency across scenarios. For each alternative, SFWMD provided 24-hour flood files in four-hour intervals (six files per alternative). These files were statistically analyzed to determine the four-hour period with the greatest flooding. Supporting data, statistical interval-level and daily analyses, and the identification of the most severe four-hour flood are included in **Appendix A**.

6.1 Conversion from PM Peak to Daily Estimates

Although the SERPM analyses were conducted for the weekday PM peak period, the resulting Vehicle-Miles Traveled (VMT) and Vehicle-Hours Traveled (VHT) values were scaled to represent daily totals. This was accomplished by applying the ratio of PM peak VMT/VHT to daily VMT/VHT observed under non-flooded baseline conditions.

By applying this proportional factor, the analysis accounts for less congested periods of the day and ensures that results represent daily exposure to flood conditions rather than an isolated peak period. This approach yields more conservative daily delay and distance estimates while retaining the PM peak as the bounding case for congestion effects.

6.2 Analysis Considerations

Key considerations are highlighted below to provide context for interpreting the modeling results and understanding the scope of the analysis.

- **Artificial Links**: The SERPM network includes *centroid connectors* and artificial links to represent access where smaller roads are not explicitly coded. In low-lying areas with canals and water bodies, these connectors may abstractly connect zones in ways that do not fully capture local flooding conditions. This abstraction, however, is consistent with FDOT and MPO practice for regional models and is not expected to materially bias systemwide outcomes. Nevertheless, at the neighborhood scale, trips maintained in the model may not always be feasible in reality.

- **Peak Period Focus**: The modeling of the weekday PM peak as a conservative upper-bound scenario is intended to represent the maximum plausible exposure of commuter traffic to flood-related closures; results should be interpreted as an upper bookend, not an expected average. Flood events occurring at off-peak times or weekends would likely coincide with reduced demand and, therefore, lower total delay. The proportional impacts of flooding, however, would remain directionally similar. The present analysis provides *an upper-bound* estimate of delay costs. Sensitivity runs at reduced demand levels could be performed in future refinements to illustrate differences between bounding and expected outcomes. It is noteworthy that this sensitivity is only needed if study decisions hinge on these outputs; otherwise, the reported values should be interpreted as stress-test scenario.

- **Use of Peak Flood Depth**: Road closures were applied for a 24-hour window based on peak inundation exceeding 0.5 feet. In practice, some segments may exceed this threshold for shorter periods. The assumption of a fixed closure window provides a *conservative bounding estimate of maximum travel disruption*. Future refinements could incorporate time-varying closures based on flood hydrographs. As with the peak period focus, this additional more detailed analysis might only be needed if the study decisions are mainly based on these outputs; otherwise, the reported values should be interpreted as a worst-case plausible scenario. Moreover, under extreme closures, fixed-demand assignment can produce penalty hours that exceed physically realizable daily travel. Such outputs are used **only** as an upper-bound stress signal; planning decisions should consider the bracketed mid-case.

- **SERPM Modeling Assumptions and Boundaries**: Models are, by definition, simplified representations of reality. They are designed to capture the most essential features of complex systems while necessarily abstracting from certain details. As such, trade-offs are unavoidable: some aspects of reality must be generalized, omitted, or approximated to make the analysis tractable and consistent. These inherent simplifications do not diminish the value of the modeling results; they provide a structured framework for evaluating scenarios in a transparent and replicable manner.

  The conventions used here—network abstractions consistent with regional practice, a weekday PM peak assignment as a bounding stress test, expansion to daily totals via baseline PM-to-daily ratios, and a conservative closure rule—are transparent choices that emphasize upper-bound disruption and results should be interpreted as such. If critical decisions are sensitive to these assumptions, outcomes can be bracketed using reduced-demand scenarios and time-varying or duration-based closure rules to demonstrate the likely range—always within the capabilities and flexibility of SERPM.

6.3 SERPM Results

Although the model was run for the full region—capturing trips to and from Miami-Dade and Palm Beach Counties that interact with Broward County traffic—results are reported for the watershed polygon provided by SFWMD and depicted in **Exhibit 7**.

Exhibit 7: Study Watershed

Reporting at the full-region scale would dilute meaningful differences in VMT and VHT because aggregation and rounding across a large, congested network can mask small changes.

Accordingly, **Exhibits 8–10** summarize the Without Project condition and the three alternatives for each SLR scenario—2035 iSLR (**Exhibit 8**), 2085 iSLR (**Exhibit 9**), and 2085 hSLR **(Exhibit 10**)—and report results for the watershed area only.

Scenario	Truck VMT	Truck VHT	Auto VMT	Auto VHT
Without Project	3,648,000	353,000	51,041,000	8,022,000
Alternative A	3,622,000	212,000	50,612,000	4,410,000
Alternative B	3,629,000	209,000	50,532,000	4,362,000
Alternative C	3,626,000	209,000	50,545,000	4,352,000

Exhibit 8: 2035 – Intermediate SLR

Scenario	Truck VMT	Truck VHT	Auto VMT	Auto VHT
Without Project	3,630,000	1,182,000	51,031,000	29,759,000
Alternative A	3,586,000	855,000	49,868,000	21,744,000
Alternative B	3,611,000	939,000	50,401,000	24,159,000
Alternative C	3,597,000	958,000	49,858,000	24,840,000

Exhibit 9: 2085 – Intermediate SLR

Scenario	Truck VMT	Truck VHT	Auto VMT	Auto VHT
Without Project	3,464,000	336,021,000	48,123,000	*Modeled*
Alternative A	3,461,000	85,295,000	48,093,000	*Vehicle-Hours*
Alternative B	3,475,000	86,031,000	48,160,000	*(fixed-demand*
Alternative C	3,475,000	86,031,000	48,160,000	*stress test)*[3]

Exhibit 10: 2085 – High SLR

7 Evaluation of Flood Inputs and Reasonableness of SERPM Results

The reliability of any modeling exercise depends first and foremost on the accuracy and representativeness of its input data. In the case of SERPM, flooding is not a variable predicted by the model itself, but rather *an exogenous input that shapes the supply conditions* under which the model operates.

This section does not evaluate the quality or appropriateness of the flood data; instead, it analyzes and summarizes the statistical characteristics of the inputs and examines how these trends are reflected in the model results. Patterns in the input assumptions propagate through the model, influencing performance measures such as vehicle miles traveled (VMT), vehicle hours traveled (VHT), and facility-specific impacts. Linking the analysis of SERPM outputs with a review of flood inputs ensures that observed results are interpreted within the proper context.

The objective of this section is to verify whether observed hydrologic changes—quantified in both absolute terms and probability distributions—are consistent with and predictive of changes in VMT and VHT under varying SLR and storm scenarios.

7.1 Flood Depth Trends

The progression from *2035 iSLR → 2085 iSLR* (different years, but same SLR) represents a moderate hydrologic intensification (~10% depth increase), while the leap from *2085 iSLR → 2085 hSLR* (same year, different SLR) is substantially larger (>26%), indicating that system performance in later scenarios will be disproportionately sensitive to the assumed SLR trajectory.

The flood depth increments reported below (e.g., +0.61 ft, +1.73 ft) are based on the mean (**μ**) of the Gaussian distributions, representing the *expected average flood depth*. They do not reflect maximum values, which would yield larger changes but are less directly comparable to system-wide average performance metrics such as VMT and VHT.

Without Project

- *2035→2085 iSLR:* *+0.61 ft* *(10.1%)*
- *2085 iSLR→2085 hSLR:* *+1.75 ft* *(27.3%)*

[3] Values reflect a fixed-demand assignment under 24-hr closures. They represent an **upper-bound penalty** under infeasible conditions and are not an operational forecast.

Alternative A

- *2035→2085 iSLR:* *+0.61 ft* *(10.2%)*
- *2085 iSLR→2085 hSLR:* *+1.73 ft* *(26.5%)*

Alternative B

- *2035→2085 iSLR:* *+0.61 ft* *(10.2%)*
- *2085 iSLR→2085 hSLR:* *+1.74 ft* *(26.6%)*

Alternative C

- *2035→2085 iSLR:* *+0.61 ft* *(10.4%)*
- *2085 iSLR→2085 hSLR:* *+1.75 ft* *(26.9%)*

Exhibit 11 summarizes the flood depth trend analyses—stepwise escalation between time horizons and SLR severity levels—and reveals consistent behavior across the Without Project and all build alternatives. The graphical representations of these trends are included in **Appendix B.**

Alternative	2035 iSLR (ft)	2085 iSLR (ft)	2085 hSLR (ft)	2035 iSLR→ 2085 iSLR (%)	2085 iSLR→ 2085 hSLR (%)
Without Project	5.9	6.5	8.3	10.1	27.3
Alternative A	5.9	6.6	8.3	10.2	26.5
Alternative B	5.9	6.5	8.3	10.2	26.6
Alternative C	5.9	6.5	8.3	10.4	26.9

Exhibit 11: Impact of Time and SLR Scenarios on Average Flood Depths

7.2 Flood Depth Distributions

A Gaussian curve, also referred to as a *normal distribution* or *bell curve*, is a statistical representation of how values are distributed around a central average. It is characterized by a single peak at the mean and a symmetrical shape, where values closer to the mean occur more frequently, and values farther from the mean occur less frequently.

In the context of this study, these curves were applied to represent the distribution of flood depths. By examining shifts in the mean of these distributions across scenarios, the analysis identifies whether average conditions under each alternative meaningfully differ from one another.

Without Project

- *Mean **μ** rises from ~5.9 ft in 2035 iSLR to ~8.2 ft in 2085 hSLR.*
- *Standard deviation **σ** remains stable (~0.48–0.49 ft).*

Alternative A

- *Mean* ***μ*** *increases from ~5.92 ft in 2035 iSLR to ~8.25 ft in 2085 hSLR.*
- *Standard deviation* ***σ*** *remains stable at ~0.48–0.49 ft.*

Alternative B

- *Mean* ***μ*** *increases from ~5.9 ft in 2035 iSLR to ~8.24 ft in 2085 hSLR.*
- *Standard deviation* ***σ*** *remains stable at ~0.48–0.49 ft.*

Alternative C

- *Mean* ***μ*** *increases from ~5.87 ft in 2035 iSLR to ~8.24 ft in 2085 hSLR.*
- *Standard deviation* ***σ*** *remains stable at ~0.48–0.49 ft.*

The stability of **σ** indicates that the range of day-to-day variability is unchanged; the upward shift of the mean (***μ)*** with hSLR signals a systematic baseline rise in flood depth. This behavior suggests that flood events will not only remain frequent but will, on average, occur at significantly higher depths—amplifying travel disruption risks even under 'typical' flood days. These results are also graphically depicted in **Appendix B**.

8 Quantitative Correlation of Flood Hazard with SERPM VMT/VHT Results

This section demonstrates how incremental increases in flood hazard—expressed as depth and/or probability and provided externally to SERPM—translate into modeled network performance in terms of Vehicle-Miles Traveled (VMT) and Vehicle-Hours Traveled (VHT) across analysis years, SLR/storm scenarios, and build alternatives.

Performance changes are expected to be nonlinear: small additional inundations can disable critical links or nodes, lengthen detours, and reduce effective speeds, which elevates VHT and, under severe conditions, can reduce VMT due to suppressed trips or shorter feasible paths.

Because hazard inputs are essentially consistent across alternatives within a given scenario, observed differences in VMT/VHT primarily reflect differences in network design and operations (capacity, connectivity, and routing options). The exhibits that follow link trends in network exposure to changes in VMT/VHT to support a reasonableness assessment of model outcomes given the supplied flood assumptions.

8.1 Overview of Findings

Comparing flood depth changes to modeled performance metrics reveals a strong qualitative correlation.

- **2035 iSLR (~0.6 ft increase)**: Build alternatives reduce Auto VHT by ~45–47% vs Without Project (base). Impacts are moderate because the network still has convenient rerouting routes with available capacity.

- **2085 iSLR (~0.6 ft increase)**: Auto VHT increases sharply under more severe closures; build alternatives still trims delay when compared with Without Project (Alt A ≈–27%, Alt B ≈–19%, Alt C ≈–16.5%). This indicates growing sensitivity as the system approaches saturation.

- **2085 hSLR (~1.73–1.75 ft increase)**: Without Project Auto VHT grows to orders of magnitude higher; build alternatives still reduce delay ≈73–74%, showing material adaptation benefits even under extreme conditions.

Across scenarios, the direction of change in Auto VMT and Auto VHT tracks the intensity and spatial reach of flooding, but the magnitude is distinctly ***nonlinear***. When closures are limited and viable relievers exist, flows can reroute with modest delay.

As flooding encroaches on mid-tier relievers and collectors, detours lengthen and speeds fall, compounding delay even when the additional inundation appears small. This context frames the scenario comparisons below (**Exhibit 12**) and explains why a given depth increment has very different network effects in 2035 iSLR, 2085 iSLR, and 2085 hSLR.

Scenario	Δ Flood vs prior (%)	WOP Auto VHT	Δ VHT vs prior WOP (%)	Build VHT vs WOP (Alt A/B/C)	Network state
2035iSLR	—	8,022,000	—	Alt A -45.0% Alt B -45.6% Alt C -45.7%	Capacity remains available
2085iSLR	10.2–11.9	29,759,000	271%	Alt A -26.9% Alt B -18.8% Alt C -16.5%	Strained capacity / approaching saturation
2085hSLR	27.7–25.8	N/A	N/A	Alt A -73.7% Alt B -73.4% Alt C -73.4%	Network failure (stress test)

Exhibit 12: Flood Depth vs. Performance — Scenario Summary

8.2 Observed Proportionality and Scenario Sensitivity

While the proportionality between flood depth and VHT/VMT degradation is generally strong, the sensitivity is ***nonlinear***—small depth increases in already-constrained networks yield disproportionately large delay impacts. When road closure (water level on road ≥ 0.5 ft) is modest and redundancy exists, a small depth increase causes limited delay.

Under more severe road closures, the same depth increase forces widespread detours onto slower facilities, compounding congestion and producing outsized VHT growth. With large depth jumps (e.g., 2085 hSLR), closures are extensive; some trips are suppressed altogether (VMT can decrease) while delays surge (in order of magnitude) as the network approaches gridlock.

Deviations among Alternatives A–C in performance metrics under similar hydrologic conditions are minimal, suggesting that while their intrinsic differences may influence localized resilience, they do not materially alter flood exposure at the macro scale across the roadway network.

8.3 Alignment in Model Results

This subsection evaluates face validity by comparing the spatial and temporal progression of flood inputs with corresponding SERPM outcomes. The objective is to verify that changes in Auto VMT/VHT align with the geographic extent and intensity of inundation, the availability of detour routes, and the exposure of specific facility types. In essence, the analysis tests whether the input patterns plausibly generate the modeled results.

8.3.1 Vulnerability to Flood of Different Roadway Types

The SERPM highway network classifies all roadway links using the **Facility Type Class 1 (FTC1)** system, which provides a broad categorization of facilities consistent with standard roadway hierarchies. FTC1 identifies links as freeways, principal arterials, minor arterials, collectors, or local roads, and this classification is used in reporting, network summaries, and post-processing of model outputs. These categories (described in **Exhibit 13**) provide an interpretable framework for understanding flooding risk and system performance at a regional scale as shown in **Exhibit 14**.

FTC1	Facility type	Access / operating characteristics	Role in detours
10	Freeway	Fully access-controlled, high speed	Even low exposure is consequential; ramp/segment closures spill traffic to slower classes.
20	Uninterrupted roadway	Long signal spacing / divided	Parallel reliever to freeways; closures push traffic to 40/60.
40	Higher-speed interrupted facility	Signalized arterial	Flooding moves demand to collectors/locals; delays propagate.
60	Lower-speed & collector facility	Collectors/locals	Primary detour class; high exposure explains nonlinear VHT.
70	Ramps	Freeway ramps	Localized but critical; closures sever movements and reduce usable mainline capacity.
80	HOV/Managed lanes	Co-located with freeways	Exposure reduces effective capacity when closed.
90	Toll roads	Limited-access tolled	Often resilient corridors that absorb detours when open.

Exhibit 13: SERPM Model Facility Type 1 (FTC 1) Dictionary

When flooding affects freeways and uninterrupted roadways, displaced demand shifts to interrupted facilities and collectors, where side friction and signal control dominate, amplifying delay. Exposure of ramps constrains access, and exposure of managed/toll lanes reduces redundancy that would otherwise absorb rerouted flows.

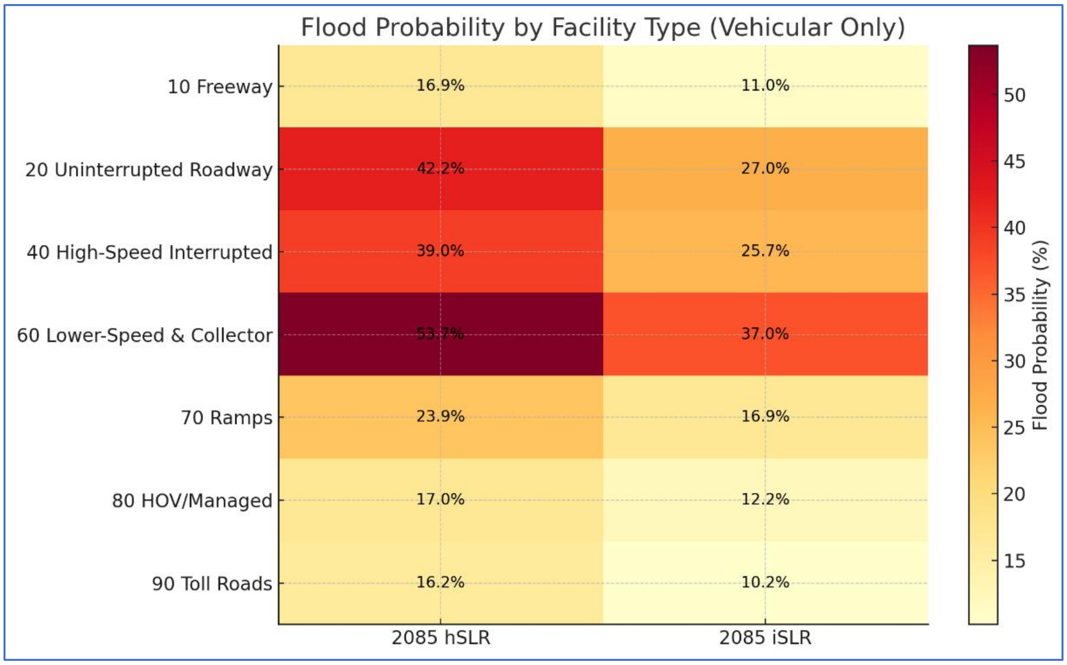


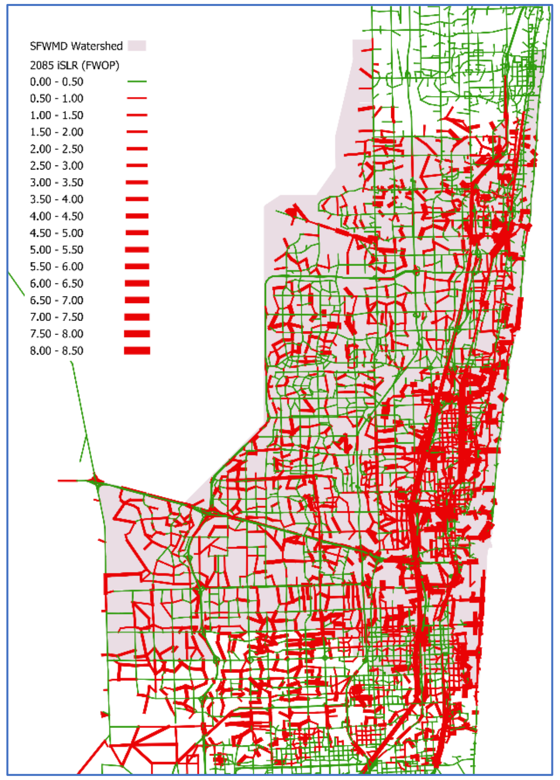
Exhibit 14: Flood Probability by Facility Type — iSLR vs. hSLR

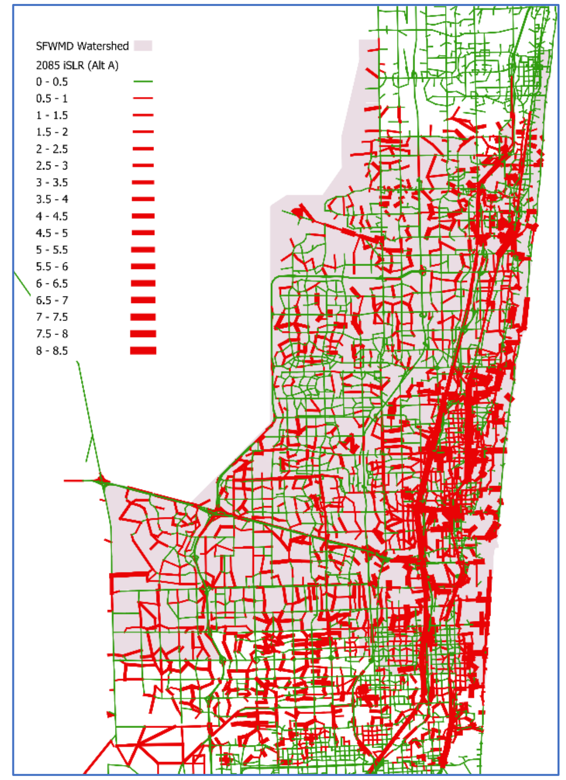
8.3.2 Hazard Progression – Spatial Verification

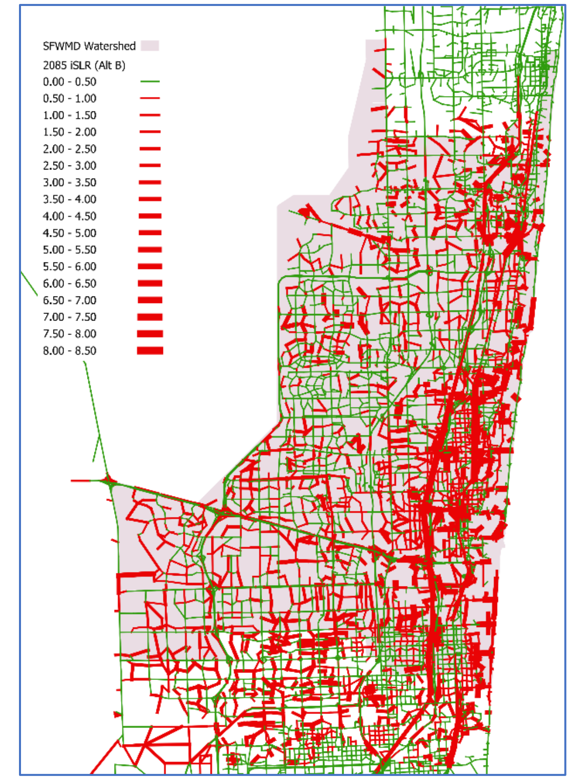
Exhibit 15 maps the flooded roadway links within the watershed in Broward County for 2085 iSLR (top row) and 2085 hSLR (bottom row), shown side-by-side across Without Project and the three build alternatives (columns). Links are color-ramped by retained water depth (ft); red segments indicate higher depths—i.e., links that would exceed the SERPM closure threshold and be removed from the network—while green segments remain passable.

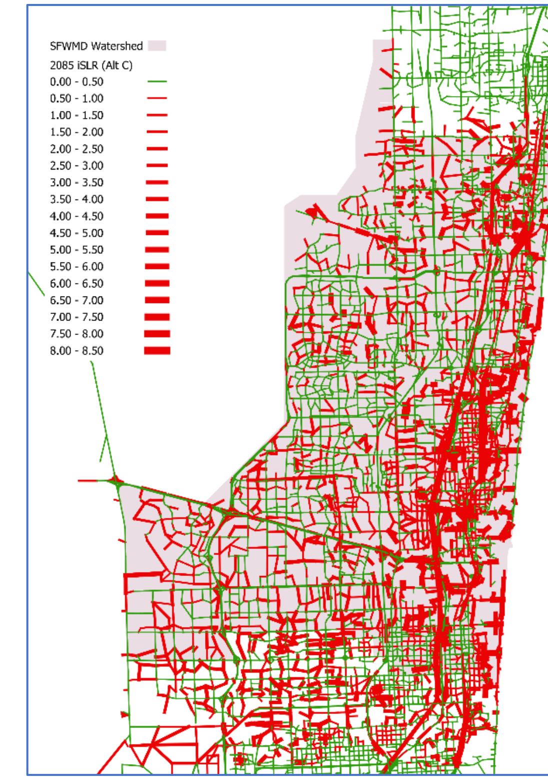
The pattern is clear: under 2085 iSLR, flooding is concentrated along the coast and tidal channels, with inland grids largely intact; under 2085 hSLR, inundation spreads westward and along key arterials, severing many more coastal, near-coastal, and mid-tier reliever/collector links. Visual differences among alternatives are modest compared with the scenario step itself, reinforcing that performance changes are driven primarily by the hazard intensity and spatial reach (iSLR → hSLR), not by materially different exposure across alternatives.

2085 iSLR (Intermedia Sea-Level Rise)

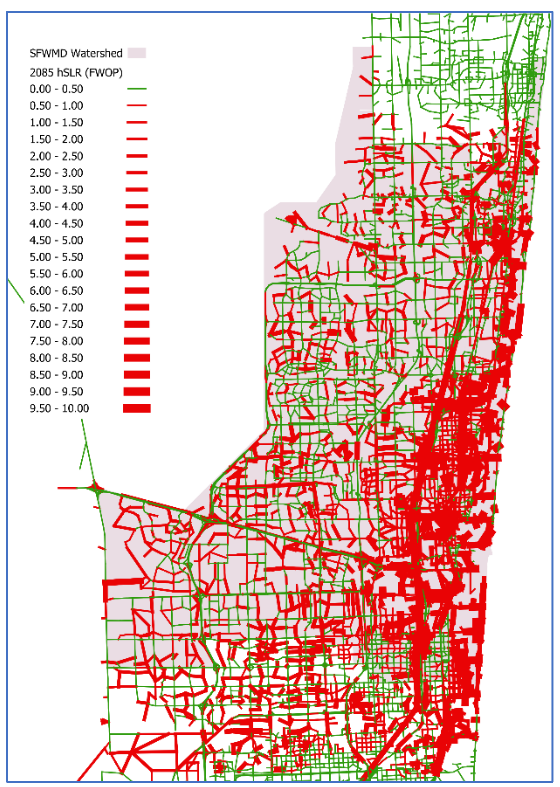


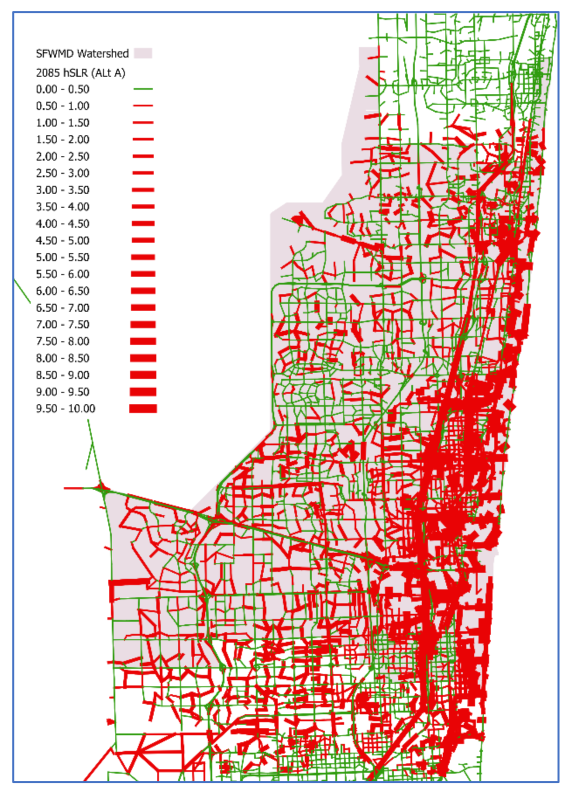


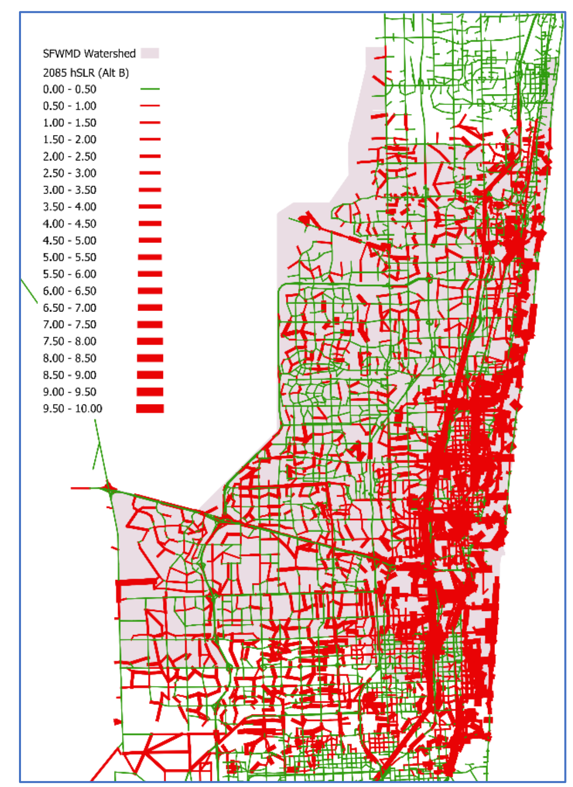




2085 hSLR (High Sea-Level Rise)







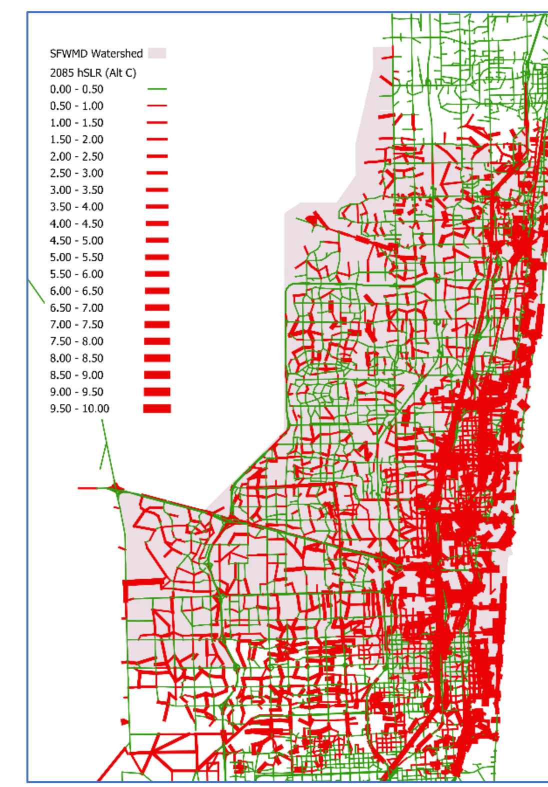


Exhibit 15: Spatial Progression of Flood by SLR and Alternatives

9 Conclusions and Methodological Recommendations

This study deliberately adopted a conservative, stress-test framing: weekday PM peak assignment, a fixed 24-hour closure window based on peak inundation, and baseline PM-to-daily expansion factors. This approach was appropriate for an initial trial, given the limited understanding of the flood files at project start and the need to establish an upper bound on disruption.

That said, several methodological refinements could materially improve reliability and reproducibility while preserving the stress-test intent. Key improvements include: (i) shifting from a single-period PM run with baseline expansion to multi-period assignments with time-varying closures, and (ii) bracketing results with both an upper-bound and a mid-case scaling rather than relying on a single daily number. These refinements would help control unrealistic VHT inflation under near-failure conditions and align the workflow more closely with the model's capabilities.

Even with such methodological enhancements, the qualitative conclusions of this report remain unchanged: as sea-level rise severity and event intensity increase, closures compound nonlinearly, and well-targeted projects (the tested alternatives) continue to deliver substantial relative delay reductions under stress. The refinements serve primarily to make the magnitude estimates more defensible and the analysis more transparent

APPENDIX A: Statistical Analysis of SERPM Flood Input Data

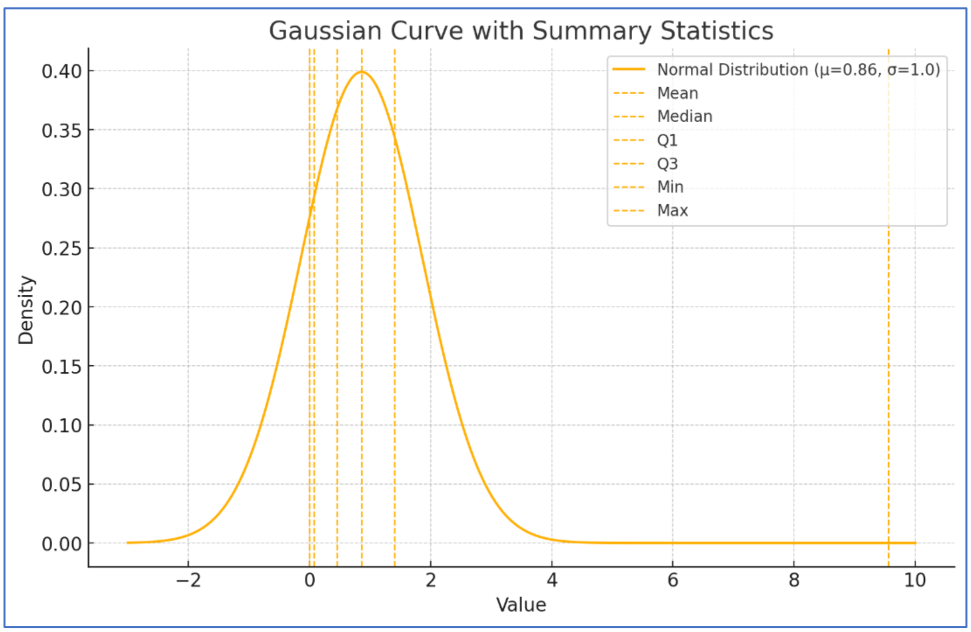
1) Without Project – 2035 iSLR

Flood Data in Four-Hour Periods

12_ECB_2S25R35i -- Statistics Excluding Zeros								
File ID	Count	Mean	Std	Min	Q1	Median	Q3	Max
096	495,295	0.66	0.92	0.0001	0.04	0.19	1.07	7.62
100	516,951	0.65	0.81	0.0001	0.06	0.22	1.10	6.74
104	522,127	0.68	0.82	0.0001	0.06	0.25	1.16	6.84
108	720,145	0.92	1.00	0.0001	0.24	0.54	1.36	9.14
112	591,550	0.98	1.05	0.0001	0.11	0.58	1.65	9.56
116	574,919	0.97	1.04	0.0001	0.07	0.59	1.69	9.41
120	564,573	1.06	1.17	0.0001	0.08	0.66	1.80	9.52

Daily Flood Data

Statistic	Without Zeros
Count	3,985,560
Mean	0.86
Std Deviation	1.00
Min Value	0.00
Q1 (25%)	0.07
Median (50%)	0.45
Q3 (75%)	1.40
Max Value	9.56



Without Project – 2035 iSLR

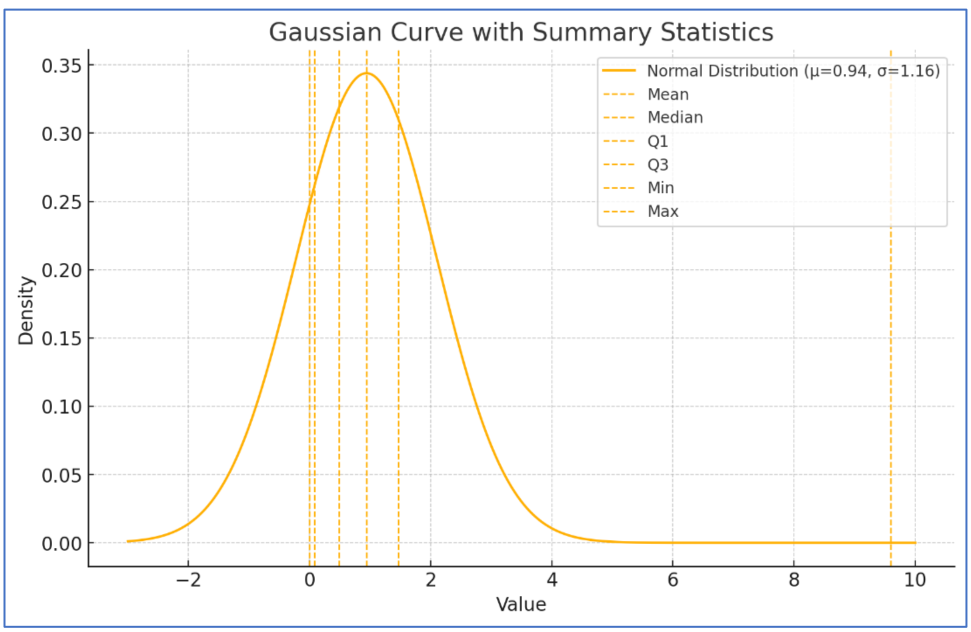
2) Without Project – 2085 iSLR

Flood Data in Four-Hour Periods

13_FWOPi_2S25R85i -- Statistics Excluding Zeros								
File ID	Count	Mean	Std	Min	Q1	Median	Q3	Max
096	503,434	0.76	1.14	0.0001	0.04	0.24	1.16	6.84
100	523,034	0.75	1.00	0.0001	0.06	0.25	1.19	7.13
104	527,000	0.77	0.97	0.0001	0.06	0.29	1.25	7.71
108	728,602	1.00	1.18	0.0001	0.24	0.56	1.42	9.24
112	610,070	1.05	1.20	0.0001	0.11	0.61	1.70	9.59
116	586,098	1.04	1.15	0.0001	0.08	0.63	1.76	9.44
120	583,514	1.15	1.33	0.0001	0.08	0.70	1.85	9.54

Daily Flood Data

Statistic	Without Zeros
Count	4,061,752
Mean	0.94
Std Deviation	1.16
Min Value	0.00
Q1 (25%)	0.08
Median (50%)	0.49
Q3 (75%)	1.47
Max Value	9.59



Without Project – 2085 iSLR

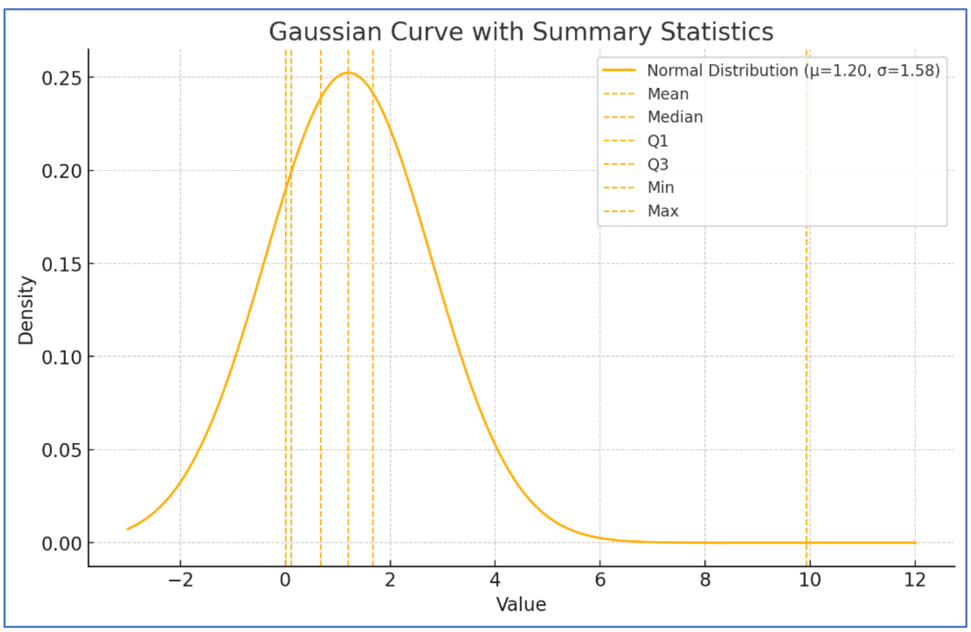
3) Without Project – 2085 hSLR

Flood Data in Four-Hour Periods

14_FWOPh_2S25R85h -- Statistics Excluding Zeros								
File ID	Count	Mean	Std	Min	Q1	Median	Q3	Max
096	540,554	1.05	1.64	0.0001	0.04	0.47	1.36	9.27
100	562,112	1.02	1.49	0.0001	0.07	0.47	1.38	8.49
104	563,856	1.02	1.45	0.0001	0.07	0.47	1.42	8.24
108	758,141	1.24	1.60	0.0001	0.27	0.67	1.66	9.86
112	655,945	1.30	1.58	0.0001	0.15	0.83	1.84	9.92
116	630,594	1.27	1.50	0.0001	0.13	0.83	1.85	9.57
120	635,161	1.40	1.72	0.0001	0.13	0.93	1.98	9.65

Daily Flood Data

Statistic	Without Zeros
Count	4,346,363
Mean	1.20
Std Deviation	1.58
Min Value	0.00
Q1 (25%)	0.11
Median (50%)	0.67
Q3 (75%)	1.66
Max Value	9.92



Without Project – 2085 hSLR

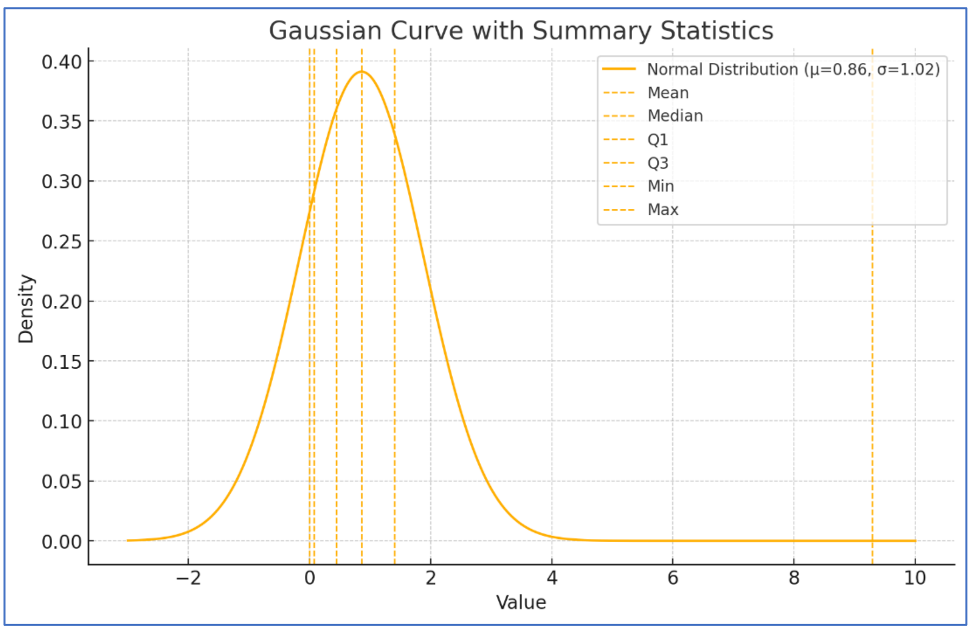
4) Alternative A – 2035 iSLR

Flood Data in Four-Hour Periods

15_ECWP_AltA_2S25R35i -- Statistics Excluding Zeros								
File ID	Count	Mean	Std	Min	Q1	Median	Q3	Max
096	494,709	0.66	0.93	0.0001	0.04	0.17	1.06	6.63
100	513,037	0.66	0.84	0.0001	0.05	0.21	1.10	7.67
104	517,347	0.68	0.85	0.0001	0.05	0.24	1.16	6.88
108	716,290	0.92	1.02	0.0001	0.23	0.53	1.35	9.04
112	587,369	0.97	1.08	0.0001	0.10	0.56	1.63	9.29
116	559,864	0.98	1.07	0.0001	0.07	0.61	1.70	9.17
120	559,809	1.06	1.19	0.0001	0.06	0.64	1.79	9.27

Daily Flood Data

Statistic	Without Zeros
Count	3,948,425
Mean	0.86
Std Deviation	1.02
Min Value	0.00
Q1 (25%)	0.07
Median (50%)	0.44
Q3 (75%)	1.40
Max Value	9.29



Alternative A – 2035 iSLR

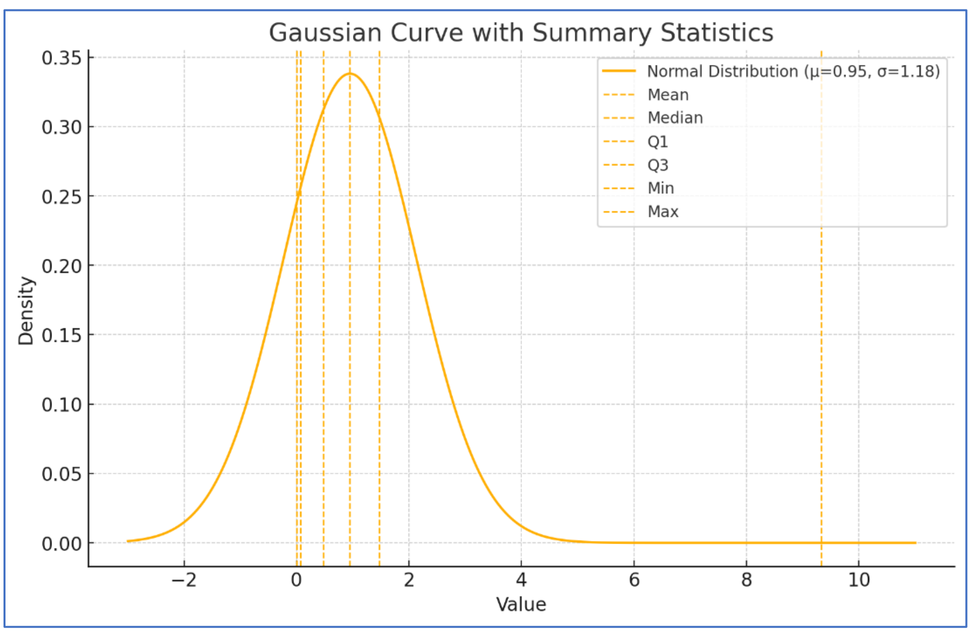
5) Alternative A – 2085 iSLR

Flood Data in Four-Hour Periods

16_FWPi_AltA_2S25R85i -- Statistics Excluding Zeros								
File ID	Count	Mean	Std	Min	Q1	Median	Q3	Max
096	502,783	0.77	1.16	0.0001	0.04	0.23	1.16	6.84
100	519,180	0.75	1.02	0.0001	0.05	0.24	1.19	7.71
104	522,309	0.77	1.00	0.0001	0.05	0.27	1.26	6.88
108	725,967	1.00	1.19	0.0001	0.24	0.55	1.40	9.12
112	600,284	1.06	1.22	0.0001	0.11	0.61	1.70	9.33
116	578,040	1.05	1.18	0.0001	0.07	0.62	1.75	9.20
120	574,821	1.15	1.36	0.0001	0.07	0.69	1.84	9.32

Daily Flood Data

Statistic	Without Zeros
Count	4,023,384
Mean	0.95
Std Deviation	1.18
Min Value	0.00
Q1 (25%)	0.07
Median (50%)	0.48
Q3 (75%)	1.47
Max Value	9.33



Alternative A – 2085 iSLR

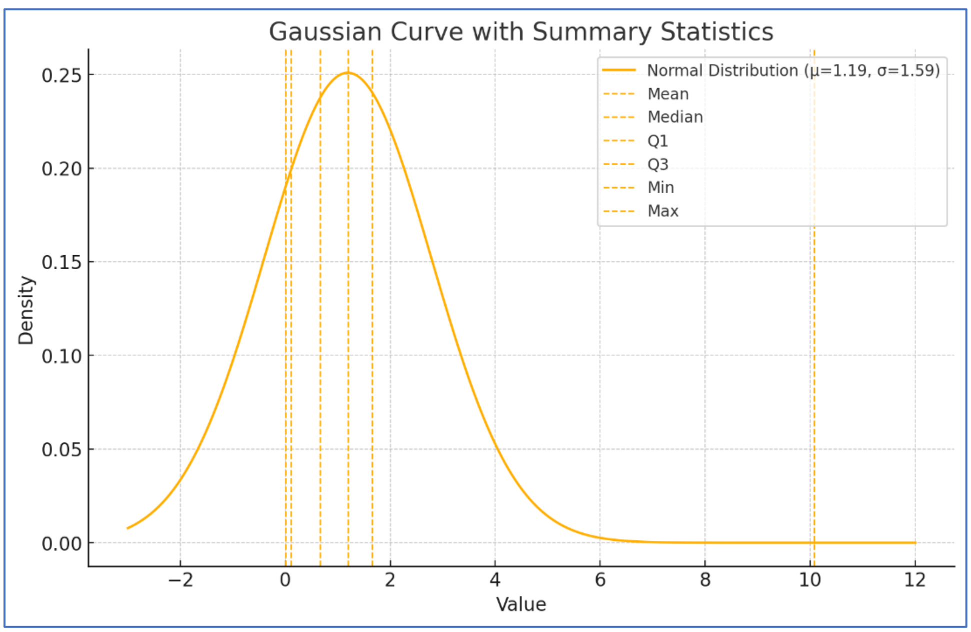
6) Alternative A – 2085 hSLR

Flood Data in Four-Hour Periods

17_FWPh_AltA_2S25R85h -- Statistics Excluding Zeros								
File ID	Count	Mean	Std	Min	Q1	Median	Q3	Max
096	539,355	1.05	1.65	0.0001	0.04	0.45	1.36	9.27
100	558,071	1.02	1.50	0.0001	0.06	0.45	1.38	8.55
104	558,990	1.01	1.46	0.0001	0.06	0.46	1.42	8.29
108	751,720	1.23	1.61	0.0001	0.27	0.65	1.65	9.91
112	645,765	1.30	1.59	0.0001	0.15	0.83	1.83	10.07
116	621,501	1.27	1.50	0.0001	0.12	0.82	1.85	9.66
120	625,381	1.40	1.73	0.0001	0.12	0.93	1.97	9.79

Daily Flood Data

Statistic	Without Zeros
Count	4,300,783
Mean	1.19
Std Deviation	1.59
Min Value	0.00
Q1 (25%)	0.11
Median (50%)	0.66
Q3 (75%)	1.65
Max Value	10.07



Alternative A – 2085 hSLR

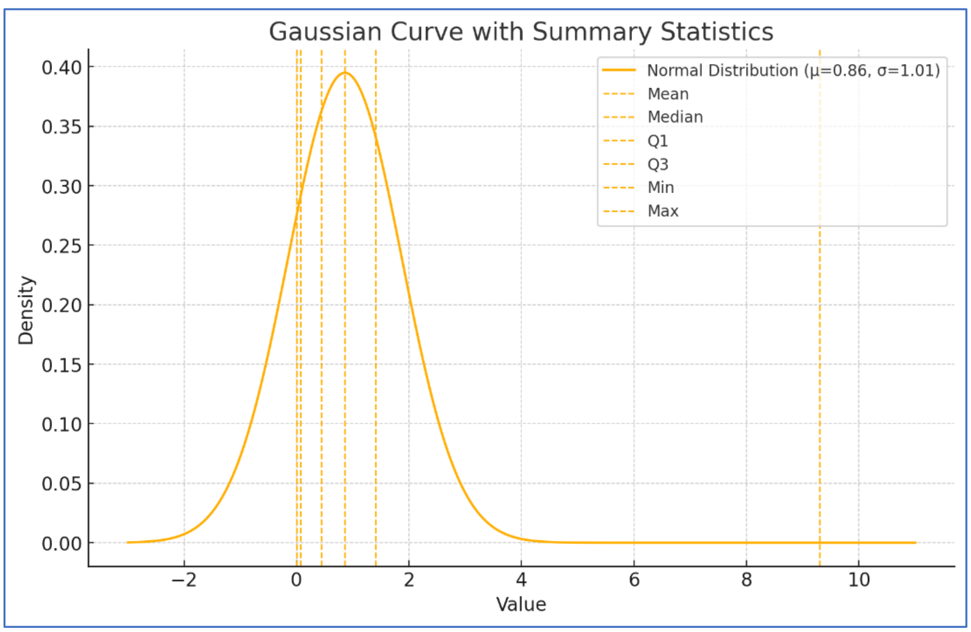
7) Alternative B – 2035 iSLR

Flood Data in Four-Hour Periods

18_ECWP_AltB_2S25R35i -- Statistics Excluding Zeros								
File ID	Count	Mean	Std	Min	Q1	Median	Q3	Max
096	494,682	0.66	0.93	0.0001	0.04	0.17	1.06	6.98
100	512,991	0.66	0.83	0.0001	0.05	0.20	1.10	6.58
104	517,296	0.68	0.84	0.0001	0.05	0.24	1.16	6.67
108	715,928	0.92	1.01	0.0001	0.23	0.53	1.34	9.04
112	583,603	0.98	1.07	0.0001	0.10	0.57	1.64	9.30
116	562,991	0.97	1.06	0.0001	0.07	0.59	1.69	9.17
120	559,307	1.05	1.18	0.0001	0.06	0.64	1.79	9.28

Daily Flood Data

Statistic	Without Zeros
Count	3,946,798
Mean	0.86
Std Deviation	1.01
Min Value	0.00
Q1 (25%)	0.07
Median (50%)	0.44
Q3 (75%)	1.40
Max Value	9.30



Alternative B – 2035 iSLR

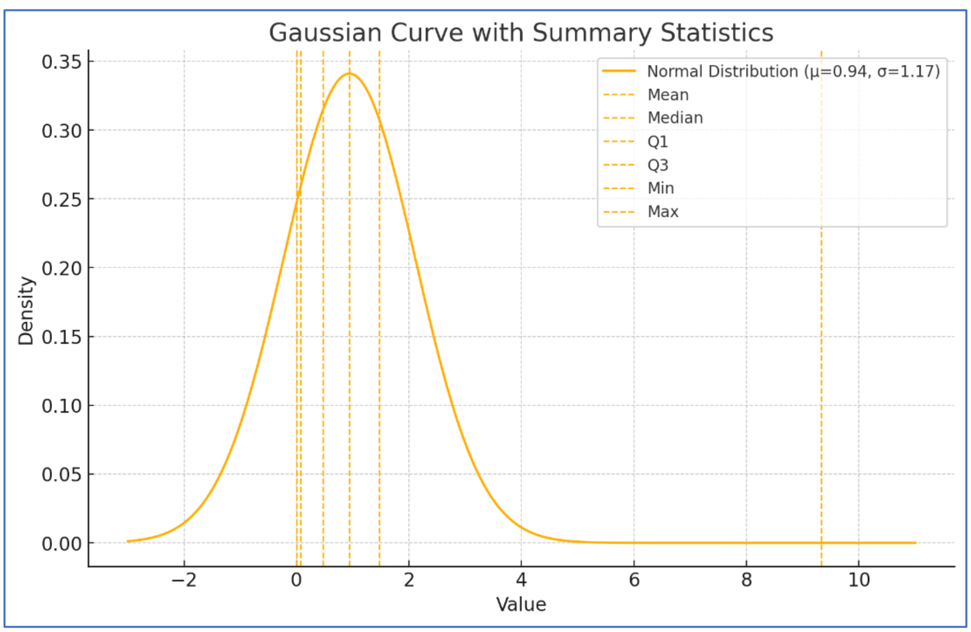
8) Alternative B – 2085 iSLR

Flood Data in Four-Hour Periods

19_FWPi_AltB_2S25R85i -- Statistics Excluding Zeros								
File ID	Count	Mean	Std	Min	Q1	Median	Q3	Max
096	502,808	0.76	1.15	0.0001	0.04	0.22	1.16	6.84
100	519,193	0.75	1.02	0.0001	0.05	0.24	1.19	6.99
104	522,250	0.77	0.99	0.0001	0.05	0.27	1.26	6.73
108	725,476	0.99	1.19	0.0001	0.24	0.55	1.40	9.12
112	602,651	1.05	1.22	0.0001	0.10	0.59	1.69	9.33
116	573,896	1.05	1.17	0.0001	0.07	0.63	1.76	9.21
120	574,023	1.15	1.35	0.0001	0.07	0.69	1.84	9.32

Daily Flood Data

Statistic	Without Zeros
Count	4,020,297
Mean	0.94
Std Deviation	1.17
Min Value	0.00
Q1 (25%)	0.07
Median (50%)	0.47
Q3 (75%)	1.47
Max Value	9.33



Alternative B – 2085 iSLR

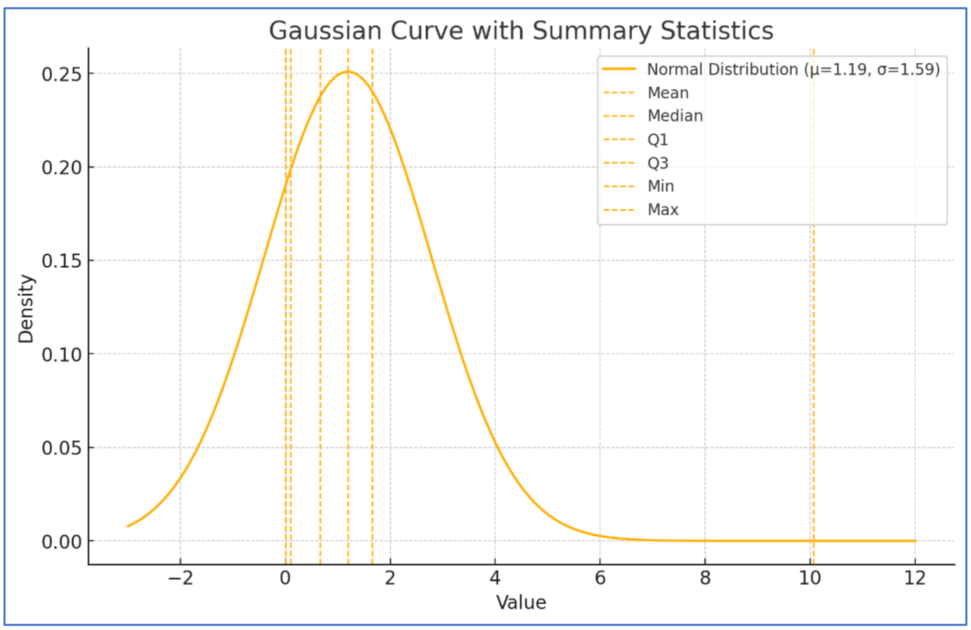
9) Alternative B – 2085 hSLR

Flood Data in Four-Hour Periods

20_FWPh_AltB_2S25R85h -- Statistics Excluding Zeros								
File ID	Count	Mean	Std	Min	Q1	Median	Q3	Max
096	539,800	1.05	1.65	0.0001	0.04	0.45	1.36	9.27
100	558,342	1.02	1.50	0.0001	0.06	0.45	1.38	8.55
104	559,263	1.01	1.46	0.0001	0.06	0.46	1.41	8.29
108	752,227	1.23	1.61	0.0001	0.26	0.65	1.65	9.91
112	644,032	1.30	1.58	0.0001	0.14	0.83	1.83	10.06
116	619,799	1.26	1.50	0.0001	0.11	0.82	1.85	9.66
120	623,714	1.40	1.72	0.0001	0.11	0.93	1.97	9.78

Daily Flood Data

Statistic	Without Zeros
Count	4,297,177
Mean	1.19
Std Deviation	1.59
Min Value	0.00
Q1 (25%)	0.10
Median (50%)	0.66
Q3 (75%)	1.65
Max Value	10.06



Alternative B – 2085 hSLR

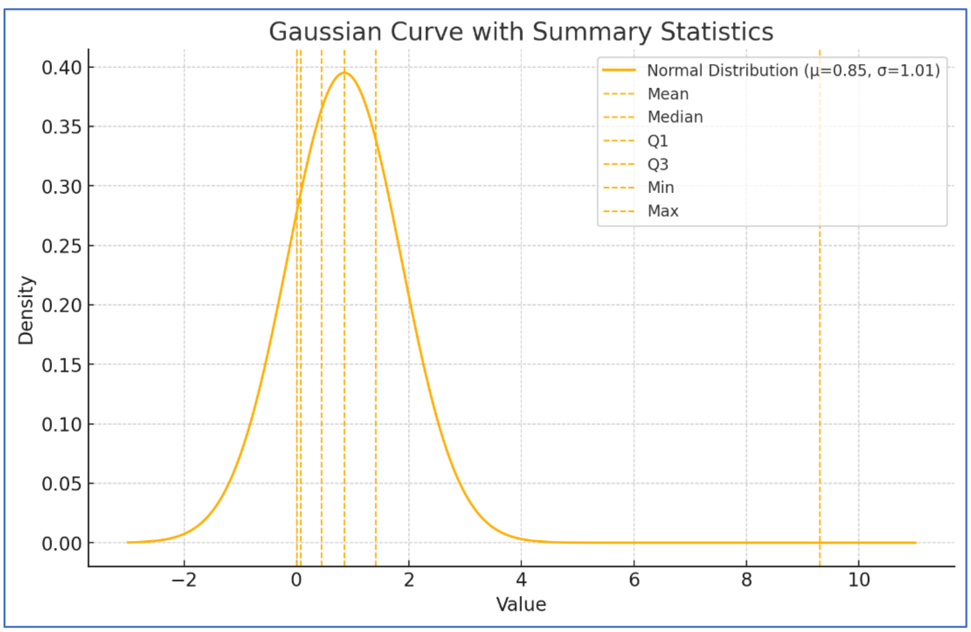
10) Alternative C – 2035 iSLR

Flood Data in Four-Hour Periods

21_ECWP_AltC_2S25R35i -- Statistics Excluding Zeros								
File ID	Count	Mean	Std	Min	Q1	Median	Q3	Max
096	494,812	0.66	0.93	0.0001	0.04	0.18	1.06	6.50
100	513,104	0.66	0.83	0.0001	0.05	0.21	1.09	6.58
104	517,368	0.68	0.83	0.0001	0.05	0.24	1.15	6.67
108	715,772	0.92	1.01	0.0001	0.23	0.53	1.34	9.04
112	589,628	0.96	1.06	0.0001	0.09	0.56	1.63	9.30
116	565,990	0.97	1.06	0.0001	0.06	0.59	1.68	9.17
120	562,389	1.05	1.18	0.0001	0.06	0.64	1.78	9.28

Daily Flood Data

Statistic	Without Zeros
Count	3,959,063
Mean	0.85
Std Deviation	1.01
Min Value	0.00
Q1 (25%)	0.07
Median (50%)	0.44
Q3 (75%)	1.40
Max Value	9.30



Alternative C – 2035 iSLR

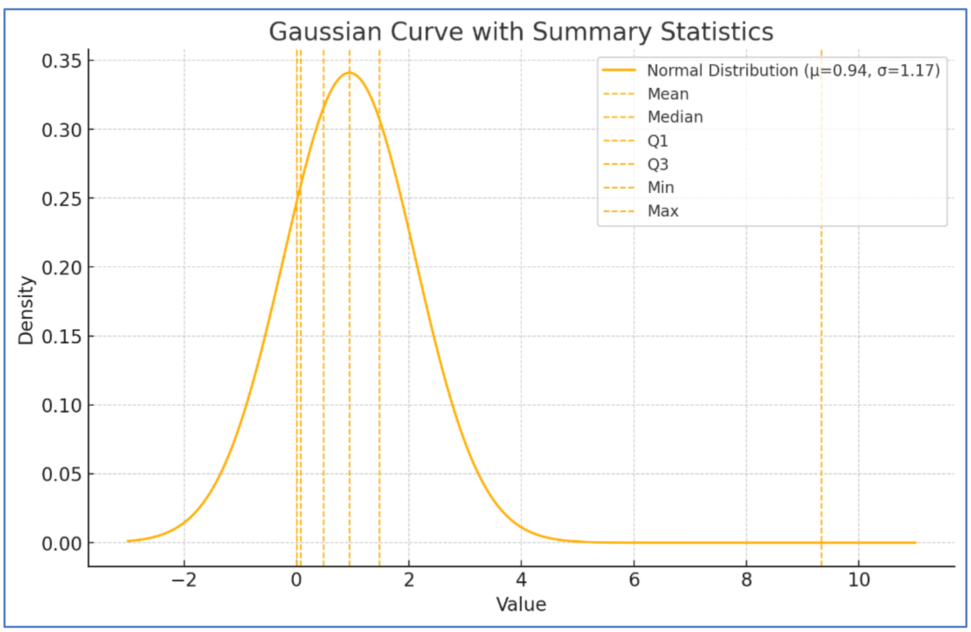
11) Alternative C – 2085 iSLR

Flood Data in Four-Hour Periods

22_FWPi_AltC_2S25R85i -- Statistics Excluding Zeros								
File ID	Count	Mean	Std	Min	Q1	Median	Q3	Max
096	503,028	0.76	1.15	0.0001	0.04	0.22	1.15	6.84
100	519,397	0.75	1.01	0.0001	0.05	0.24	1.18	6.63
104	522,337	0.77	0.99	0.0001	0.05	0.28	1.25	7.37
108	725,166	0.99	1.19	0.0001	0.24	0.55	1.40	9.12
112	599,035	1.05	1.21	0.0001	0.10	0.61	1.68	9.33
116	576,230	1.04	1.16	0.0001	0.07	0.63	1.74	9.20
120	576,493	1.14	1.34	0.0001	0.07	0.69	1.82	9.32

Daily Flood Data

Statistic	Without Zeros
Count	4,021,686
Mean	0.94
Std Deviation	1.17
Min Value	0.00
Q1 (25%)	0.07
Median (50%)	0.48
Q3 (75%)	1.47
Max Value	9.33



Alternative C – 2085 iSLR

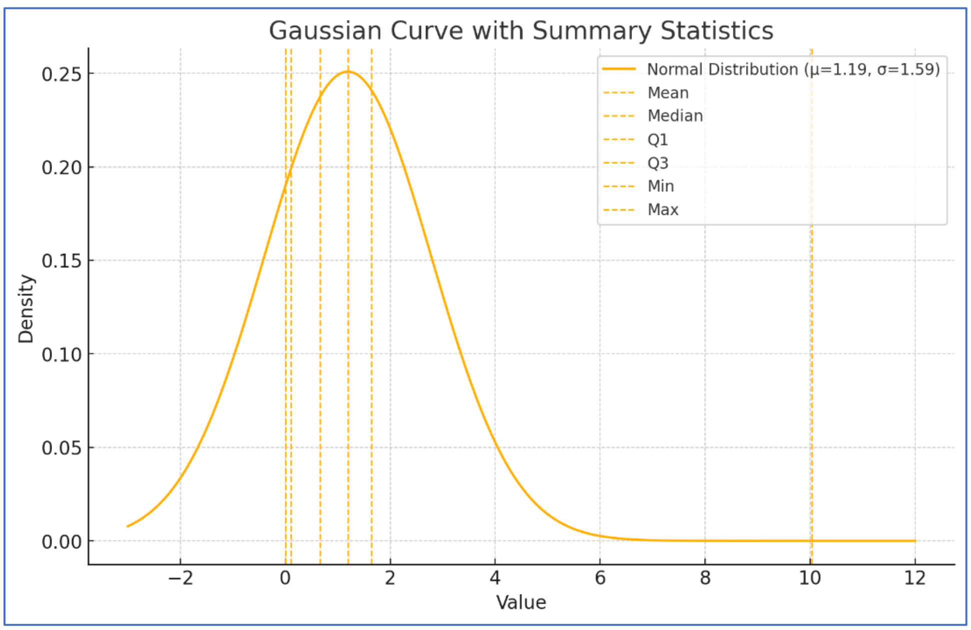
12) Alternative C – 2085 hSLR

Flood Data in Four-Hour Periods

23_FWPh_AltC_2S25R85h -- Statistics Excluding Zeros								
File ID	Count	Mean	Std	Min	Q1	Median	Q3	Max
096	540,271	1.05	1.65	0.0001	0.04	0.45	1.35	9.27
100	558,745	1.02	1.50	0.0001	0.06	0.45	1.37	8.58
104	559,596	1.01	1.46	0.0001	0.06	0.45	1.41	8.30
108	751,647	1.23	1.61	0.0001	0.26	0.65	1.64	9.93
112	642,117	1.30	1.58	0.0001	0.15	0.84	1.82	10.03
116	614,226	1.27	1.50	0.0001	0.12	0.85	1.85	9.64
120	624,139	1.39	1.72	0.0001	0.11	0.93	1.95	9.75

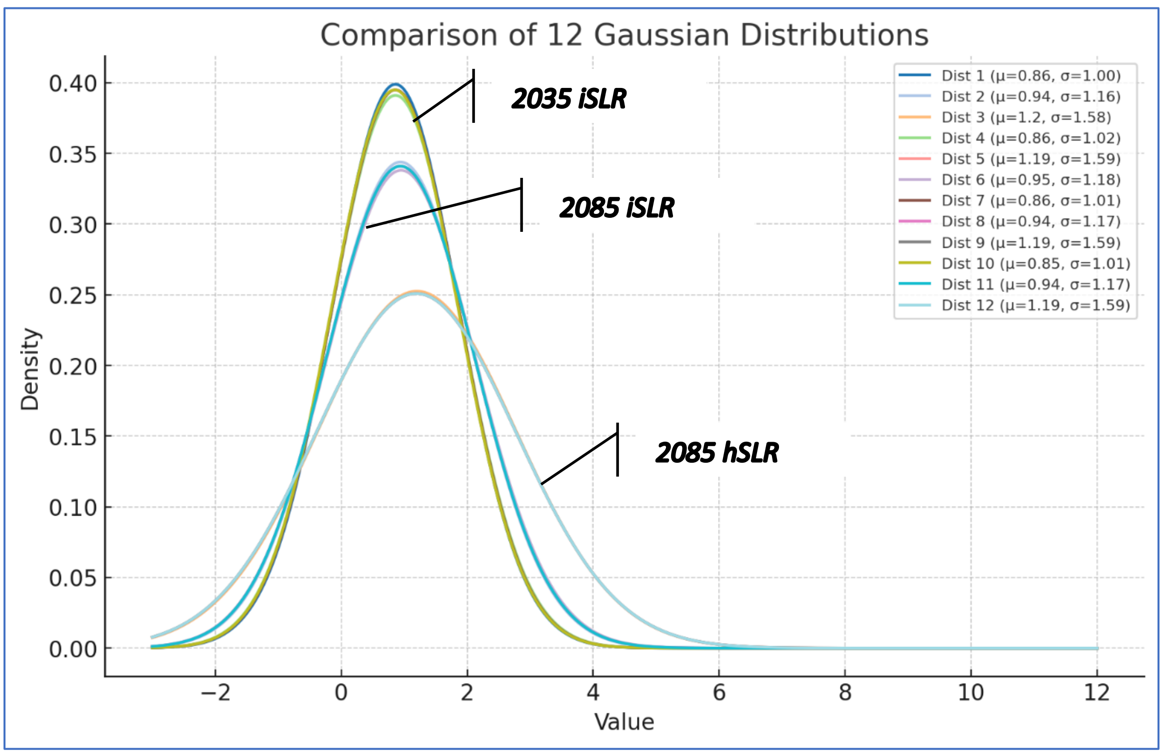
Daily Flood Data

Statistic	Without Zeros
Count	4,290,741
Mean	1.19
Std Deviation	1.59
Min Value	0.00
Q1 (25%)	0.11
Median (50%)	0.66
Q3 (75%)	1.64
Max Value	10.03



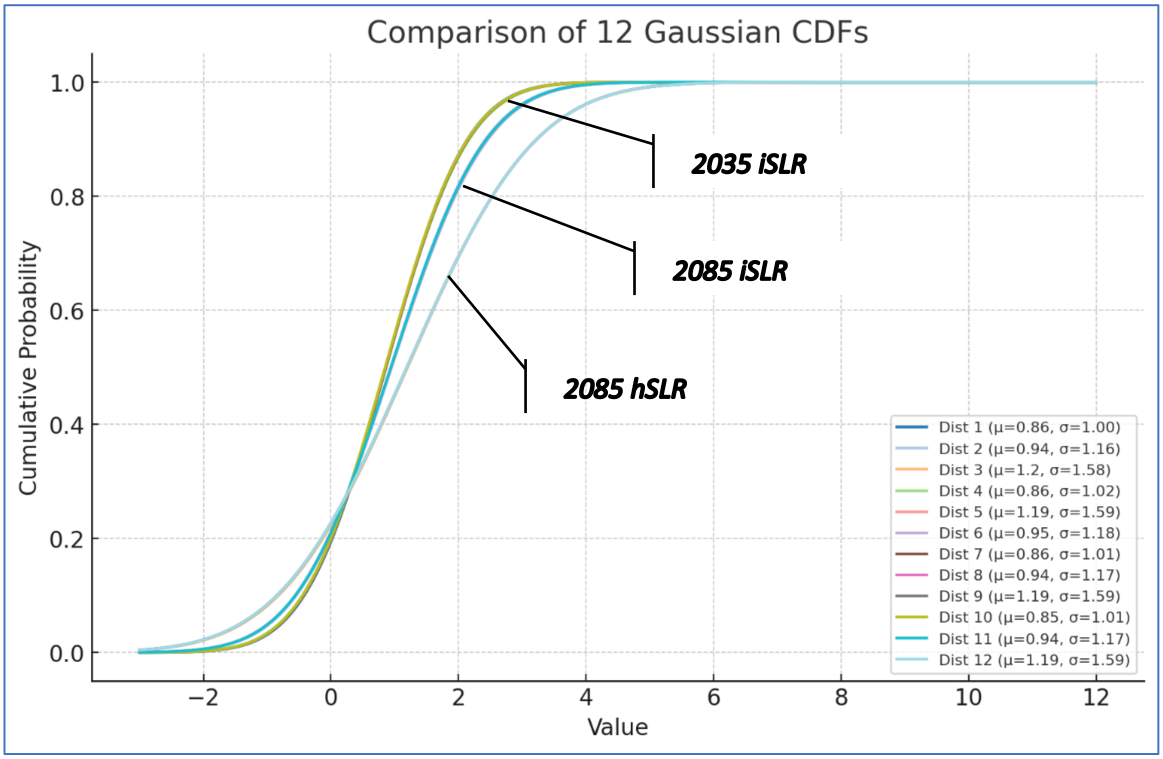
Alternative C – 2085 hSLR

ID	Scenario	Mean	StdDev	Min	Q1	Median	Q3	Max
1	Without Project – 2035 iSLR	0.86	1.00	0	0.07	0.45	1.40	9.56
2	Without Project – 2085 iSLR	0.94	1.16	0	0.08	0.49	1.47	9.59
3	Without Project – 2085 hSLR	1.20	1.58	0	0.11	0.67	1.66	9.92
4	Alternative A – 2035 iSLR	0.86	1.02	0	0.07	0.44	1.40	9.29
5	Alternative A – 2085 iSLR	0.95	1.18	0	0.07	0.48	1.47	9.33
6	Alternative A – 2085 hSLR	1.19	1.59	0	0.11	0.66	1.65	10.07
7	Alternative B – 2035 iSLR	0.86	1.01	0	0.07	0.44	1.40	9.30
8	Alternative B – 2085 iSLR	0.94	1.17	0	0.07	0.47	1.47	9.33
9	Alternative B – 2085 hSLR	1.19	1.59	0	0.10	0.66	1.65	10.06
10	Alternative C – 2035 iSLR	0.85	1.01	0	0.07	0.44	1.40	9.30
11	Alternative C – 2085 iSLR	0.94	1.17	0	0.07	0.48	1.47	9.33
12	Alternative C – 2085 hSLR	1.19	1.59	0	0.11	0.66	1.64	10.03



The floods are grouped into three distinct Gauss profiles:

- **2035 iSLR (IDs 1, 4, 7, 10)**: Narrow, centered around $\mu \approx 0.86$
- **2085 iSLR (IDs 2, 6, 8, 11)**: Slightly wider, centered around $\mu \approx 0.94$
- **2085 hSLR (IDs 3, 5, 9, 12)**: Widest, centered around $\mu \approx 1.19$



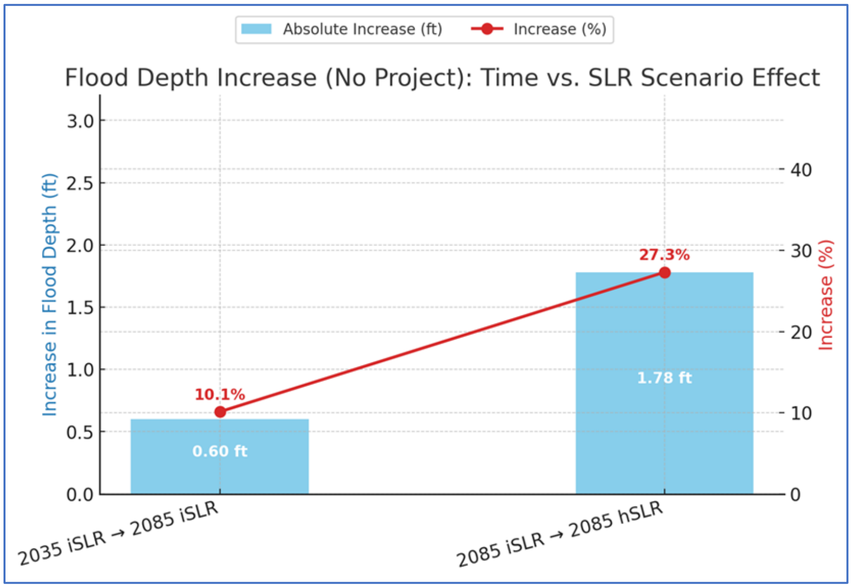
The comparison of the 12 Gaussian CDFs shows the following:

- **2035 iSLR (IDs 1, 4, 7, 10)**: The curve rises steeply → probability mass is tightly clustered near the mean.
- **2085 iSLR (IDs 2, 6, 8, 11)**: Smoother slope → more spread around the mean.
- **2085 hSLR (IDs 3, 5, 9, 12)**: Widest slope → values are most dispersed, with probability accumulating more gradually.

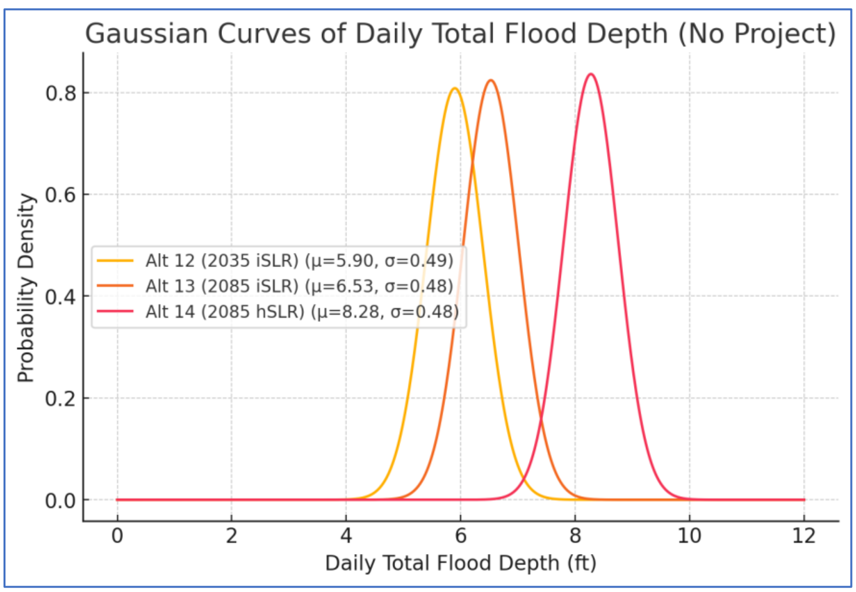
This confirms that as the mean increases, variance also increases, leading to a slower climb in the CDF.

APPENDIX B: Scenarios Flood Trends and Distribution Analysis

1. No Project Flood Trends and Distribution

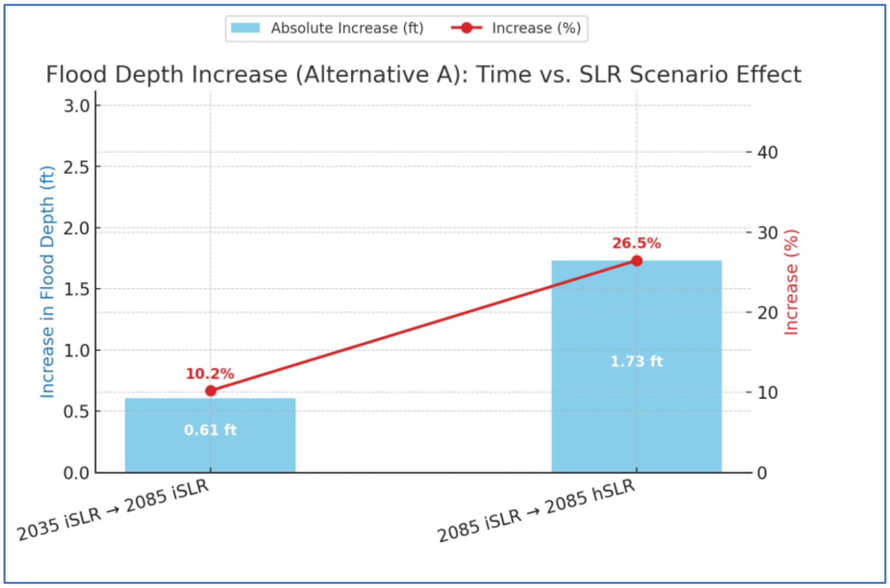


Trend1: No Project Time (2035-2085) vs SLR (i-h) Effect on Flood Depth

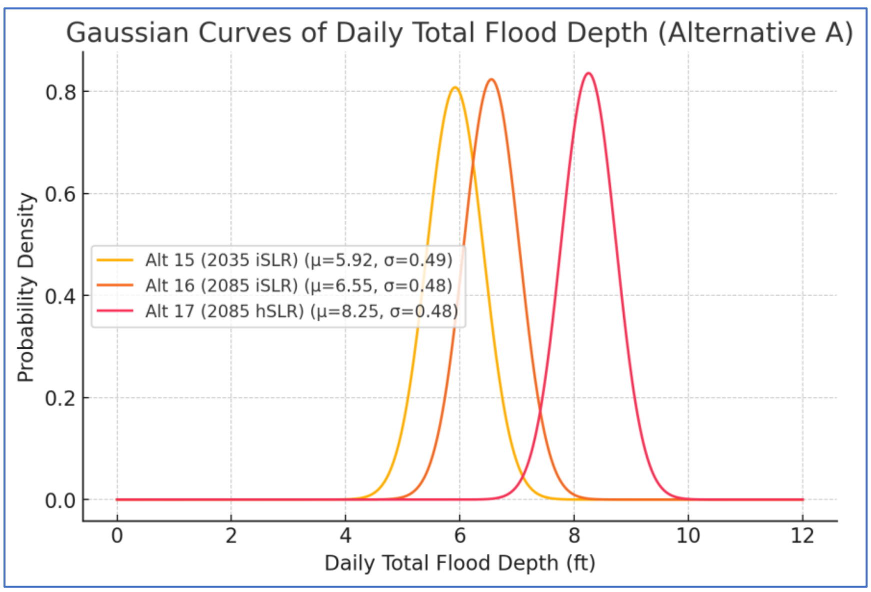


Distribution 1: No Project Daily Flood Depth Gaussian Curves

2. Build Alternative A Flood Trends and Distribution

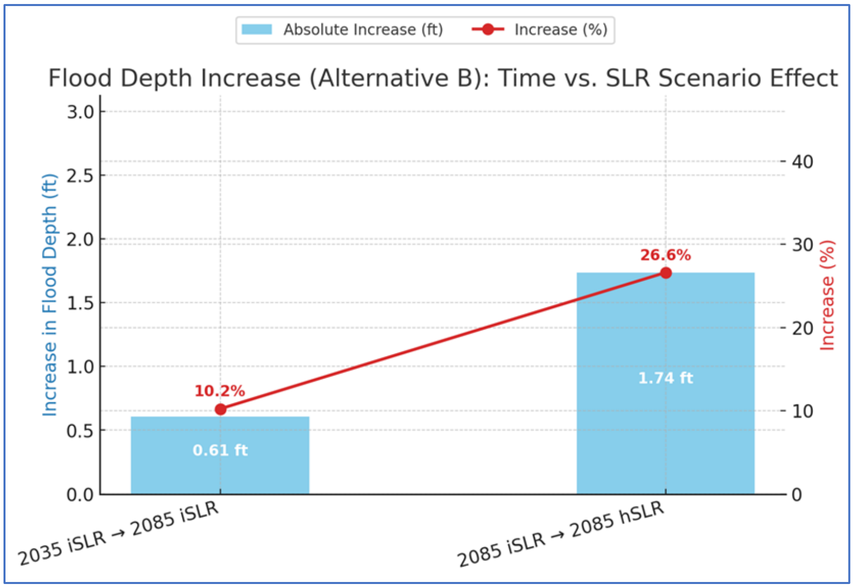


Trend 2: Alternative A (2035-2085) vs SLR (i-h) Effect on Flood Depth

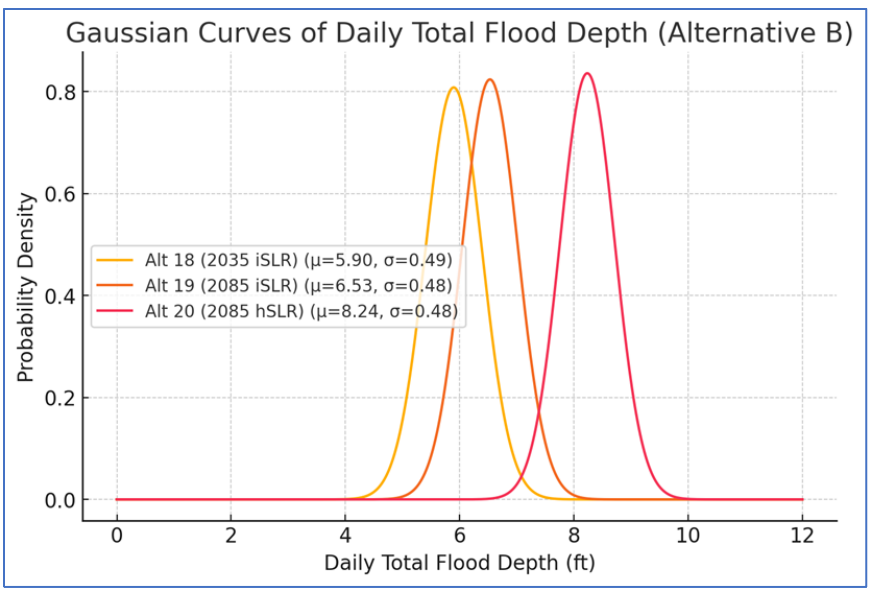


Distribution 2: Alternative A Daily Flood Depth Gaussian Curves

3. Build Alternative B Flood Trends and Distribution

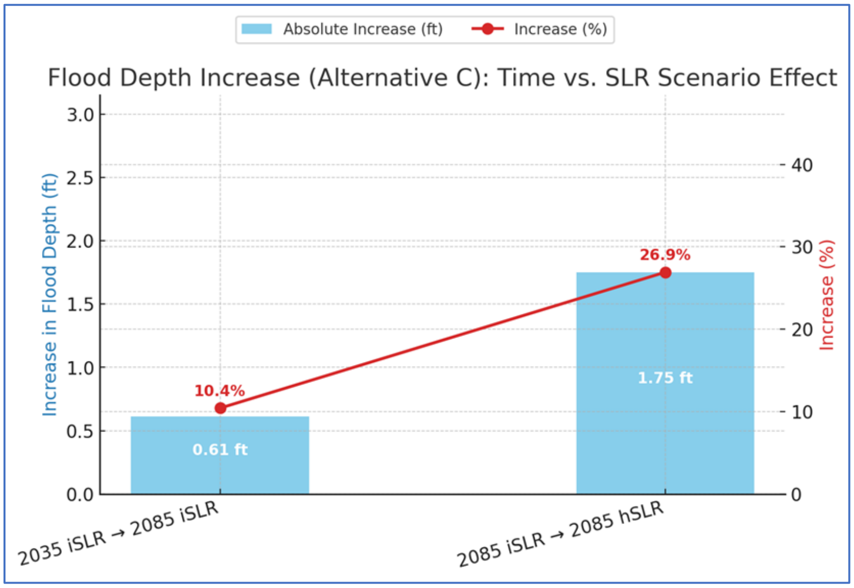


Trend 3: Alternative B (2035-2085) vs SLR (i-h) Effect on Flood Depth

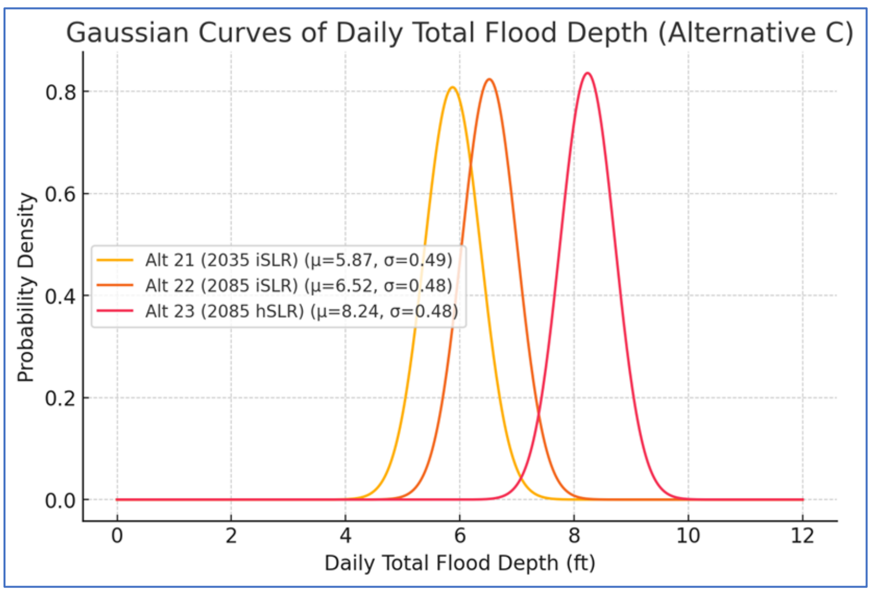


Distribution 3: Alternative B Daily Flood Depth Gaussian Curves

4. Build Alternative C Flood Trends and Distribution



Trend 4: Alternative C (2035-2085) vs SLR (i-h) Effect on Flood Depth



Distribution 4: Alternative C Daily Flood Depth Gaussian Curves

D.5 National Economic Development Benefits Transportation Benefits Technical Memorandum, Part B

Prepared for:	South Florida Water Management District
Prepared by:	J-Tech, an Alliance between Jacobs Engineering and Tetra Tech, Inc.
Date:	October 2025
Subject:	C&SF Flood Resiliency (Section 203) Study for Broward Basins, Transportation Benefits

DRAFT

1 Introduction:

This memo outlines the transportation benefits analysis, carried out as part of the South Florida Water Management District's (SFWMD) Central and Southern Florida (C&SF) Flood Resiliency (Section 203) Study for Broward Basins (203 Study).

This Section 203 Study focuses on enhancing the resiliency of the water control structures and adjacent primary canals in Broward Basins Reach A, a reach of the ongoing USACE C&SF Section 216 Study. Broward Basins Reach A is referred to herein as the Section 203 Study Area (or Study Area).

This analysis estimates the impact on travel times and vehicle operations that flooding of the transportation network in the analysis area would have on the transportation system. The benefits of three proposed build options and the tentatively selected plan (TSP) were compared to the future without project (FWOP) option to estimate the benefits of the proposed build options.

2 Methodology/Assumptions

The Transportation Benefits analysis used the USDOT's Benefit-Cost Analysis Guidance for Discretionary Grant Programs (May 2025) to set the analysis framework and guide calculation inputs. The assumptions and inputs used in the benefits calculations utilized standard inputs and values from USDOT's BCA guidance. The overall methodology includes the following steps:

- Define existing and future conditions under both FWOP and "with project" scenarios.
- The FWOP and with project scenarios incorporated a return interval that was applied to the transportation benefits because the exact timing of the next flood event in the study area is unknown. For this analysis, it was assumed a flood return period would be 25 years. Taking sea level rise into consideration, the annual probability of the event occurrence was 3.3 percent.
- Estimate benefits through 50 years of operations beyond the completion of work (from 2035 to 2084).
- Input USDOT-recommended monetized values for travel time savings and operating costs
- Input USDOT estimates for occupancy rates in passenger and commercial vehicles.
- Use dollar values in 2025 dollars and in instances where values are expressed in historical dollar years, using the Bureau of Labor Statistics (BLS) Consumer Price Index (CPI) to adjust the values
- Discount future benefits and costs with real discount rates of 3 percent consistent with USACE guidance.

The Southeast Florida Regional Planning Model (SERPM) was used to generate vehicle miles travelled and vehicle hours travelled under different storm events. The Federal Government requires Metropolitan Planning Organization (MPOs) serving urbanized areas with populations greater than 200,000 people to have a robust, validated, and regionally coordinated travel demand models to support long-range transportation planning processes. The SERPM travel demand model is maintained by the Regional Transportation Technical Advisory Committee-Modeling Subcommittee (RTTAC-MS) that is comprised of modeling experts from various agencies including Broward County, Miami-Dade Transportation Planning Organization, Florida Department of Transportation, and other government agencies. The U.S. Army Corps of Engineers (USACE) frequently uses outputs from MPO-approved travel demand models (like SERPM) during their participation in the NEPA (National Environmental Policy Act) processes and alternative evaluations.

The approach followed to estimate flood impact in transportation included the following assumptions:

- Utilized the approved SERPM travel demand model future network (2045).
- Added roadway elevation data by intersecting network with slope shapefile.
- Calculated flood depths by intersecting roadway elevations with flood shapefile.
- Run SERPM under the FWOP scenario and closing roadways where flood depth exceeded 0.5 feet.
- Run SERPM with project (Build Scenario) closing roadways where flood depth exceeded 0.5 feet.
- The model was run for a 24-hour period. Results were not annualized.

Section D.5 presents a comprehensive summary of the methodology, an expanded description of the SERPM model, and a statistical evaluation of input networks and flood datasets to corroborate the modeling results.

The following storm scenarios were modeled against the transportation network to estimate the impact on flooding under the build alternatives:

- Future Without Project Conditions, 2035 and 2085
- Alternative A, 2035 and 2085
- Alternative B, 2035 and 2085
- Alternative C, 2035 and 2085
- TSP, 2035 and 2085

The travel demand model was run assuming a 25-year rain event, a 2-foot surge, and intermediate sea level rise. The transportation benefits analysis was limited to the intermediate sea level rise scenario as the road network was heavily flooded under the high sea level rise scenario which made many roads impassable, leading to unreliable vehicle hours travelled results.

Figure 1 presents part of the geographic area covered by SERPM. The network used in the alternatives evaluation includes known and planned improvements through 2045. It was assumed that a roadway with more than 0.5 feet of flooding was considered impassable.

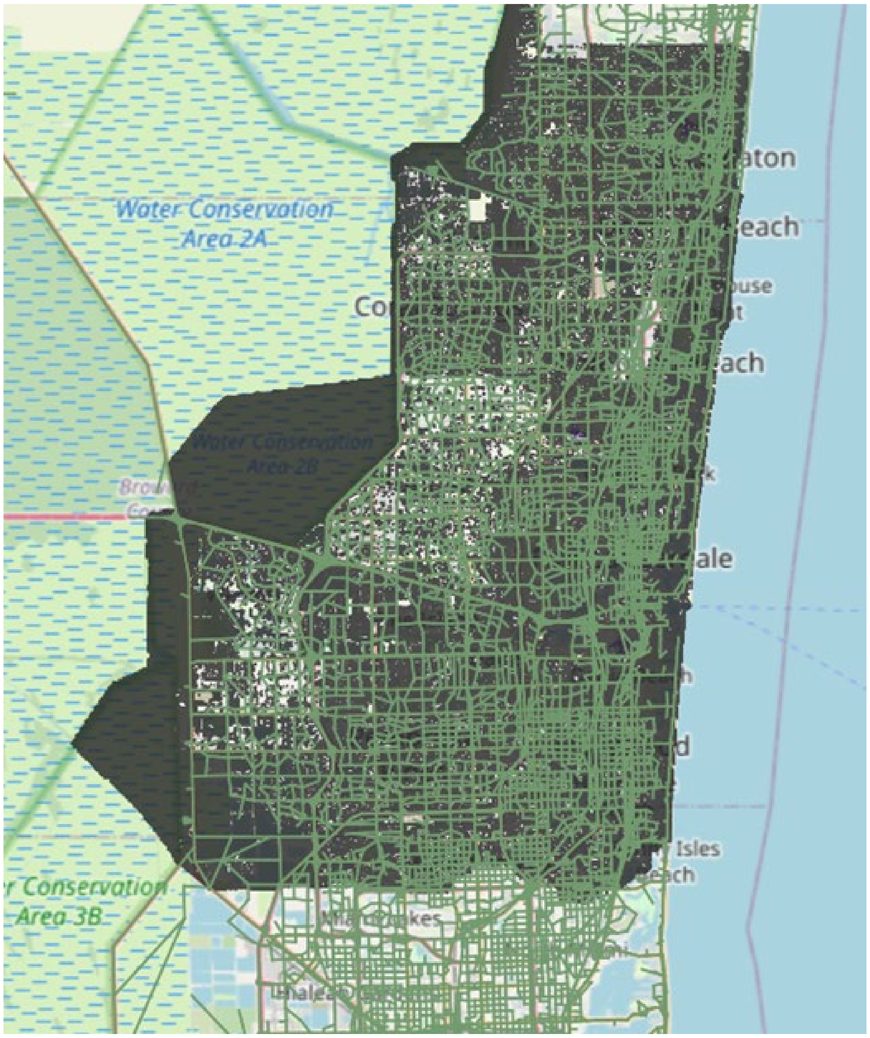


Figure 1. SERPM Travel Demand Model Network

3 Project Benefits

3.1 Travel Time Savings

For the Transportation Benefits analysis, the model was used to provide daily vehicle hours traveled (VHT) results from the 2035 and 2085 model years using the model's ultimate horizon (2045). To estimate the VHT in each of the years of the analysis between the endpoints, the data was interpolated. The 2045 model network inputs include the existing roadway network and all planned future improvements classified as "Cost Feasible" in South Florida's counties Long Range Transportation Plans (LRTPs). The VHT results are shown in Table 1.

Table 1. Vehicle Hours Travelled by Alternative

Alternative	2035	2085
Future Without Project	8,375,000	30,941,000
Alternative A	4,622,000	22,599,000

Alternative B	4,571,000	25,098,000
Alternative C	4,561,000	25,798,000
TSP	2,083,000	7,440,000

The value of travel time savings was calculated in accordance with U.S. DOT guidance. The guidance suggests $21.10 per person-hour (2023$) for all purpose local travel (auto), which assumes that 88.2 percent of local travel by surface modes (or trips) are personal while the remaining 11.8 percent are business. Value of travel time savings for trucks is assumed to be $35.70 (2023$) per person-hour. Hourly rates were adjusted to 2025 dollars. The average occupancy was assumed to be 1.52 for autos and 1.0 for trucks and trucks were assumed to represent 7.0 percent of the total traffic.

The estimated vehicle hours traveled summarized in Table X are adjusted based on type of vehicle and number of passengers. The VHT for private vehicles (i.e., cars) are estimated based on the following formula:

- Car VHTs = Total VHT * 93.0 percent car traffic * 1.52passenger per vehicle

The VHT for commercial vehicles (i.e., trucks) are estimated based on the following formula:

- Truck VHTs = Total VHT * 7.0 percent truck traffic * 1 passenger per vehicle

The adjusted total VHT are the sum of Car VHTs and Truck VHTs, which are computed for both No Build and With Project conditions. The annual VTTS are determined for the same period for With (i.e., under each of the three alternatives) and Without Project conditions based on the following formulas:

- Car VTTs = Total VHT * Value of Time for Private Vehicle Travel-All-Purposes
- Truck VTTs = Total VHT * Value of Time for Commercial Vehicle Travel-Truck Drivers

The analysis assumed a storm event annual probability of 3.3 percent. Because the timing of the event is unknown, the VHT in each year was adjusted by applying the annual probability of the storm event occurring. The present value of travel time savings over the 50-year analysis period for each of the alternatives when compared to the FWOP alternative are summarized in Table 2.

Table 2. Value of Travel Time Savings (VTTS) Benefits

Alternative	NPV Travel Time Savings (2025$)
Alternative A	$121,078,000
Alternative B	$110,968,000
Alternative C	$108,117,000
TSP	$248,847,000

3.2 Vehicle Operating Cost Savings

The project will result in savings in vehicle operating costs when compared to the no-build scenario due to better flow of traffic because fewer roads are closed due to flooding. The value of vehicle operating cost savings was calculated in accordance with U.S. DOT guidance which suggests vehicle operating costs of $0.56 per mile and $1.27 per mile for autos and truck, respectively. These costs are in 2023$ and are adjusted to 2025$ in the analysis. The per-mile vehicle operating cost estimates were multiplied by the difference between the annualized VMT under the FWOP alternative and the annualized VMT under the build alternative. Table 3 presents the VMT for each alternative.

Table 3. Vehicle Miles Travelled by Alternative

Alternative	2035	2085
Future Without Project	54,689,000	54,661,000
Alternative A	54,234,000	53,454,000
Alternative B	54,161,000	54,012,000
Alternative C	54,171,000	53,455,000
TSP	16,119,000	16,021,000

The annual vehicle operating cost savings are determined for the same period for FWOP and With Project conditions based on the following formulas:

- Car VOCS = Total VMT * Vehicle Operating Costs
- Truck VOCS = Total VMT * Vehicle Operating Costs

VOCS is determined as the difference between FWOP and With Project conditions

The analysis assumed a storm event annual probability of 3.3 percent. Because the timing of the event is unknown, the VHT in each year was adjusted by applying the annual probability of the storm event occurring. The present value of vehicle operating cost savings over the 50-year analysis period when compared to the FWOP alternative are summarized in Table 4.

Table 4. Vehicle Operating Cost Savings

Alternative	NPV Vehicle Operating Cost Savings (2025$)
Alternative A	$314,000
Alternative B	$245,000
Alternative C	$331,000
TSP	$16,436,000

3.3 Summary

The results of the Transportation Benefits analysis for the project alternatives are summarized in Table 5. The NPV calculation takes projected benefits over the study period and discounts these benefits at the 3 percent discount rate, which reduces the value of future benefits by the time value of money (discount rate). Benefits that begin in 2035 are discounted over the 50-years of operation.

Table 5. Summary of Total Project Benefits, 2025$

Alternative	NPV Travel Time Savings	NPV Vehicle Operating Cost Savings	NPV Total Benefits
Alternative A	$121,078,000	$314,000	$121,392,000
Alternative B	$110,968,000	$245,000	$111,213,000
Alternative C	$108,117,000	$331,000	$108,448,000
TSP	$248,847,000	$16,436,000	$265,283,000

D.6 Regional Economic Development Benefits Business Interruption Technical Memorandum

Business Interruption Analysis DRAFT Technical Report

Assessment of Business Interruption for the South Florida Water Management District

Submitted to:
South Florida Water Management District
David Griffin
Resiliency Project Manager
dgriffin@sfwmd.gov

Written by:
ICF Incorporated, LLC
1902 Reston Metro Plaza
Reston, VA 20190
www.icf.com

1 Introduction

This report presents the findings of a business interruption analysis for the South Florida Water Management District (SFWMD), as part of the Section 203 Comprehensive Benefits Analysis. The research team estimated the financial impacts of business interruptions caused by flooding by calculating Direct Output Loss in a Future Without Project (FWOP) condition, as well as three resiliency alternatives. The Direct Output Loss metric used to underpin this analysis refers to the reduction in sales and production value due to disruption to a non-residential building's use and is calculated based on HAZUS Flood Technical Manual methodologies. The analysis shows how losses could be avoided by implementing various levels of flood protection.

1.1 Location

The Study Area consists of the eastern portion of Broward County and a small portion of southern Palm Beach County. The Study Area is inland and does not border the Atlantic Ocean. Broward and Palm Beach Counties are two of the most populated counties in Florida, boasting diverse economies with high employment rates in transportation and utilities; professional and business services; education and health services; and leisure and hospitality sectors.[1] Given this context, as well as South Florida's connections to global trade, understanding the potential impacts of a severe flood event to businesses is critical for decision-making regarding resilience investments.

The Study Area consists of nine upstream and six downstream watershed basins with a network of seven primary canals managed by nine water control structures (seven of which are coastal structures), in addition to other existing water control structures not directly relevant to this study. The analysis focuses on the 302 square miles of managed watersheds upstream of the coastal water control structures, shown in Figure 1 and described in Table 1.

[1] Bureau of Labor Statistics, Miami Area Economic Summary. July 3, 2024. Website: https://www.bls.gov/regions/southeast/summary/blssummary_miami.pdf.

Figure 1. Study area basins, primary canals, and primary water control structures.

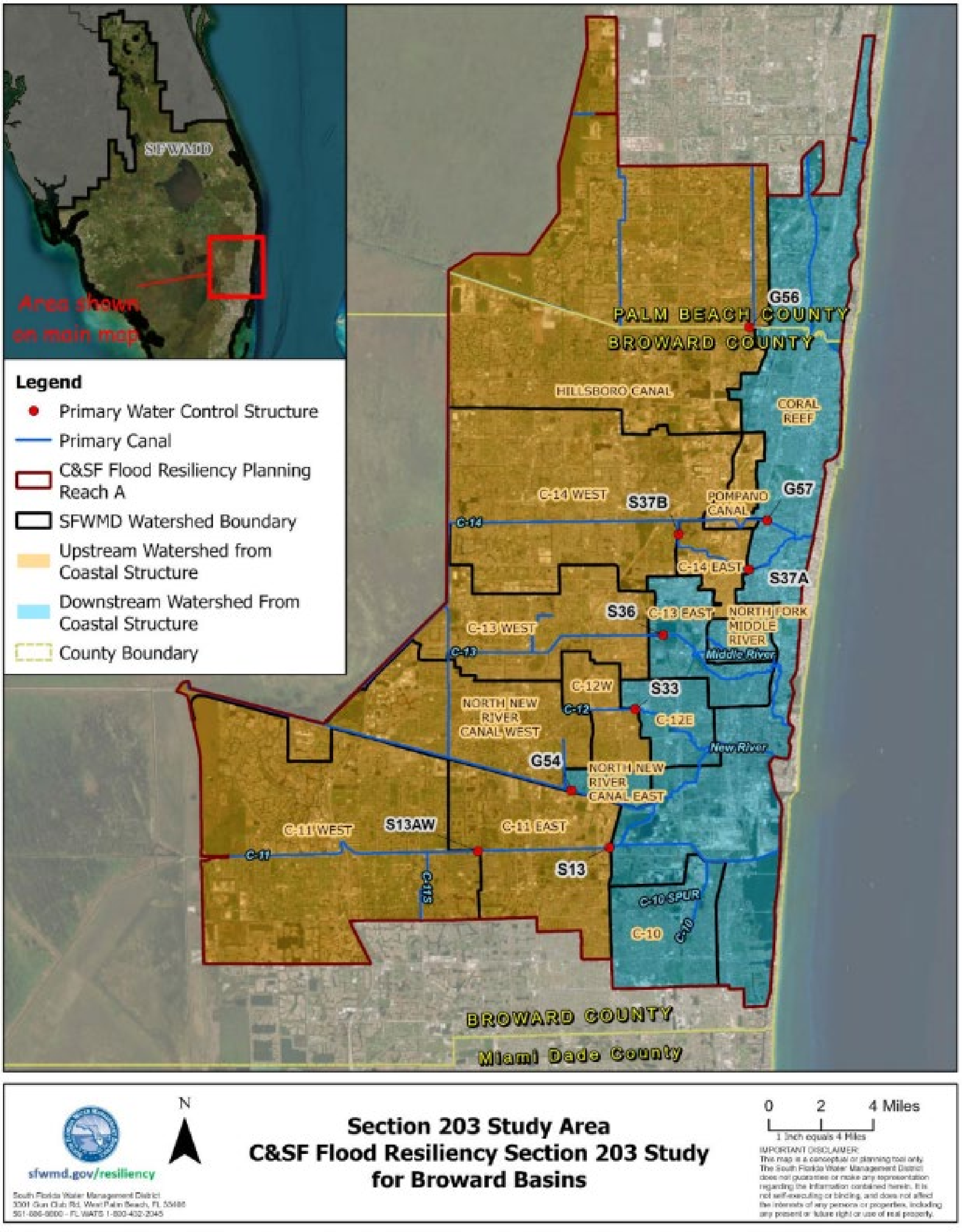


Table 1. Study Area Basins

Managed Upstream Watershed Basin	Primary Canal	Primary Water Control Structure	Downstream Watershed Basin
Hillsboro Canal Basin	G-08 (Hillsboro) Canal	G-56 Gated Spillway	Coral Reef Basin
Pompano Canal Basin	G-16 (Pompano) Canal	G-57 Gated Spillway	Coral Reef Basin
C-14 West Basin	C-14 (Cypress Creek) Canal	S-37B Gated Spillway	C-14 East Basin
C-14 East Basin	C-14 (Cypress Creek) Canal	S-37A Gated Spillway	Coral Reef Basin
C-13 West Basin	C-13 (Middle River) Canal	S-36 Gated Spillway	C-13 East, North Fork Middle River, and Coral Reef Basins
C-12 West Basin	C-12 (Plantation) Canal	S-33 Gated Spillway	C-12 East and Coral Reef Basins
North New River Canal West Basin	C-15 (North New River) Canal	G-54 Gated Spillway	North New River Canal East and Coral Reef Basins
C-11 West Basin	C-11 (South New River) Canal	S-13AW Gated Culvert	C-11 East Basin
C-11 East Basin	C-11 (South New River) Canal	S-13 Pump Station and Gated Spillway	Coral Reef and C-10 Basins

This report documents the quantification of economic impact for buildings in the Study Area. The intent of this report is to supplement a parent document about the comprehensive benefits analysis in support of the alternative plans analysis included in Section 4 of the Main Report.

1.2 Flood Scenarios

Modeling by a separate consultant was conducted to calculate flood depths across the Study Area using MIKE SHE and MIKE Hydro. Flood depths from this modeling are provided as peak flood depths (feet). This modeling quantifies depth duration and peak flood depths for eight compound flood frequency events at the base year (2035) and the outyear (2085). The 2085 future conditions incorporate low, intermediate, and high sea level rise scenarios. This business interruption analysis evaluates exposure to structures in the Study

Area and is calculated using HEC-FDA Version 2.0.. Table 2 describes the three flood scenarios used in this analysis. For every flood scenario, the analysis considers both intermediate and high sea level change (SLC) projections.

Table 2. Design storm scenarios for the business interruption analysis

Coastal Water Level Return Period (CHS Data)	Rainfall Return Period (NOAA-Atlas 14)	Compound Flooding Frequency	Probability Event % (AEP)	Scenario Flooding Focus
2-year	25-year	30-year	3.33%	- Upstream Events - Rainfall Events
2-year	100-year	110-year	0.91%	- Upstream Events - Rainfall Events
100-year	100-year	430-year	0.23%	- Compound Flooding and Rainfall Events - Storm Surge Events

1.3 Alternative Plans

Four conditions were included in this Section 203 analysis, the Future Without Project (FWOP), and three project alternatives (Alternatives A, B, and C). Each alternative contains effective features in reducing flood levels in the managed upstream water basins. These features consist of storage and nature based proposed projects, primary structure modifications, and Central and South Florida (C&SF) Canal improvements included in Section 4 of the Main Report.

2 Direct Output Loss

2.1 Methodology

This analysis calculates business interruption in the Study Area using the Direct Output Loss metric. Direct Output Loss refers to reduced sales and production value due to functional disruption of a building's use. Direct Output Loss is calculated using the methodology described in the HAZUS Flood Technical Manual, Equation 6-7.

Equation 6-7. Direct Output Loss by Occupancy

$$\textbf{Direct Output Loss}_i = \sum_j (1 - WRF_i) \times FA_{ij} \times DO_i \times RT_{ij}$$

Where:

i = HAZUS-specific occupancy *i*
$\mathbf{WRF_i}$ = Wage recapture factor for occupancy *i*
$\mathbf{FA_{ij}}$ = Floor area of occupancy *i* (in ft^2) at depth *j*
$\mathbf{DO_i}$ = Direct output ($\$/ft^2/day$) for occupancy *i*
$\mathbf{RT_{ij}}$ = Restoration time (in days) for occupancy *i* and water depth *j* (see Table 6-4 through Table 6-15)

The Direct Output Loss equation calculates how a given flood inundation depth impacts the economic production of the building's services by considering the building's wage recapture factor, floor area of occupancy, direct output for occupancy, and restoration time for occupancy and flood depth. The HAZUS Inventory Technical Manual[2] provides these standard values, including Direct Output, in 2021 $ and this analysis utilizes the Consumer Price Index Inflation Calculator[3] to adjust for inflation, from January 2021 to January 2025 $ values.

Damage to non-residential buildings in the Study Area can have direct impacts on the South Florida economy, including non-recoverable and non-transferrable loss of sales and revenues due to business closure. Direct Output Loss estimates are calculated using HAZUS building occupancy definitions and national standard values for output expected for varying types of building occupancies and economic industries. The standard values for direct output and wage recapture factor applied to the calculations in order to assume potential recouped losses, are provided in Table 3.

[2] Hazus 6.0 Inventory Technical Manual
[3] CPI Inflation Calculator

Table 3: HAZUS Occupancies, Standard Values for Direct Output and Wage Recapture Factor

HAZUS Code	Definition	Direct Output per Square Foot ($)	Wage Recapture Factor (%)
RES 4	Temporary Lodging	0.69	60
RES 6	Nursing Home	1.15	60
COM 1	Retail Trade	0.60	87
COM 2	Wholesale Trade	0.78	87
COM 3	Personal and Repair Services	0.92	51
COM 4	Professional, Technical, Business Services	1.35	90
COM 5	Banks	4.38	90
COM 6	Hospital	1.15	60
COM 7	Medical Office or Clinic	2.31	60
COM 8	Entertainment and Recreation	1.45	60
COM 9	Theatres	1.38	60
IND 1	Heavy Industry	2.32	98
IND 2	Light Industry	2.32	98
IND 3	Food, Drugs, Chemical	3.12	98
IND 4	Metals, Minerals Processing	2.47	98
IND 5	High Technology	4.68	98
IND 6	Construction	2.32	98
AGR 1	Agriculture	1.15	75
REL 1	Church or Membership Organization	2.31	60
GOV 1	General Services	0.92	80
GOV 2	Emergency Response	1.06	0
EDU 1	Schools and Libraries	4.47	60
EDU 2	Colleges and Universities	6.8	60

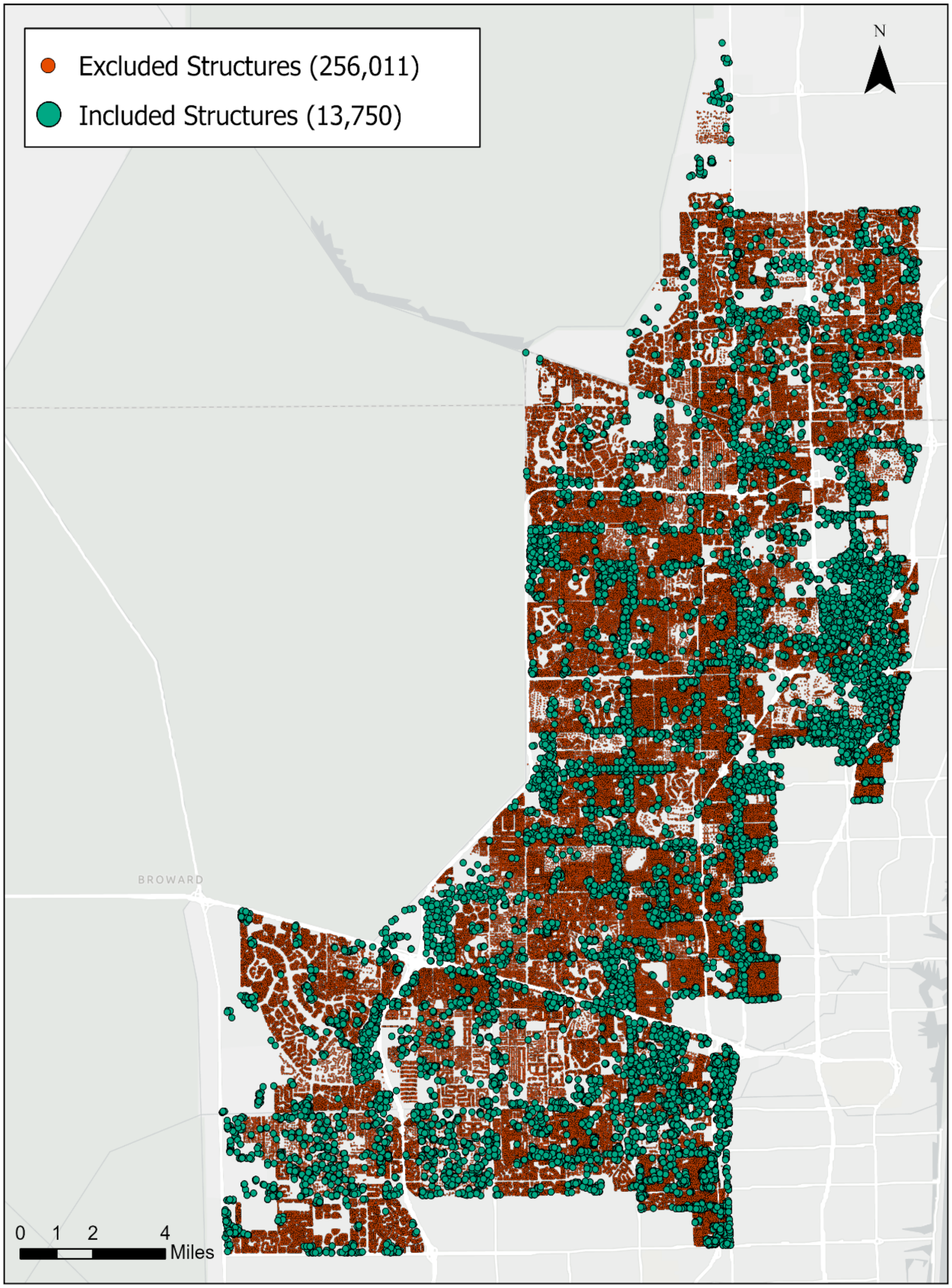
The following building types do not generate business sales or revenue, so the Direct Output Loss value associated with these structures is $0:

- COM-10 (parking structure)
- ESSM (electric substation)
- PWTM (water treatment plant)
- WWTM (wastewater treatment plant)
- RES1 (single-family dwelling)
- RES2 (mobile home)

- RES 3C – RES3F (multi-family dwellings)
- RES5 (institutional dormitory)

The structure inventory includes 269,761 buildings in the Study Area. The majority of these buildings - 256,011 structures – are structures that do not produce revenues and are therefore excluded from this analysis. Direct output losses are calculated for the remaining 13,750 structures (Figure 2).

Figure 2. Structures in the study area.



Business interruption losses depend on the amount of time required to restore business operations. HAZUS provides restoration times related to maximum flood depths in four-foot increments in Tables 6-4 through 6-15 of the HAZUS Flood Model Technical Manual.[4] To develop restoration times with greater flood depth-specificity, this analysis computed unique restoration time polynomial functions for each HAZUS structure type to provide finer resolution estimates of restoration time for flood depths within the four foot increments. Each restoration time function is derived by performing a regression analysis of maximum flood depth versus restoration time, based on data from Tables 6-4 through 6-15 in the HAZUS Flood Model Technical Manual. The resulting regression lines exhibit high goodness-of-fit, with R-squared values ranging from 0.995 to 1 (Appendix A).

After calculating Direct Output Loss for each flood scenario, analysts aggregated these losses to compute an annualized value for each future condition (either Future Without Project or Alternative A, B, or C) using the following equation:

$$\text{Annualized Direct Output Loss}_{\text{Future Condition}} = 3.33\% \times \text{Direct Output Loss}_{3.33\%\ \text{AEP}} + 0.91\% \times \text{Direct Output Loss}_{0.91\%\ \text{AEP}} + 0.23\% \times \text{Direct Output Loss}_{0.23\%\ \text{AEP}}$$

This analysis utilizes Quickbase, a low-code application development platform to aid in running calculations and creating illustrative graphics and reports.

2.2 Data Sources

- *Structure Inventory* – Microsoft Building Footprint database enriched by normalized tax assessor parcel, US Census Florida 2020, and CDC data sources (2025)
- *Flood-Depths* – HEC-FDA output flood depths above first floor (2025)
- *Watershed Boundaries* – SFWMD Broward Basins (2024)

3 Results

It is important to note that the modeled structural flood data are being refined because in some cases, structures located across two raster cells may have inconsistencies in flood depth values due to variations in the MIKE model cell extraction. As a result, the HEC-FDA modeling results produce some unexpected flood depths for certain structures in certain

[4] Hazus 7.0 Flood Model Technical Manual

flood scenarios, such as structures which show greater flood depths in one or more alternative relative to FWOP.

3.1 Structures Exposed to Flooding

Of the 13,750 structures in the Study Area, 945 structures are exposed to flooding under at least one flood event and sea level rise projection. The remaining 93.1% of structures are not exposed to flooding under any scenario evaluated in this analysis. (Figure 3).

Figure 3. Structures exposed to flooding in the study area.

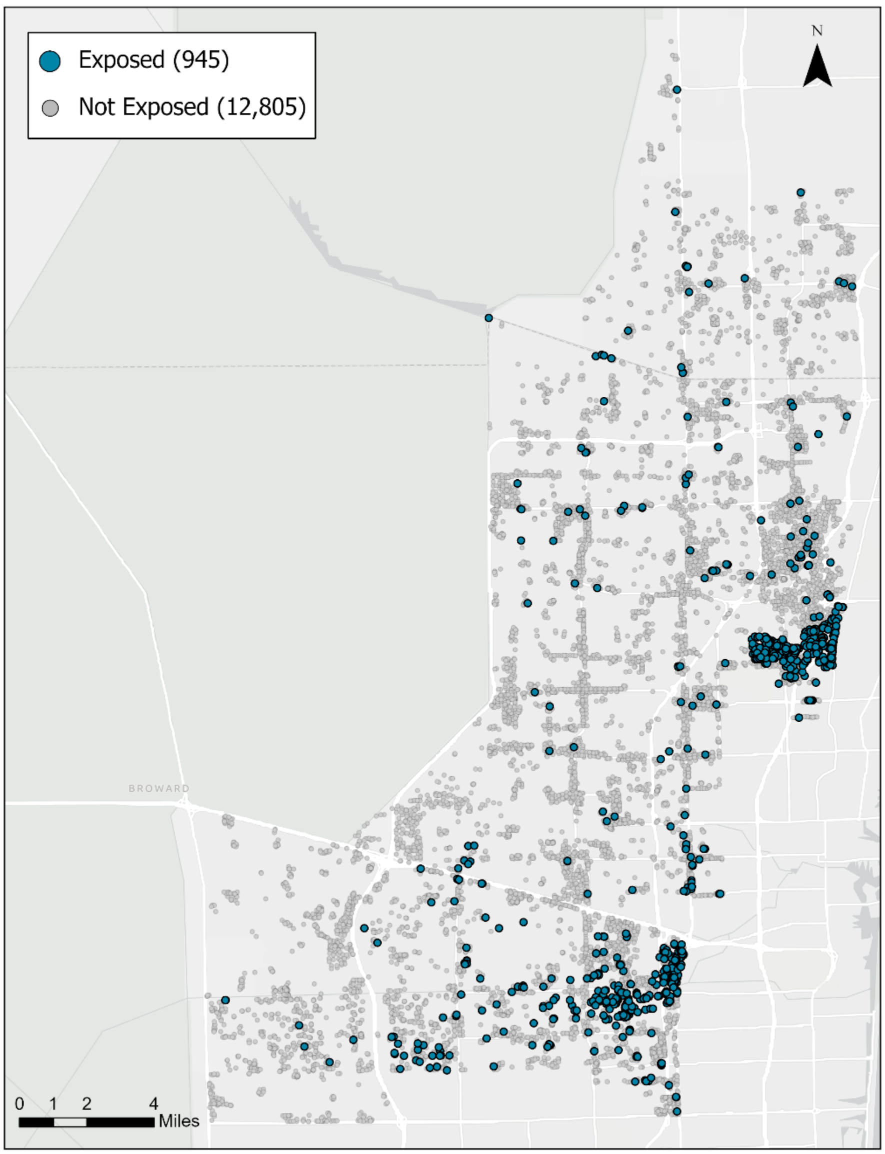


Figure 4. Change from FWOP in the number of buildings exposed to > 0 ft. of flooding

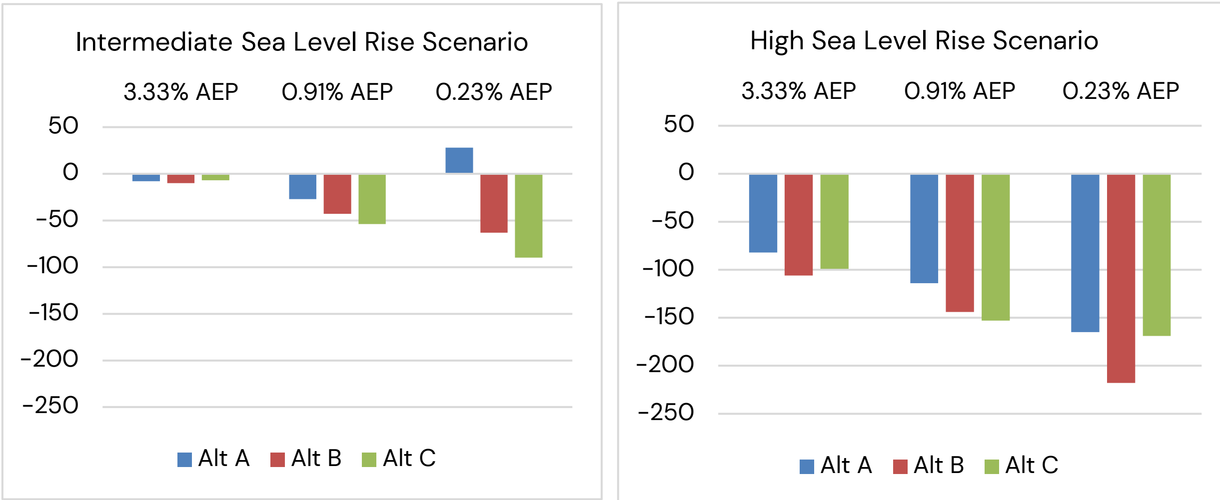
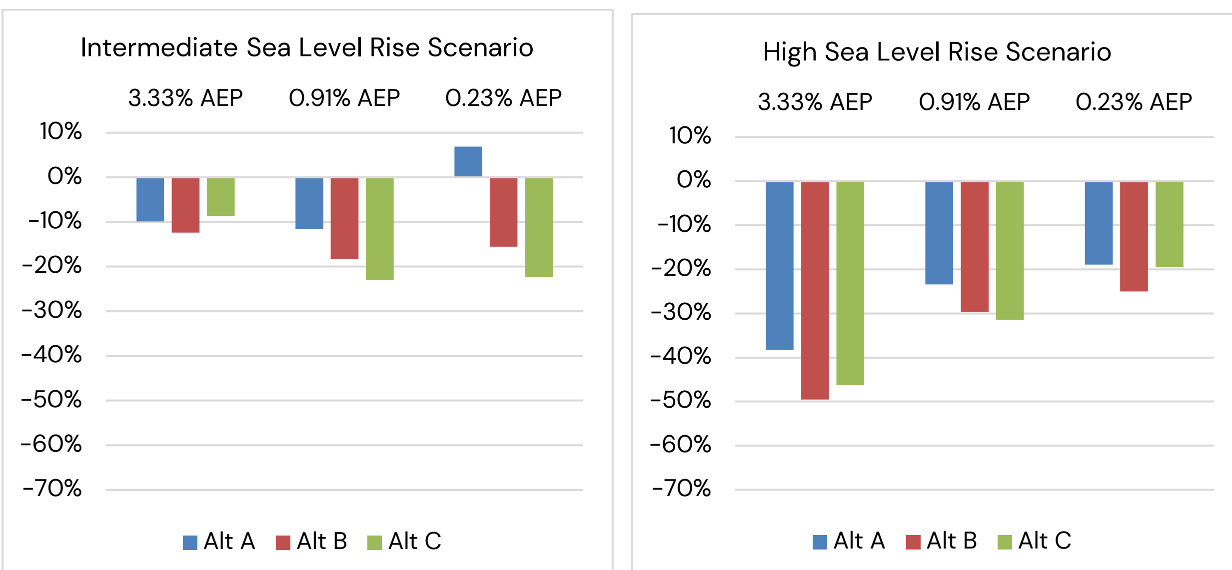


Figure 4. Percent change from FWOP in number of buildings exposed to > 0 ft. of flooding.



There are fewer structures exposed to flooding in Alternatives B and C compared to FWOP for every flooding event under both intermediate and high SLC scenarios. In Alternative A, the number of buildings exposed to flooding above 0 ft. is less than FWOP for *almost* every flood event under both sea level rise scenarios, the exception being the 0.23% AEP flood under an intermediate sea level rise scenario, in which the number of buildings exposed increases by 28, representing a +7% change (see Figure 4). This inconsistency is due to 20 structures, mostly in the C-14 East basin, that have greater flood depths in Alternative A than in FWOP. These unexpected flood depths are likely due to the modeling inconsistencies described in Section 1.2.

Across all flood events and sea level rise scenarios, the greatest reduction in total number of buildings exposed relative to FWOP occurs during the 0.23% AEP event under the high sea level rise scenario—the most severe future condition modeled. Under this scenario, Alternative B provides the highest level of protection, reducing exposure by 218 buildings, a 25% decrease from the Future Without Project condition. Alternative A reduces exposure by 165 buildings, while Alternative C reduces exposure by 169 buildings, each representing an approximate 19% reduction from the Future Without Project condition.

Across all flood events and sea level rise scenarios, the largest proportional reduction in building exposure relative to FWOP occurs during the 3.33% AEP event under the high sea level rise scenario. Under this condition, Alternative B offers the greatest level of protection, reducing the number of buildings exposed by 50%—from 204 buildings under the Future Without Project condition to 108 buildings. Alternative A reduces exposure by 38% (to 132 buildings), while Alternative C reduces exposure by 46% (to 115 buildings).

3.2 Direct Output Loss

Annualized Direct Output Losses range from $2M to $5M across the various design alternatives. These values are presented by basin in Appendix B and by HAZUS building type in Appendix D. Individual structure Direct Output Losses are presented in the maps in Appendix C.

Direct output losses are highly correlated with flood exposure. Since flood depths are generally greater in FWOP than in the project alternatives, Direct Output Losses also tend to be greater in FWOP than in alternatives A, B, or C (Table 4 and Table 5).

Table 4: Total Direct Output Losses among structures exposed to >0ft. of flooding.

	Intermediate Sea Level Rise Scenario			
	3.33% AEP	***0.91% AEP***	***0.23% AEP***	***Annualized Damages***
FWOP	$23,775,316	$83,178,578	$204,746,376	$2,024,836
Alt A	$33,459,123	$78,992,002	$212,008,020	$2,326,457
Alt B	$33,450,487	$72,550,195	$148,807,944	$2,120,629
Alt C	$33,459,157	$66,304,469	$134,491,460	$2,030,845
	High Sea Level Rise Scenario			
	3.33% AEP	***0.91% AEP***	***0.23% AEP***	***Annualized Damages***
FWOP	$42,440,726	$155,137,835	$308,351,766	$5,268,073
Alt A	$42,440,726	$155,137,835	$308,351,766	$3,542,135
Alt B	$39,834,365	$107,411,455	$269,194,159	$2,930,316

Alt C	$39,357,632	$105,720,829	$301,294,892	$2,973,709

Table 5: Avoided annual damage among structures exposed to >0ft. of flooding.

	Intermediate Sea Level Rise Scenario			
	3.33% AEP	***0.91% AEP***	***0.23% AEP***	***Annualized Damages***
Alt A	+$9,683,806	-$4,186,575	+$7,261,643	$301,621
Alt B	+$9,675,171	-$10,628,383	-$55,938,431	$95,793
Alt C	+$9,683,841	-$16,874,109	-$70,254,916	-$4,055,681
	High Sea Level Rise Scenario			
	3.33% AEP	***0.91% AEP***	***0.23% AEP***	***Annualized Damages***
Alt A	-$28,961,642	-$70,485,559	-$51,502,311	-$1,725,938
Alt B	-$31,568,002	-$118,211,939	-$90,659,918	-$2,337,757
Alt C	-$32,044,735	-$119,902,566	-$58,559,185	-$2,294,364

The exceptions to this trend are the 0.23% AEP flood event under the intermediate SLC scenario, which induces greater Direct Output Losses in Alternative A than in FWOP, and the 3.33% AEP flood event under the intermediate SLC scenario, which induces greater Direct Output Losses in each of the design alternatives than in FWOP. The 0.23% AEP anomaly is due to the 20 structures, primarily in the C-14 East basin, that have greater flood depths in Alternative A than in FWOP. The resulting Direct Output Losses for these structures are greater in Alternative A than in FWOP. The 3.33% AEP anomaly is driven by greater flood exposure to eleven structures in the design alternatives than in FWOP. The structures are included in Table 6.

Table 6: Structures for which flood exposure is greater in the design alternatives than in FWOP. 3.33% AEP; Intermediate SLC scenario

Structure FID	Hazus Code	FWOP Depth (ft)	Alt A Depth (ft)	Alt B Depth (ft)	Alt C Depth (ft)	FWOP Direct Output Loss ($)	Alt A Direct Output Loss ($)	Alt B Direct Output Loss ($)	Alt C Direct Output Loss ($)
12111131	COM4	0.097	0.579	0.579	0.579	$172,562.62	$180,999.11	$180,999.11	$180,999.11
21273307	COM1	0.605	0.605	0.618	0.47	$11,192.43	$11,192.43	$11,237.03	$10,727.55
12203030	IND2	0.445	0.447	0.446	0.451	$1,453.54	$1,460.07	$1,456.81	$1,473.14
40363605	AGR1	0.418	0.397	0.397	2.152	$828.65	$787.02	$787.02	$4,266.18
12180803	IND2	0.048	0.05	0.049	0.055	$157.16	$163.71	$160.44	$180.08
40394048	IND3	-0.024	0.119	0.119	0.119	$0	$212,321.25	$212,321.25	$212,321.25
20015802	COM1	-0.3	0.048	0.048	0.048	$0	$362,736.31	$362,736.31	$362,736.31
40369282	AGR1	-0.552	-0.629	-0.629	2.174	$0	$0	$0	$5,679.48

Structure FID	Hazus Code	FWOP Depth (ft)	Alt A Depth (ft)	Alt B Depth (ft)	Alt C Depth (ft)	FWOP Direct Output Loss ($)	Alt A Direct Output Loss ($)	Alt B Direct Output Loss ($)	Alt C Direct Output Loss ($)
40376777	AGR1	-0.996	-1.001	-1.001	2.159	$0	$0	$0	$9,219.62
48144717	EDU1	-1.068	0.149	0.149	0.149	$0	$12,042,960.98	$12,042,960.98	$12,042,960.98
40373218	AGR1	-1.24	-1.24	-1.24	2.15	$0	$0	$0	$9,805.11

Direct output losses among structures exposed to >0 ft. of flooding are less than FWOP under almost every flood event and sea level rise scenario for all Alternatives (Figure 6). The 3.33% AEP flood event under an intermediate sea level rise scenario is the major exception, as all three Alternatives are associated with an approximately $9.7 million increase in Direct Output Losses for buildings experiencing flooding above the first floor, representing a 41% change from FWOP. Alternative A is also associated with an approximately $7.2 million increase in Direct Output Losses for a 0.23% AEP flood event under an intermediate sea level rise scenario, representing a 4% change from FWOP. These anomalies are a direct result of the modeling inconsistencies discussed above.

Across all flood events and sea level rise scenarios, the largest total reduction and proportional reduction in Direct Output Losses occurs during the 0.91% AEP flood event under a high sea level rise scenario. Under this condition Alternative C offers the greatest proportional reduction in Direct Output Losses, decreasing losses by 53%, or approximately $119.9 million. Alternative A reduces Direct Output Losses by 31% (approximately $70.5 million), while Alternative B reduces Direct Output Losses by 52% (approximately $118.2 million). Proportional reductions in Direct Output Losses compared to FWOP for each alternative are provided in Figure 7

Figure 5. Change from FWOP in direct output losses among structures exposed to >0 ft. of flooding.

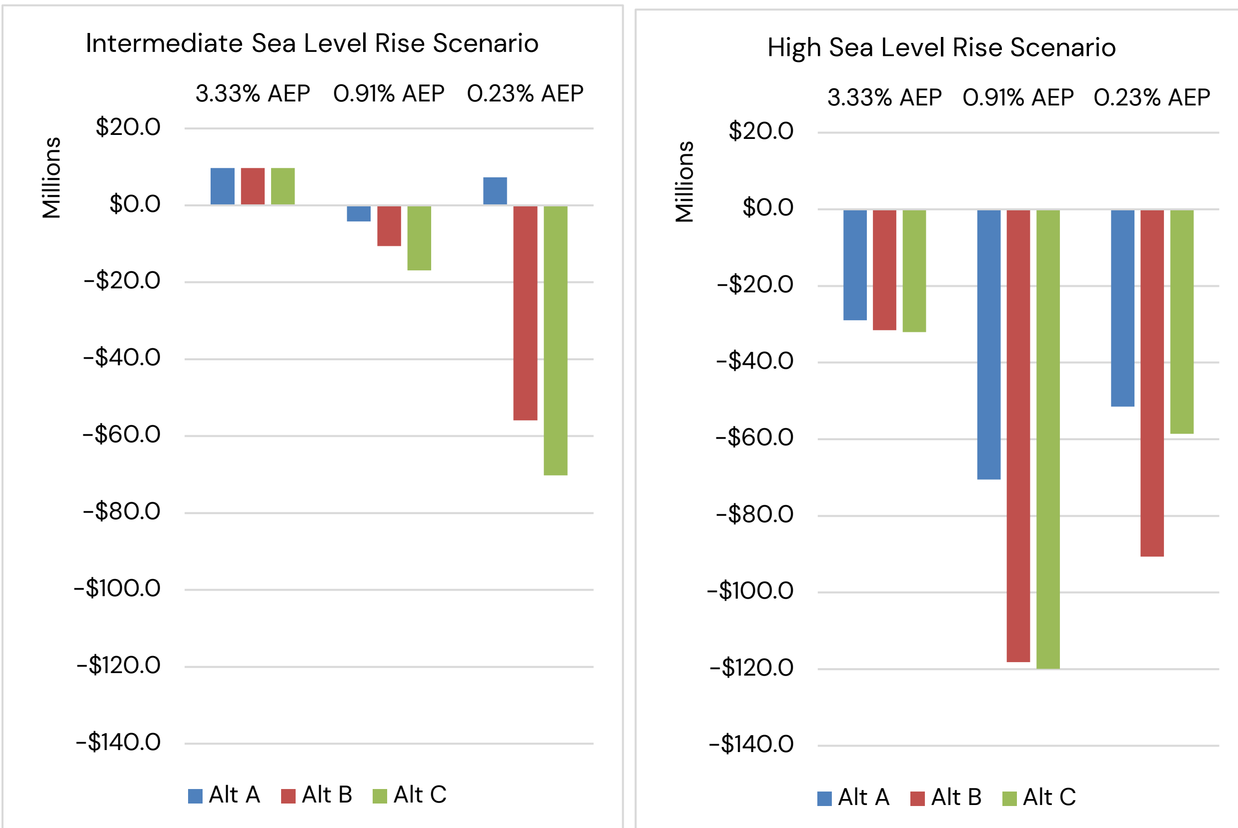


Table 7. Percent change from FWOP in total Direct Output Losses among structures exposed to >0ft. of flooding.

	Intermediate Sea Level Rise Scenario			
	3.33% AEP	***0.91% AEP***	***0.23% AEP***	***Annualized Damages***
Alternative A	41%	-5%	4%	+14%
Alternative B	41%	-13%	-27%	+4.7%
Alternative C	41%	-20%	-34%	+0.3%
	High Sea Level Rise Scenario			
	3.33% AEP	***0.91% AEP***	***0.23% AEP***	***Annualized Damages***
Alternative A	-41%	-31%	-14%	-32%
Alternative B	-44%	-52%	-25%	-44%
Alternative C	-45%	-53%	-16%	-44%

Discussion

The research team identified two areas with high concentrations of structures exposed to flooding (Figure 3). One cluster is on the border between Fort Lauderdale and Pompano Beach, along West McNab Road and Interstate 95 and between Northwest 21st Avenue and South Dixie Highway. The other cluster is in Davie, situated between South University Drive and South State Road 7, and between Interstate 595/FL 84 and Sheridan Street.

The cluster in Fort Lauderdale/Pompano Beach is located along C-14 Canal in C-14 East Basin between primary water control structures S37B and S37A. The cluster in Davie is located around C-11 (South New River) Canal at the approximate site of primary water control structure S13 along the easternmost border of C-11 East Basin (Figure 1).

Many businesses in both areas are home improvement retailers and contractors (mattress stores, plumbers, glass repair stores, countertop stores, roofers, upholsterers, fence contractors, floor contractors, HVAC contractors, garage door suppliers, cabinet makers, etc.). These areas also have a significant number of wholesalers and commercial contractors (aircraft repair contractors, computer wholesalers, commercial printers, scuba equipment suppliers, vending machine suppliers, industrial equipment suppliers, turf suppliers, petroleum product wholesalers, etc.). Both areas have a relatively high number of pharmaceutical manufacturers (examples include Health Genesis, Kaycha Labs, Teva Pharmaceutical Company, and SKNV). HAZUS generally classifies these types of structures as retail trade (COM1), wholesale trade (COM2), professional, technical, business services (COM4), and light industry (IND2).

The Fort Lauderdale/Pompano Beach area also has a small number of general retail storefronts, such as grocery stores and shopping centers that include amenities like ATMs and urgent care centers, as well as franchise businesses like Chipotle and UPS. The area immediately off exit 33B from Interstate 95 in Fort Lauderdale has a few businesses of note, including the Westin Fort Lauderdale Hotel and corporate offices for Microsoft.

The cluster of buildings in the Davie area, in contrast to Fort Lauderdale/Pompano Beach, has a significant number of agricultural businesses (like plant nurseries, farmers markets, and stables). HAZUS classifies these structures as agricultural (ARG1).

These HAZUS types are associated with relatively low direct output per square foot, likely contributing to the small percent change in Direct Output Losses. Among the most common HAZUS types in these clusters, light industry (IND2) has the highest direct output per square foot at $2.32. This is approximately 50% less than the highest possible direct output per square foot ($4.68 for IND5, or “high technology” structures, of which there is only one in the entire Study Area).

Conclusion

ICF conducted this business interruption analysis to support the Section 203 study with an understanding of economic effects of flooding from multiple flood events and sea level rise scenarios and multiple project Alternatives in comparison to a future without project (FWOP).

This study finds that Alternatives B and C are generally associated with decreases in the number of buildings exposed to flooding and decreases in Direct Output Losses. For the most extreme flooding and sea level rise scenarios, Alternative B provides more protection than Alternative C in terms of reducing the number of buildings exposed to sea level rise and reducing Direct Output Losses. Alternative A does not consistently reduce the number of buildings exposed to flooding for all flood events and sea level rise scenarios. Additionally, this Alternative is associated with increases in Direct Output Losses for more flood events and sea level rise scenarios than Alternatives B and C.

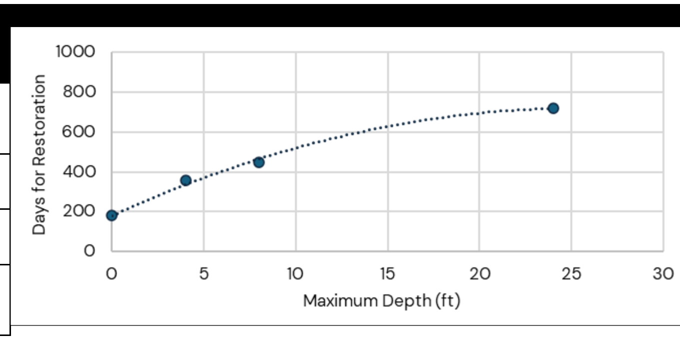
All Alternatives tend to provide the most protection under the most extreme flood events and sea level rise scenarios, both in terms of reducing the number of buildings exposed to more than 0 ft. of flooding and in terms of reducing Direct Output Losses.

Complete results of this analysis are attached to this technical memorandum under Appendices B and D.

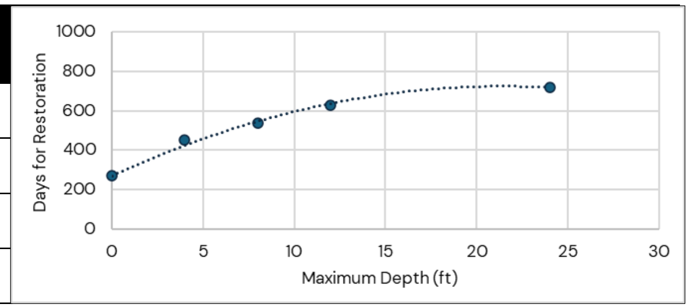
Appendix A

Table 8: Direct Output Loss equations using Maximum Depth and Days for Restoration values from ________

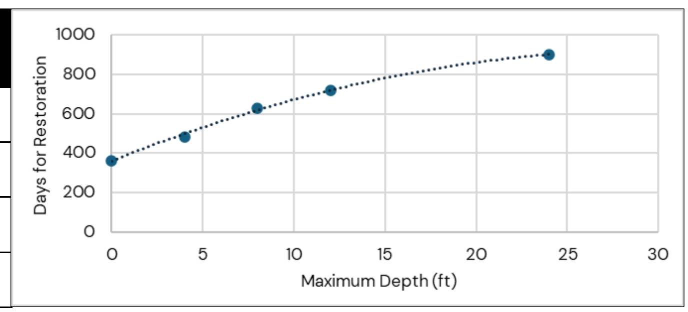
COM3				
Line of Best Fit				$y = -0.8241x^2 + 42.237x + 180$
R^2 Value				0.995
Maximum Depth (ft)				0
Days for Restoration	180	360	450	720



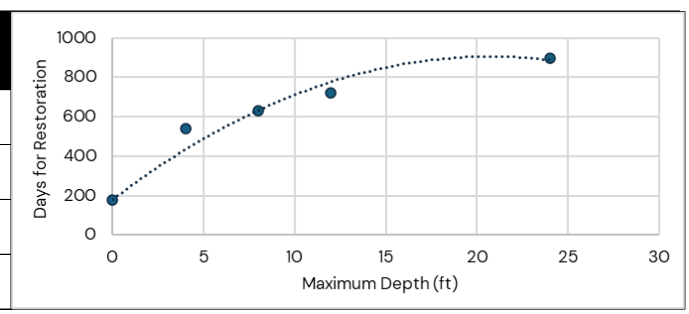
RES4					
Line of Best Fit	$y = -0.9986x^2 + 42.632x + 270$				
R^2 Value	0.9945				
Maximum Depth (ft)	0	4	8	12	24
Days for Restoration	270	450	540	630	720



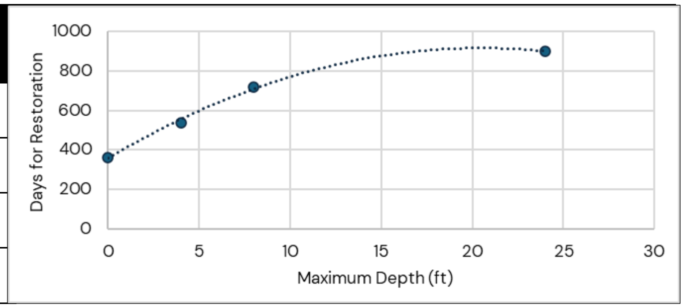
RES5, RES6, COM4, COM5, COM7, GOV1, GOV2, EDU1, and EDU2					
Line of Best Fit	$y = -0.6149x^2 + 37.297x + 360$				
R^2 Value	0.9974				
Maximum Depth (ft)	0	4	8	12	24
Days for Restoration	360	480	630	720	900



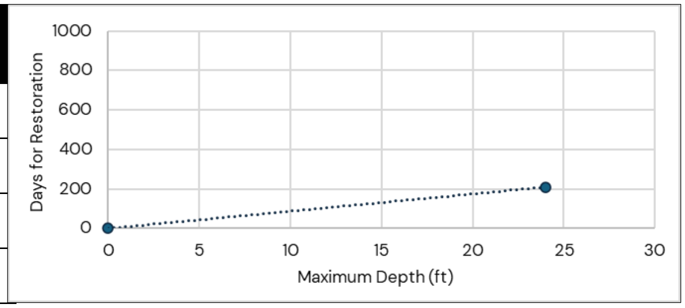
COM1, COM2, COM8, COM9, and REL1					
Line of Best Fit	$y = -1.6886x^2 + 70.042x + 180$				
R^2 Value	0.9565				
Maximum Depth (ft)	0	4	8	12	24
Days for Restoration	180	540	630	720	900



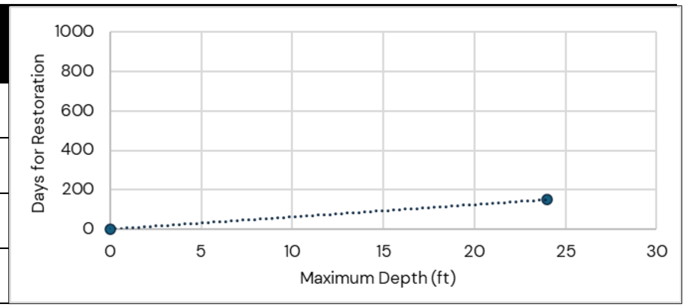
COM6				
Line of Best Fit	$y = -1.3256x^2 + 54.342x + 360$			
R^2 Value	0.9980			
Maximum Depth (ft)	0	4	8	24
Days for Restoration	360	540	720	900



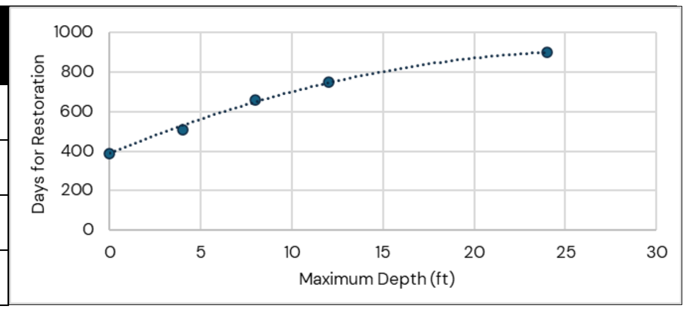
IND1 and AGR1		
Line of Best Fit	$y = 8.75x$	
R^2 Value	1	
Maximum Depth (ft)	0	24
Days for Restoration	0	210



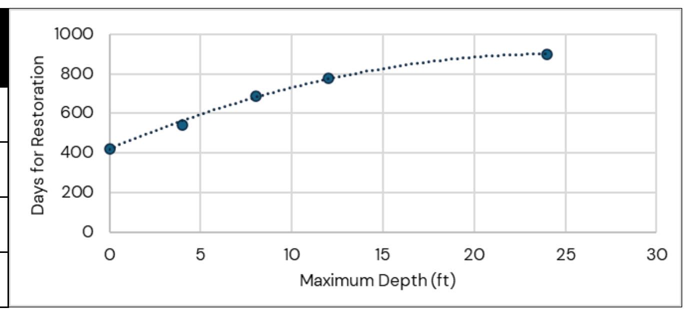
IND2 and IND6		
Line of Best Fit	$y = 6.25x$	
R^2 Value	1	
Maximum Depth (ft)	0	24
Days for Restoration	0	150



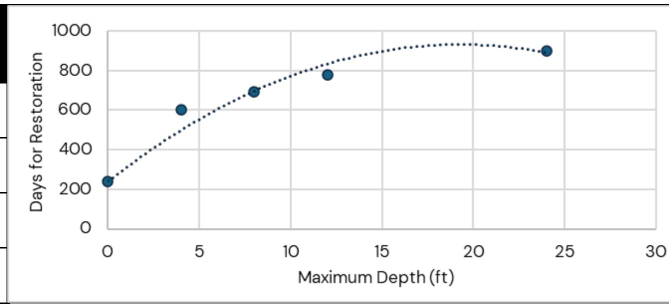
IND3					
Line of Best Fit	$y = -0.7021x^2 + 38.154x + 390$				
R^2 Value	0.9968				
Maximum Depth (ft)	0	4	8	12	24
Days for Restoration	390	510	660	750	900



IND4					
Line of Best Fit	$y = -0.7892x^2 + 39.011x + 420$				
R^2 Value	0.9960				
Maximum Depth (ft)	0	4	8	12	24
Days for Restoration	420	540	690	780	900



IND5					
Line of Best Fit	$y = -1.8629x^2 + 71.756x + 240$				
R^2 Value	0.9556				
Maximum Depth (ft)	0	4	8	12	24
Days for Restoration	240	600	690	780	900



Appendix B

Table 9: Direct Output Loss Summary Table by Sub-basin

3.33% AEP Intermediate SLC				
Sub-basin	***FWOP***	***Alt A***	***Alt B***	***Alt C***
C-11 EAST	$7,859,382.46	$5,223,766.23	$5,223,466.35	$5,223,479.83
C-11 WEST	$777,002.69	$776,512.92	$776,501.77	$776,481.71
C-12W	$4,011,251.85	$3,988,172.36	$3,988,172.36	$3,988,170.12
C-13 WEST	$0	$362,736.31	$362,736.31	$362,736.31
C-14 EAST	$4,470,382.62	$4,455,722.84	$4,451,528.71	$4,449,792.23
C-14 WEST	$2,271,428.11	$2,135,634.30	$2,135,433.11	$2,135,433.11
HILLSBORO CANAL	$1,652,789.93	$1,762,292.84	$1,762,292.84	$1,790,476.20
NORTH NEW RIVER CANAL WEST	$2,733,078.38	$14,754,285.22	$14,750,355.66	$14,732,587.56
POMPANO CANAL	$0	$0	$0	$0
Total	**$23,775,316.04**	**$33,459,123.02**	**$33,450,487.11**	**$33,459,157.07**

3.33% AEP High SLC				
Sub-basin	***FWOP***	***Alt A***	***Alt B***	***Alt C***
C-11 EAST	$38,537,552.05	$8,698,267.78	$6,760,657.00	$5,987,700.79
C-11 WEST	$777,140.93	$776,664.35	$776,586.50	$776,550.82
C-12W	$4,011,599.05	$3,988,526.98	$3,988,524.74	$3,988,522.51
C-13 WEST	$133,053.90	$502,148.41	$363,012.79	$362,736.31
C-14 EAST	$20,005,615.13	$8,537,367.68	$8,032,338.02	$8,348,868.77
C-14 WEST	$2,273,693.24	$2,137,248.21	$2,136,043.34	$2,135,493.64
HILLSBORO CANAL	$1,651,940.20	$1,763,318.66	$1,762,102.61	$1,796,255.92
NORTH NEW RIVER CANAL WEST	$2,777,286.82	$14,812,579.93	$14,790,998.08	$14,743,545.15

DRAFT

POMPANO CANAL	$1,234,486.85	$1,224,603.52	$1,224,102.40	$1,217,958.42
Total	**$71,402,368.18**	**$42,440,725.50**	**$39,834,365.48**	**$39,357,632.34**
0.91% AEP Intermediate SLC				
Sub-basin	***FWOP***	***Alt A***	***Alt B***	***Alt C***
C-11 EAST	$24,382,697.70	$13,037,961.07	$11,112,459.34	$10,655,287.47
C-11 WEST	$2,761,602.60	$2,917,600.28	$2,914,522.62	$2,781,544.05
C-12W	$4,439,877.91	$4,276,427.68	$4,276,425.45	$4,276,423.22
C-13 WEST	$9,625,385.43	$7,274,486.37	$2,801,451.82	$2,653,686.89
C-14 EAST	$18,158,693.16	$16,938,891.41	$16,905,167.64	$11,556,920.96
C-14 WEST	$9,424,920.02	$11,149,342.22	$11,146,934.02	$11,148,064.74
HILLSBORO CANAL	$5,548,681.37	$5,434,824.17	$5,434,802.32	$5,303,214.50
NORTH NEW RIVER CANAL WEST	$6,905,040.82	$16,042,082.30	$16,038,169.84	$16,008,558.85
POMPANO CANAL	$1,931,679.31	$1,920,386.99	$1,920,261.97	$1,920,768.12
Total	**$83,178,578.32**	**$78,992,002.48**	**$72,550,195.03**	**$66,304,468.80**
0.91 % AEP High SLC				
Sub-basin	***FWOP***	***Alt A***	***Alt B***	***Alt C***
C-11 EAST	$59,647,896.09	$21,032,621.98	$17,819,053.75	$17,691,534.64
C-11 WEST	$2,862,567.53	$2,969,170.26	$2,963,109.93	$2,900,303.53
C-12W	$4,636,589.69	$4,416,982.28	$4,416,834.80	$4,417,179.12
C-13 WEST	$9,998,515.89	$10,726,559.25	$9,932,875.17	$8,883,051.98
C-14 EAST	$117,666,338.19	$74,487,684.00	$36,231,337.63	$35,782,831.69
C-14 WEST	$9,437,658.05	$11,152,595.23	$11,148,795.76	$11,153,210.54
HILLSBORO CANAL	$5,549,069.95	$5,434,063.42	$5,434,081.17	$5,463,924.22
NORTH NEW RIVER CANAL WEST	$12,397,555.53	$21,504,227.67	$16,055,260.19	$16,030,288.56

POMPANO CANAL	$3,427,203.42	$3,413,930.64	$3,410,106.13	$3,398,503.53
Total	**$225,623,394.34**	**$155,137,834.73**	**$107,411,454.54**	**$105,720,827.82**
0.23% AEP Intermediate SLC				
Sub-basin	***FWOP***	***Alt A***	***Alt B***	***Alt C***
C-11 EAST	$52,129,741.34	$25,675,438.26	$29,487,625.53	$24,231,083.11
C-11 WEST	$4,524,161.60	$4,805,223.26	$4,537,380.61	$4,624,389.49
C-12W	$8,749,266.94	$8,020,372.65	$7,803,428.30	$8,102,000.83
C-13 WEST	$10,727,583.33	$11,204,231.61	$8,282,813.53	$3,843,456.87
C-14 EAST	$71,662,065.10	$116,340,711.51	$43,390,443.05	$36,555,253.25
C-14 WEST	$32,318,553.09	$19,917,998.08	$31,434,141.82	$31,246,661.15
HILLSBORO CANAL	$13,984,890.63	$5,582,886.67	$5,726,879.52	$5,812,561.84
NORTH NEW RIVER CANAL WEST	$7,290,295.15	$18,357,147.48	$16,044,409.60	$17,976,430.46
POMPANO CANAL	$3,359,818.79	$2,104,010.13	$2,100,822.24	$2,099,622.97
Total	**$204,746,375.97**	**$212,008,019.66**	**$148,807,944.20**	**$134,491,459.97**
0.23% AEP High SLC				
Sub-basin	***FWOP***	***Alt A***	***Alt B***	***Alt C***
C-11 EAST	$102,774,220.77	$62,920,939.26	$51,299,364.50	$60,982,190.82
C-11 WEST	$4,760,069.99	$3,491,017.45	$3,237,391.51	$4,715,269.34
C-12W	$8,824,004.91	$13,570,632.15	$13,570,104.03	$13,598,558.01
C-13 WEST	$10,346,221.62	$10,882,100.24	$10,198,887.69	$11,231,656.39
C-14 EAST	$161,966,213.58	$140,460,216.76	$136,572,003.97	$137,697,315.61
C-14 WEST	$27,454,974.39	$31,627,347.95	$19,203,481.66	$33,983,991.42
HILLSBORO CANAL	$23,923,271.29	$15,636,688.09	$5,447,800.79	$15,890,921.47
NORTH NEW RIVER CANAL WEST	$14,434,285.35	$24,066,348.57	$23,967,358.01	$17,906,091.95

POMPANO CANAL	$5,370,815.49	$5,696,475.37	$5,697,767.16	$5,288,896.68
Total	**$359,854,077.38**	**$308,351,765.84**	**$269,194,159.32**	**$301,294,891.68**

Appendix C

Figure 6. Annualized direct output loss for structures with depth greater than 0 ft under the FWOP High SLC scenario.

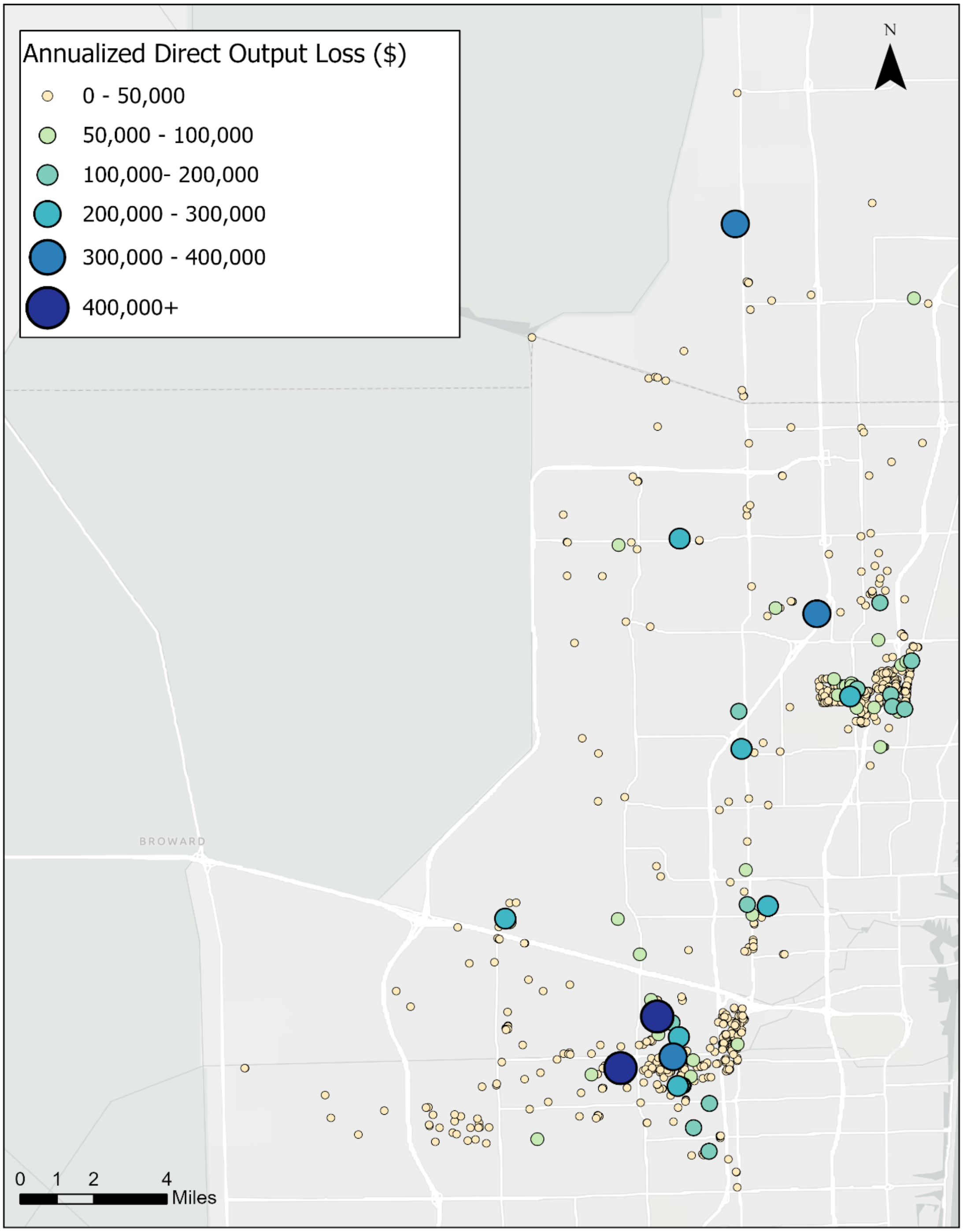


Figure 7. Annualized direct output loss for structures with depth greater than 0 ft under the Alt A High SLC scenario.

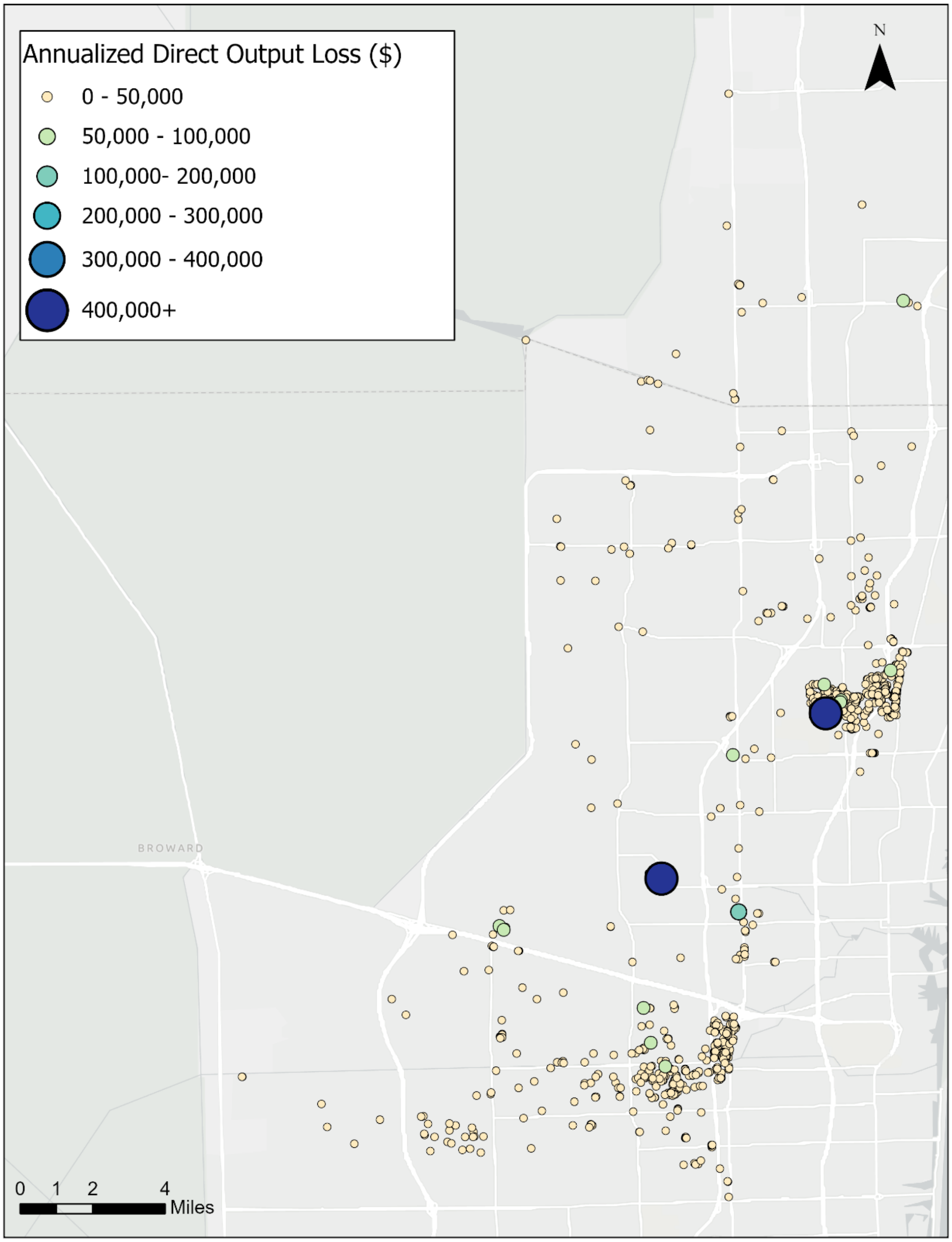


Figure 8. Annualized direct output loss for structures with depth greater than 0 ft under the Alt B High SLC scenario.

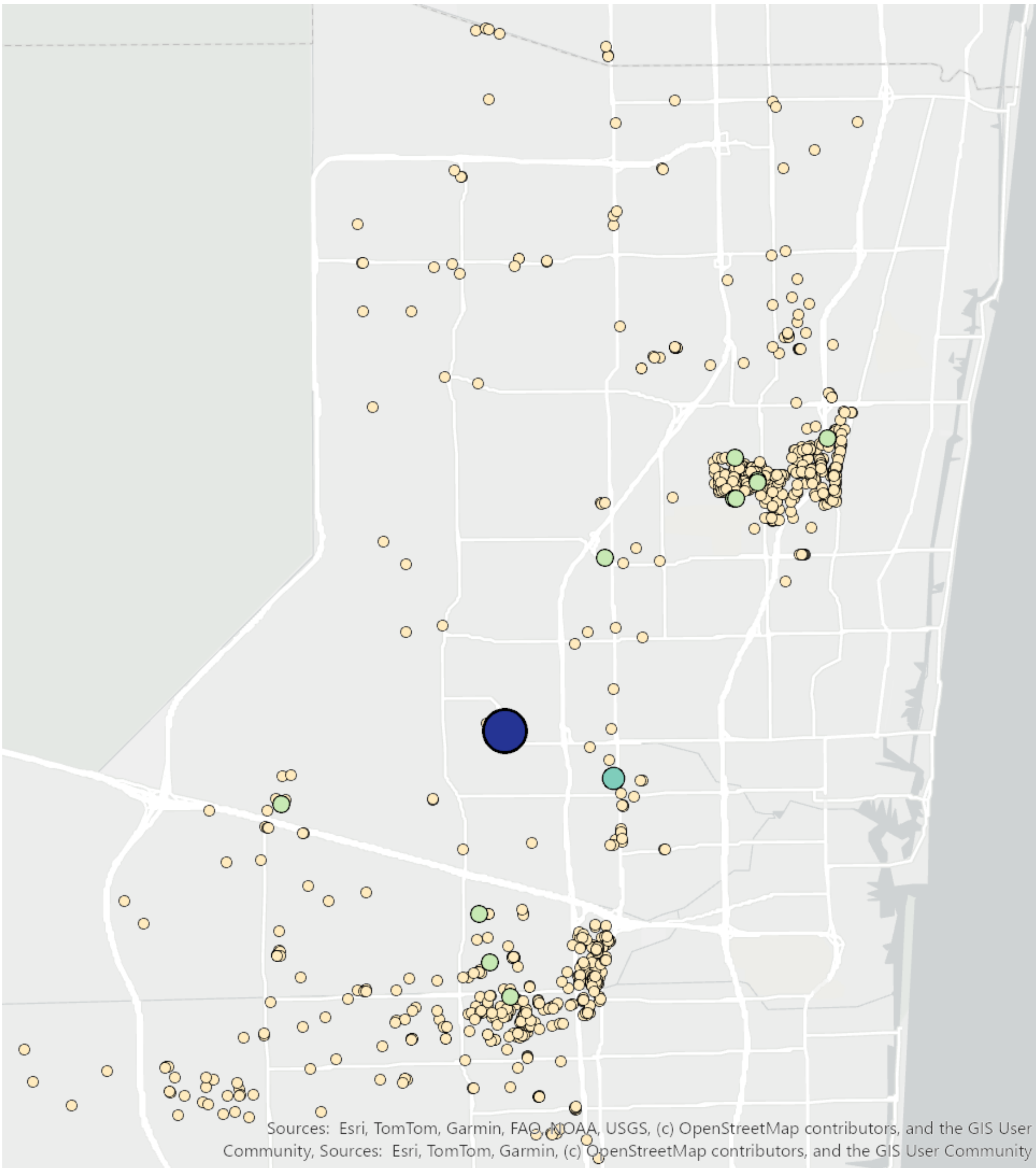
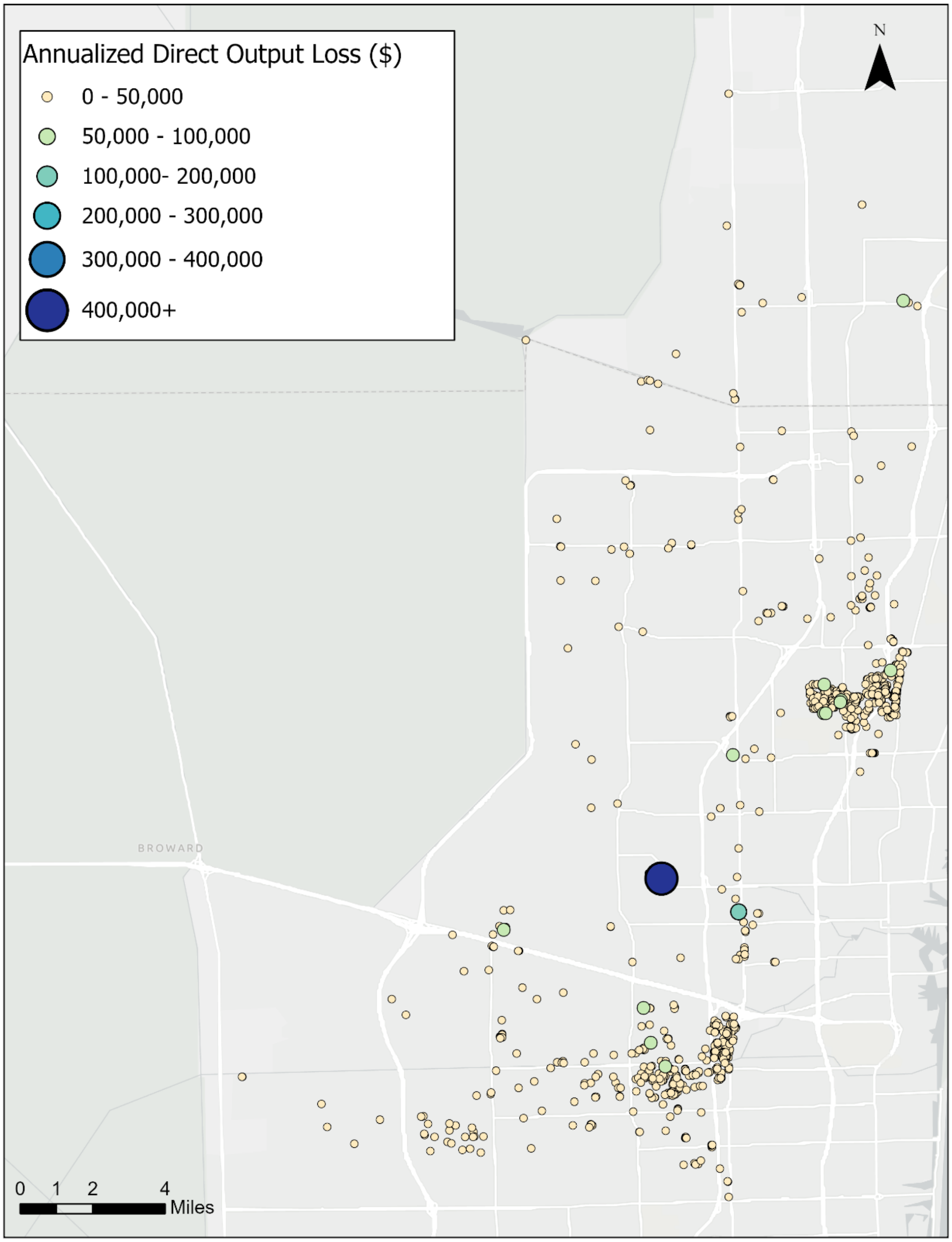


Figure 9. Annualized direct output loss for structures with depth greater than 0 ft under the Alt C High SLC scenario.



Appendix D

Table 10: Direct Output Loss Summary Table by Hazus Code

3.33% AEP Intermediate SLC				
Hazus Code	***FWOP***	***Alt A***	***Alt B***	***Alt C***
AGR1	$80,747.12	$78,178.04	$77,873.55	$106,042.26
COM1	$50,389.54	$373,928.74	$373,973.34	$373,463.87
COM2	$20,337.22	$20,204.34	$20,204.34	$20,204.34
COM3	$0	$0	$0	$0
COM4	$5,148,211.14	$5,135,293.14	$5,135,293.14	$5,135,293.14
COM5	$344,011.33	$237,165.40	$237,165.40	$237,165.40
COM6	$0	$0	$0	$0
COM8	$0	$0	$0	$0
COM9	$0	$0	$0	$0
EDU1	$10,958,974.01	$20,864,400.68	$20,860,269.92	$20,842,501.83
EDU2	$0	$0	$0	$0
GOV1	$99,490.60	$0	$0	$0
IND1	$0	$0	$0	$0
IND2	$53,648.19	$45,510.93	$41,460.96	$40,630.66
IND3	$588,491.47	$676,827.84	$676,827.84	$676,825.60
IND4	$0	$0	$0	$0
IND5	$0	$0	$0	$0
REL1	$388,642.63	$0	$0	$0
RES4	$0	$0	$0	$0
RES6	$6,042,372.78	$6,027,613.91	$6,027,418.62	$6,027,029.98
Total	**$23,775,316.04**	**$33,459,123.02**	**$33,450,487.11**	**$33,459,157.07**
3.33% AEP High SLC				
Hazus Code	***FWOP***	***Alt A***	***Alt B***	***Alt C***
AGR1	$192,960.18	$92,288.99	$83,074.14	$115,401.49
COM1	$4,092,941.25	$2,976,620.37	$2,362,199.18	$2,704,985.34
COM2	$43,419.81	$41,019.47	$41,120.43	$41,664.21
COM3	$0	$0	$0	$0
COM4	$12,645,054.96	$7,481,442.45	$7,386,711.19	$7,382,516.83
COM5	$344,612.14	$237,606.22	$237,536.64	$237,513.44
COM6	$0	$0	$0	$0

COM8	$0	$0	$0	$0
COM9	$0	$0	$0	$0
EDU1	$35,549,251.17	$22,520,758.26	$20,901,791.25	$20,853,526.49
EDU2	$0	$0	$0	$0
GOV1	$538,169.33	$0	$0	$0
IND1	$0	$0	$0	$0
IND2	$216,690.70	$102,436.87	$90,335.12	$91,021.04
IND3	$588,568.32	$677,051.33	$676,956.89	$676,870.84
IND4	$0	$0	$0	$0
IND5	$0	$0	$0	$0
REL1	$4,694,392.93	$1,046,057.61	$790,122.70	$0
RES4	$4,270,629.37	$0	$0	$0
RES6	$8,225,678.00	$7,265,443.93	$7,264,517.95	$7,254,132.66
Total	**$71,402,368.18**	**$42,440,725.50**	**$39,834,365.48**	**$39,357,632.34**

0.91% AEP Intermediate SLC				
Hazus Code	***FWOP***	***Alt A***	***Alt B***	***Alt C***
AGR1	$151,745.82	$132,917.56	$122,139.52	$142,051.27
COM1	$7,693,597.61	$7,895,371.62	$3,201,662.08	$3,066,050.25
COM2	$22,054.05	$21,929.98	$21,922.68	$21,886.17
COM3	$0	$0	$0	$0
COM4	$10,550,766.61	$9,712,569.66	$9,715,917.84	$8,147,498.74
COM5	$8,479,893.74	$5,288,130.07	$5,288,291.73	$5,288,174.34
COM6	$0	$0	$0	$0
COM8	$318,291.05	$332,661.44	$330,896.46	$294,228.48
COM9	$0	$0	$0	$0
EDU1	$37,385,232.95	$37,935,416.25	$36,293,241.69	$36,255,184.18
EDU2	$0	$0	$0	$0
GOV1	$102,276.68	$0	$0	$0
IND1	$0	$0	$0	$0
IND2	$168,381.32	$139,957.46	$138,782.54	$129,356.98
IND3	$2,544,480.10	$2,280,633.53	$2,280,650.12	$2,120,817.52
IND4	$0	$0	$0	$0
IND5	$0	$0	$0	$0
REL1	$1,525,845.79	$1,056,871.18	$960,694.73	$370,619.95
RES4	$0	$0	$0	$0
RES6	$14,236,012.61	$14,195,543.72	$14,195,995.64	$10,468,600.94
Total	**$83,178,578.32**	**$78,992,002.48**	**$72,550,195.03**	**$66,304,468.80**

0.91% AEP High SLC				
Hazus Code	***FWOP***	***Alt A***	***Alt B***	***Alt C***
AGR1	$369,315.74	$214,150.86	$173,964.14	$175,018.31
COM1	$13,759,735.93	$12,618,196.12	$11,909,459.58	$11,477,230.10
COM2	$215,427.83	$207,997.63	$209,827.76	$220,520.32
COM3	$154,757.80	$0	$0	$0
COM4	$21,199,313.42	$20,569,992.51	$19,671,501.67	$19,569,576.41
COM5	$9,944,076.95	$5,289,256.89	$5,288,222.26	$5,287,650.48
COM6	$2,097,965.38	$0	$0	$0
COM8	$432,887.15	$341,257.36	$338,568.47	$321,632.04
COM9	$0	$0	$0	$0
EDU1	$139,487,228.70	$84,384,822.47	$43,757,549.10	$42,794,904.54
EDU2	$0	$0	$0	$0
GOV1	$558,115.54	$0	$0	$0
IND1	$0	$0	$0	$0
IND2	$910,611.05	$574,681.41	$477,433.43	$346,171.75
IND3	$2,778,188.96	$2,299,971.29	$2,299,569.96	$2,327,511.39
IND4	$0	$0	$0	$0
IND5	$12,770.43	$0	$0	$0
REL1	$8,689,761.59	$6,905,689.81	$1,597,778.41	$1,498,711.02
RES4	$4,501,853.83	$4,397,175.78	$4,356,378.33	$4,385,077.04
RES6	$20,511,384.04	$17,334,642.60	$17,331,201.42	$17,316,824.43
Total	**$225,623,394.34**	**$155,137,834.73**	**$107,411,454.54**	**$105,720,827.82**

0.23% AEP Intermediate SLC				
Hazus Code	***FWOP***	***Alt A***	***Alt B***	***Alt C***
AGR1	$214,570.89	$181,067.39	$142,415.10	$164,289.87
COM1	$11,528,723.25	$15,249,098.99	$10,907,559.51	$6,018,926.75
COM2	$42,788.72	$24,269.50	$23,260.06	$41,991.33
COM3	$0	$0	$0	$0
COM4	$21,964,806.09	$24,732,807.97	$20,763,230.04	$16,357,414.13
COM5	$13,492,030.82	$15,563,004.75	$12,511,794.56	$16,410,795.56
COM6	$0	$0	$0	$0
COM8	$322,362.17	$417,457.23	$414,935.05	$294,756.73
COM9	$0	$0	$0	$0
EDU1	$116,995,098.42	$127,621,068.86	$68,130,360.59	$63,132,631.93
EDU2	$8,552,017.32	$0	$0	$0

GOV1	$105,636.28	$0	$0	$0
IND1	$0	$0	$0	$0
IND2	$418,046.15	$895,052.14	$298,335.37	$239,460.44
IND3	$3,484,975.69	$3,132,587.92	$3,257,255.79	$3,255,980.29
IND4	$0	$0	$0	$0
IND5	$0	$0	$0	$0
REL1	$4,530,019.40	$4,224,911.34	$3,405,073.62	$1,429,431.44
RES4	$4,249,410.06	$4,427,056.88	$4,169,952.72	$4,211,960.35
RES6	$18,845,890.71	$15,539,636.69	$24,783,771.79	$22,933,821.16
Total	**$204,746,375.97**	**$212,008,019.66**	**$148,807,944.20**	**$134,491,459.97**

0.23% AEP High SLC				
Hazus Code	***FWOP***	***Alt A***	***Alt B***	***Alt C***
AGR1	$573,941.29	$370,430.60	$324,338.39	$354,720.41
COM1	$23,159,636.47	$19,408,983.70	$18,921,104.03	$18,011,419.61
COM2	$579,968.79	$519,740.59	$517,883.16	$517,791.88
COM3	$473,799.80	$174,202.81	$170,458.83	$172,707.41
COM4	$52,145,254.33	$42,728,348.89	$31,473,079.92	$42,329,769.64
COM5	$18,443,483.85	$15,902,517.91	$15,832,488.21	$19,992,173.17
COM6	$2,727,961.16	$2,116,113.69	$2,099,177.00	$2,097,359.56
COM8	$2,402,731.91	$795,926.93	$787,328.55	$767,724.23
COM9	$0	$0	$0	$0
EDU1	$197,703,877.02	$174,268,338.94	$153,543,068.68	$165,233,189.35
EDU2	$0	$0	$0	$0
GOV1	$2,109,729.16	$1,212,837.64	$1,204,883.06	$846,217.59
IND1	$0	$0	$0	$0
IND2	$2,106,201.41	$1,529,444.78	$1,444,961.46	$1,351,586.45
IND3	$4,057,724.67	$3,700,430.27	$2,819,738.55	$4,104,029.75
IND4	$0	$0	$0	$0
IND5	$16,026.81	$14,639.18	$14,418.96	$14,607.76
REL1	$15,779,640.93	$13,247,291.06	$10,673,007.67	$12,940,767.98
RES4	$6,603,657.09	$4,730,236.96	$4,680,511.43	$4,687,982.72
RES6	$30,970,442.68	$27,632,281.88	$24,687,711.43	$27,872,844.15
Total	**$359,854,077.38**	**$308,351,765.84**	**$269,194,159.32**	**$301,294,891.68**

D.7 Regional Economic Development Benefits Temporary Displacement Technical Memorandum

Prepared for:	South Florida Water Management District
Prepared by:	J-Tech, an Alliance between Jacobs Engineering and Tetra Tech, Inc.
Date:	October 26, 2025
Subject:	C&SF Flood Resiliency (Section 203) Study for Broward Basins Temporary Displacement Analysis

DRAFT

1 Introduction and Purpose:

This memo outlines the temporary displacement analysis, carried out as part of the South Florida Water Management District's (SFWMD) Central and Southern Florida (C&SF) Flood Resiliency (Section 203) Study for Broward Basins (203 Study).

This Section 203 Study focuses on enhancing the resiliency of the water control structures and adjacent primary canals in Broward Basins Reach A, a reach of the ongoing USACE C&SF Section 216 Study. Broward Basins Reach A is referred to herein as the Section 203 Study Area (or Study Area).

This analysis estimates the impact that flooding of the analysis area under three design storms and associated storm surges, and two sea level rise scenarios would have on residents and the costs they would incur to temporarily relocate while the flooding recedes, and their homes are restored to habitable condition. The benefits of three proposed build alternatives were then compared to the future without project (FWOP) alternative to estimate the benefits of the proposed build alternatives.

2 Methodology

The temporary displacement analysis was based on HECFDA analyses for 9 watersheds in Broward County:

- C11E
- C11W
- C12W
- C13W
- C14E
- C14W
- Hillsboro
- NNRW
- Pompano

For each watershed. the MKE SHE output presents the projected number of properties with projected flooding above 0.25, 1, 2, 3, 4, and 5 feet above the 1st floor elevation for 3 design storms for the year 2085:

- 25 year storm and 2 year storm surge (2S25R)
- 100 year storm and 2 year storm surge (2S110R), and
- 100 year storm and 100 year storm surge (100S100R).

Each of these design storms and storm surge scenarios was examined with an intermediate sea level rise and under a high sea level rise conditions (6 total scenarios). The flooding was estimated for the year 2085 conditions for the Future With Out Project (FWOP) and 4 build alternatives (A, B, C, and TSP). While the initial HECFDA results were presented for all properties in each watershed, the results were sorted to isolate only residential properties that would be the subject of this temporary displacement analysis.

The average persons per household in Broward County was then applied to the number of residential properties impacted at each flood depth to estimate the number of people estimated to be impacted by the forecast flooding.

Hazus Flood Model Table 6-4 presents the maximum restoration time for Res 1, Res 3A, Res 3B, and Com 3 occupancies based on Flood Depth. For this analysis, it was assumed that the average restoration time would be approximately 75% of the maximum restoration days, and that reoccupancy would be 90% of the estimated average restoration days.

An estimate of the number of person days displaced was then estimated by multiplying the persons at risk by flood depth for each alternative by the flood reoccupancy days by flood depth.

The difference between the number of person days displaced for each of the build alternatives and the FWOP Alternative was then calculated.

The person days displaced by storm was then multiplied by the annual probabilities for the 3 design storms and associated intermediate and high sea level rise, to derive the estimated annual average person days displaced associated with each Alternative.

Per diem rates for lodging and food and incidentals for Fort Lauderdale were then applied to the estimated annual person days displaced to determine the estimated annual costs associated with the displacements. It was assumed that only 25% of the food and incidentals per diem costs would be applicable due to residents obtaining food and incidentals over longer periods from grocery stores and other usual sources.

The difference between the estimated annual costs associated with the displacements for the FWOP and the build alternatives was then calculated to determine the resulting savings associated with the build alternatives as compared to the FWOP.

3 Assumptions

1. Assumes the average population per household in Broward County of 2.56 based on U.S. Census Bureau Quick Facts (American Community Survey 2023: ACS 1 Year Estimates Subject Tables).
2. Person Days displaced based on flood depth derived from Hazus Flood Technical Manual which provided maximum days for restoration by flood depth for -4 to +4 feet above first floor flood elevation. Interpolation was used to develop estimated maximum days of restoration for intermediate flood depths.
3. It was assumed that the average days of flood restoration would be 75% of the maximum days of flood restoration.

4. It is assumed for this analysis that average time for reoccupancy will be 90% of the average restoration time. Person days displaced based on average time for reoccupancy by flood depth multiplied by the number of people at risk by flood depth.
5. For the purposes of this analysis, it was assumed that there would not be any permanent dislocations due to the flooding.
6. Storm probabilities were based on storm and storm surge frequencies.
7. Per diem rates were based on U.S. General Services Administration FY 2025 per diem rates for Fort Lauderdale Florida of $177/per day for lodging and $86 per day for food and incidentals.
8. Analysis assumes that flood displacements would increase food and incidental expenses by 25% of the food and incidentals per diem rates.

4 Results

Table 1 summarizes the estimated annual temporary displacement costs for the FWOP and the four build alternatives. The table shows that under the future without project the total annual impact in the 9 watersheds amounts to $12.2 million under the intermediate sea level rise. The results are shown for 1 year (2085), and reflect the impacts of each storm adjusted for their annual probability of occurring. Comparatively, the total annual impact based on the 2085 results for Alternative A is $10.7 million. For Alternative B the impact is $10.5 million, for Alternative C is $10.2 million, and for the TSP Alternative the impact is $10.7 million. Under the high sea level rise, these impacts are estimated at $17.5 million for the FWOP Alternative, $13.1 million for Alternative A, $12.3 million for Alternative B, $11.8 million for Alternative C, and $13.1 million for the TSP Alternative.

Table
SFWMD Broward 203 Study
Benefits Analysis - Annualized Value of Total Temporary Displacements
2085

	Design Storm			
	2S25R	2S100R	100S100R	Total
Intermediate Sea Level Rise				
Annualized Total Displacement Days				
Future Without Project (FWOP)	30,414	24,378	6,655	61,447
Option A	26,456	21,328	5,802	53,586
Option B	26,083	20,967	5,473	52,523
Option C	25,761	20,282	5,308	51,351

Option TSP	26,500	21,197	5,882	53,579
Annualized Value of Total Displacement Days				
Future Without Project (FWOP)	$ 6,052,338	$ 4,851,237	$ 1,324,374	$ 12,227,949
Option A	$ 5,264,734	$ 4,244,342	$ 1,154,529	$ 10,663,604
Option B	$ 5,190,532	$ 4,172,374	$ 1,089,096	$ 10,452,002
Option C	$ 5,126,508	$ 4,036,111	$ 1,056,199	$ 10,218,818
Option TSP	$ 5,273,488	$ 4,218,186	$ 1,170,523	$ 10,662,196
High Sea Level Rise				
Annualized Total Displacement Days				
Future Without Project (FWOP)	42,330	33,190	12,173	87,693
Option A	31,007	25,835	8,989	65,831
Option B	29,422	24,322	8,317	62,060
Option C	28,332	23,249	7,843	59,424
Option TSP	30,566	25,520	9,498	65,583
Annualized Value Total Displacement Days				
Future Without Project (FWOP)	$ 8,423,768	$ 6,604,833	$ 2,422,392	$ 17,450,992
Option A	$ 6,170,444	$ 5,141,134	$ 1,788,782	$ 13,100,360
Option B	$ 5,854,890	$ 4,840,037	$ 1,655,017	$ 12,349,944
Option C	$ 5,638,136	$ 4,626,461	$ 1,560,719	$ 11,825,316
Option TSP	$ 6,082,653	$ 5,078,387	$ 1,890,004	$ 13,051,045

The savings associated with each of the build alternatives as compared to the FWOP is presented in Table 2. The table shows that Alternative A would reduce the temporary displacement costs by $1.6 million, as compared to the FWOP under the intermediate sea level rise scenario, while Alternative B would reduce these costs by $1.8 million, Alternative C would reduce the temporary displacement costs by $2.0 million, and the TSP Alternative by $1.6 million. Under the high sea level rise scenario Alternative A would save $4.4 million annually, Alternative B would save $5.1 million, Alternative C would save $5.6 million, and the TSP Alternative would save $4.4 million as compared to the FWOP.

Table
SFWMD Broward 203 Study
Benefits Analysis - Annualized Value of Net Temporary Displacements
2085

	Design Storm			
	2S25R	2S100R	100S100R	Total
Intermediate Sea Level Rise				
Annualized Net Change in Displacement Days				
Option A	(3,958)	(3,050)	(853)	(7,861)
Option B	(4,331)	(3,411)	(1,182)	(8,924)
Option C	(4,652)	(4,096)	(1,348)	(10,096)
Option TSP	(3,914)	(3,181)	(773)	(7,868)
Annualized Value of Change in Displacement Days				
Option A	$ (787,604)	$ (606,895)	$ (169,846)	$ (1,564,345)
Option B	$ (861,806)	$ (678,863)	$ (235,279)	$ (1,775,948)
Option C	$ (925,830)	$ (815,126)	$ (268,176)	$ (2,009,131)
Option TSP	$ (778,850)	$ (633,051)	$ (153,852)	$ (1,565,753)
High Sea Level Rise				
Annualized Net Change in Displacement Days				
Option A	(11,323)	(7,355)	(3,184)	(21,862)
Option B	(12,909)	(8,868)	(3,856)	(25,633)

Option C	(13,998)	(9,942)	(4,330)	(28,270)
Option TSP	(11,764)	(7,671)	(2,675)	(22,110)
Annualized Value of Change in Displacement Days				
Option A	$ (2,253,324)	$ (1,463,699)	$ (633,609)	$ (4,350,632)
Option B	$ (2,568,878)	$ (1,764,796)	$ (767,374)	$ (5,101,048)
Option C	$ (2,785,631)	$ (1,978,372)	$ (861,672)	$ (5,625,676)
Option TSP	$ (2,341,115)	$ (1,526,446)	$ (532,387)	$ (4,399,947)

References

1. U.S. Census Bureau Quick Facts: Broward County Persons per Household S1101: Households and Families - Census Bureau Table
2. Hazus Flood Technical Manual, Hazus 5.1, July 2022 FEMA. Table 6-4. Maximum Restoration Time for RES1, RES3A, RES3B and COM3 Occupancies. Hazus 5.1 Flood Model Technical Manual
3. U.S. General Services Administration, FY 2025 per diem rates for Fort Lauderdale Florida. FY 2025 per diem rates for Fort Lauderdale, Florida | GSA

D.8 Regional Economic Development Benefits IMPLAN Technical Memorandum

Prepared for:	South Florida Water Management District
Prepared by:	J-Tech, an Alliance between Jacobs Engineering and Tetra Tech, Inc.
Date:	October 27, 2025
Subject:	C&SF Flood Resiliency (Section 203) Study for Broward Basins, RED Analysis

DRAFT

1 Purpose:

This technical memorandum (TM) documents the economic benefits analysis and more specifically the analysis conducted for the Regional Economic Development (RED) account, as part of the South Florida Water Management District's (SFWMD) Central and Southern Florida (C&SF) Flood Resiliency (Section 203) Study for Broward Basins (203 Study).

The Section 203 Study focuses on enhancing the resiliency of the water control structures and adjacent primary canals in Broward Basins Reach A, a reach of the ongoing USACE C&SF Section 216 Study. Broward Basins Reach A is referred to herein as the Section 203 Study Area (or Study Area). However, for the purposes of evaluating the RED analysis, a larger area encompassing the Miami-Fort Lauderdale-West Palm Beach Metropolitan Statistical (MSA) and which is comprised of the three counties of Broward, Miami-Dade and Palm Beach was assumed to represent the Study Area. This study area is referred to as the 3-County Study Area in this TM.

The RED account is one four accounts used to evaluate the project alternatives associated with water resources project per the following Federal guidelines:

- These evaluations will be based on the acceptable USACE methods as prescribed in specific documents including the following: Principles, Requirements, and Guidelines for Federal Investments in Water Resources (PR&G), 2013.
- Final Interagency Guidelines on the Principles, Requirements and Guidelines (PR&G) for Water and Land Related Resources Implementation Studies, 2014.
- Policy for Conducting Civil Works Planning Studies (ER 1105-2-103), 2023.
- USACE Institute for Water Resources Regional Economic Development (RED) Procedures Handbook (2011-RPT-01). March 2011.
- Water Resources Policies and Authorities Studies of Water Resources Development Projects by Non-Federal Interests (ER 1165-2-209), 2016.

The RED account measures the changes in the distribution of the regional economic activity resulting from an action and does not account for gains or losses out of the region of study. Section 2 of this TM consists of the introduction. Section 3 describes the technical approach including a brief discussion of the model used and the inputs from other studies that form the basis for the RED analysis. The RED analysis and results are summarized and discussed in Section 4.

2 Introduction:

The RED analysis is primarily focused with the evaluation of the short-term construction, long-term operation, and temporary displacement and relocation impacts associated with the Section 203 Study for Broward Basins Project. The RED account registers changes in regional economic activity that result from each alternative evaluated in the Section 203 Study for Broward Basins Project Feasibility Study.

The USACE uses the RECONS 2.0 model to evaluate regional economics. However, because the RECONS 2.0 model uses the 2015 IMPLAN model's multipliers, ratios, and regional purchase coefficients (RPCs), it was determined that it would not accurately capture any changes in the underlying economy resulting from the effects of the COVID-19 pandemic. Instead, the IMPLAN Input-Output (I/O) model was proposed as an alternative as it uses more recent economic data. The most recent IMPLAN data available at the time of this analysis is the 2023 IMPLAN data.

3 Methodology, Assumptions, and Inputs

3.1 IMPLAN

The IMPLAN model is the most widely used input-output impact model system in the U.S. It is much more than a set of multipliers; it provides users with the ability to define industries, economic relationships, and projects to be analyzed. It can be customized for any county, region, or state, and used to assess the "ripple effects" or "multiplier effects" caused by increasing or decreasing spending in various parts of the economy. This is used primarily to assess the economic impacts of facilities or industries, or changes in their level of activity in a given area.

IMPLAN is a static model that estimates impacts for a snapshot in time when the impacts are expected to occur, based on the makeup of the economy at the time of the underlying IMPLAN data. IMPLAN measures the initial impact to the economy but does not consider long-term adjustments as labor and capital move into alternative uses. This approach was used to compare the Final Array of Alternatives. Realistically, the structure of the economy will adapt and change; therefore, the IMPLAN results can only be used to compare relative changes between the specific alternative and the Future Without Project (FWOP) alternative and cannot be used to predict or forecast future employment, labor income, or output (sales).

Input-output models measure commodity flows from producers to intermediate and final consumers. Purchases for final use (final demand) drive the model. Industries produce goods and services for final demand and purchase goods and services from other producers. These other producers, in turn, purchase goods and services. This buying of goods and services (indirect purchases) continues until leakages from the analysis area (imports and value added) stop the cycle. These indirect and induced effects (the effects of household spending) can be mathematically derived using a set of multipliers. The multipliers describe the change in output for each regional industry caused by a $1 change in final demand. Figure 3-1 illustrates the concept of input-output modeling.

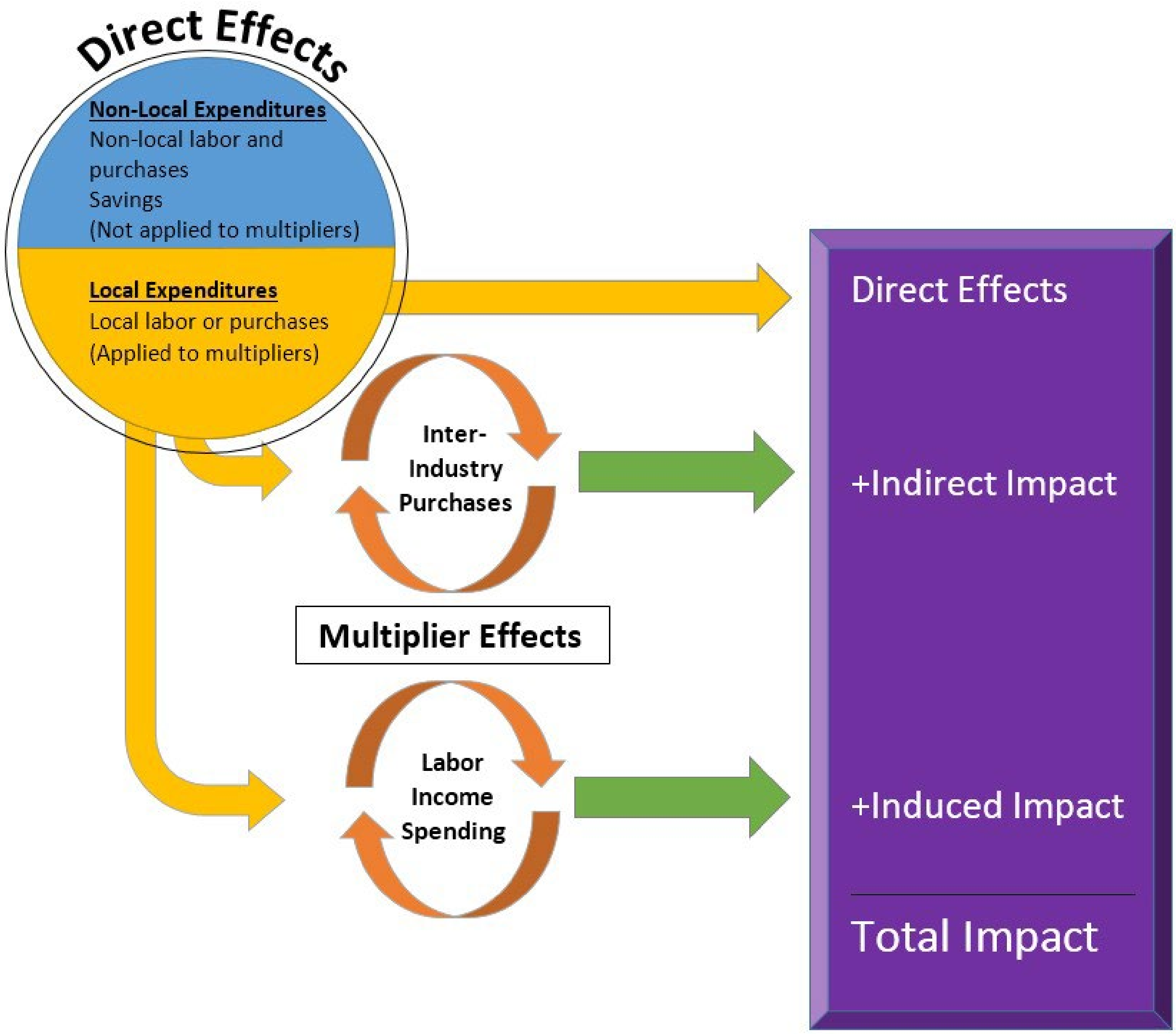


Figure 1. Input-Output Modeling Concept[1]

The IMPLAN model package includes state-level or county-level data to describe the local economy in a given year and a licensed cloud-based tool that allows users to input more refined and/or accurate input data reflecting the regional economy.

The economic impacts associated with the construction and operation of the each of the Final Array of Alternatives as well as those associated with temporary displacement under each of these alternatives were evaluated using the IMPLAN model representing the combined regional economy of the three counties of Broward, Miami-Dade, and Palm Beach. The model uses 2023 IMPLAN data, the most current available data which represents the economy of the 3-County Study Area in 2023.

[1] Leakages resulting after the direct effects are not captured in the figure.

3.2 Assumptions

Construction of the Final Array of Alternatives is expected to take 7 years (from 2029 through 2035) with operations commencing in 2036. The material and labor inputs required to construct the new structures under of each of the alternatives is assumed to be sourced from within the 3-County Study Area (i.e., local) as well as outside the study area (nonlocal). For the purposes of evaluating the RED analysis, the local portion of these costs are assumed to be 80 percent with the remaining 20 percent assumed to be nonlocal.

The avoided evacuation and relocation costs associated with the temporary displacement of households affected by the flooding were estimated using estimates of the population affected. The estimates of the affected population were developed by evaluating the difference between the population under FWOP and Final Array of Alternatives. The Final Array of Alternatives in this case include both sea level rise scenarios (intermediate and high) under each of the three design storms (2S25R, 2S100R, 100S100R) scenarios and the estimated impacts are for 2085 only. The probabilities of each combination of sea level rise and storm events is applied to derive an annual average cost savings estimate associated with each sea level rise/storm. The average annual costs associated with each storm is summed up to derive the total annual costs savings of the final Array of Alternatives related to the FWOP. These annual costs savings are based on population estimates associated with each sea level rise and storm event combination and multiplied by the GSA per diem rates for Fort Lauderdale (see *Temporary Displacement Analysis TM in Section D.7*). The per diem rate is a combined lodging and meals and incidentals (M&I) rate.

The estimated temporary displacement costs are assumed to be split between lodging and food with the food expenditure further split between grocery purchases (85 percent) and restaurants (15 percent).

The alternatives are assumed to be operational over a 50-year period and are expected to require additional operations and maintenance (O&M) costs net of the existing SFWMD's O&M expenditures.

All inputs into the model are in 2025 dollars and by using the IMPLAN model's BLS Growth Model to convert nominal dollars into 2025 dollars, the results are also reported in 2025 dollars.

3.3 Inputs

Table 1 summarizes the construction cost estimates for each of the three alternatives in the Final Array of Alternatives.

Table 1. ROM Construction Costs (Millions 2025$)

Cost	Alternative A	Alternative B	Alternative C	TSP
Total ROM Estimated Construction Cost	$734.54	$1,226.07	$2,038.89	$1,303.31
Local ROM Construction Cost (80%)	$587.63	$980.86	$1,631.11	$1,042.65
Annual Local ROM Construction Costs	$83.95	$140.12	$233.02	$148.95

The annual local ROM construction costs were run through the IMPLAN's construction sector 51, the construction of other new non-residential structures. This sector is assumed to best represent the construction of the components associated with each of the Final Array of Alternatives.

Table 2 summarizes the total temporary displacement cost savings net of the temporary displacement costs under the FWOP while **Table 3** shows these displacement cost savings split between lodging, grocery purchases and restaurants. The cost savings were run through IMPLAN sectors 489 (Hotels and motels), 389 (Retail – food and beverage stores) and 492 (Limited-service restaurants) to estimate regional economic impacts associated with the temporary displacement cost savings under each of the alternatives.

Table 2. Total Temporary Displacement Costs (Millions 2025$)

	2S25R	2S100R	100S100R	Total
Intermediate Sea Level Rise				
Alternative A	($0.8)	($0.6)	($0.2)	($1.6)
Alternative B	($0.9)	($0.7)	($0.2)	($1.8)
Alternative C	($0.9)	($0.8)	($0.3)	($2.0)
TSP	($0.8)	($0.6)	($0.2)	($1.6)
High Sea Level Rise				
Alternative A	($2.3)	($1.5)	($0.6)	($4.4)
Alternative B	($2.6)	($1.8)	($0.8)	($5.1)
Alternative C	($2.8)	($2.0)	($0.9)	($5.6)
TSP	($2.3)	($1.5)	($0.5)	($4.4)

Table 3. Temporary Displacement Costs by Expenditure Category (Millions 2025$)

	Lodging	Grocery	Restaurant	Total
Intermediate Sea Level Rise				
Alternative A	($1.4)	($0.1)	($0.0)	($1.6)
Alternative B	($1.6)	($0.2)	($0.0)	($1.8)
Alternative C	($1.8)	($0.2)	($0.0)	($2.0)
TSP	($1.4)	($0.1)	($0.0)	($1.6)
High Sea Level Rise				
Alternative A	($3.9)	($0.4)	($0.1)	($4.3)
Alternative B	($4.5)	($0.5)	($0.1)	($5.1)
Alternative C	($5.0)	($0.5)	($0.1)	($5.6)
TSP	($3.9)	($0.4)	($0.1)	($4.4)

The totals from Table 3 are slightly different from those in Table 2 due to rounding. For the purposes of using these estimates in the IMPLAN model these slight differences are not significant enough to generate different results.

Table 4 summarizes the annualized direct output losses, under the high sea level rise scenario, associated with business interruption due to reduced sales and production value resulting from flooding in structures. The direct output losses under each alternative were estimated and compared to the direct output losses under the Future Without Project (FWOP). The estimates shown in the table represent the net output loss under each the alternatives and the TSP compared to the FWOP therefore these numbers represent the annual savings (i.e., reduction in direct output losses) under each of the alternative. For details on the methodology, assumptions and detailed data see *Business Interruptions Analysis Draft Technical Report: Assessment of Business Interruption for the South Florida Water Management District in Section D.6.*

While the direct output losses were estimated for both the intermediate and high sea level rise scenarios, the estimates for the intermediate scenario were not large enough to run through the IMPLAN model to estimate the potential economic impacts. Thus, only the annual direct output losses under the high sea level rise shown in Table 4 below were used to estimate the economic impacts under each of the three Final Array of Alternatives and the TSP.

Table 4. Annualized Direct Output Loss – High Sea Level Rise (2025$)

Hazus Code	IMPLAN Sector	Alternative A	Alternative B	Alternative C	TSP
AGR1	3	($5,240)	($6,019)	($4,861)	($4,610)
COM1	394	($95,247)	($123,197)	($117,837)	($60,460)
COM2	383	($288)	($272)	($157)	($241)
COM3	499	($2,104)	($2,112)	($2,107)	($1,429)
COM4	449	($211,194)	($241,724)	($217,542)	($97,512)
COM5	424	($54,085)	($54,260)	($44,592)	($16,251)
COM6	472	($20,495)	($20,535)	($20,539)	($20,421)
COM8	486	($4,570)	($4,614)	($4,814)	($4,522)
EDU1	462	($1,569,730)	($2,027,205)	($2,010,479)	($1,367,184)
GOV1	516	($25,099)	($25,117)	($25,951)	($16,619)
IND2	374	($8,259)	($9,736)	($11,121)	($5,034)
IND3	177	($9,346)	($11,393)	($8,163)	($6,277)
IND5	289	($119)	($120)	($119)	($119)
REL1	503	($149,215)	($206,491)	($233,949)	($109,704)
RES4	489	($147,663)	($148,149)	($147,871)	($7,415)
RES6	473	($68,650)	($75,560)	($68,630)	($67,976)
	Total	**($2,371,304)**	**($2,956,504)**	**($2,918,732)**	**($1,785,773)**

Table 5 summarizes the operations and maintenance (O&M) costs incurred by SFWMD annually to operate and maintain the structures both under the FWOP as well as the under each of the three alternatives. The FWOP O&M costs were adjusted from 2010 Q1 dollars to 2025 Q1 dollars using the BEA's GDP Implicit Price Deflators (BEA 2025). The net annual O&M costs, in 2025$, were run through IMPLAN's sector 55, maintenance and repair of nonresidential structures, to estimate the regional economic impacts associated with the O&M under each of the alternatives.

Table 5. Annual O&M Costs (Millions)

Cost	FWOP	Alternative A	Alternative B	Alternative C	TSP
2010$	$1.13	$2.05	$2.85	$4.51	$2.81
2025$	$1.69	$3.01	$4.16	$6.55	$4.09
Net Annual O&M Costs (2025$)		**$1.32**	**$2.47**	**$4.86**	**$2.40**

4 Results

The impacts associated with the construction phase are temporary and thus different from the long-term effects associated with the operational phase of the project. These impacts are measured in terms employment, labor income, value added and total industry output. Employment is a combination of wage and salary employment and proprietor employment and is converted to full-time equivalent (FTE) using IMPLAN's job to FTE conversion factors. Labor income includes both wage and salary income as well as proprietor income. Value added is a large proportion of total industry output and includes labor income, other property income (e.g., dividends, royalties, corporate profits, and interest income), and taxes on production and imports. Total industry output (i.e., output) is the value of production that occurred in an economy during the calendar year.

4.1 Construction

Construction of the Final Array of Alternatives is expected to take 7 years. **Tables 6 through 9** show the annual direct and secondary (indirect and induced) economic impacts within 3-County Study Area associated with the construction of each of the three alternatives and the TSP.

The construction of Alternative A results in 481 full-time equivalent (FTE) direct annual jobs and another 259 FTEs in annual secondary jobs for a total of 739 total annual FTEs (**Table 6**). These jobs are associated with a total $50.7 million in labor income, $84.6 million in value added and $143.3 million in output.

Table 6. Alternative A: Annual Construction Impacts

Impact	Employment (FTEs)	Labor Income (Millions 2025$)	Value Added (Millions 2025$	Output (Millions 2025$)
Direct	481	$31.9	$50.3	$84.0
Secondary	259	$18.8	$34.3	$59.3
Total	**739**	**$50.7**	**$84.6**	**$143.3**

The construction of Alternative B is expected to result in 802 direct (FTE) annual jobs during the construction period and lead to the creation or support of an additional 431 secondary jobs annually, for a total of 1,234 annual jobs within the 3-County Study Area (**Table 7**). These additional jobs are estimated to generate a total of $84.7 million in labor income, $141.2 million in value added, and $239 million in output.

Table 7. Alternative B: Annual Construction Impacts

Impact	Employment (FTEs)	Labor Income (Millions 2025$)	Value Added (Millions 2025$	Output (Millions 2025$)
Direct	802	$53.2	$84.0	$140.1
Secondary	431	$31.5	$57.2	$98.9
Total	**1,234**	**$84.7**	**$141.2**	**$239.0**

The construction of Alternative C is expected to result in 1,334 direct (FTE) annual jobs during the construction period and lead to the creation or support of an additional 718 annual secondary jobs annually, for a total of 2,052 annual jobs within the 3-County Study Area (**Table 8**). These additional jobs are estimated to generate a total of $140.7 million in labor income, $234.8 million in value added, and $397.5 million in output.

Table 8. Alternative C: Annual Construction Impacts

Impact	Employment (FTEs)	Labor Income (Millions 2025$)	Value Added (Millions 2025$	Output (Millions 2025$)
Direct	1,334	$88.4	$139.6	$233.0
Secondary	718	$52.3	$95.2	$164.5
Total	**2,052**	**$140.7**	**$234.8**	**$397.5**

The construction of the TSP is expected to result in 1,312 direct (FTE) annual jobs during the construction period and lead to the creation or support of an additional 459 annual secondary jobs annually, for a total of 1,312 annual jobs within the 3-County Study Area (**Table 9**). These additional jobs are estimated to generate a total of $89.9 million in labor income, $150.1 million in value added, and $254.2 million in output.

Table 9. TSP: Annual Construction Impacts

Impact	Employment (FTEs)	Labor Income (Millions 2025$)	Value Added (Millions 2025$	Output (Millions 2025$)
Direct	853	$56.5	$89.3	$149.0
Secondary	459	$33.4	$60.8	$105.2
Total	**1,312**	**$90.0**	**$150.1**	**$254.2**

Because the annual local construction cost under Alternative B is higher than that under Alternative A, the impacts under Alternative B are higher than those under Alternative A. Alternative C has the highest annual local construction cost and the highest impacts among the three alternatives. The TSP's annual construction costs are higher than those under both Alternative A and Alternative B and lower than those under Alternative C. Thus, the impacts under the TSP are higher than those under both Alternative A and Alternative B and lower than those under Alternative C.

4.2 Temporary Displacement

The regional economic impacts associated with savings in temporary displacement costs are summarized in **Tables 10 through 13**. The savings in displacement costs are not the full savings but rather the annualized savings based on the probabilities of the combination of sea level rise and storm events occurring, which are summed for the each of the Final Array of Alternatives analyzed and the TSP. The estimates shown in the tables correspond to the direct and secondary (indirect and induced) economic impacts within the 3-County Study Area associated with temporary displacement cost savings under each of the three alternatives net of the FWOP.

Table 10. Alternative A: Temporary Displacement Impacts

Impact	Employment (FTEs)	Labor Income (Millions 2025$)	Value Added (Millions 2025$	Output (Millions 2025$)
Intermediate Sea Level Rise				
Direct	(8)	($0.5)	($1.0)	($1.3)
Secondary	(4)	($0.3)	($0.5)	($0.8)
Total	**(12)**	**($0.7)**	**($1.5)**	**($2.1)**
High Sea Level Rise				
Direct	(21)	($1.4)	($3.1)	($4.1)
Secondary	(11)	($0.8)	($1.4)	($2.4)
Total	**(32)**	**($2.2)**	**($4.5)**	**($6.5)**

Table 11. Alternative B: Temporary Displacement Impacts

Impact	Employment (FTEs)	Labor Income (Millions 2025$)	Value Added (Millions 2025$	Output (Millions 2025$)
Intermediate Sea Level Rise				
Direct	(9)	($0.6)	($1.3)	($1.7)
Secondary	(5)	($0.3)	($0.6)	($1.0)
Total	**(13)**	**($0.9)**	**($1.9)**	**($2.7)**
High Sea Level Rise				
Direct	(25)	($1.6)	($3.6)	($4.8)
Secondary	(13)	($0.9)	($1.6)	($2.8)
Total	**(38)**	**($2.5)**	**($5.2)**	**($7.6)**

Table 12. Alternative C: Temporary Displacement Impacts

Impact	Employment (FTEs)	Labor Income (Millions 2025$)	Value Added (Millions 2025$	Output (Millions 2025$)
Intermediate Sea Level Rise				
Direct	(10)	($0.6)	($1.4)	($1.9)

Impact	Employment (FTEs)	Labor Income (Millions 2025$)	Value Added (Millions 2025$	Output (Millions 2025$)
Secondary	(5)	($0.4)	($0.6)	($1.1)
Total	**(15)**	**($1.0)**	**($2.0)**	**($3.0)**
High Sea Level Rise				
Direct	(27)	($1.8)	($4.0)	($5.2)
Secondary	(14)	($1.0)	($1.8)	($3.1)
Total	**(41)**	**($2.8)**	**($5.8)**	**($8.3)**

Table 13. TSP: Temporary Displacement Impacts

Impact	Employment (FTEs)	Labor Income (Millions 2025$)	Value Added (Millions 2025$	Output (Millions 2025$)
Intermediate Sea Level Rise				
Direct	(21)	($0.5)	($1.1)	($1.5)
Secondary	(11)	($0.3)	($0.5)	($0.9)
Total	**(32)**	**($0.8)**	**($1.6)**	**($2.4)**
High Sea Level Rise				
Direct	(26)	($1.4)	($3.1)	($4.1)
Secondary	(14)	($0.8)	($1.4)	($2.4)
Total	**(40)**	**($2.2)**	**($4.5)**	**($6.5)**

4.3 Business Interruption

The regional economic impacts associated with the savings in direct output losses under each of the Final Array Alternatives and the TSP are summarized in **Tables 14 through 17**. The savings in direct business output losses are not the full savings but rather the annualized savings based on the probabilities of the combination of sea level rise and storm events occurring, which are summed for the each of the Final Array of Alternatives analyzed and the TSP. The estimates shown in the tables correspond to the direct and secondary (indirect and induced) economic impacts within the 3-County Study Area associated reduction in direct output losses under each of the three alternatives net of the FWOP.

Table 14. Alternative A: Annual Business Interruption Impacts, High Sea Level Rise

Impact	Employment (FTEs)	Labor Income (Millions 2025$)	Value Added (Millions 2025$	Output (Millions 2025$)
Direct	(30)	($1.9)	($1.8)	($2.3)
Secondary	(10)	($0.6)	($1.2)	($2.0)
Total	**(40)**	**($2.5)**	**($3.0)**	**($4.3)**

Table 15. Alternative B: Annual Business Interruption Impacts, High Sea Level Rise

Impact	Employment (FTEs)	Labor Income (Millions 2025$)	Value Added (Millions 2025$	Output (Millions 2025$)
Direct	(39)	($2.4)	($2.3)	($2.9)
Secondary	(12)	($0.8)	($1.5)	($2.6)
Total	**(51)**	**($3.2)**	**($3.8)**	**($5.5)**

Table 16. Alternative C: Annual Business Interruption Impacts, High Sea Level Rise

Impact	Employment (FTEs)	Labor Income (Millions 2025$)	Value Added (Millions 2025$	Output (Millions 2025$)
Direct	(38)	($2.4)	($2.3)	($2.8)
Secondary	(12)	($0.8)	($1.5)	($2.5)
Total	**(50)**	**($3.2)**	**($3.8)**	**($5.3)**

Table 17. TSP: Annual Business Interruption Impacts, High Sea Level Rise

Impact	Employment (FTEs)	Labor Income (Millions 2025$)	Value Added (Millions 2025$	Output (Millions 2025$)
Direct	(25)	($1.6)	($1.4)	($1.7)
Secondary	(8)	($0.5)	($0.9)	($1.6)
Total	**(33)**	**($2.1)**	**($2.3)**	**($3.3)**

4.4 Operation

In addition to the economic benefits resulting from the construction of the alternatives, there will be ongoing economic benefits from the O&M under each of the alternatives. **Tables 18 through 21** summarize the annual direct and secondary (indirect and induced) economic impacts within 3-County Study Area associated with the operation of each of the three alternatives. **Table 18** shows that the operation of Alternative A results in the addition of 6 full-time equivalent (FTE) direct jobs on top of the current/existing SFWMD operational workforce. The additional O&M expenditures results in another 4 FTEs in secondary jobs for a total of 10 total FTEs. These jobs are associated with a total $0.7 million in labor income, $1.2 million in value added and $2.3 million in output.

Table 18. Alternative A: Annual Operation Impacts

Impact	Employment (FTEs)	Labor Income (Millions 2025$)	Value Added (Millions 2025$	Output (Millions 2025$)
Direct	6	$0.4	$0.7	$1.3
Secondary	4	$0.3	$0.6	$1.0
Total	**10**	**$0.7**	**$1.2**	**$2.3**

The operation of Alternative B is expected to require an additional 11 direct annual (FTE) jobs on top of the existing SFMWD operational workforce and lead to the creation or support of an additional 8 annual secondary jobs annually, within the 3-County Study Area, for a total of 19 annual FTEs (**Table 19**). These additional jobs are estimated to generate a total of $1.3 million in labor income, $2.3 million in value added, and $4.3 million in output.

Table 19. Alternative B: Annual Operation Impacts

Impact	Employment (FTEs)	Labor Income (Millions 2025$)	Value Added (Millions 2025$	Output (Millions 2025$)
Direct	11	$0.7	$1.2	$2.5
Secondary	8	$0.6	$1.0	$1.8
Total	**19**	**$1.3**	**$2.3**	**$4.3**

The operation of Alternative C is expected to require an additional 22 direct annual (FTE) jobs on top of the existing SFMWD operational workforce and lead to the creation or support of an additional 15 annual secondary jobs annually, within the 3-County Study Area, for a total of 37 annual FTEs (**Table 20**). These additional jobs are estimated to generate a total of $2.5 million in labor income, $4.5 million in value added, and $8.4 million in output.

Table 20. Alternative C: Annual Operation Impacts

Impact	Employment (FTEs)	Labor Income (Millions 2025$)	Value Added (Millions 2025$	Output (Millions 2025$)
Direct	22	$1.4	$2.4	$4.9
Secondary	15	$1.1	$2.0	$3.5
Total	**37**	**$2.5**	**$4.5**	**$8.4**

The operation of the TSP is expected to require an additional 11 direct annual (FTE) jobs on top of the existing SFMWD operational workforce and lead to the creation or support of an additional 7 annual secondary jobs annually, within the 3-County Study Area, for a total of 18 annual FTEs (**Table 21**). These additional jobs are estimated to generate a total of $1.2 million in labor income, $2.2 million in value added, and $4.1 million in output.

Table 21. TSP Annual Operation Impacts

Impact	Employment (FTEs)	Labor Income (Millions 2025$)	Value Added (Millions 2025$	Output (Millions 2025$)
Direct	11	$0.7	$1.2	$2.4
Secondary	7	$0.5	$1.0	$1.7
Total	**18**	**$1.2**	**$2.2**	**$4.1**

Because the annual O&M cost under Alternative B is higher than that under Alternative A, the impacts under Alternative B are higher than those under Alternative A. Alternative C has the highest annual O&M

cost and the highest impacts among the three alternatives. The annual O&M cost under the TSP is lower than the annual O&M cost under both Alternative B and Alternative C though higher than the cost under Alternative A. Thus, the impacts are under the TSP are lower than those under both Alternative B and Alternative C and higher than those under Alternative A.

5 References

U.S. Bureau of Economic Analysis (BEA). 2025. "GDP and Personal Income, National Data." Table 1.1.9. Implicit Price Deflators for Gross Domestic Product. Accessed July 9. "Table 1.1.9. Implicit Price Deflators for Gross Domestic Product"

D.9 Environmental Quality and Other Social Effects Benefits Technical Memorandum

Impacts to Septic Tanks and Cultural Resources

Central and Southern Florida Flood Resiliency Study Broward Basins (Section 203)

South Florida Water Management District

Broward County, Florida

October 17, 2025

Contents

Tables

Attachment

DRAFT

1 Introduction

South Florida Water Management District (SFWMD) is utilizing Section 203 of the Water Resources Development Act of 1986, as amended, to advance the Central and Southern Florida (CS&F) Flood Resiliency Study – Broward Basins with support from the Florida Department of Environmental Protection, Broward County, and technical/federal assistance from the U.S. Army Corps of Engineers (USACE) – Jacksonville District, for inclusion in the Water Resources Development Act (WRDA) 2026.

This memorandum documents the quantification of economic indicators for both septic tanks and cultural resources within the study area. The intent of this memorandum is supplemental to a parent document about the comprehensive benefits analysis in support of the alternative plans.

1.1 Flood Scenarios

An integrated/coupled surface-groundwater MIKE SHE/MIKE Hydro (2022) model was created by the SFWMD and was used to generate flood hazard information for use in the flood damage assessment. This 2D hydrologic and hydraulic (H&H) model covers the entire study area and extends past the tidal boundary condition to the east. The focus on this study is the primary canal system; however, the model includes a high level of detail within the secondary and tertiary canal systems.

The following table includes all flood scenarios included in the modeling, three of which are included in the quantification of indicators discussed in this memorandum.

Table 1. Flood Hazard Simulations

Coastal Water Level Return Period (CHS Data)	Rainfall Return Period (NOAA Atlas 14 Data)	Joint Probability (%)	Joint Recurrent Frequency (years)	Used in Indicator Analysis?
2-year	5-year	0.125	8	
2-year	10-year	0.0714	14	
2-year	25-year	0.0333	30	X
10-year	10-year	0.0313	32	
20-year	25-year	0.0133	75	
2-year	100-year	0.0091	110	X
100-year	100-year	0.0023	430	X
2-year	500-year	0.0019	538	

1.2 Alternative Plans

Five conditions over two planning horizons (2035 and 2085) were included in this Section 203 analysis. In addition to the Without Project alternative, the final array of alternatives considered in this analysis are denoted as Alternative A, B, C, and a Tentatively Selected Plan (TSP) based on the results of the first alternatives. Each alternative contains features shown to be effective in improving flood levels in the seven upstream drainage areas of the study. The features consist of primary structure modifications, primary C&SF Canal improvements, and storage and nature based proposed projects.

2 Metrics/Benefits

This technical memorandum focuses on two indicators of project performance in the study area: septic tanks and cultural resources. Both metrics are social and/or environmental in nature and are non-monetary.

2.1 Septic Tank Impacts

Impacts to underground septic tanks or onsite sewage treatment and disposal systems (OSTDS) can occur from a flood hazard and can cause difficulties for the owner and long-term environmental impairments to the watershed. Unlike above-ground assets, septic tanks have an indirect relationship with flooding. Septic tanks may still be damaged during flood events even if no surface water flooding is present above the asset. Additionally, flooding above the septic tank does not necessarily constitute an impact.

Direct impacts to septic tanks are based on a variety of factors: the condition of the septic tank, the design and configuration of the various components, the soil and groundwater conditions, and the influent and effluent quality. Failure modes of septic tanks, in relation to floodwaters, are commonly caused by buoyancy of the tank, soil saturation that prevents effluent infiltration, or inflow into compromised pieces of the system. Therefore, it is difficult to predict risks for a large-scale study area.

To provide comparison of the various alternative project plans' ability to reduce flood impacts to septic tanks, two metrics were quantified across the study area.

- The **number of septic tanks at-risk of any form of surface flooding** shows the total number of assets that are removed from the floodplain.
- The **number of septic tanks with some reduction in flood risk** shows assets that experience lesser surface flooding due to the project.

Together, these metrics intend to provide a high-level comparison across alternative plans and flood scenarios.

2.1.1 Data Sources

- *Septic Tanks* – Florida Water Management Inventory (FDEP FLWMI, May 2025).

- *Flood-Depth Rasters* – 36 grids supplied by SFWMD (2023 hindcast, 2040 & 2070 SLR scenarios, multiple return periods; processed June 2025).
    - *Refer to separate hydrologic and hydraulic technical memorandum for more information on the flood hazard information used in this analysis.*
- *Watershed Boundaries* – SFWMD Broward Basins (2024).

2.1.2 Methodology

The process below overviews how metrics were quantified using ArcGIS Pro. Model Builder was utilized to automate most tasks:

1. Downloaded septic tank data layer, selected only tanks within the Section 203 Study Area to include in final feature class layer in file geodatabase.
2. Used ArcGIS Pro's "Multipart to Single part" tool to ensure discrete sampling locations. Converted features to centroid points using ArcGIS Pro's "Feature to Point" tool.
3. Joined basin names to septic tank point feature class using ArcGIS Pro's spatial join, preserving the "NAME" attribute from the attributes from the *AHED_Watersheds* Watershed layer.
4. Used the "Sample" tool to extract values from each of the 36 peak flood depth rasters to each septic point.
5. Created binary "is flooded" *isf_* fields* (Short Int), where value = 1 if sampled depth > 0.0 ft.
6. Created binary "flood reduced" *reduced_** fields for each alternative scenario (Alt A, Alt B, Alt C), where value = 1 if:
    - Alternative depth < Base depth (without project); and
    - Base depth > 0 ft.
7. Used the "Summary Statistics" tool to total each isf_* and reduced_* field by BASINNAME.
8. Output summary tables as separate geodatabase tables for each scenario and indicator.
9. Exported these summary table results to excel along with the raw attribute table displaying all original and result fields that were added.

2.1.3 Discussion

The results of this septic tank impact analysis show that each alternative plan provides a reduction in the number of septic tanks that experience any kind of surface flooding (i.e. total removal of septic tanks from the associated flood scenario) and provides overall reduction in flood depths above septic tanks across the study area.

Results from analysis are shown in the *"Number of Septic Tanks with Reduced Flood Values"* in the Attachment. In the 100S100R35i scenario, Alt C reduced flooding for 8,984 septic systems, with prominent gains in C-11 EAST (5,164), HILLSBORO CANAL (1,451), and C-11 WEST (1,745). As flood severity increased (e.g., 100S100R85h and 100S100R85i), Alt C provided even greater reductions (9,354 and 9,033, respectively).

The 2S100R scenarios demonstrated similar performance. Under 2S100R85i, Alt C reduced flooding for 9,033 septic systems—again with major reductions in C-11 EAST, C-11 WEST, and HILLSBORO CANAL. Even under lower storm return periods (2S25R), Alt C outperformed others (e.g., 7,164 reduced in 2S25R85i).

DRAFT

Similarly, the Tentatively Selected Plan (TSP) achieved comparable or greater flood reduction benefits across basins, with the highest reductions again observed in C-11 EAST, C-11 WEST, and HILLSBORO CANAL, ranging from approximately 7,000 to 9,300 septic systems reduced across scenarios.

2.2 Cultural Resource Impacts

Cultural resources are important to community identity, quality of life, property values, equity, and other community values. Several publicly available data sets were used in this analysis and include cemeteries, cultural centers, and tribal areas. Some of these cultural resources represent structures, such as community centers, while others represent generally open areas of land for public gatherings, such as parks or cemeteries. Economic damage to structures may already be accounted for under the HEC-FDA analysis, which is presented in a separate technical memorandum; however, this indictor is treated as a social indicator for areas of cultural significance. Regardless of direct damage to the asset, impacts to cultural resources cause strain on a community.

For the purposes of this indicator and noting the broad scale of the study area, two metrics have been quantified:

- The **number of cultural resources that are impacted by surface flooding** shows the total number of assets removed from the floodplain.
- The **number of cultural resources with some reduction in flood risk flooding**, shows assets that experience lesser flooding due to the project.

A foundation height estimate was acquired for all cultural resources that have an identifiable structure on the asset area, and this was used to determine whether the asset is impacted or not. For example, if an asset has a foundation height of 0.5-feet, but a flood depth of 0.4-feet, it would not be noted as impacted by flooding.

Some assets that are noted as impacted may not experience significant damage or restriction in usage. A cultural center that becomes impacted may be closed for a period of time after the flood event, causing a social impact to the community members that gain value from that asset. However, a non-structural asset, such as a cemetery, may be noted as impacted if it experiences surface flooding on the site, but may still have social and cultural benefit directly after the flood event. The purpose of this metric is to draw correlations among the various alternative plans in regard to their potential to reduce flood risk for the cultural resources within the study area.

2.2.1 Data Sources

- *SHPO Resource Groups* – Florida Master Site File (FMSF), updated April 2025.
- *Cemeteries & Cultural Centers* – Florida Geographic Data Library (May 2025).
- *NRHP & SHPO Eligible Bridges* – National Park Service & FMSF (March 2025).
- *American Indian & Tribal Lands* – SFWMD (2024)
- *Flood-Depth Rasters* – 36 grids supplied by USACE (2023 hindcast, 2040 & 2070 SLR scenarios, multiple return periods; processed June 2025).

- *National Structures Inventory* (NSI) – Attributes used: foundation height (feet).

2.2.2 Methodology

1. Downloaded all cultural resource data and clipped or selected data within the Section 203 study area to include in file geodatabase layers.
2. Used the "Multipart to Single part" and "Feature to Point" tools to ensure discrete sampling locations.
3. Combined all points into one feature class using ArcGIS Pro's "Merge" tool preserving the unique attributes of all data layers and added a "source_layer" attribute to maintain the source layer's origin throughout the merging process.
4. Added available foundation heights from the NSI to structures in cultural resource layer, and added as attribute (found_ht), if none were available, attributed as "0".
5. Used the "Sample" tool to extract values from each of the 36 requested peak flood depth rasters to each cultural point.
6. Created binary "is flooded" *isf_* fields* (Short Int), where value = 1 if sampled depth > 0.0 ft.
7. Created binary "flood reduced" *reduced_** fields for each alternative scenario (Alt A, Alt B, Alt C), where value = 1 if:
    - Alternative depth < Base depth(without project); and
    - Base depth > 0 ft.
8. Used the "Summary Statistics" tool to total each isf_* and reduced_* field by BASINNAME.
9. Output summary tables as separate geodatabase tables for each scenario and indicator.
10. Exported these summary table results to excel along with the raw attribute table displaying all original and result fields that were added.

2.2.3 Discussion

Results from analysis are shown in the *"Number of Cultural Resources with Reduced Flood Values"* in the Attachment. The updated analysis of cultural resources under reduced flooding conditions shows variations across basins and alternatives. Overall, reduced inundation impacts were greatest in the HILLSBORO CANAL and NORTH NEW RIVER CANAL WEST basins across all scenarios. Among the alternatives, Alternative C generally resulted in the greatest number of cultural resource points with reduced flood exposure, followed closely by Alternatives B and A.

Under the 100S100R35i scenario, Alternative C yielded the highest reduction (135 features), with substantial mitigation in the HILLSBORO CANAL (57) and NORTH NEW RIVER CANAL WEST (17) basins. This trend continues under the 100S100R85h and 100S100R85i scenarios, where reductions increased with flood intensity, especially for Alt C (137 and 139 features, respectively).

A similar pattern is observed in the 2S scenarios. For example, under 2S100R85i, Alt C again showed the highest reduction (139), with HILLSBORO CANAL (56) and NORTH NEW RIVER CANAL WEST (17) being major contributors. Notably, 2S25R85h and 2S25R85i had lower overall reductions but still followed the same hierarchy across alternatives.

The Tentatively Selected Plan (TSP) results reflect a similar distribution, with the highest reductions occurring in the HILLSBORO CANAL, C-11 EAST, and C-14 WEST basins, totaling between approximately 97 and 132 cultural resources with reduced flood exposure across scenarios.

3 Conclusion

The results of these two indicators affirm that all three alternative plans and the TSP provide substantial benefit and reduction of flood risk for septic tanks and cultural resources. All plans considered provide similar levels of improvement across the various flood scenarios. Alternative C provided notable improvements beyond Alternative A and B. Reductions were consistently highest in HILLSBORO CANAL, NORTH NEW RIVER CANAL WEST, and C-11 EAST basins, demonstrating the geographic concentration of benefits. The Tentatively Selected Plan (TSP) yielded comparable or greater reductions across both resource types, further emphasizing the effectiveness of the selected measures in these key basins.

Complete results of this analysis are attached to this technical memorandum under **Attachment 1**.

Attachment 1

Impacts to Septic Tanks
(Direct Impacts)

Number of Septic tanks with Flood Values

100S100R 35i					***100S100R 85h***				***100S100R 85i***			
Basin Name	***Without Project***	***Alt A***	***Alt B***	***Alt C***	***Without Project***	***Alt A***	***Alt B***	***Alt C***	***Without Project***	***Alt A***	***Alt B***	***Alt C***
C-11 EAST	5307	5185	5180	5177	5637	5426	5414	5405	5374	5247	5208	5202
C-11 WEST	1847	1839	1841	1836	1882	1866	1869	1869	1853	1850	1851	1848
C-12W	215	215	215	215	215	215	215	215	215	215	215	215
C-13 WEST	13	13	13	13	14	14	14	14	13	13	13	13
C-14 EAST	18	18	18	18	18	18	18	18	18	18	18	18
C-14 WEST	44	42	42	42	44	42	42	42	44	42	42	42
HILLSBORO CANAL	1484	1460	1457	1440	1489	1465	1467	1441	1485	1461	1460	1440
NORTH NEW RIVER CANAL WEST	331	323	320	310	389	372	360	323	345	334	332	314
POMPANO CANAL	21	19	20	20	25	24	22	23	21	20	21	20
Total	**9280**	**9114**	**9106**	**9071**	**9713**	**9442**	**9421**	**9350**	**9368**	**9200**	**9160**	**9112**

2S100R 35i					***2S100R 85h***				***2S100R 85i***			
Basin Name	***Without Project***	***Alt A***	***Alt B***	***Alt C***	***Without Project***	***Alt A***	***Alt B***	***Alt C***	***Without Project***	***Alt A***	***Alt B***	***Alt C***
C-11 EAST	5261	5179	5182	5181	5497	5332	5310	5288	5332	5206	5199	5192
C-11 WEST	1846	1846	1842	1840	1890	1866	1862	1870	1851	1849	1849	1846
C-12W	215	215	215	215	215	215	215	215	215	215	215	215
C-13 WEST	13	13	13	13	14	14	14	14	13	13	13	13
C-14 EAST	18	18	18	18	18	18	18	18	18	18	18	18
C-14 WEST	44	42	42	42	44	42	42	42	44	42	42	42
HILLSBORO CANAL	1483	1453	1443	1440	1487	1459	1459	1441	1483	1462	1462	1440
NORTH NEW RIVER CANAL WEST	326	317	316	305	362	354	346	323	335	327	324	310
POMPANO CANAL	21	20	19	20	23	23	23	23	21	21	21	20
Total	**9227**	**9103**	**9090**	**9074**	**9550**	**9323**	**9289**	**9234**	**9312**	**9153**	**9143**	**9096**

Number of Septic tanks with Flood Values

2S25R 35i					*2S25R 85h*				*2S25R 85i*			
Basin Name	***Without Project***	***Alt A***	***Alt B***	***Alt C***	***Without Project***	***Alt A***	***Alt B***	***Alt C***	***Without Project***	***Alt A***	***Alt B***	***Alt C***
C-11 EAST	4477	4415	4411	4407	4669	4494	4479	4466	4499	4432	4429	4421
C-11 WEST	1564	1572	1571	1568	1592	1581	1578	1577	1570	1574	1572	1570
C-12W	197	195	195	195	198	196	196	195	198	195	195	195
C-13 WEST	11	11	11	11	12	12	11	11	11	11	11	11
C-14 EAST	13	13	13	13	15	14	14	14	13	13	13	13
C-14 WEST	36	35	35	35	36	35	35	35	36	35	35	35
HILLSBORO CANAL	1269	1258	1258	1256	1270	1257	1257	1256	1269	1258	1258	1256
NORTH NEW RIVER CANAL WEST	240	231	231	222	269	261	255	236	251	244	242	224
POMPANO CANAL	6	6	6	6	10	10	10	8	7	7	7	7
Total	**7813**	**7736**	**7731**	**7713**	**8071**	**7860**	**7835**	**7798**	**7854**	**7769**	**7762**	**7732**

Number of Septic tanks with Flood Values

100S100R35i			***100S100R85h***		***100S100R85i***	
Basin Name	***Without Project***	***TSP***	***Without Project***	***TSP***	***Without Project***	***TSP***
C-11 EAST	5307	5240	5637	5470	5374	5295
C-11 WEST	1847	1832	1882	1860	1853	1840
C-12W	215	215	215	215	215	215
C-13 WEST	13	12	14	14	13	13
C-14 EAST	18	18	18	18	18	18
C-14 WEST	44	41	44	41	44	41
HILLSBORO CANAL	1484	1443	1489	1462	1485	1460
NORTH NEW RIVER CANAL WEST	331	316	389	345	345	329
POMPANO CANAL	21	21	25	24	21	21
Total	**9280**	**9138**	**9713**	**9449**	**9368**	**9232**

2S100R35i			***2S100R85h***		***2S100R85i***	
Basin Name	***Without Project***	***TSP***	***Without Project***	***TSP***	***Without Project***	***TSP***
C-11 EAST	5261	5185	5497	5338	5332	5245
C-11 WEST	1846	1836	1890	1861	1851	1838
C-12W	215	215	215	215	215	215
C-13 WEST	13	12	14	14	13	13
C-14 EAST	18	18	18	18	18	18
C-14 WEST	44	41	44	41	44	41
HILLSBORO CANAL	1483	1443	1487	1445	1483	1443
NORTH NEW RIVER CANAL WEST	326	310	362	327	335	318
POMPANO CANAL	21	20	23	23	21	21
Total	**9227**	**9080**	**9550**	**9282**	**9312**	**9152**

Number of Septic tanks with Flood Values

2S25R 35i			***2S25R 85h***		***2S25R 85i***	
Basin Name	***Without Project***	***TSP***	***Without Project***	***TSP***	***Without Project***	***TSP***
C-11 EAST	4477	4421	4669	4515	4499	4436
C-11 WEST	1564	1573	1592	1578	1570	1574
C-12W	197	194	198	195	198	194
C-13 WEST	11	11	12	11	11	11
C-14 EAST	13	13	15	15	13	13
C-14 WEST	36	34	36	34	36	34
HILLSBORO CANAL	1269	1259	1270	1259	1269	1259
NORTH NEW RIVER CANAL WEST	240	224	269	240	251	233
POMPANO CANAL	6	6	10	9	7	7
Total	**7813**	**7735**	**8071**	**7856**	**7854**	**7761**

Impacts to Septic Tanks
(Reduced Flooding)

Number of Septic Tanks with Reduced Flood Values

100S100R 35i				100S100R 85h			100S100R 85i		
Basin Name	Alt A	Alt B	Alt C	Alt A	Alt B	Alt C	Alt A	Alt B	Alt C
C-11 EAST	5169	5171	5164	5605	5607	5604	5237	5241	5213
C-11 WEST	1513	1562	1745	1658	1713	1717	1442	1463	1724
C-12W	215	215	215	215	215	214	215	215	215
C-13 WEST	8	9	10	9	10	10	9	8	10
C-14 EAST	18	15	18	18	18	18	12	18	18
C-14 WEST	39	39	39	39	39	39	39	39	39
HILLSBORO CANAL	1354	1366	1451	1177	1327	1352	1270	1297	1452
NORTH NEW RIVER CANAL WEST	325	325	330	381	386	386	332	341	345
POMPANO CANAL	15	17	12	16	21	14	10	9	17
Total	**8656**	**8719**	**8984**	**9118**	**9336**	**9354**	**8566**	**8631**	**9033**

2S100R 35i				2S100R 85h			2S100R 85i		
Basin Name	Alt A	Alt B	Alt C	Alt A	Alt B	Alt C	Alt A	Alt B	Alt C
C-11 EAST	5123	5124	5119	5443	5447	5452	5170	5195	5199
C-11 WEST	1548	1603	1744	1733	1733	1756	1429	1484	1742
C-12W	215	215	215	215	215	215	215	215	215
C-13 WEST	8	10	10	8	10	10	8	8	10
C-14 EAST	18	18	18	18	18	18	18	18	18
C-14 WEST	39	39	39	39	39	39	39	39	39
HILLSBORO CANAL	1380	1452	1450	1182	1198	1348	1302	1331	1451
NORTH NEW RIVER CANAL WEST	319	325	325	347	358	359	331	334	335
POMPANO CANAL	19	17	13	18	18	14	9	10	15
Total	**8669**	**8803**	**8933**	**9003**	**9036**	**9211**	**8521**	**8634**	**9024**

Number of Septic Tanks with Reduced Flood Values

2S25R 35i				*2S25R 85h*			*2S25R 85i*		
Basin Name	***Alt A***	***Alt B***	***Alt C***	***Alt A***	***Alt B***	***Alt C***	***Alt A***	***Alt B***	***Alt C***
C-11 EAST	4348	4356	4360	4573	4574	4583	4368	4372	4371
C-11 WEST	1298	1381	1422	1356	1357	1420	1321	1357	1391
C-12W	196	196	196	197	197	197	197	197	197
C-13 WEST	10	11	11	9	12	12	10	11	11
C-14 EAST	13	13	12	14	15	15	12	12	13
C-14 WEST	34	34	34	35	34	34	34	34	34
HILLSBORO CANAL	1044	1044	1042	1158	977	985	896	897	900
NORTH NEW RIVER CANAL WEST	226	228	232	263	266	269	233	239	242
POMPANO CANAL	5	6	1	4	9	10	5	6	5
Total	**7174**	**7269**	**7310**	**7609**	**7441**	**7525**	**7076**	**7125**	**7164**

TSP									
Basin Name	***100S100R 35i***	***100S100R 85h***	***100S100R 85i***	***2S100R 35i***	***2S100R 85h***	***2S100R 85i***	***2S25R 35i***	***2S25R 85h***	***2S25R 85i***
C-11 EAST	4994	5595	5106	5103	5453	5159	4336	4580	4342
C-11 WEST	1728	1723	1687	1685	1851	1710	1357	1418	1365
C-12W	213	213	214	213	213	213	193	194	194
C-13 WEST	12	10	13	12	13	12	8	9	8
C-14 EAST	15	18	16	17	15	16	12	15	11
C-14 WEST	38	38	38	38	38	38	33	33	33
HILLSBORO CANAL	1450	1221	1376	1451	1369	1445	1046	988	896
NORTH NEW RIVER CANAL WEST	331	388	346	326	362	335	233	271	243
POMPANO CANAL	12	18	10	13	21	14	6	9	5
Total	**8793**	**9224**	**8806**	**8858**	**9335**	**8942**	**7224**	**7517**	**7097**

Impacts to Cultural Resources (Directly Impacted)

Number of Cultural Resources with Flood Values

100S100R 35i					***100S100R 85h***				***100S100R 85i***			
Basin Name	***Without Project***	***Alt A***	***Alt B***	***Alt C***	***Without Project***	***Alt A***	***Alt B***	***Alt C***	***Without Project***	***Alt A***	***Alt B***	***Alt C***
C-11 EAST	20	20	20	20	22	22	22	22	20	20	20	20
C-11 WEST	6	6	6	6	6	6	6	6	6	6	6	6
C-12W	5	5	5	5	5	5	5	5	5	5	5	5
C-13 WEST	5	4	4	4	5	5	5	5	5	5	5	4
C-14 EAST	5	5	5	5	5	5	5	5	5	5	5	5
C-14 WEST	8	8	8	8	9	9	8	8	8	8	8	8
HILLSBORO CANAL	50	50	50	48	50	48	50	48	50	50	50	48
NORTH NEW RIVER CANAL WEST	16	16	16	16	17	16	16	16	16	16	16	16
POMPANO CANAL	1	1	1	1	2	2	2	2	1	1	2	1
Total	**116**	**115**	**115**	**113**	**121**	**118**	**119**	**117**	**116**	**116**	**117**	**113**

2S100R 35i					***2S100R 85h***				***2S100R 85i***			
Basin Name	***Without Project***	***Alt A***	***Alt B***	***Alt C***	***Without Project***	***Alt A***	***Alt B***	***Alt C***	***Without Project***	***Alt A***	***Alt B***	***Alt C***
C-11 EAST	20	20	20	20	21	20	20	20	20	20	20	20
C-11 WEST	6	6	6	6	6	6	6	6	6	6	6	6
C-12W	5	5	5	5	5	5	5	5	5	5	5	5
C-13 WEST	4	4	4	4	5	5	5	5	5	5	5	4
C-14 EAST	5	5	5	5	5	5	5	5	5	5	5	5
C-14 WEST	8	8	8	8	9	9	8	8	8	8	8	8
HILLSBORO CANAL	50	50	50	48	50	50	50	48	50	50	50	48
NORTH NEW RIVER CANAL WEST	16	16	16	16	16	16	16	16	16	16	16	16
POMPANO CANAL	1	1	1	1	2	2	2	2	1	1	1	1
Total	**115**	**115**	**115**	**113**	**119**	**118**	**117**	**115**	**116**	**116**	**116**	**113**

Number of Cultural Resources with Flood Values

2S25R 35i					2S25R 85h				2S25R 85i			
Basin Name	***Without Project***	***Alt A***	***Alt B***	***Alt C***	***Without Project***	***Alt A***	***Alt B***	***Alt C***	***Without Project***	***Alt A***	***Alt B***	***Alt C***
C-11 EAST	16	15	15	15	17	17	17	17	17	17	16	16
C-11 WEST	5	5	5	5	5	5	5	5	5	5	5	5
C-12W	5	5	5	5	5	5	5	5	5	5	5	5
C-13 WEST	3	4	4	4	5	5	5	4	3	4	4	4
C-14 EAST	5	5	5	5	5	5	5	5	5	5	5	5
C-14 WEST	7	7	7	7	7	7	7	7	7	7	7	7
HILLSBORO CANAL	45	45	45	43	45	45	45	43	45	45	45	43
NORTH NEW RIVER CANAL WEST	16	16	16	16	16	16	16	16	16	16	16	16
POMPANO CANAL	1	1	1	1	1	1	1	1	1	1	1	1
Total	**103**	**103**	**103**	**101**	**106**	**106**	**106**	**103**	**104**	**105**	**104**	**102**

Number of Cultural Resources with Flood Values

100S100R35i			*100S100R85h*		*100S100R85i*	
Basin Name	***Without Project***	***TSP***	***Without Project***	***TSP***	***Without Project***	***TSP***
C-11 EAST	20	20	22	22	20	20
C-11 WEST	6	6	6	6	6	6
C-12W	5	5	5	5	5	5
C-13 WEST	5	4	5	5	5	5
C-14 EAST	5	5	5	5	5	5
C-14 WEST	8	8	9	8	8	8
HILLSBORO CANAL	50	50	50	48	50	50
NORTH NEW RIVER CANAL WEST	16	16	17	16	16	16
POMPANO CANAL	1	1	2	2	1	1
Total	**116**	**115**	**121**	**117**	**116**	**116**

2S100R35i			*2S100R85h*		*2S100R85i*	
Basin Name	***Without Project***	***TSP***	***Without Project***	***TSP***	***Without Project***	***TSP***
C-11 EAST	20	20	21	20	20	20
C-11 WEST	6	6	6	6	6	6
C-12W	5	5	5	5	5	5
C-13 WEST	4	4	5	5	5	4
C-14 EAST	5	5	5	5	5	5
C-14 WEST	8	8	9	9	8	8
HILLSBORO CANAL	50	50	50	48	50	50
NORTH NEW RIVER CANAL WEST	16	16	16	16	16	16
POMPANO CANAL	1	1	2	2	1	1
Total	**115**	**115**	**119**	**116**	**116**	**115**

Number of Cultural Resources with Flood Values

2S25R 35i			***2S25R 85h***		***2S25R 85i***	
Basin Name	***Without Project***	***TSP***	***Without Project***	***TSP***	***Without Project***	***TSP***
C-11 EAST	16	16	17	17	17	17
C-11 WEST	5	5	5	5	5	5
C-12W	5	5	5	5	5	5
C-13 WEST	3	4	5	4	3	4
C-14 EAST	5	5	5	5	5	5
C-14 WEST	7	7	7	7	7	7
HILLSBORO CANAL	45	45	45	45	45	45
NORTH NEW RIVER CANAL WEST	16	16	16	16	16	16
POMPANO CANAL	1	1	1	1	1	1
Total	**103**	**104**	**106**	**105**	**104**	**105**

Impacts to Cultural Resources (Reduced Flooding)

Number of Cultural Resources with Reduced Flood Tables

100S100R 35i				***100S100R 85h***			***100S100R 85i***		
Basin Name	***Alt A***	***Alt B***	***Alt C***	***Alt A***	***Alt B***	***Alt C***	***Alt A***	***Alt B***	***Alt C***
C-11 EAST	26	26	27	27	27	27	25	25	26
C-11 WEST	6	7	7	4	7	8	2	4	7
C-12W	4	4	4	2	2	3	4	4	5
C-13 WEST	6	6	6	5	7	6	5	7	6
C-14 EAST	6	5	2	6	6	6	5	6	6
C-14 WEST	13	14	14	15	15	15	10	14	14
HILLSBORO CANAL	51	54	57	46	44	55	40	46	57
NORTH NEW RIVER CANAL WEST	17	17	17	12	14	16	13	13	17
POMPANO CANAL	1	1	1	2	2	1	1	1	1
Total	**130**	**134**	**135**	**119**	**124**	**137**	**105**	**120**	**139**

2S100R 35i				***2S100R 85h***			***2S100R 85i***		
Basin Name	***Alt A***	***Alt B***	***Alt C***	***Alt A***	***Alt B***	***Alt C***	***Alt A***	***Alt B***	***Alt C***
C-11 EAST	25	26	27	27	27	27	26	26	27
C-11 WEST	7	7	7	5	5	7	2	4	7
C-12W	4	4	5	2	2	3	4	4	5
C-13 WEST	5	5	5	5	7	6	6	7	6
C-14 EAST	6	6	6	6	6	6	6	6	6
C-14 WEST	13	14	14	15	15	15	13	14	14
HILLSBORO CANAL	54	54	56	44	35	47	42	51	56
NORTH NEW RIVER CANAL WEST	17	17	17	11	11	15	12	13	17
POMPANO CANAL	1	1	1	2	2	1	1	1	1
Total	**132**	**134**	**138**	**117**	**110**	**127**	**112**	**126**	**139**

Number of Cultural Resources with Reduced Flood Tables

2S25R 35i				*2S25R 85h*			*2S25R 85i*		
Basin Name	***Alt A***	***Alt B***	***Alt C***	***Alt A***	***Alt B***	***Alt C***	***Alt A***	***Alt B***	***Alt C***
C-11 EAST	22	22	22	23	23	23	23	23	23
C-11 WEST	2	3	3	3	2	4	2	2	2
C-12W	4	4	4	5	5	5	4	4	4
C-13 WEST	4	3	4	3	4	5	4	4	4
C-14 EAST	6	5	6	6	6	6	5	5	6
C-14 WEST	12	12	12	12	11	11	10	12	12
HILLSBORO CANAL	37	37	40	28	27	45	42	44	46
NORTH NEW RIVER CANAL WEST	14	14	14	14	15	15	11	11	14
POMPANO CANAL	1	1	1	1	1	1	1	1	1
Total	**102**	**101**	**106**	**95**	**94**	**115**	**102**	**106**	**112**

TSP									
Basin Name	***100S100R 35i***	***100S100R 85h***	***100S100R 85i***	***2S100R 35i***	***2S100R 85h***	***2S100R 85i***	***2S25R 35i***	***2S25R 85h***	***2S25R 85i***
C-11 EAST	21	26	24	24	27	24	20	23	19
C-11 WEST	8	5	8	7	8	4	2	2	2
C-12W	4	2	4	4	3	5	4	5	4
C-13 WEST	6	7	6	5	6	6	4	5	4
C-14 EAST	5	6	5	5	1	5	5	6	5
C-14 WEST	13	15	13	13	14	13	12	12	11
HILLSBORO CANAL	54	47	54	56	41	53	36	31	44
NORTH NEW RIVER CANAL WEST	17	12	17	17	16	17	13	15	14
POMPANO CANAL	1	1	0	1	1	1	1	1	1
Total	**129**	**121**	**131**	**132**	**117**	**128**	**97**	**100**	**104**

ANNEX D-1
Flood Damage Assessment Technical Memorandum

Flood Damage Assessment Technical Memorandum

Central and Southern Florida Flood Resiliency Study Broward Basins (Section 203)

South Florida Water Management District

Broward County, Florida

October 17, 2025

Contents

Tables

Figures

Introduction

South Florida Water Management District (SFWMD) is utilizing Section 203 of the Water Resources Development Act of 1986, as amended, to advance the Central and Southern Florida Flood Resiliency Study – Broward Basins with support from the Florida Department of Environmental Protection, Broward County, and technical/federal assistance from the U.S. Army Corps of Engineers (USACE) – Jacksonville District, for inclusion in the Water Resources Development Act (WRDA) 2026.

This memorandum documents a flood damage assessment in support of the overall Section 203 Study.

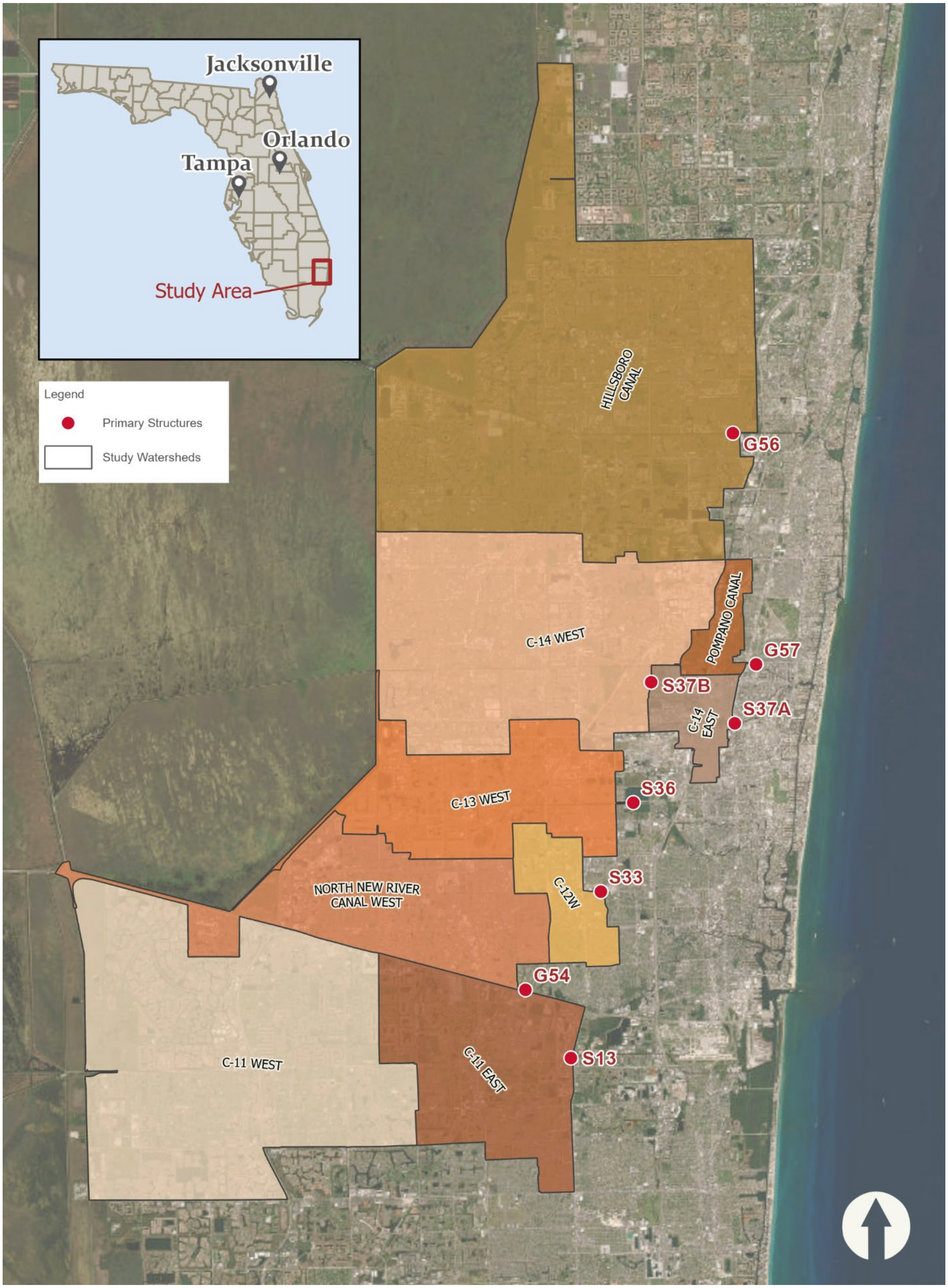


Figure 1 – Study Watersheds in Broward County

Existing Studies and Data Sources

Section 216 Study

This Section 203 Study is split from the CS&F Flood Resiliency Section 216 Study, which includes four reaches. The Broward and Hillsboro Basins of the Section 203 Study are known as Reach A within this Section 216 Study. The target completion date of the Section 216 Study is currently aiming to be incorporated into the 2030 WRDA.

Flood Hazard Data (H&H Modeling)

An integrated/coupled surface-groundwater MIKE SHE/MIKE Hydro (2022) model was created by the SFWMD and was used to generate flood hazard information for use in the flood damage assessment. This 2D hydrologic and hydraulic (H&H) model covers the entire study area and extends past the tidal boundary condition to the east. The focus on this study is the primary canal system; however, the model includes a high level of detail within the secondary and tertiary canal systems (Model Documentation Report, 2025).

The South Atlantic Coastal Study (SACS) Coastal Hazard System (CHS) was utilized as downstream boundary conditions in the modeling. This study provides numerical and probabilistic modeling results for coastal forcings, including storm surge. Three (3) scenarios or conditions were analyzed in the modeling: the Existing Condition Baseline for 2035 (ECB); the Future Without Project for 2085 (FWOP); and the Future With Project for 2085 (FWP). A combination of eight (8) simulations were conducted for various combinations of rainfall-based (pluvial) flooding and coastal hazards such as storm surge. The calculation of joint probability, or probability of both coastal hazard and rainfall return periods occurring together and at the same point in time, was documented in the report, Incorporating ATLAS14 and CHS data into the joint probability framework for C&SF Flood Resiliency (Section 216) Study (reference to UCF report). Coastal water level return periods, rainfall return periods, joint probabilities, and associated joint return frequencies are shown in Table 1.

Table 1. Flood Hazard Simulations

Coastal Water Level Return Period (CHS Data)	Rainfall Return Period (NOAA Atlas 14 Data)	Joint Probability (%)	Joint Recurrent Frequency (years)
2-year	5-year	0.125	8
2-year	10-year	0.0714	14
2-year	25-year	0.0333	30
10-year	10-year	0.0313	32
20-year	25-year	0.0133	75
2-year	100-year	0.0091	110
100-year	100-year	0.0023	430
2-year	500-year	0.0019	538

Project Alternatives

The Final Array of Alternatives consists of three alternatives (denoted as A, B, and C) which were built in the H&H model. Each alternative contains features shown to be effective in improving flood levels in the seven upstream drainage areas of the study. The features consist of primary structure modifications, primary C&SF Canal improvements, and storage and nature based proposed projects. Primary structure modifications may include increased gravity capacity by adding additional gates and/or pumps, hardening of the structures to block backflow during high tide conditions, and alternative operation of the structure with pre-storm drawdown and, where available, operation of pumps both pre- storm and during the storm to maintain lower canal water levels. It should be noted that operations for pre-storm drawdown also are applied to the secondary system due to improved primary canal stages and structure discharge capability.

The three alternatives increase in complexity starting with Alternative A, which has the least number of features and expected lower cost; Alternative B, which adds additional complexity and project features; and Alternative C, which includes the most projects and therefore expected to be the most expensive. These alternatives allow for the determination of which drainage areas are improved most by the additional cost and complexity so that the best projects for each drainage area can be carried forward to the tentatively selected plan (TSP).

The table below provides an overview of the modeled alternatives.

Table 2. Project Alternatives Components Overview

Cost/No Cost	Project Type	Project Type Detail	Alternatives		
			A	B	C
Capital	Primary Structure Modification	Gates	S-37A (4 x 25 ft) - C-14 East, S-36 (2 x 25 ft) - C-13 West	G-56 (5 x 20 ft) - Hillsboro S-37B (2 x 35 ft) - C-14 West, G-57 (2 x 21 ft) - Pompano, S-36 (2 x 25 ft) - C-12 West, G-54 (5 x 16 ft) - NNR West	G-56 (5 x 20 ft) - Hillsboro, S-37Q (4 x 25 ft) - C-14 East, G-57 (2 x 21 ft) - Pompano, S-36 (2 x 25 ft) - C-13 West, S-33 (2 x 20 ft) - C-12 West, G-54 (5 x 16 ft) - NNR West
		Pump	S-37A (add new 1200 Cfs) - C-14 East, S-33 (add new 510 cfs) - C-12 West, S-13 (add'l 160 cfs) - C-11 East	S-37A (add new 1500 cfs) - C-14 East, S-36 (add new 510 cfs) - C-13 West, S-33 (add new 510 cfs) - C-12 West, S-13 (add'l 540 cfs) - C-11 East	G-56 (Hillsboro), S-37A (Cypreee Creek/C-14), G-57 (Pompano), S-36 (C-13 West), S-33 (C-12 West), G-54 (NNR West), S-13 (C-11 East)
		Hardening	G-56 (Hillsboro), S-37A (Cypress Creek/C-14), G-57 (Pompano), S-36 (C-13 West), S-33 (C-12 West), G-54 (NNR West), S-13 (C-11 East)	G-56 (Hillsboro), S-37A (Cypress Creek/C-14), G-57 (Pompano), S-36 (C-13 West), S-33 (C-12 West), G-54 (NNR West), S-13 (C-11 East)	G-56 (Hillsboro), S-37A (Cypress Creek/C-14), G-57 (Pompano), S-36 (C-13 West), S-33 (C-12 West), G-54 (NNR West), S-13 (C-11 East)
	Primary C & SF Canals	Canal Cross Section Modification		Hillsboro, C-14 West, C-11 West, C-11 East	Hillsboro, C-14 West, C-14 East, C-13 West, C-12 West, NNR, C-11 West, C-11 East
		Canal Levees			
		Culverts/Bridges	Triple culvert u/s of G-57 - Pompano Canal	Triple culvert u/s of G-57 - Pompano Canal	G-65 - Pompano Canal, Triple culvert u/s of G-57 - Pompano Canal Winkopp Bridge - C-11 West
	Storage & Nature Based			NNR West	Hillsboro, NNR West
	Secondary Structure Modification	Pump			
NA - Operations	Primary Structure Modification	Pre-storm Drawdown	All basins, all alternatives - Except C-11 West, C-14 West	All basins, all alternatives - except C-11 West	All basins, all alternatives - except C-11 West
	Assumed Inflows from Secondary to Primary	Pre-storm Drawdown	All basins, all alternatives		

Flood Damage Assessment

This flood damage assessment estimated five (5) types of quantitative flood risk reduction benefits: avoided damages to structures, contents, vehicles, roadways, and “other”, which includes emergency clean-up costs associated with an asset. Life risk benefits were not included as the forms of flood hazards are relatively low in energy and depth, thus not life threatening. Damages caused by wave action and other hazards were not included.

The benefits of each alternative were estimated using the US Army Corps of Engineers’ Hydrologic Engineering Center’s (HEC) Flood Damage Assessment software (HEC-FDA) version 2.0. Inputs to the HEC-FDA software, such as the structure exposure dataset, depth-frequency curves, and depth-damage functions are described later in this section and are derived from a variety of best-available sources. These relationships are combined within HEC-FDA to calculate expected annual damage, the average value of economic flood damage. Economic flood damages relate the potential harm to property, infrastructure, and other assets, quantified in dollars, to the likelihood of that harm occurring.

Hydraulics

The HEC-FDA analysis uses gridded data in the form of peak flood depth rasters, which are results of the MIKE SHE hydrologic and hydraulic (H&H) model. The modeling set-up and approach are described under a separate report (Model Documentation Report, 2025).

Under the 216 study, USACE Jacksonville Office developed a worksheet for performing monotonicity adjustments on H&H input datasets required for HEC-FDA Version 1.4.3. This approach was reviewed and approved by the USACE PCX team. In this Section 203 Study, building on that methodology, a Python script was developed to apply the same monotonicity adjustments while preserving the flood depth data from eight storm events in TIFF format— the required format for HEC-FDA Version 2.0. *(Reference: Python Script for Adjusting MIKE SHE Overland Depth Result Rasters and Creating Georeferenced TIFFs for Input to HEC-FDA 2.0, March 2025, SFWMD).*

Frequency Functions

The frequency function defines the relationship between annual peak flood magnitude or stage and the probability of that flood magnitude or stage being exceeded at an index point. The index point is normally chosen at a location along the reach that best represents the point that is the driver of overbank flooding such as a low spot in the levee or channel bank. For this study, this is not possible as the overbank flooding is based on two disparate factors: precipitation and storm surge.

- The precipitation is applied to the model as rain on mesh. This means that the precipitation is being applied in all overbank locations, as opposed to the usual method of applying discharge hydrographs (such as from HEC-HMS) to the canal system and having the hydraulic model predict overbank flooding. The rain on mesh approach means flooding may occur within the study area even if the canal banks are not overtopped.

- The storm surge is applied as a boundary condition to the drainage channels and the overland. As such the storm surge directly affects the overland flooding and the hydraulics within the drainage channel and can cause overbank flooding early on for the downstream (easterly) study domain.

At the extremes both of the factors are the primary driver of the overbank flooding. With the storm surge dominating near the channel (easterly and downstream) and precipitation dominating in the areas furthest from the channel (westerly and upstream). The issue is that the majority of the overbank flooding and affect inventory is located between these two extremes and are each affected by the 2 factors to differing degrees based on the distance from the drainage channel and the overall overbank drainage patterns. As a result, there is no single location that accurately represents the performance of the drainage system across the entire overbank area that could be used as a reliable index point. To develop a frequency curve that more realistically reflects overbank flooding conditions, the average depth values of individual structures within the floodplain were used for each storm event. Specifically, the frequency function was derived using peak flood depth TIFF files generated from the H&H model outputs for eight storm events, each associated with different joint probabilities. The methodology for developing the frequency curve is outlined below:

1. First, the maximum flood depth grids for all eight storm events were directly extracted from the MIKE SHE/MIKE HYDRO model for the nine impact areas (nine study basins).
2. For each basin, grid cells with positive flood depths from the most frequent event (with a joint probability of 0.125, corresponding to a 2-year surge and 5-year rainfall) were selected for the frequency curve calculation for this point on the frequency curve.
3. To develop the remaining points on the frequency curve, the same set of grid cells were then used for frequency curve calculations across the remaining seven storm events with different joint probabilities. This was done to use a consistent dataset for calculations at all points. A Python script was developed to automate these calculations for each impact area.

Economics

Inventory

Valued Assets (Structures)

The structure inventory, which represents buildings at-risk of flooding within our study area, was taken from the FIAT exposure dataset. This spatially georeferenced point feature dataset represents building centroids within study area.

The structure inventory quality control (QC) was performed by the USACE Jacksonville office under the 216 Study. To avoid overestimating flood damages, some structures located near waterbodies were repositioned. As part of the quality control process, asset coordinates (x, y) were spatially adjusted to reduce the risk of placing assets within waterbodies (e.g., canals, ponds), which can occur due to the resolution of the MIKE SHE grid. This adjustment was completed in GIS by creating a buffer polygon—equal to the grid cell resolution in feet—around each waterbody, and snapping any assets found within the buffer to the nearest edge of the polygon.

The exposure dataset was refined to ensure compliance with 33 U.S. Code §2318 (Floodplain Management). The updated inventory excludes buildings constructed after 1991 that do not comply with the most recent effective FEMA Base Flood Elevation (BFE) based on the construction or structural improvement date of the structure. Specifically, a filter was applied to identify structures built or improved after 1991 in which the finished floor elevation (FFE) is lower than the most recent effective FEMA BFE for the year of construction, which resulted in 491 buildings being excluded from the damage calculations.

The resulting structure inventory shapefile served as the baseline for integrating additional attribute data, as described in the sections below.

The following HEC-FDA asset inventory required attributes were used:

- **Structure ID**
  - This is a unique ID created for each structure point and combines the watershed (first two digits) with the GIS ObjectID (last six digits) to create an eight-character integer.
- **Depreciated Replacement Value (DRV) – Structure**
  - DRVs are used in flood risk planning studies to reflect the cost of replacing an asset less deductions for physical deterioration. A structure value was calculated for each individual structure and then depreciated using the methodology below. This methodology mirrors the USACE-provided depreciation method (Reference: Deriving the Depreciated Replacement Values for the Structure Inventory, USACE), with the only difference being the use of 2024 as the base year (instead of 2035, as used in the Section 216 Study). This adjustment was reviewed and approved by USACE, as it better reflects the current condition of the exposure dataset. Using 2035 assumes no maintenance or changes to structures between now and that year, which may lead to over-depreciation

    1) Structure values (not depreciated) were first taken from the original SFWMD FIAT exposure dataset. This field (Max Potential Damage: Structure) was calculated using the square footage of each structure and a per-square-foot structure replacement cost from the FEMA HAZUS technical manual 4.0.
    2) Each structure was then matched to a structure effective age-built year value from data provided by USACE, taken from Census data. Refer to the *Deriving the Depreciated Replacement Values for the Structure Inventory* outline provided by USACE as part of the Section 216 study.
    3) Effective structure age was calculated by subtracting 2024 (year of inventory) from the effective age-built year.

4) Depreciation was applied using curves from the FEMA HAZUS technical manual, Section 6.4. Curves are linear percent (%) reductions in structure value based on effective structure age. This percent reduction was applied in ArcGIS Pro, with the result being the Depreciated Replacement Value of each structure.

- **Contents Value**

1) The contents value for each individual structure was calculated based on a structure-to-contents ratio and the Depreciated Replacement Value. The resultant value represents a depreciated contents value for each individual structure and was used in HEC-FDA to estimate damage to contents.
2) The CSVR for residential structures was derived from Engineering Manual 1110-2-1619 “Risk-Based Analysis for Flood Damage Reduction Studies”. Table 6-4 of the EM estimates an average and standard deviation from over 120,000 sampled NFIP claims.
3) Non-residential CSVR’s were estimated based on IWR’s “Nonresidential Flood Depth-Damage Functions Derived from Expert Elicitation” based on occupancy type
4) A detailed review suggested revisions to four occupancy types are needed to meet the conditions for the Broward County study area. The review focused on the actual structures classified by occupancy types of the exposure database to determine if the structure-to-content ratios reflected real-world assets. It was determined that most of the COM1 occupancies within Reach A were grocery stores which have a higher structure-to-content ration than the suggested 36%. Professional offices are a majority of COM4, most COM6 are hospitals, and RES4 were hotels. For this reason, the *Nonresidential Flood Depth-Damage Functions Derived from Expert Elicitation, published April 2009,* was referenced for the contents to structure ratios. This document was produced by expert loss-risk specialists throughout the Country. Recommended replacement structure-to-content ratios are shown in Table 3.

Table 3. Recommended structure-to-content ratios

Occupancy (Primary Object Class)	Recommended Replacement (%)	CSVR from HEC-FDA (%)
AGR1		12
COM1	70	~~36~~
COM10		66
COM2		0
COM3		66
COM4	18	~~12~~
COM5		28
COM6	43.9	~~28~~
COM8		27
COM9		7
EDU1		7
EDU2		69
GOV1		69
IND1		38
IND2		38
IND3		38
IND4		38
IND5		38
REL1		7
RES1		43
RES2		64
RES3A-F		43
RES4	26	~~15~~
RES5		10
RES6		28

- **Other (Emergency Clean-Up Costs) Value**
    1) "Other" values were provided by the USACE for each structure and include emergency clean-up costs associated with flood impacts.
- **Foundation Height**

This section and Table 3 below summarize the techniques applied to develop foundation heights and standard deviations for different structures inventories.

1) Structure foundation height was estimated for each individual structure using averages obtained from elevation certificates within the study area. In cases where an elevation certificate exists, a “C- “prefix was used in the occupancy type field and the actual foundation height from the certificate was applied.
2) To accurately estimate foundation heights for various structure types, a random point sampling method was applied using ArcGIS and Google Earth Street View. Based on the sampling results, average foundation heights were recommended for RES1-1SNB and RES2-SNB structures (Appendix A).
3) For all other structure categories, a robust statistical analysis was conducted to estimate average foundation heights and standard deviations, using limited data from certified structures and triangular distribution parameters provided by the Jacksonville office (Appendix B)

Table 4. Foundation Heights and Standard Deviation used in Structures Inventory

Occupancy (Primary Object Class)	Average Foundation Height (ft)	Std. Dev. for Normal Distribution (ft)
AGR1	1.24	0.50
COM1	1.27	1.14
COM10	1.20	0.87
COM2	1.27	1.14
COM3	1.27	1.14
COM5	0.58	0.26
COM6	2.94	1.06
COM8	2.03	2.48
COM9	1.27	1.14
EDU1	1.08	0.59
EDU2	1.08	0.59
ESSM	1.75	0.75
GOV1	1.68	2.44
IND1	1.42	1.35
IND2	1.42	1.35
IND3	0.65	0.30
IND4	1.42	1.35
IND5	1.42	1.35
PWTM	1.75	0.75
REL1	1.88	2.26
RES1-1SNB	0.75	0.61
RES1-2SNB	0.75	0.46
RES2	2.92	2.00
RES3C	1.27	0.70
RES3E	1.18	0.54
RES4	1.61	1.39
RES5	0.86	0.16
RES6	1.00	0.27
WWTM	1.75	0.75

- **Ground Elevation**
    1) Ground elevations were obtained at each individual structure using LiDAR DEM. These values were extracted at each structure location point in the original FIAT exposure dataset and were converted to NGVD 29 to match the water surface elevation datum from H&H modeling.
    2) Conversions from NAVD 88 (original LiDAR data datum) to NGVD 29 were handled using the VDatum tool by NOAA. This tool provides conversion factors at each individual point, rather than using a study area average. Vertical datum conversions across the study area range up to 0.2'.

Valued Assets (Transportation)

An inventory of transportation assets, specifically roadway infrastructure, was included in the HEC-FDA analysis. This dataset was taken from the SFWMD FIAT exposure dataset and was unmodified as part of this analysis.

Valued Assets (Vehicles)

Economic Guidance Memo 09-04 was followed for estimating the exposure value of vehicles in the study area. In details,

1) Census data was used to estimate an average number of vehicles per household (1.63).
2) All single-family and mobile homes are represented using one household. For multi-family residences, the number of residential units was determined using the NSI's "RESUnit" field. A spot check (windshield survey) of 50 units demonstrated a sufficient level of accuracy to utilize this field. Any locations missing RESUnit in the field were replaced by the average based on the occupancy type. Some RESUnit values in the NSI appeared erroneously large and a maximum of 50 res-units was placed on any given multi-family residence (building code limits 50 units per acre). So the number of residential units was then multiplied by 1.63 to determine total number of vehicles for each multi-family residence.
3) The average used vehicle value was determined using Edmunds and a zip code for each unique reach.
4) The most-likely (remaining) value was estimated at 19.4% using USACE Economic Guidance Memorandum (EGM) 09-04, Generic Depth-Damage Relationships for Vehicles (2009) assuming at least 6-12 hours of warning time. A maximum value of 49.5% and minimum value of 11.5% was assumed based on EGM 09-04 survey of less than 6-hour warning time and greater than 24-hour time respectively.

Table 5. Vehicles Per Household

Average Vehicles Per Household	1.63
Remaining value 6-12 Hours of warning (EGM 09-04)	0.194

Vulnerability/Damage Functions

Vulnerability is the susceptibility to harm of people, property, and the environment exposed to a hazard. Although flood damage can be a function of a number of variables, such as flood depth, velocity, and duration, flood depth is the primary factor used in HEC-FDA, as described by depth-percent damage or similar functions. Depth-damage functions (DDFs) estimate damage either as a percentage of an asset's economic value or as a percentage of an asset's direct flood damage.

Residential damage functions and several non-residential damage functions were assigned based on the North Atlantic Coast Comprehensive Study: Physical Depth Damage Function Summary Report. The majority of non-residential occupancy types were assigned damage functions derived from IWR's "Nonresidential Flood Depth-Damage Functions Derived from Expert Elicitation *published April 2009*. This document was produced by expert loss-risk specialists throughout the Country.

Results for Alternatives

Expected Annual Damage (EAD)

Expected annual damage (EAD) is calculated as the integral of a damage-probability function, which weights the damage for each flood event by the annual exceedance probability of that event happening and then sums across all possible events. As described above, this analysis accounted for damage to structures, contents, roads, and vehicles. The EAD values are the means of each probability distribution resulting from the analyses of the Without Project and With Project scenarios described above.

The EAD for each basin for structures (including contents and others), roads, vehicles for alternatives A, B, and C are reported in Table 6 through Table 14.

Table 6. EAD Structure Damage Alt A (Q1 2021 Dollars)

Impact area	ECB 2035 ($)	FWOP low 2085 ($)	FWOP i 2085 ($)	FWOP h 2085 ($)	Alt A 2035 ($)	Alt A low 2085 ($)	Alt A i 2085 ($)	Alt A h 2085 ($)
C-11 EAST	240,668,446	240,578,385	241,409,103	256,573,344	237,432,763	237,711,215	238,267,387	244,992,400
C-11 WEST	395,763,018	396,006,810	395,808,144	396,978,558	393,837,620	393,761,483	393,814,488	394,189,175
C-12 West	70,693,692	70,770,402	70,716,548	71,852,512	68,187,574	68,204,778	68,265,257	69,021,485
C-13 WEST	176,117,172	176,499,224	176,717,730	180,726,197	174,855,519	175,096,382	175,335,206	178,725,787
C-14 EAST	49,453,276	49,565,064	49,946,262	65,220,662	48,726,656	48,885,853	49,449,101	56,010,671
C-14 WEST	420,481,254	419,079,139	420,440,440	421,226,388	414,352,923	414,226,599	414,383,527	414,768,587
HILLSBORO CANAL	676,664,528	676,622,842	676,378,914	677,416,986	671,590,642	671,431,702	671,571,940	671,876,464
NORTH NEW RIVER CANAL WEST	181,198,801	181,222,059	181,586,296	183,647,644	178,996,312	179,027,541	179,136,579	180,456,223
POMPANO CANAL	27,836,875	27,915,588	27,997,683	28,582,576	27,598,836	27,672,456	27,785,096	28,340,071

Table 7. EAD Structure Damage Alt B (Q1 2021 Dollars)

Impact area	ECB 2035 ($)	FWOP low 2085 ($)	FWOP i 2085 ($)	FWOP h 2085 ($)	Alt B 2035 ($)	Alt B low 2085 ($)	Alt B i 2085 ($)	Alt B h 2085 ($)
C-11 EAST	240,668,446	240,578,385	241,409,103	256,573,344	237,343,295	237,532,214	238,043,690	244,254,315
C-11 WEST	395,763,018	396,006,810	395,808,144	396,978,558	393,817,403	393,585,934	393,796,125	394,431,619
C-12 West	70,693,692	70,770,402	70,716,548	71,852,512	68,184,777	68,198,732	68,256,385	68,990,258
C-13 WEST	176,117,172	176,499,224	176,717,730	180,726,197	174,553,631	174,864,185	175,010,204	176,351,834
C-14 EAST	49,453,276	49,565,064	49,946,262	65,220,662	48,553,862	48,703,391	48,975,322	54,211,756
C-14 WEST	420,481,254	419,079,139	420,440,440	421,226,388	414,505,246	414,141,583	414,083,269	415,024,474
HILLSBORO CANAL	676,664,528	676,622,842	676,378,914	677,416,986	671,853,951	671,476,476	671,470,489	672,397,046
NORTH NEW RIVER CANAL WEST	181,198,801	181,222,059	181,586,296	183,647,644	178,926,450	179,012,045	179,119,041	180,060,209
POMPANO CANAL	27,836,875	27,915,588	27,997,683	28,582,576	27,607,103	27,687,599	27,753,047	28,312,380

Table 8. EAD Structure Damage Alt C (Q1 2021 Dollars)

Impact area	ECB 2035 ($)	FWOP low 2085 ($)	FWOP i 2085 ($)	FWOP h 2085 ($)	Alt C 2035 ($)	Alt C low 2085 ($)	Alt C i 2085 ($)	Alt C h 2085 ($)
C-11 EAST	240,668,446	240,578,385	241,409,103	256,573,344	237,124,154	237,385,341	237,960,045	244,416,721
C-11 WEST	395,763,018	396,006,810	395,808,144	396,978,558	393,412,896	393,276,462	393,431,651	393,599,896
C-12 West	70,693,692	70,770,402	70,716,548	71,852,512	68,132,741	68,153,634	68,203,887	68,957,946
C-13 WEST	176,117,172	176,499,224	176,717,730	180,726,197	174,245,527	174,297,758	174,432,222	175,156,045
C-14 EAST	49,453,276	49,565,064	49,946,262	65,220,662	48,471,545	48,630,730	48,882,753	54,165,899
C-14 WEST	420,481,254	419,079,139	420,440,440	421,226,388	413,942,541	413,928,133	414,034,185	414,145,039
HILLSBORO CANAL	676,664,528	676,622,842	676,378,914	677,416,986	672,036,292	672,039,434	672,096,438	673,002,763
NORTH NEW RIVER CANAL WEST	181,198,801	181,222,059	181,586,296	183,647,644	178,690,894	178,674,292	178,818,425	179,270,084
POMPANO CANAL	27,836,875	27,915,588	27,997,683	28,582,576	27,613,364	27,689,310	27,786,750	28,182,124

Table 9. EAD Road Damage Alt A (Q1 2021 Dollars)

Impact area	ECB 2035 ($)	FWOP low 2085 ($)	FWOP i 2085 ($)	FWOP h 2085 ($)	Alt A 2035 ($)	Alt A low 2085 ($)	Alt A i 2085 ($)	Alt A h 2085 ($)
C-11 EAST	22,390,701	22,384,305	22,659,980	26,103,607	21,856,725	21,954,128	22,096,719	23,781,120
C-11 WEST	28,251,083	28,345,945	28,280,294	28,664,635	27,951,764	27,970,618	27,997,695	28,161,620
C-12 West	11,169,485	11,179,662	11,192,868	11,621,318	10,718,435	10,725,174	10,742,436	10,973,755
C-13 WEST	14,171,830	14,224,044	14,346,855	15,349,931	13,838,772	13,920,922	14,022,531	14,874,286
C-14 EAST	5,821,589	5,832,655	5,947,845	8,663,881	5,578,536	5,624,977	5,711,996	6,932,340
C-14 WEST	35,408,831	35,322,048	35,405,949	35,640,997	34,119,614	34,106,823	34,132,417	34,216,893
HILLSBORO CANAL	46,608,665	46,334,537	46,541,719	46,743,274	45,393,067	45,367,498	45,392,703	45,456,122
NORTH NEW RIVER CANAL WEST	15,674,097	15,615,831	15,868,708	16,709,268	14,971,232	15,023,891	15,103,528	15,643,402
POMPANO CANAL	2,336,462	2,388,767	2,399,844	2,638,968	2,285,438	2,315,153	2,348,476	2,595,606

Table 10. EAD Road Damage Alt B (Q1 2021 Dollars)

Impact area	ECB 2035 ($)	FWOP low 2085 ($)	FWOP i 2085 ($)	FWOP h 2085 ($)	Alt B 2035 ($)	Alt B low 2085 ($)	Alt B i 2085 ($)	Alt B h 2085 ($)
C-11 EAST	22,390,701	22,384,305	22,659,980	26,103,607	21,842,830	21,926,423	22,063,602	23,638,139
C-11 WEST	28,251,083	28,345,945	28,280,294	28,664,635	27,975,221	27,944,069	27,981,362	28,162,738
C-12 West	11,169,485	11,179,662	11,192,868	11,621,318	10,716,550	10,721,858	10,735,136	10,946,629
C-13 WEST	14,171,830	14,224,044	14,346,855	15,349,931	13,768,404	13,829,494	13,904,974	14,328,597
C-14 EAST	5,821,589	5,832,655	5,947,845	8,663,881	5,528,543	5,572,525	5,633,019	6,628,184
C-14 WEST	35,408,831	35,322,048	35,405,949	35,640,997	34,115,602	34,081,270	34,079,817	34,213,935
HILLSBORO CANAL	46,608,665	46,334,537	46,541,719	46,743,274	45,423,987	45,372,714	45,378,988	45,518,247
NORTH NEW RIVER CANAL WEST	15,674,097	15,615,831	15,868,708	16,709,268	15,004,745	15,062,190	15,129,694	15,549,144
POMPANO CANAL	2,336,462	2,388,767	2,399,844	2,638,968	2,286,220	2,314,275	2,346,539	2,590,748

Table 11. EAD Road Damage Alt C (Q1 2021 Dollars)

Impact area	ECB 2035 ($)	FWOP low 2085 ($)	FWOP i 2085 ($)	FWOP h 2085 ($)	Alt C 2035 ($)	Alt C low 2085 ($)	Alt C i 2085 ($)	Alt C h 2085 ($)
C-11 EAST	22,390,701	22,384,305	22,659,980	26,103,607	21,819,741	21,908,873	22,054,418	23,744,494
C-11 WEST	28,251,083	28,345,945	28,280,294	28,664,635	27,911,502	27,909,624	27,924,936	28,077,779
C-12 West	11,169,485	11,179,662	11,192,868	11,621,318	10,705,390	10,710,796	10,721,441	10,908,171
C-13 WEST	14,171,830	14,224,044	14,346,855	15,349,931	13,694,078	13,715,933	13,754,924	13,913,955
C-14 EAST	5,821,589	5,832,655	5,947,845	8,663,881	5,514,620	5,561,091	5,620,432	6,639,223
C-14 WEST	35,408,831	35,322,048	35,405,949	35,640,997	34,050,560	34,048,153	34,069,846	34,116,678
HILLSBORO CANAL	46,608,665	46,334,537	46,541,719	46,743,274	45,444,863	45,445,460	45,460,676	45,608,966
NORTH NEW RIVER CANAL WEST	15,674,097	15,615,831	15,868,708	16,709,268	14,942,418	14,964,577	15,006,752	15,205,990
POMPANO CANAL	2,336,462	2,388,767	2,399,844	2,638,968	2,290,883	2,318,569	2,348,470	2,488,512

Table 12. EAD Vehicle Damage Alt A (Q1 2024 Dollars)

Impact area	ECB 2035 ($)	FWOP low 2085 ($)	FWOP i 2085 ($)	FWOP h 2085 ($)	Alt A 2035 ($)	Alt A low 2085 ($)	Alt A i 2085 ($)	Alt A h 2085 ($)
C-11 EAST	5,239,183	5,306,212	5,385,660	7,225,919	5,045,123	5,091,522	5,197,337	6,287,661
C-11 WEST	11,029,543	11,031,042	11,032,913	11,101,336	10,895,976	10,893,383	10,897,676	10,918,549
C-12 West	5,692,623	5,714,257	5,696,956	5,878,779	5,433,152	5,435,873	5,442,257	5,542,168
C-13 WEST	6,486,703	6,561,531	6,538,964	6,875,632	6,420,115	6,443,760	6,470,912	6,760,399
C-14 EAST	1,981,975	1,982,042	2,003,806	3,154,401	1,903,557	1,899,039	1,929,826	2,364,008
C-14 WEST	16,023,548	16,041,173	16,019,992	16,095,767	15,658,742	15,650,515	15,661,935	15,692,400
HILLSBORO CANAL	19,035,080	18,987,605	19,018,476	19,074,824	18,692,029	18,682,367	18,690,052	18,706,540
NORTH NEW RIVER CANAL WEST	5,194,592	5,195,316	5,222,635	5,382,202	5,040,762	5,045,275	5,055,274	5,147,120
POMPANO CANAL	1,021,204	1,059,828	1,102,634	1,419,702	993,060	1,028,574	1,074,409	1,341,236

Table 13. EAD Vehicle Damage Alt B (Q1 2024 Dollars)

Impact area	ECB 2035 ($)	FWOP low 2085 ($)	FWOP i 2085 ($)	FWOP h 2085 ($)	Alt B 2035 ($)	Alt B low 2085 ($)	Alt B i 2085 ($)	Alt B h 2085 ($)
C-11 EAST	5,239,183	5,306,212	5,385,660	7,225,919	5,045,123	5,091,522	5,197,337	6,287,661
C-11 WEST	11,029,543	11,031,042	11,032,913	11,101,336	10,895,976	10,893,383	10,897,676	10,918,549
C-12 West	5,692,623	5,714,257	5,696,956	5,878,779	5,433,152	5,435,873	5,442,257	5,542,168
C-13 WEST	6,486,703	6,561,531	6,538,964	6,875,632	6,420,115	6,443,760	6,470,912	6,760,399
C-14 EAST	1,981,975	1,982,042	2,003,806	3,154,401	1,903,557	1,899,039	1,929,826	2,364,008
C-14 WEST	16,023,548	16,041,173	16,019,992	16,095,767	15,658,742	15,650,515	15,661,935	15,692,400
HILLSBORO CANAL	19,035,080	18,987,605	19,018,476	19,074,824	18,692,029	18,682,367	18,690,052	18,706,540
NORTH NEW RIVER CANAL WEST	5,194,592	5,195,316	5,222,635	5,382,202	5,040,762	5,045,275	5,055,274	5,147,120
POMPANO CANAL	1,021,204	1,059,828	1,102,634	1,419,702	993,060	1,028,574	1,074,409	1,341,236

Table 14. EAD Vehicle Damage Alt C (Q1 2024 Dollars)

Impact area	ECB 2035 ($)	FWOP low 2085 ($)	FWOP i 2085 ($)	FWOP h 2085 ($)	Alt C 2035 ($)	Alt C low 2085 ($)	Alt C i 2085 ($)	Alt C h 2085 ($)
C-11 EAST	5,239,183	5,306,212	5,385,660	7,225,919	5,019,929	5,063,934	5,185,145	6,270,385
C-11 WEST	11,029,543	11,031,042	11,032,913	11,101,336	10,872,320	10,866,623	10,874,825	10,887,709
C-12 West	5,692,623	5,714,257	5,696,956	5,878,779	5,427,541	5,430,745	5,435,824	5,537,897
C-13 WEST	6,486,703	6,561,531	6,538,964	6,875,632	6,375,456	6,383,281	6,394,702	6,461,968
C-14 EAST	1,981,975	1,982,042	2,003,806	3,154,401	1,902,458	1,909,802	1,924,536	2,303,945
C-14 WEST	16,023,548	16,041,173	16,019,992	16,095,767	15,627,952	15,626,687	15,634,046	15,647,691
HILLSBORO CANAL	19,035,080	18,987,605	19,018,476	19,074,824	18,709,243	18,709,193	18,711,742	18,751,693
NORTH NEW RIVER CANAL WEST	5,194,592	5,195,316	5,222,635	5,382,202	5,023,586	5,024,537	5,033,030	5,066,415
POMPANO CANAL	1,021,204	1,059,828	1,102,634	1,419,702	1,005,665	1,038,857	1,075,286	1,244,078

Avoided Flood Damage

The difference in EAD between the “with project condition” and the “without Project condition” is the damage reduced (or avoided damages). The avoided damage values for each basin for structures (including contents and others), roads, vehicles for alternatives A, B, and C are reported in Table 15 through Table 23.

Table 15. Avoided Damage Structure Models Alt A (Q1 2021 Dollars)

Impact area	ECB 2035 – Alt A 2035 ($)	FWOP low – Alt A low 2085 ($)	FWOP i – Alt A i 2085 ($)	FWOP h – Alt A h 2085 ($)
C-11 EAST	3,235,683	2,867,170	3,141,716	11,580,944
C-11 WEST	1,925,398	2,245,327	1,993,656	2,789,384
C-12 West	2,506,118	2,565,624	2,451,291	2,831,027
C-13 WEST	1,261,653	1,402,842	1,382,524	2,000,411
C-14 EAST	726,620	679,211	497,161	9,209,991
C-14 WEST	6,128,332	4,852,540	6,056,914	6,457,802
HILLSBORO CANAL	5,073,886	5,191,140	4,806,974	5,540,522
NORTH NEW RIVER CANAL WEST	2,202,489	2,194,519	2,449,717	3,191,421
POMPANO CANAL	238,039	243,132	212,587	242,505
Total	23,298,218	22,241,505	22,992,540	43,844,005

Table 16. Avoided Damage Structure Models Alt B (Q1 2021 Dollars)

Impact area	ECB 2035 – Alt A 2035 ($)	FWOP low – Alt A low 2085 ($)	FWOP i – Alt A i 2085 ($)	FWOP h – Alt A h 2085 ($)
C-11 EAST	3,325,151	3,046,170	3,365,413	12,319,029
C-11 WEST	1,945,615	2,420,877	2,012,019	2,546,940
C-12 West	2,508,915	2,571,670	2,460,162	2,862,254
C-13 WEST	1,563,540	1,635,039	1,707,526	4,374,363
C-14 EAST	899,415	861,673	970,940	11,008,906
C-14 WEST	5,976,008	4,937,556	6,357,171	6,201,914
HILLSBORO CANAL	4,810,578	5,146,366	4,908,426	5,019,940
NORTH NEW RIVER CANAL WEST	2,272,351	2,210,015	2,467,255	3,587,435
POMPANO CANAL	229,772	227,990	244,636	270,196
Total	23,531,345	23,057,356	24,493,547	48,190,976

Table 17. Avoided Damage Structure Models Alt C (Q1 2021 Dollars)

Impact area	ECB 2035 – Alt A 2035 ($)	FWOP low – Alt A low 2085 ($)	FWOP i – Alt A i 2085 ($)	FWOP h – Alt A h 2085 ($)
C-11 EAST	3,544,292	3,193,043	3,449,058	12,156,623
C-11 WEST	2,350,123	2,730,349	2,376,493	3,378,662
C-12 West	2,560,951	2,616,768	2,512,661	2,894,565
C-13 WEST	1,871,645	2,201,466	2,285,508	5,570,153
C-14 EAST	981,731	934,334	1,063,509	11,054,763
C-14 WEST	6,538,713	5,151,006	6,406,256	7,081,349
HILLSBORO CANAL	4,628,236	4,583,408	4,282,477	4,414,223
NORTH NEW RIVER CANAL WEST	2,507,907	2,547,767	2,767,870	4,377,560
POMPANO CANAL	223,511	226,278	210,933	400,452
Total	25,207,108	24,184,419	25,354,764	51,328,350

Table 18. Avoided Damage Road Models Alt A (Q1 2021 Dollars)

Impact area	ECB 2035 – Alt A 2035 ($)	FWOP low – Alt A low 2085 ($)	FWOP i – Alt A i 2085 ($)	FWOP h – Alt A h 2085 ($)
C-11 EAST	533,977	430,177	563,261	2,322,487
C-11 WEST	299,319	375,327	282,599	503,015
C-12 West	451,050	454,488	450,432	647,564
C-13 WEST	333,057	303,122	324,323	475,645
C-14 EAST	243,053	207,678	235,848	1,731,541
C-14 WEST	1,289,217	1,215,225	1,273,532	1,424,104
HILLSBORO CANAL	1,215,598	967,038	1,149,016	1,287,152
NORTH NEW RIVER CANAL WEST	702,865	591,940	765,180	1,065,866
POMPANO CANAL	51,024	73,614	51,368	43,362
Total	5,119,161	4,618,610	5,095,560	9,500,734

Table 19. Avoided Damage Road Models Alt B (Q1 2021 Dollars)

Impact area	ECB 2035 – Alt A 2035 ($)	FWOP low – Alt A low 2085 ($)	FWOP i – Alt A i 2085 ($)	FWOP h – Alt A h 2085 ($)
C-11 EAST	547,871	457,882	596,378	2,465,468
C-11 WEST	275,862	401,875	298,933	501,897
C-12 West	452,935	457,804	457,732	674,689
C-13 WEST	403,426	394,549	441,881	1,021,334
C-14 EAST	293,047	260,130	314,825	2,035,696
C-14 WEST	1,293,229	1,240,778	1,326,132	1,427,062
HILLSBORO CANAL	1,184,679	961,823	1,162,731	1,225,027
NORTH NEW RIVER CANAL WEST	669,351	553,641	739,014	1,160,124
POMPANO CANAL	50,242	74,493	53,305	48,220
Total	5,170,642	4,802,976	5,390,931	10,559,518

Table 20. Avoided Damage Road Models Alt C (Q1 2021 Dollars)

Impact area	ECB 2035 – Alt C 2035 ($)	FWOP low – Alt C low 2085 ($)	FWOP i – Alt C i 2085 ($)	FWOP h – Alt C h 2085 ($)
C-11 EAST	570,960	475,433	605,562	2,359,113
C-11 WEST	339,581	436,321	355,359	586,856
C-12 West	464,095	468,866	471,427	713,148
C-13 WEST	477,751	508,111	591,931	1,435,976
C-14 EAST	306,969	271,565	327,412	2,024,658
C-14 WEST	1,358,271	1,273,895	1,336,103	1,524,319
HILLSBORO CANAL	1,163,803	889,077	1,081,043	1,134,308
NORTH NEW RIVER CANAL WEST	731,678	651,254	861,956	1,503,278
POMPANO CANAL	45,580	70,198	51,374	150,456
Total	5,458,689	5,044,719	5,682,166	11,432,110

Table 21. Avoided Damage Vehicle Models Alt A (Q1 2024 Dollars)

Impact area	ECB 2035 – Alt A 2035 ($)	FWOP low – Alt A low 2085 ($)	FWOP i – Alt A i 2085 ($)	FWOP h – Alt A h 2085 ($)
C-11 EAST	194,060	214,689	188,323	938,258
C-11 WEST	133,567	137,659	135,237	182,786
C-12 West	259,471	278,384	254,698	336,611
C-13 WEST	66,588	117,771	68,051	115,233
C-14 EAST	78,419	83,003	73,981	790,393
C-14 WEST	364,806	390,658	358,057	403,367
HILLSBORO CANAL	343,051	305,238	328,424	368,283
NORTH NEW RIVER CANAL WEST	153,830	150,040	167,361	235,082
POMPANO CANAL	28,144	31,254	28,225	78,466
Total	1,621,935	1,708,697	1,602,357	3,448,480

Table 22. Avoided Damage Vehicle Models Alt B (Q1 2024 Dollars)

Impact area	ECB 2035 – Alt B 2035 ($)	FWOP low – Alt B low 2085 ($)	FWOP i – Alt B i 2085 ($)	FWOP h – Alt B h 2085 ($)
C-11 EAST	205,470	233,019	204,661	1,002,831
C-11 WEST	133,835	145,808	136,854	172,860
C-12 West	260,329	279,779	255,734	343,660
C-13 WEST	89,524	140,270	101,380	316,741
C-14 EAST	78,507	71,772	80,214	887,454
C-14 WEST	384,328	398,614	380,907	394,728
HILLSBORO CANAL	329,200	302,650	334,144	342,394
NORTH NEW RIVER CANAL WEST	157,897	152,121	170,597	264,045
POMPANO CANAL	27,738	30,843	32,013	82,626
Total	1,666,826	1,754,875	1,696,503	3,807,338

Table 23. Avoided Damage Vehicle Models Alt C (Q1 2024 Dollars)

Impact area	ECB 2035 – Alt C 2035 ($)	FWOP low – Alt C low 2085 ($)	FWOP i – Alt C i 2085 ($)	FWOP h – Alt C h 2085 ($)
C-11 EAST	219,254	242,277	200,515	955,535
C-11 WEST	157,223	164,419	158,088	213,627
C-12 West	265,082	283,512	261,132	340,883
C-13 WEST	111,246	178,250	144,262	413,665
C-14 EAST	79,517	72,240	79,270	850,456
C-14 WEST	395,596	414,486	385,947	448,076
HILLSBORO CANAL	325,837	278,411	306,734	323,131
NORTH NEW RIVER CANAL WEST	171,006	170,778	189,605	315,787
POMPANO CANAL	15,539	20,971	27,348	175,624
Total	1,740,300	1,825,344	1,752,901	4,036,782

Avoided Annual Damage for Optimization of Alternative C for Structures

Optimization of Alternative C (O_Alt C) includes the incorporation of nonstructural measures such as dry floodproofing and elevating foundation heights. Accordingly, the avoided damages for structures for this alternative were recalculated and summarized in Table 24 below.

Table 24. Avoided Damage Structure Models Optimization of Alternative C (Q1 2025 Dollars)

Impact area	ECB 2035 – O_Alt C 2035 ($)	FWOP low – O_Alt C low 2085 ($)	FWOP i – O_Alt C i 2085 ($)	FWOP h – O_Alt C h 2085 ($)
C-11 EAST	4,196,441	3,780,563	4,083,684	14,393,441
C-11 WEST	2,977,637	3,428,797	3,012,276	4,197,933
C-12 West	9,217,929	9,283,938	9,159,238	9,629,505
C-13 WEST	2,301,680	2,694,883	2,794,923	6,685,130
C-14 EAST	2,143,403	2,103,280	2,281,526	14,328,845
C-14 WEST	7,917,621	6,275,284	7,761,280	8,560,632
HILLSBORO CANAL	5,587,317	5,535,861	5,180,590	5,343,408
NORTH NEW RIVER CANAL WEST	3,592,778	3,642,025	3,901,363	5,796,062
POMPANO CANAL	272,458	277,804	261,025	486,556
Total	38,207,263	37,022,436	38,435,906	69,421,511

It is important to note the first three sets of data provided as input to HEC-FDA were ECB, FWOPi, and FWOPh. These sets used a custom coordinate system NAD 1983 (2011) Florida State Plane East in feet. The custom coordinate system was assigned via an accompanying “world” file (*.tfw) for each tif. For all other scenarios, a standard NAD 1983 projection with Well Known ID (WKID) 2236 was applied and embedded in the *.tif files. The NAD 1983 (2011) shift is an adjustment to the NAD 1983 geographic projection that considers updated coordinates of the North American NGS Continuous Operating Reference Stations (CORS) in a 'National Adjustment of 2011 Project' conducted by NGS. A review indicated approximate 5-foot horizontal shift between the Existing and Future Without Project Rasters and the Final Array/TSP Rasters. To evaluate the impact of the shift, a rerun of ECB, FWOPi, and FWOPh were conducted using tiffs projected with NAD 1983, WKID 2236. The results, summarized in Appendix C, confirmed that the differences are negligible. Accordingly, comparisons utilizing the HEC-FDA results in plan formulation remain valid.

Tentatively Selected Plan and Damage Assessment Results

Tentatively Selected Plan (TSP) Summary

The selection of the TSP is documented in the Model Documentation Report (2025). Table 25 summarizes the components included in the TSP plan.

Table 25. Tentatively Selected Plan Components

Project Type	Project Type Detail	Tentatively Selected Plan (TSP)
Primary Structure Modification	Gates	G-56 (4 x 25 ft) - Hillsboro, S-37A (3 x 25 ft) - C-14 East, G-57 (2x21 ft) - Pompano S-33 (2 x 20 ft) - C-12 West, G-54 (4 x 20 ft) - NNR West, S-36 (2 x 16) S-13 gate (2 x 14)
	Pump	S-37A (add new 1200 Cfs) - C-14 East, S-36 (add new 510 cfs) - C-13 West, S-33 (add new 510 cfs) - C-12 West, G-54 (add new 810 cfs) - NNR West, S-13 (add'l 540 cfs) - C-11 East
	Hardening	G-56 (Hillsboro), S-37A (Cypress Creek/C-14), G-57 (Pompano), S-36 (C-13 West), S-33 (C-12 West), G-54 (NNR West), S-13 (C-11 East)
Primary C&SF Canals	Canal Cross Section Modification	Hillsboro (AltB)
		C-11 West (AltB)
		C-11 East (AltB)
		C14 at S37B (ALTB)
	Culverts/Bridges	Triple culvert u/s of G-57 - Pompano Canal
Storage & Nature Based		None
Secondary Structure Modification	Pump	Pre storm operations at secondary pumps
Primary Structure Modification	Pre-storm Drawdown	All basins, all alternatives - except C-11 West (include S37B in drawdown operations)
Assumed Inflows from Secondary to Primary	Pre-storm Drawdown	All *upstream* basins
Operations		Turn off pump & add'l gravity based on tidal reach sensors

HEC-FDA Assessment Results

This section summarizes the TSP assessment results.

- **Tables 26–28** present the EAD results for structures (in Q1 2021 dollars), vehicles (in Q1 2024 dollars), and roads (in Q1 2021 dollars) across four scenarios: TSP 2035, TSP 2085low, TSP 2085i, and TSP 2085h.
- **Tables 29–31** summarize the avoided annual damages for structures (in Q1 2021 dollars), vehicles (in Q1 2024 dollars), and roads (in Q1 2021 dollars) across four scenarios: TSP 2035, TSP 2085low, TSP 2085i, and TSP 2085h.
- **Tables 32–34** document the avoided annual damages for structures, vehicles, and roads after conversion to Q1 2025 dollars.

Table 26. TSP Structure Damage EAD (Q1 2021 Dollars)

Impact area	TSP 2035 ($)	TSP low 2085 ($)	TSP i 2085 ($)	TSP h 2085 ($)
C-11 EAST	237,329,627	237,844,726	238,703,520	246,054,188
C-11 WEST	393,510,978	393,462,506	394,094,276	394,460,869
C-12 West	68,224,672	68,284,942	68,525,084	69,045,900
C-13 WEST	174,545,311	174,798,856	175,018,240	175,809,061
C-14 EAST	48,619,582	48,819,606	49,147,074	57,170,702
C-14 WEST	413,950,514	414,017,732	415,091,727	415,270,120
HILLSBORO CANAL	671,279,571	671,299,624	672,540,626	672,679,604
NORTH NEW RIVER CANAL WEST	178,779,929	178,901,823	179,328,792	180,015,215
POMPANO CANAL	27,663,817	27,754,309	27,856,233	28,385,178

Table 27. TSP Vehicle Damage EAD (Q1 2024 Dollars)

Impact area	TSP 2035 ($)	TSP low 2085 ($)	TSP i 2085 ($)	TSP h 2085 ($)
C-11 EAST	5,042,538	5,107,971	5,221,869	6,387,953
C-11 WEST	10,878,338	10,877,119	10,909,829	10,929,931
C-12 West	5,437,984	5,444,062	5,464,685	5,539,287
C-13 WEST	6,395,104	6,416,227	6,434,458	6,510,331
C-14 EAST	1,912,532	1,920,204	1,936,774	2,558,439
C-14 WEST	15,628,785	15,633,572	15,700,254	15,717,000
HILLSBORO CANAL	18,673,718	18,674,886	18,739,384	18,746,885
NORTH NEW RIVER CANAL WEST	5,028,526	5,036,300	5,057,953	5,113,995
POMPANO CANAL	1,001,854	1,038,748	1,083,146	1,355,203

Table 28. TSP Road Damage EAD (Q1 2021 Dollars)

Impact area	TSP 2035 ($)	TSP low 2085 ($)	TSP i 2085 ($)	TSP h 2085 ($)
C-11 EAST	21,855,773	21,982,801	22,170,603	23,997,441
C-11 WEST	27,913,779	27,930,561	28,004,712	28,176,278
C-12 West	10,729,977	10,750,382	10,790,401	11,029,700
C-13 WEST	13,756,292	13,823,109	13,886,788	14,128,060
C-14 EAST	5,548,170	5,604,707	5,666,646	7,150,637
C-14 WEST	34,054,805	34,065,609	34,184,462	34,245,938
HILLSBORO CANAL	45,351,029	45,353,548	45,506,952	45,534,015
NORTH NEW RIVER CANAL WEST	14,912,528	14,956,468	15,177,855	15,299,214
POMPANO CANAL	2,324,398	2,356,487	2,391,687	2,634,228

Table 29. TSP Structures Avoided Annual Damage (Q1 2021 Dollars)

Impact area	ECB 2035 – TSP 2035 ($)	FWOP low – TSP low 2085 ($)	FWOP i – TSP i 2085 ($)	FWOP h – TSP h 2085 ($)
C-11 EAST	3,338,819	2,733,659	2,705,583	10,519,156
C-11 WEST	2,252,040	2,544,304	1,713,869	2,517,689
C-12 West	2,469,020	2,485,461	2,191,464	2,806,611
C-13 WEST	1,571,860	1,700,368	1,699,491	4,917,137
C-14 EAST	833,694	745,458	799,188	8,049,960
C-14 WEST	6,530,741	5,061,407	5,348,713	5,956,268
HILLSBORO CANAL	5,384,957	5,323,217	3,838,288	4,737,382
NORTH NEW RIVER CANAL WEST	2,418,871	2,320,237	2,257,504	3,632,429
POMPANO CANAL	173,058	161,279	141,450	197,399
Total	24,973,060	23,075,390	20,695,550	43,334,032

Table 30. TSP Vehicles Avoided Annual Damage (Q1 2024 Dollars)

Impact area	ECB 2035 – TSP 2035 ($)	FWOP low – TSP low 2085 ($)	FWOP i – TSP i 2085 ($)	FWOP h – TSP h 2085 ($)
C-11 EAST	196,645	198,240	163,792	837,966
C-11 WEST	151,205	153,924	123,084	171,404
C-12 West	254,639	270,195	232,270	339,492
C-13 WEST	91,599	145,304	104,506	365,301
C-14 EAST	69,443	61,838	67,032	595,962
C-14 WEST	394,763	407,600	319,738	378,767
HILLSBORO CANAL	361,363	312,718	279,091	327,938
NORTH NEW RIVER CANAL WEST	166,066	159,016	164,681	268,207
POMPANO CANAL	19,350	21,080	19,488	64,499
Total	1,705,072	1,729,914	1,473,683	3,349,536

Table 31. TSP Roads Avoided Annual Damage (Q1 2021 Dollars)

Impact area	ECB 2035 – TSP 2035 ($)	FWOP low – TSP low 2085 ($)	FWOP i – TSP i 2085 ($)	FWOP h – TSP h 2085 ($)
C-11 EAST	534,928	401,505	489,377	2,106,166
C-11 WEST	337,304	415,384	275,582	488,358
C-12 West	439,507	429,280	402,467	591,618
C-13 WEST	415,538	400,935	460,066	1,221,871
C-14 EAST	273,420	227,948	281,199	1,513,244
C-14 WEST	1,354,026	1,256,439	1,221,488	1,395,059
HILLSBORO CANAL	1,257,636	980,989	1,034,766	1,209,259
NORTH NEW RIVER CANAL WEST	761,569	659,363	690,854	1,410,054
POMPANO CANAL	12,064	32,280	8,157	4,740
Total	5,385,992	4,804,123	4,863,957	9,940,368

Table 32. TSP Structures Avoided Annual Damage (Q1 2025 Dollars)

Impact area	ECB 2035 – TSP 2035 ($)	FWOP low – TSP low 2085 ($)	FWOP i – TSP i 2085 ($)	FWOP h – TSP h 2085 ($)
C-11 EAST	3,953,162	3,236,652	3,203,410	12,454,681
C-11 WEST	2,666,416	3,012,456	2,029,220	2,980,944
C-12 West	2,923,319	2,942,785	2,594,693	3,323,028
C-13 WEST	1,861,083	2,013,236	2,012,197	5,821,890
C-14 EAST	987,093	882,622	946,239	9,531,153
C-14 WEST	7,732,397	5,992,706	6,332,877	7,052,221
HILLSBORO CANAL	6,375,789	6,302,689	4,544,533	5,609,060
NORTH NEW RIVER CANAL WEST	2,863,944	2,747,160	2,672,885	4,300,796
POMPANO CANAL	204,900	190,955	167,476	233,720
Total	29,568,104	27,321,262	24,503,531	51,307,493

Table 33. TSP Vehicles Avoided Annual Damage (Q1 2025 Dollars)

Impact area	ECB 2035 – TSP 2035 ($)	FWOP low – TSP low 2085 ($)	FWOP i – TSP i 2085 ($)	FWOP h – TSP h 2085 ($)
C-11 EAST	201,757	203,395	168,050	859,753
C-11 WEST	155,137	157,926	126,285	175,861
C-12 West	261,260	277,220	238,309	348,318
C-13 WEST	93,980	149,082	107,223	374,799
C-14 EAST	71,249	63,446	68,775	611,457
C-14 WEST	405,026	418,198	328,051	388,615
HILLSBORO CANAL	370,758	320,849	286,348	336,465
NORTH NEW RIVER CANAL WEST	170,384	163,150	168,963	275,180
POMPANO CANAL	19,853	21,628	19,995	66,176
Total	1,749,404	1,774,892	1,511,999	3,436,624

Table 34. TSP Roads Avoided Annual Damage (Q1 2025 Dollars)

Impact area	ECB 2035 – TSP 2035 ($)	FWOP low – TSP low 2085 ($)	FWOP i – TSP i 2085 ($)	FWOP h – TSP h 2085 ($)
C-11 EAST	633,355	475,382	579,422	2,493,700
C-11 WEST	399,368	491,815	326,290	578,216
C-12 West	520,377	508,267	476,521	700,476
C-13 WEST	491,997	474,707	544,719	1,446,695
C-14 EAST	323,729	269,891	332,939	1,791,681
C-14 WEST	1,603,167	1,487,624	1,446,242	1,651,750
HILLSBORO CANAL	1,489,041	1,161,491	1,225,163	1,431,763
NORTH NEW RIVER CANAL WEST	901,697	780,686	817,971	1,669,504
POMPANO CANAL	14,284	38,220	9,658	5,612
Total	6,377,014	5,688,082	5,758,925	11,769,396

Appendix A: Review of First Floor Elevations and Other Structure Inventory Attributes for Residential Structure Category

This document has been developed to present findings from a comparison of the current structure inventory attributes with visual documentation of those attributes. Primarily this document looks at the first-floor elevation (FFE) values in the existing structure inventory dataset. Additionally other required structure inventory attributes have been reviewed during the completion of this work and other key findings from these visual inspections are discussed.

This document presents the following:

(1) Preliminary findings of cursory review of first floor elevations.
(2) Proposed sampling methodology for visually reviewing FFEs.
(3) Presentation of results from sampling of three representative basins within the study area.
(4) Recommendation for updating FFE for key residential structures.
(5) Discussion of additional findings from sampling process.

First Floor Elevation Preliminary Findings

As preliminary results from the FDA models were generated, additional review of the structure inventory was being conducted to better understand the results from the FDA runs. In delving deeper into the structure inventory data some attributes stood out as potentially inconsistent with the actual structures in the study area. The first-floor elevation (FFE) was one of these parameters.

In looking at just the one-story, single family residential structure category (occupancy: RES1-1SNB) all of the structures in the inventory have a FFE value input of 1.24 feet. A cursory review of available imagery using Google Earth Streetview, and other readily available imagery sources, showed that many structures have an FFE below the 1.24 value in the database. After performing this cursory review, it was determined that a larger sample of structures should be reviewed to verify the accuracy of the 1.24 feet, as well as the accuracy of the input values for the other structure occupancy types.

Therefore, a sampling of one reach was performed to analyze potential discrepancies between the actual structure elevations and the values found in the current structure inventory. This initial sampling was performed on basin C-10 which contains 20,452 total structures. Given the high number of structures in the reach a relatively small portion of the study area could reasonably be sampled at this time. But a sample of approximately one percent of total structures was the goal which would equate to reviewing at minimum 205 structures.

Sampling Methodology

Flood damage studies that use depth-to-damage curves require structure points to have a first-floor elevation (FFE). The FFE signifies the elevation at which a structure's first living floor is above the ground elevation immediately below, or immediately surrounding, the structure. A standard practice in developing structure inventories for flood damage analysis is a visual inspection to approximate the FFE for structures. Based on the size of a study area, and primarily the number of structures potentially inundated, FFE elevations are often sampled in order to reasonably estimate an average FFE for a neighborhood, reach, county, etc. For the sampling completed for this document the following steps were taken:

- Perform random number generator, random point selection using ArcGIS, or other method to determine which structures to sample in each basin.
- Number of structures sampled in each reach is dependent on number of residential structures in the reach. Given large scale of project, assume approximately one percent (1%) of all structures in a given basin.

- Used Google Earth Streetview to visually review a selected structure's first floor elevation.

- Typically assume 0.5-ft of elevation for each step leading up to first floor. Most slab-on-grade residential structures are applied a 0.5-ft elevation for the foundation. Even if a structure appears to be built at-grade, a 0.5-ft elevation was documented during the survey. Figures 1 and 2 present sample FFE of two structures with differing foundation heights.

Figure 1 – Typical Slab-on-Grade Structure in Study Area

Figure 2 – Typical Raised Slab Residential Structure in Study Area

- Additionally, when looking in Streetview, other structures directly around the sampled building were reviewed to make sure the structure is not a significant outlier in terms of FFE.
- Given that the single-family residential occupancies make up a majority of structures in a given reach, much of the sampling focus is aimed at obtaining information on those structures.

Sampling Results

The following summary table (Table 1) presents the results of the sampling for basin C-10. The table provides the number of structures by occupancy in the inventory, the current average FFE for each occupancy, the number of structures surveyed for the occupancy type, and the resulting FFE found through the sampling process.

Table 1 – Summary of FFE Sampling by Occupancy Type

Occupancy	Count	Average FFE (ft)	Surveyed Count	Percent Surveyed	Avg. FFE of Surveyed Structures (ft)
AGR1	8	1.26	0	0.0%	-
C-COM1	4	0.94	4	100.0%	0.38
C-COM10	1	1.00	0	0.0%	-
C-COM4	3	1.07	1	33.3%	0.00
C-COM6	1	0.71	0	0.0%	-
C-IND2	3	0.53	1	33.3%	0.00
COM1	252	1.26	10	4.0%	0.50
COM10	82	1.26	3	3.7%	0.50
COM2	11	1.46	2	18.2%	0.50
COM3	7	1.46	2	28.6%	0.25
COM4	332	1.21	12	3.6%	1.38
COM5	7	0.62	1	14.3%	0.50
COM6	21	2.73	3	14.3%	0.83
COM8	247	1.46	3	1.2%	1.17
COM9	1	1.46	1	100.0%	1.00
C-REL1	1	0.60	1	100.0%	1.00
C-RES1-1SNB	258	1.15	10	3.9%	0.65
C-RES2	1	13.90	1	100.0%	5.00
C-RES3C	21	1.29	3	14.3%	0.67
C-RES3E	1	0.50	0	0.0%	-
EDU1	139	1.10	8	5.8%	0.63
ESSM	5	1.00	0	0.0%	-
GOV1	38	1.21	3	7.9%	1.17
IND2	378	1.63	11	2.9%	0.41
IND3	36	0.63	3	8.3%	0.50
PWTM	3	1.00	0	0.0%	-
REL1	111	1.46	5	4.5%	0.70
RES1-1SNB	15,030	1.24	129	0.9%	0.61
RES1-2SNB	583	0.96	7	1.2%	0.50
RES2	534	2.99	1	0.2%	2.50
RES3C	1,681	1.32	17	1.0%	0.68
RES3E	598	1.23	0	0.0%	-

Occupancy	Count	Average FFE (ft)	Surveyed Count	Percent Surveyed	Avg. FFE of Surveyed Structures (ft)
RES4	30	1.73	0	0.0%	-
RES5	4	0.84	0	0.0%	-
RES6	20	0.99	0	0.0%	-
TOTAL	**20,452**		**242**	**1.18%**	

This sample of the study area resoundingly showed that the RES1-1SNB and RES1-2SNB occupancies predominantly are slab on grade structures, with less than 1.24 feet of elevation above the existing grade. In noting this finding, two additional basins have been sampled to verify the findings in different locations of the study area that would provide additional coverage that could account for potential variability in structures throughout the extents of the study.

Additional Basin Sampling Results

Basins C14 West and C-12 West were selected as additional basins to sample based on their geographical representativeness. Similar findings were encountering upon performing the random sample analysis. Table 2 provides the findings for the two primary residential occupancies in question for the two additional basins reviewed.

Table 2 – Summary of Additional Basins Residential Sampling

Occupancy	Count	Average FFE (ft)	Surveyed Count	Percent Surveyed	Avg. FFE of Surveyed Structures (ft)
Basin C-12 West					
RES1-1SNB	8,541	1.24	91	1.1%	0.54
RES1-2SNB	445	0.96	6	1.3%	0.50
Basin C-14 West					
RES1-1SNB	44,903	1.24	348	0.8%	0.51
RES1-2SNB	2,737	0.96	17	0.6%	0.5

As with the findings from basin C-10, the residential structures are overwhelmingly slab on grade structures that are below the 1.24-feet currently listed in the inventory. Basin C-14 West was found to consist of relatively newer structures, with far more neighborhoods that street views were not readily available for. As such the percent surveyed is slightly lower than the other reviewed basins, but as it was the largest of the basins reviewed, it still provides a sufficient sample of structures.

First Floor Elevation Recommendation

Overall, 598 single family residential structures were reviewed, and an overwhelming majority of the structures were found to be slab on grade structures with no significant elevation beyond the existing grades. The results show some variation between the three basins with the lowest average FFE being 0.51-feet and the highest basin average being 0.61-feet for the RES1 occupancy types. Given these findings it would be reasonable to lower the FFE for the RES1-1SNB and RES1-2SNB occupancy types.

It is recommended at this time that the FFE for these occupancies be both set at 0.75-feet for all structures in the study area. This value, based on the sampling presented herein, would be a conservative value between the current structure inventory input of 1.24 and the averages found during this survey. The following table (Table 3) provides the summary of the current inventory elevations, the average survey elevations, and the recommended FFE for the two occupancies in question.

Table 3 – Recommended First Floor Elevations for Single Family Residential Structures

Occupancy	Current Inventory FFE (ft)	Average FFE from Sample (ft)	Recommended FFE for Use in FDA (ft)
RES1-1SNB	1.24	1.24	0.75
RES1-2SNB	0.96	0.96	0.75

Additional Findings

The following is a list of additional findings from the sampling process, and other topics of concern regarding the current structure inventory.

- Occupancy Types – During the survey of the three basins mentioned above it was apparent that many structures have been assigned occupancies that do not accurately represent the structure point in question. In large structure inventory datasets, there are always going to be mistakes, incorrect identification, typos, etc. However, the review of these three basins found relatively large chunks of occupancies being incorrectly applied. The C-10 basin contained a large mobile home park, in excess of 100 structures, all being classified as commercial structures. There were numerous large apartment/condominium structures that were classified as single-family occupancies. The scope of this effort was not to review these, but it may be important to understand the impacts of this categorization issue and better understand if the structure values, depth-to-damage curves, and other key flood damage modeling components are reasonably being applied.
- Depreciation – USACE flood damage studies require the use of depreciated replacement values (DRV) for all structures. A visual estimation of structure depreciation was also completed during the visual survey of the FFE. Given the rates of depreciation currently applied to the structure inventory, there may be justification for adjusting the depreciation similar to the FFE. The visual survey of the depreciation rates found differing rates of relative depreciation between the three surveyed basins, but the average depreciation rate for each basin was found to be less than what is currently in the inventory dataset. However, due to the subjective nature of visual depreciation estimates, it is not recommended at this time to adjust the depreciation values in the current inventory.

Appendix B: Mean and Standard Deviation Estimates of Foundation Heights by Structure Category

HEC-FDA utilizes both normal and triangular distributions as an input to simulate Finished Floor Levels for a variety of building types. Results based on triangular distribution produces unrealistic results (extremely high estimated annual flood damage) near the distribution tails. In consultation with subject matter experts (SMEs) from USACE, it was recommended to apply a normal distribution. In this memorandum, we address this issue by mapping the triangular distribution to a normal distribution that is more stable near the tails and its two parameters (mean and standard deviation) are derived using Quantile Mapping.

Quantile Mapping Process

1. Understanding Distributions: A triangular distribution is defined by a minimum, maximum, and mode, while a normal distribution is characterized by a mean and standard deviation.

2. Quantile Mapping: This technique involves mapping each quantile (or percentile) of the triangular distribution to the corresponding quantile of the normal distribution.
3. Steps:
Generate Samples: Draw samples from the triangular distribution using its parameters (min, max, mode).
Obtain quantiles such as Minimum, 5%, 10%, Median, Average, 90%, 95%, and Maximum.
Compute

A) The <u>mean</u> is a weighted average of <u>Average</u> and <u>Median</u>;

$$\mu = \text{Average} * P_1 + \text{Median} * P_2, \text{ where } P_1 + P_2 = 1.0$$

B) The standard deviation as an average of the

$$\sigma_1 = (P_{95} - \mu) / 1.645$$
$$\sigma_2 = (\mu - P_5) / 1.645$$
$$\sigma_3 = (P_{90} - \mu) / 1.28$$
$$\sigma_4 = (\mu - P_{10}) / 1.628$$
$$\sigma_{avg} = \text{Avg}(\sigma_1, \sigma_2, \sigma_3, \sigma_4)$$

The above equations were applied for a variety if values for P_1 *and* P_2 to calculate the normal distribution parameters and found that $P_1 = 0.75$ *and* $P_2 = 0.25$ to provide similar performance to that of the triangular distribution away from the tails. Graphical depiction of Triangular-Normal quantile mapping and tail sensitivity is shown below

Graphical Justification and Use of Triangular Distributions for Normal Approximation

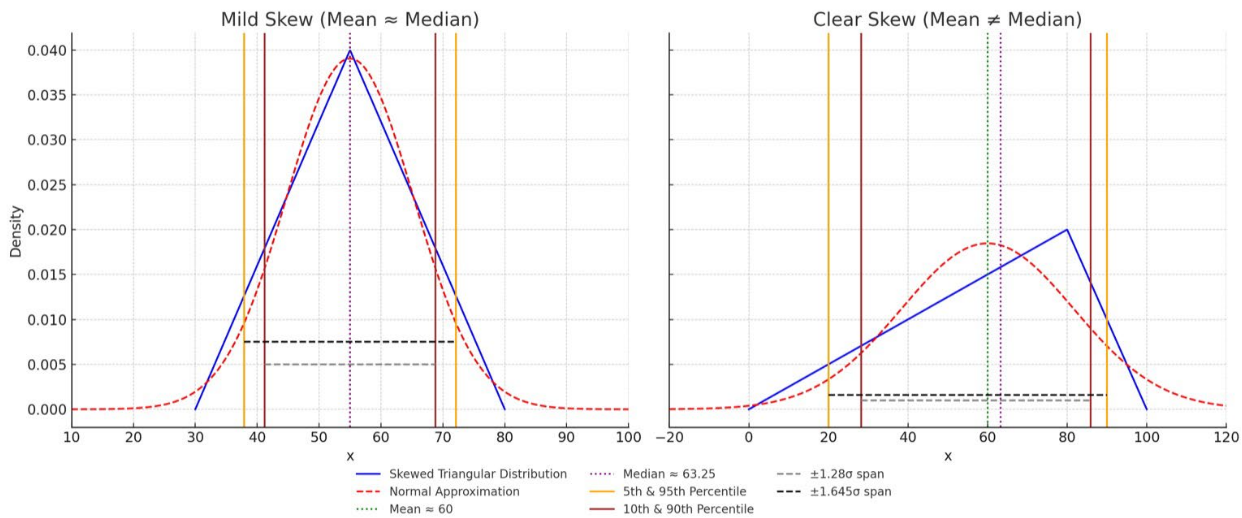
To better understand the validity and behavior of triangular distributions when estimating normal distributions, we developed a set of comparative graphs. These figures demonstrate the behavior of two triangular distributions: one with mild skewness and another with clear skewness. These visual comparisons support the mapping method described above and help justify when and how a triangular distribution can be treated as a proxy for a normal distribution using quantile mapping.

1. Mild Skewness (Mean ≈ Median)
In this case, the triangular distribution is nearly symmetric. As shown in Figure 1a below, the superimposed normal distribution aligns closely with the triangular distribution — especially around the peak. The tails remain reasonably close, making this a good candidate for approximation. This supports the use of quantile mapping with P1 = 0.75 and P2 = 0.25, as the weighted average between the mean and median results in a normal distribution that mirrors the original distribution well.

2. Clear Skewness (Mean ≠ Median)
Figure 1b highlights a more pronounced skew. The triangular distribution diverges more visibly from the normal approximation, particularly in the tails. However, quantile mapping improves tail accuracy, especially when multiple percentile-based standard deviations are averaged, as described in the σ_1 through σ_4 definitions. While the normal distribution cannot fully capture the asymmetry, the mapping still yields a stable central estimate and significantly reduces instability in the tails, which is critical for applications such as HEC-FDA modeling.

Both figures were generated using fixed triangular parameters and overlayed with their normal counterparts derived via quantile mapping. These visuals reinforce the observation that triangular distributions can serve as an effective stand-in for normal ones, particularly in applications where stability and simplicity are preferred, and especially when the tails are stabilized using the quantile method.

Figures 1a and 1b: Superimposed triangular and normal distributions under mild and clear skewness.



(a) (b)

Figure 1: Graphical comparison of triangular and normal distributions under two types of skewness.

This approach was applied to calculate average foundation heights and std. divisions for different occupancy types as summarized in Table 1.

Table 1. Calculated average foundation heights and Std. Deviations

Occupancy	Revised FDA Distribution Type	Average	Std. Dev. for Normal Distribution
AGR1	N	1.24	0.50
COM1	N	1.27	1.14
COM10	N	1.20	0.87
COM2	N	1.27	1.14
COM3	N	1.27	1.14
COM5	N	0.58	0.26
COM6	N	2.94	1.06
COM8	N	2.03	2.48
COM9	N	1.27	1.14
EDU1	N	1.08	0.59
EDU2	N	1.08	0.59
ESSM	N	1.75	0.75
GOV1	N	1.68	2.44
IND1	N	1.42	1.35
IND2	N	1.42	1.35
IND3	N	0.65	0.30
IND4	N	1.42	1.35
IND5	N	1.42	1.35
PWTM	N	1.75	0.75
REL1	N	1.88	2.26
RES2	N	2.92	2.00
RES3C	N	1.27	0.70
RES3E	N	1.18	0.54
RES4	N	1.61	1.39
RES5	N	0.86	0.16
RES6	N	1.00	0.27
WWTM	N	1.75	0.75

Appendix C: Sensitivity Testing

It is important to note the first three sets of data provided as input to HEC-FDA were ECB, FWOPi, and FWOPh. These sets used a custom coordinate system NAD 1983 (2011) Florida State Plane East in feet. The custom coordinate system was assigned via an accompanying “world” file (*.tfw) for each tif. For all other scenarios, a standard NAD 1983 projection with Well Known ID (WKID) 2236 was applied and embedded in the *.tif files. The NAD 1983 (2011) shift is an adjustment to the NAD 1983 geographic projection that considers updated coordinates of the North American NGS Continuous Operating Reference Stations (CORS) in a 'National Adjustment of 2011 Project' conducted by NGS. A review indicated approximate 5-foot horizontal shift between the Existing and Future Without Project Rasters and the Final Array/TSP Rasters. To evaluate the impact of the shift, a rerun of ECB, FWOPi, and FWOPh were conducted using tiffs projected with NAD 1983, WKID 2236. The results, summarized in Table 1 below, confirmed that the differences are negligible. Accordingly, comparisons utilizing the HEC-FDA results in plan formulation remain valid.

Table 35 Sensitivity run Comparison

	ECB_2035_initial run ($)	ECB_2035_rerun ($)	diff ($)	diff (%)
C-11 East (upstream)	240,668,446	240,266,228	402,218	0.17%
C-11 West (upstream)	395,763,018	396,144,312	-381,294	-0.10%
C-12 West (upstream)	70,693,692	70,798,238	-104,547	-0.15%
C-13 West (upstream)	176,117,172	176,270,754	-153,583	-0.09%
C-14 East (upstream)	49,453,276	49,405,359	47,917	0.10%
C-14 West (upstream)	420,481,254	419,164,145	1,317,109	0.31%
Hillsboro Canal (upstream)	676,664,528	677,075,024	-410,496	-0.06%
North New River Canal West (upstre	181,198,801	181,034,939	163,862	0.09%
Pompano Canal (upstream)	27,836,875	27,849,470	-12,595	-0.05%
Total	2,238,877,062	2,238,008,470	868,592	0.04%

	FWOP_i_2085_initial run ($)	FWOP_i_2085_rerun ($)	diff ($)	diff (%)
C-11 East (upstream)	241,409,103	241,159,843	249,260	0.10%
C-11 West (upstream)	395,808,144	396,181,236	-373,091	-0.09%
C-12 West (upstream)	70,716,548	70,820,621	-104,073	-0.15%
C-13 West (upstream)	176,717,730	176,888,311	-170,580	-0.10%
C-14 East (upstream)	49,946,262	49,889,688	56,575	0.11%
C-14 West (upstream)	420,440,440	419,120,077	1,320,363	0.31%
Hillsboro Canal (upstream)	676,378,914	676,789,915	-411,000	-0.06%
North New River Canal West (upstre	181,586,296	181,422,878	163,418	0.09%
Pompano Canal (upstream)	27,997,683	28,010,949	-13,266	-0.05%
Total	2,241,001,121	2,240,283,517	717,604	0.03%

	FWOP_h_2085_initial run ($)	FWOP_h_2085_rerun ($)	diff ($)	diff (%)
C-11 East (upstream)	256,573,344	256,859,659	-286,315	-0.11%
C-11 West (upstream)	396,978,558	397,358,455	-379,897	-0.10%
C-12 West (upstream)	71,852,512	72,000,521	-148,009	-0.21%
C-13 West (upstream)	180,726,197	180,933,958	-207,760	-0.11%
C-14 East (upstream)	65,220,662	65,240,350	-19,687	-0.03%
C-14 West (upstream)	421,226,388	419,885,072	1,341,316	0.32%
Hillsboro Canal (upstream)	677,416,986	677,801,761	-384,775	-0.06%
North New River Canal West (upstre	183,647,644	183,447,579	200,065	0.11%
Pompano Canal (upstream)	28,582,576	28,597,969	-15,392	-0.05%
Total	2,282,224,868	2,282,125,322	99,546	0.00%

Data for WKID 2236

Projected Coordinate System NAD 1983 StatePlane Florida East FIPS 0901 (US Feet)
Projection Transverse Mercator
WKID 2236
Previous WKID 102658
Authority EPSG
Linear Unit US Survey Feet (0.3048006096012192)
False Easting 656166.6666666665
False Northing 0.0
Central Meridian -81.0
Scale Factor 0.9999411764705882
Latitude Of Origin 24.33333333333333

Geographic Coordinate System NAD 1983
WKID 4269
Authority EPSG
Angular Unit Degree (0.0174532925199433)
Prime Meridian Greenwich (0.0)
Datum D North American 1983
Spheroid GRS 1980
Semimajor Axis 6378137.0
Semiminor Axis 6356752.314140356
Inverse Flattening 298.257222101

Data for Custom Projection

Projected Coordinate System NAD_1983_2011_StatePlane_Florida_East_FIPS_0901_Ft_US
Projection Transverse Mercator
Authority Custom
Linear Unit US Survey Feet (0.3048006096012192)
False Easting 656166.667
False Northing 0.0
Central Meridian -81.0
Scale Factor 0.999941177
Latitude Of Origin 24.3333333333333

Geographic Coordinate System NAD 1983 (2011)
WKID 6318
Previous WKID 104145
Authority EPSG
Angular Unit Degree (0.0174532925199433)
Prime Meridian Greenwich (0.0)
Datum D NAD 1983 2011
Spheroid GRS 1980
Semimajor Axis 6378137.0
Semiminor Axis 6356752.314140356
Inverse Flattening 298.257222101

References

Economic Guidance Memorandum, 09-04, Generic Depth-Damage Relationships for Vehicles, USACE, June 2009

Development of Depth-Emergency Cost and Infrastructure Damage Relationships for Selected South Louisiana Parishes, New Orleans District, US Army Corps of Engineers, March 2012

Nonresidential Flood Depth-Damage Functions Derived from Expert Elicitation, published April 2009

Python Script for Adjusting MIKE SHE Overland Depth Result Rasters and Creating Georeferenced TIFFs for input to HEC-FDA 2.0, South Florida Water Management District, SFMWD. March 2025

Incorporating ATLAS14 and CHS data into the joint probability framework for C&SF Flood Resiliency (Section 216) Study (reference to UCF report)

Model Documentation Report, Central and Southern Florida Flood Resiliency Study Broward Basins (Section 203), South Florida Water Management District, SFMWD. October 2025.

Risk-Based Analysis for Flood Damage Reduction Studies, Engineering Manual 1110-2-1619, USACE, August 1996