

Creating a Path to Climate Resilience for Coastal Treatment Facilities – A Case Study

Bethune Point Water Reclamation Facility (BPWRF) Resiliency Plan for City of Daytona Beach

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PRESENTERS

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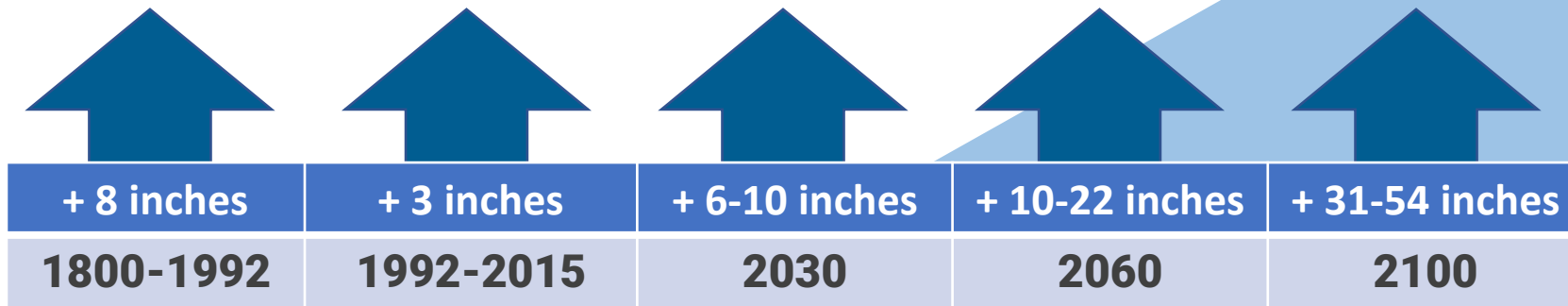
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RISING SEA LEVELS

Daytona Beach, FL

The Rise of Mean Sea Level – Historic and Future Projections



BACKGROUND

FACILITY IMPACTED

- Hurricane Matthew, October 2016 – Category 2
 - Facility power was disrupted
 - Emergency generator failed
 - Disruption of UV disinfection process.
 - 14 million gallons of wastewater flowed into Halifax
- Hurricane Irma, September 2017 – Category 2
 - Produced storm surge that came within 6 inches of MCC room doorway
- Both events arrived at less than high tide

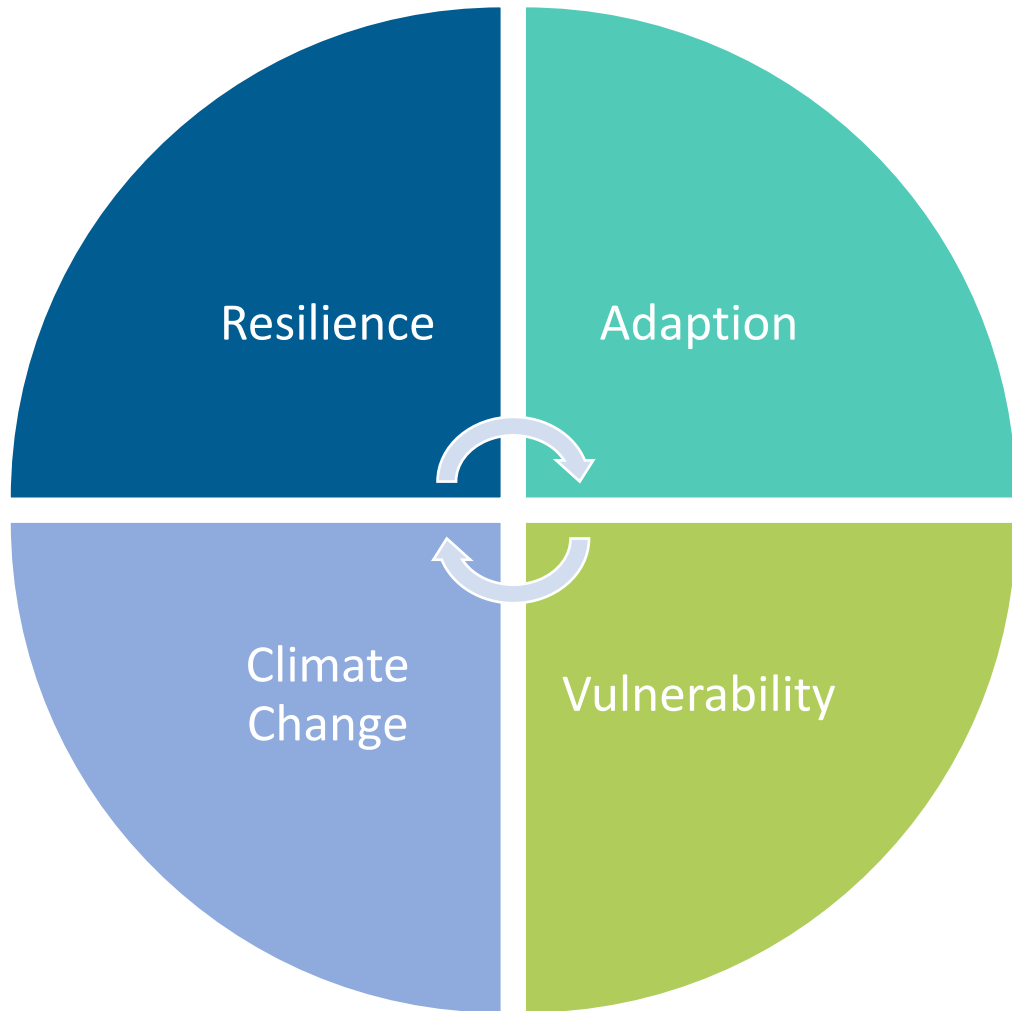


City made the decision to evaluate the facility for **climate vulnerability** and to create a road to resilience.

BPWRF Site Plan



FACILITY CLIMATE ADAPTATION PLANNING*



1. Understand projected impacts and challenges
 - Use appropriate NOAA Projected SLR Curve
 - Determine service life of facility
 - Determine event to be evaluated
 - Determine flooding evaluation
2. Identify thresholds for failure or damage
 - Evaluate projected impact
3. Assess risk
4. Determine adaptation options
5. Implement and monitor

STEP 1

SEA LEVEL RISE AND STORM SURGE PREDICTIONS FOR BPWRF

Year	2020	2030	2050	2070	2100
Sea Level Rise (feet) ¹	0.72	1.21	2.49	4.4	8.4
Intracoastal Waterway MHHW Tide Elevation ²	-0.22 ³				
MHHW Tide Elevation ² including SLR	.50	.99	2.27	4.18	8.18
Category 1 Hurricane Storm Surge + SLR Elevation ^{2,4}	6.30	6.79	8.07	9.98	13.98
Category 2 Hurricane Storm Surge + SLR Elevation ^{2,4}	8.29	8.78	10.06	11.97	15.97
Category 3 Hurricane Storm Surge + SLR Elevation ^{2,4}	13.42	13.91	15.19	17.10	21.10
Category 4 Hurricane Storm Surge + SLR Elevation ^{2,4}	20.16	20.65	21.93	23.84	27.84
Category 5 Hurricane Storm Surge + SLR Elevation ^{2,4}	24.01	24.50	25.78	27.69	31.69

¹ SLR projections were obtained from NOAA 2017 high projection curve.

² Elevations in feet are referenced to NAVD88.

³ Appendix A provides more information regarding the determination of this elevation.

⁴ Mean elevation within limits of the BPWRF.

CRITICAL INFRASTRUCTURE EXAMPLES



Electrical Gear/MCCs



Pumps, Motors and Control Panels



Diesel Generators



Blowers, Motors and Control Panels



Clarifiers

STEPS 2 & 3

WRF DAMAGE THRESHOLDS

Critical Equipment	Critical Damage Elevation ¹	Category Hurricane (2020 MHHW+ SLR)	Notes	WRF Inoperable After Water Recedes ²	Criticality ³
Plant Lift Station	5.1	1	Pump motor submerged	No	Low
Influent Pump Station	5.3		Power Panel/Disconnect Switch submerged	Yes	High
UV Disinfection Area	5.8		UV Bank Panels submerged	Yes	High
Denitrification Filters	5.8		Power supply submerged	Long-Term Yes	High
Switch Gear Building	5.9		Generator Control Panel submerged	Yes	High
Control Building	5.9		Finish floor elevation	No	Low
Effluent NPW Pump Building	6.0		Reuse motors submerged	No	Low
Blower Area	6.3		Control panel submerged	Yes	High
UV Generator Building Area	6.4	2	Transformer submerged	Long-Term Yes	High
RAS Pump Station No. 2 (Clarifiers 3, 5, & 6)	7.4		RAS Motors submerged	Yes	High
WRWRF Connect	7.6		Reuse Main Valve Control Panel submerged	No	Low
MCC-2	7.6		Panels submerged	Yes	High
MCC-3	7.9		VFDs submerged	Yes	High
RAS Pump Station No. 1 (Clarifiers 1, 2, & 4)	8.0		RAS Motors submerged	Yes	High
Final Clarifiers	8.0		Clarifiers inundated	Yes	High
Pretreatment Structure	8.1		Screening & Grit Remover Control Panel submerged	Long-Term Yes	Low
Mobile Generator	9.2	3	Generator submerged	Yes	High
Clarified Liquid Pump Station	9.8		Control panel submerged	Yes	High
Clarifier Splitter Boxes	9.9		Splitter inundated	Yes	High
Aeration Tank 3 & 4	11.4		Tank inundated	Yes	High
Clearwell	12.9	4	Tank inundated	No	Low
Aeration Tank 1 & 2	18.9		Tank inundated	Yes	High
First Anoxic Tank 2	20.4	5	Tank inundated	Yes	High
Anaerobic Tank	24.1		Tank inundated	Yes	High
First Anoxic Tank 1	24.5	N/A	Tank inundated	Yes	High

¹ Elevations in feet in reference to NAVD88

² "Yes" means damage to equipment renders WRF unable to maintain treatment within 12 hours. "Long-Term Yes" means damage to equipment renders WRF unable to maintain treatment after multiple days

³ "Low" – WRF can treat incoming wastewater to effluent standards, "Medium" – Solids processing treatment out of operation, but WRF can treat incoming wastewater to effluent standards, "High" – WRF unable to treat incoming wastewater to permitted effluent limits

ESTIMATED DAMAGE COSTS* FOR CRITICAL EQUIPMENT (STEP 2)

Critical Equipment	Electrical Component Replacement Costs	Complete Equipment Replacement Costs
Plant Lift Station	\$60,000	\$200,000
Influent Pump Station	\$240,000	\$1,500,000
UV Disinfection Area	\$570,000	\$3,800,000
Denitrification Filters	\$470,000	\$4,300,000
Switch Gear Building	\$200,000	\$200,000
Control Building	\$200,000	\$200,000
Effluent NPW Pump Building	\$80,000	\$400,000
Blower Area	\$420,000	\$2,400,000
UV Generator Building Area	\$400,000	\$400,000
RAS Pump Station No. 2 (Clarifiers 3, 5, & 6)	\$120,000	\$500,000
WRWRF Connect	\$80,000	\$200,000
MCC-2	\$3,300,000	\$3,300,000
MCC-3	\$3,400,000	\$3,400,000
RAS Pump Station No. 1 (Clarifiers 1, 2, & 4)	\$120,000	\$500,000
Final Clarifiers	\$240,000	\$7,700,000
Pretreatment Structure	\$460,000	\$2,800,000
Mobile Generator	\$300,000	\$300,000
Clarified Liquid Pump Station	\$360,000	\$2,400,000
First Anoxic Tank 2	\$100,000	\$100,000
Anaerobic Tank	\$100,000	\$100,000
First Anoxic Tank 1	\$100,000	\$100,000

* 2020 Construction Estimate

STEP 4

PROTECTION OPTIONS EVALUATED



Option 1: Do Nothing (Baseline)

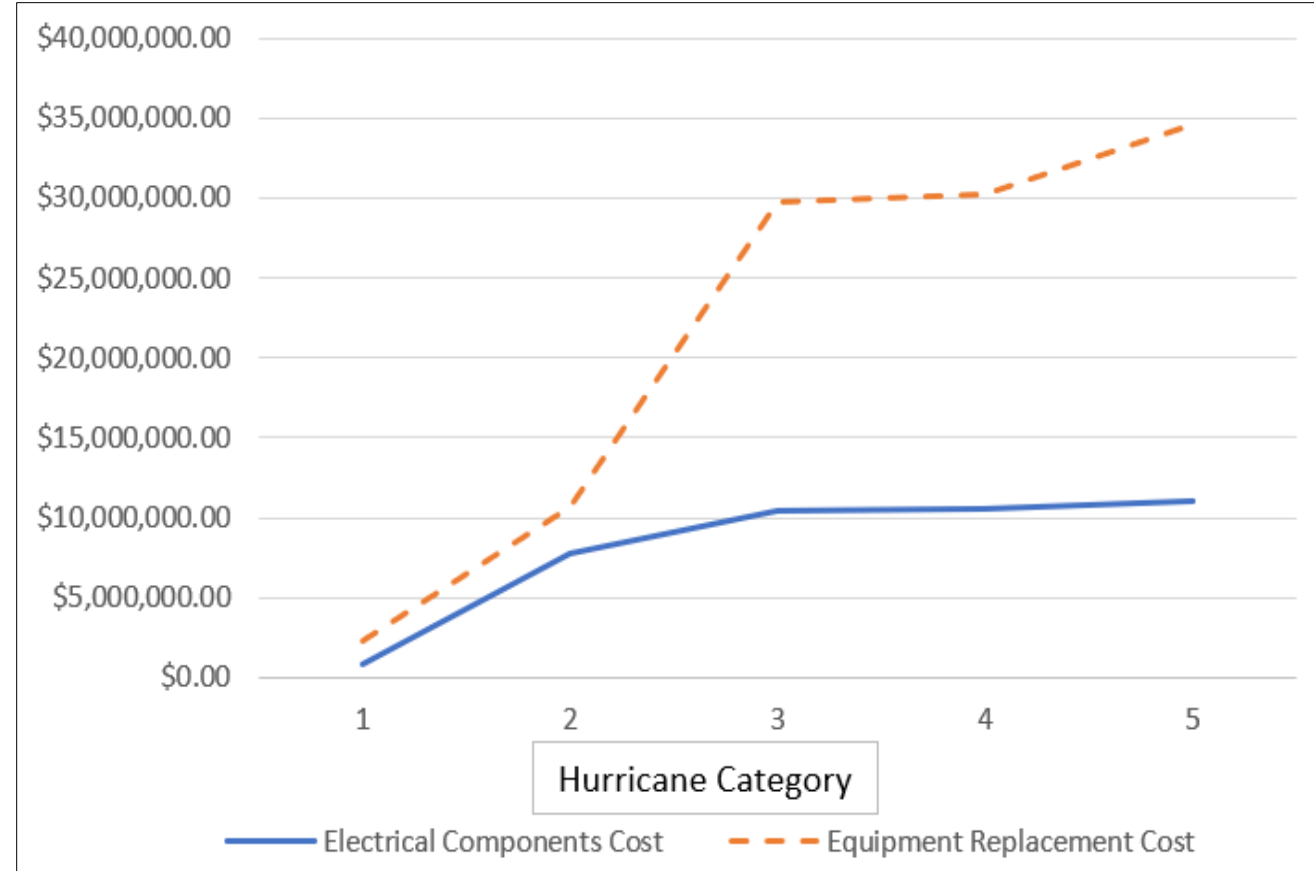
Option 2: Deployable Barriers

Option 3: Perimeter Berm Wall Options

Option 4: Convert BPWRF to Pump Station and Pump to Expanded Westside Regional WRF

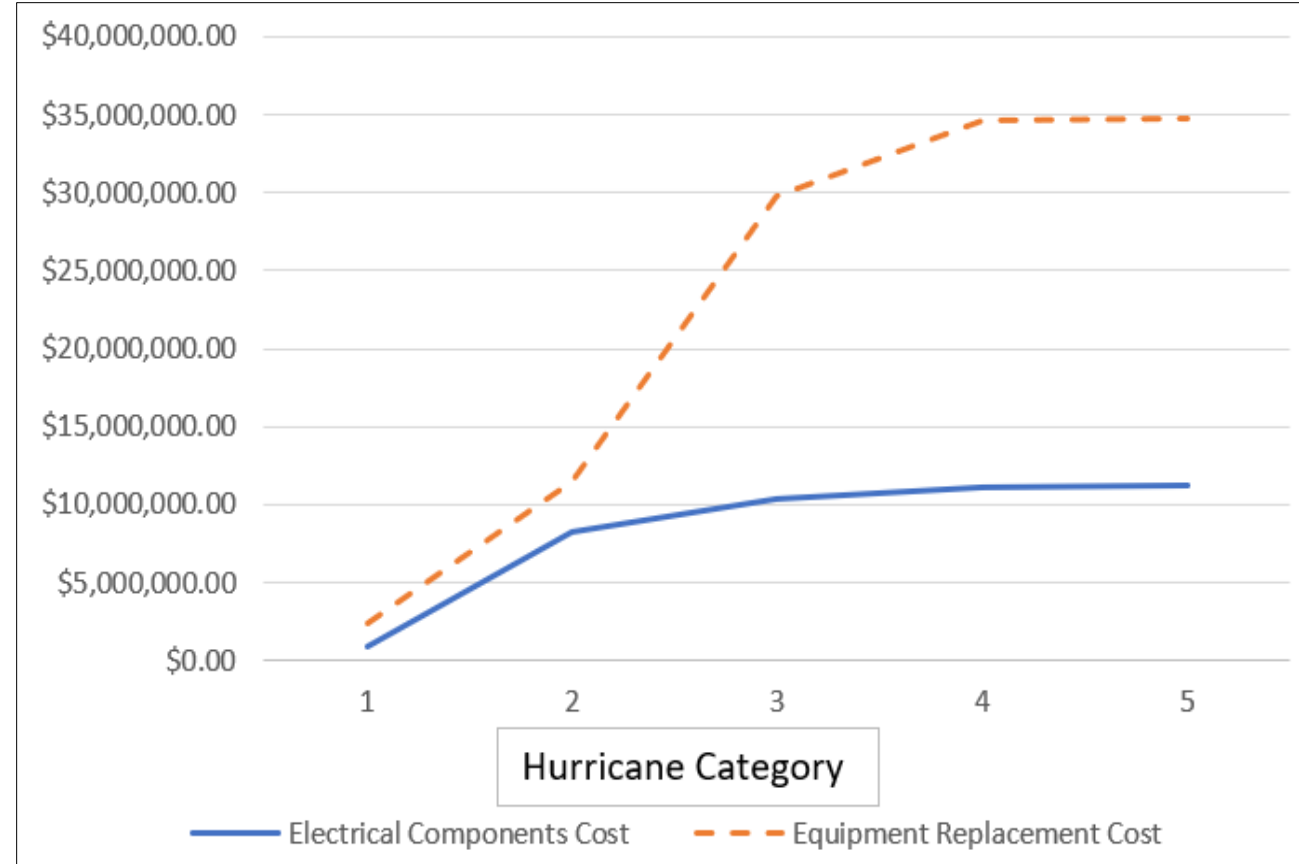
BPWRF ESTIMATED DAMAGE COSTS VS. STORM SURGE ELEVATION FOR YEAR 2020 (BASELINE)

Hurricane Category	Projected Surge Elevation (ft NAVD88)	Estimated Damage Costs	
		Electrical Components	Equipment Replacement
1	6.30	\$801,850	\$2,250,850
2	8.29	\$7,721,550	\$10,699,550
3	13.42	\$10,409,550	\$29,739,550
4	20.16	\$10,528,800	\$30,213,800
5	24.01	\$11,079,000	\$34,600,000



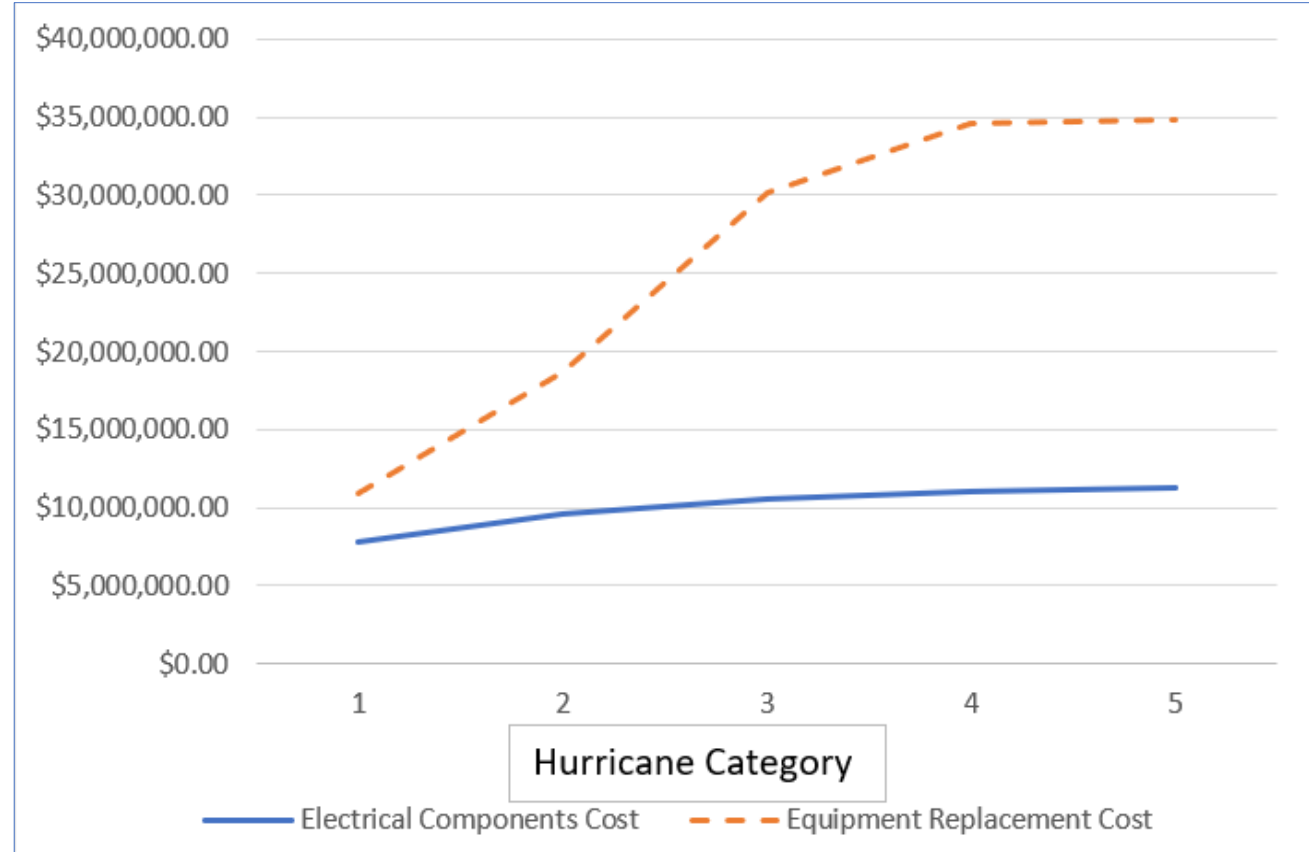
BPWRF ESTIMATED DAMAGE COSTS VS. STORM SURGE ELEVATION FOR YEAR 2030 (BASELINE)

Hurricane Category	Projected Surge Elevation (ft NAVD88)	Estimated Damage Costs	
		Electrical Components	Equipment Replacement
1	6.79	\$854,100	\$2,409,100
2	8.78	\$8,186,900	\$11,486,900
3	13.91	\$10,409,550	\$29,739,550
4	20.65	\$11,079,000	\$34,600,000
5	24.50	\$11,279,000	\$34,800,000



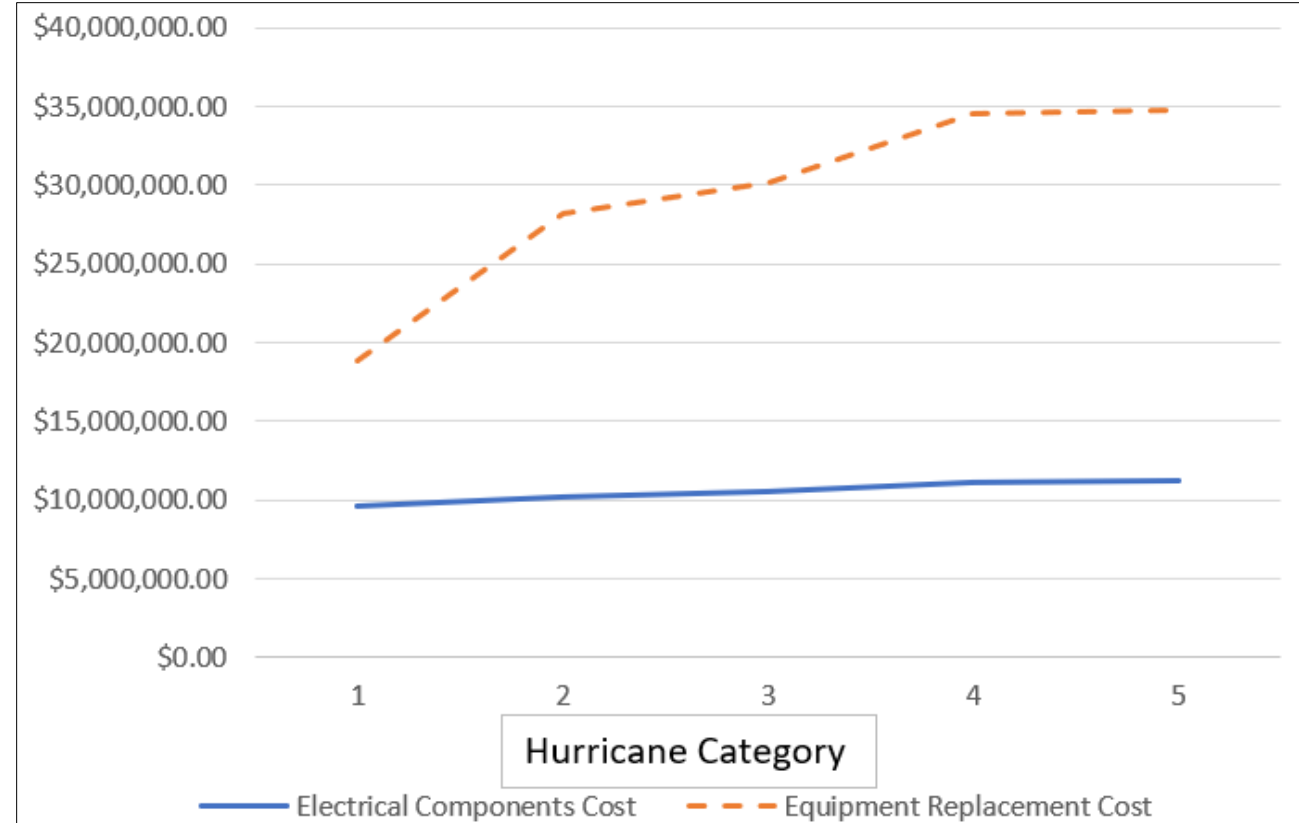
BPWRF ESTIMATED DAMAGE COSTS VS. STORM SURGE ELEVATION FOR YEAR 2050 (BASELINE)

Hurricane Category	Projected Surge Elevation (ft NAVD88)	Estimated Damage Costs	
		Electrical Components	Equipment Replacement
1	8.07	\$7,796,700	\$10,924,700
2	10.06	\$9,576,250	\$18,707,250
3	15.19	\$10,515,000	\$30,200,000
4	21.93	\$11,079,000	\$34,600,000
5	25.78	\$11,279,000	\$34,800,000



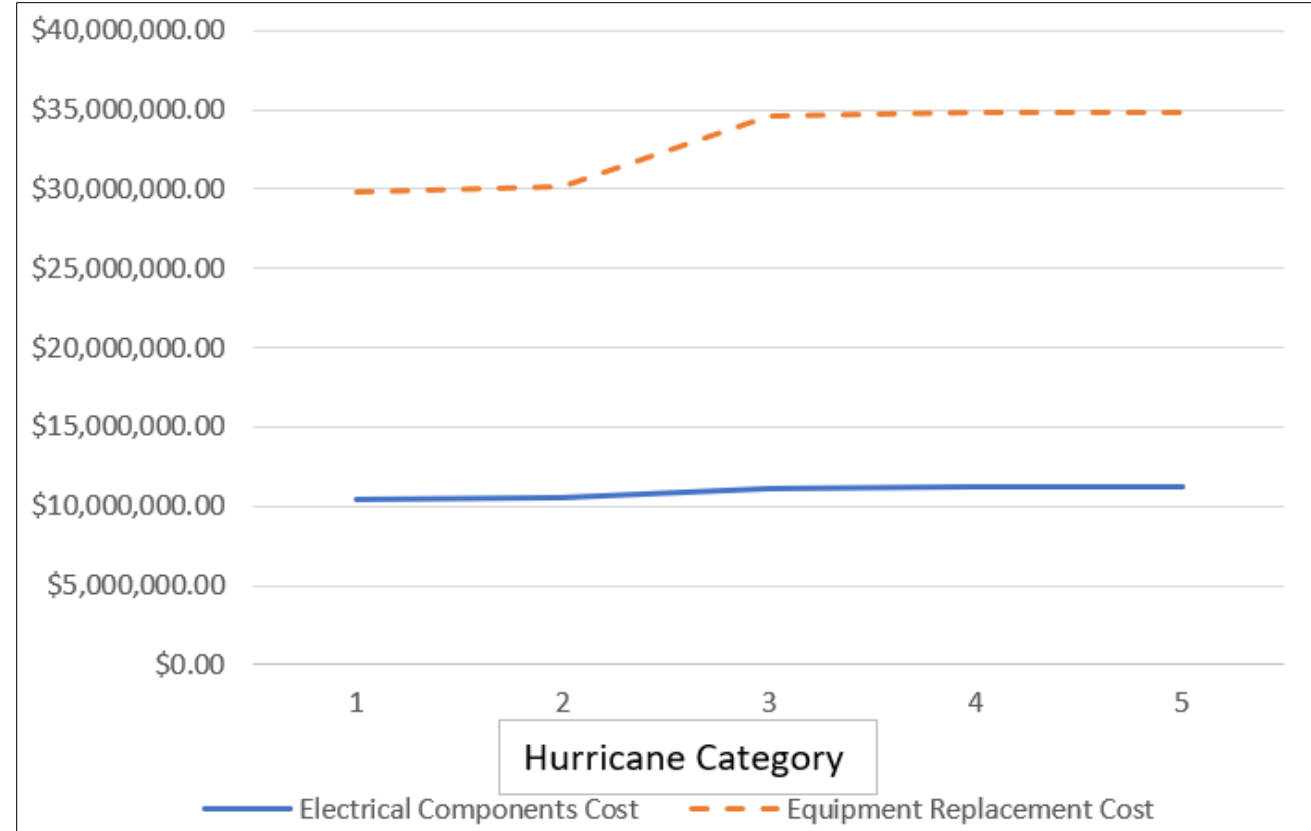
BPWRF ESTIMATED DAMAGE COSTS VS. STORM SURGE ELEVATION FOR YEAR 2070 (BASELINE)

Hurricane Category	Projected Surge Elevation (ft NAVD88)	Estimated Damage Costs	
		Electrical Components	Equipment Replacement
1	9.98	\$9,671,950	\$18,833,950
2	11.97	\$10,200,400	\$28,216,400
3	17.10	\$10,528,800	\$30,213,800
4	23.84	\$11,079,000	\$34,600,000
5	27.69	\$11,279,000	\$34,800,000



BPWRF ESTIMATED DAMAGE COSTS VS. STORM SURGE ELEVATION FOR YEAR 2100 (BASELINE)

Hurricane Category	Projected Surge Elevation (ft NAVD88)	Estimated Damage Costs	
		Electrical Components	Equipment Replacement
1	13.98	\$10,444,050	\$29,774,050
2	15.97	\$10,515,000	\$30,200,000
3	21.10	\$11,079,000	\$34,600,000
4	27.84	\$11,279,000	\$34,800,000
5	31.69	\$11,279,000	\$34,800,000



OPTION 2 – “DEPLOYABLE” FLOOD PROTECTION EXAMPLES



Flood Planks

Sliding Flood Gates



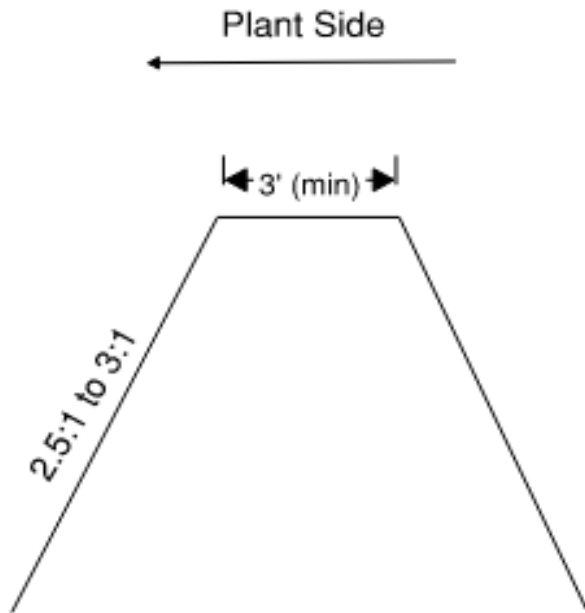
Deployable Protection Example – Up to Cat. 2, Year 2050



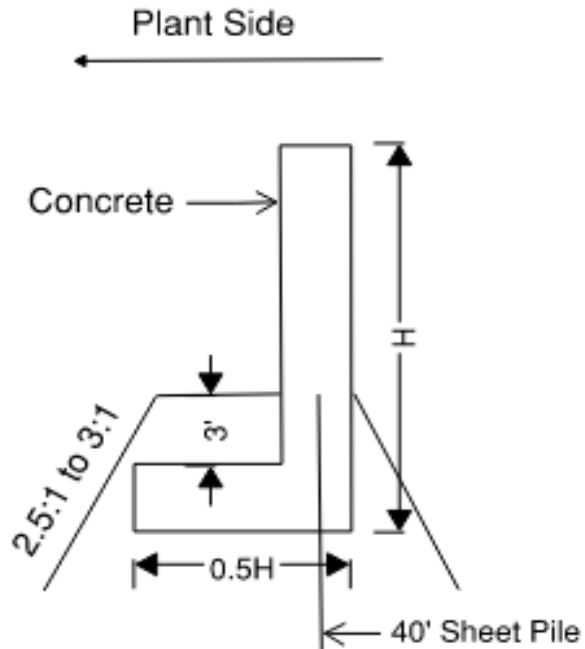
DEPLOYABLE FLOOD BARRIERS PRELIMINARY COST ESTIMATE

Storm Surge Elevation (ft. NAVD88)	Category of Hurricane Protection Level (Year)	Total Cost
8.07	1 (2050)	\$8 million
10.06	2 (2050)	\$12 million

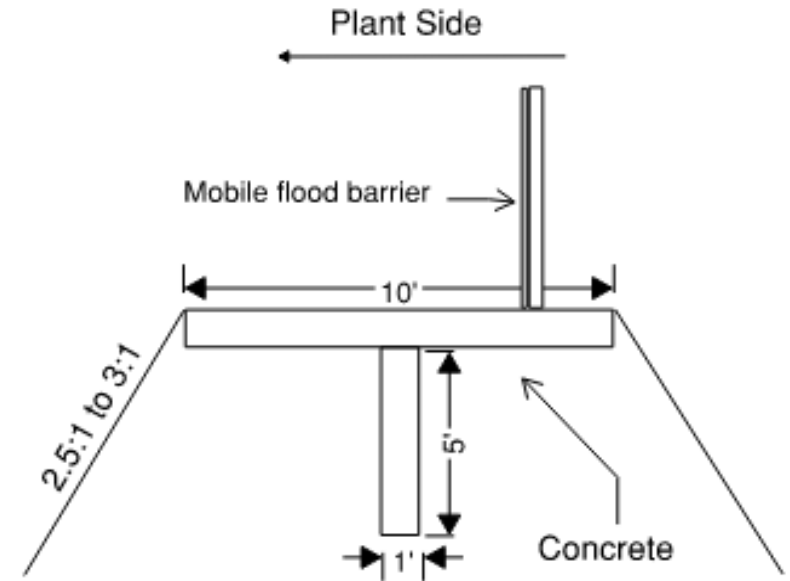
OPTION 3 – BERM WALL FLOOD PROTECTION EXAMPLES



Earthen Berm (Type A)



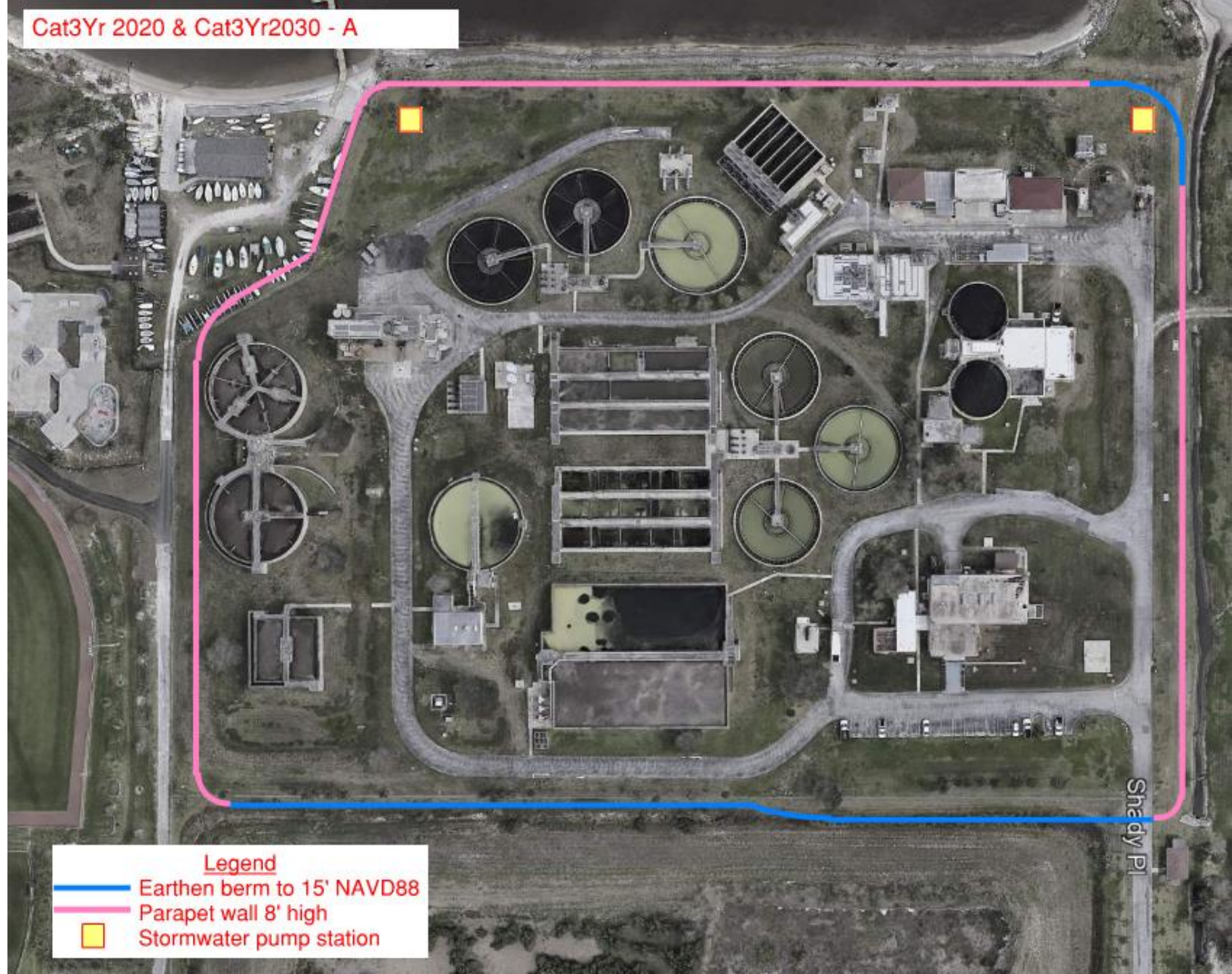
Parapet Wall (Type B)



Mobile Flood Barrier (Type C)

Berm Cross-Sections

Berm Wall Protection Example – Cat 3, Year 2030 and Greater



PERIMETER BERM OPTIONS EVALUATED

Hurricane Category	Year	Storm Surge Elevation (ft NAVD88)	Protection Level (ft NAVD88)	Berm Type	Berm Description
3	2020 / 2030	13.91	15	A	Earthen berm to 15 ft NAVD88 where possible. Otherwise, parapet wall.
				B	Earthen berm to 11 ft NAVD88 where possible. Parapet wall to 15' NAVD88. 4' high access gate on entry road.
	2050	15.19	17	A	Earthen berm to 17 ft NAVD88 where possible. Otherwise, parapet wall.
				B	Earthen berm to 11 ft NAVD88 where possible. Parapet wall to 17 ft NAVD88. 6' high access gate on entry road.
	2070	17.10	19	A	Earthen berm to 19 ft NAVD88 where possible. Otherwise, parapet wall.
				B	Earthen berm to 11 ft NAVD88 where possible. Parapet wall to 19 ft NAVD88. 8' high access gate on entry road.
	2100	21.10	23	B	Earthen berm to 11 ft NAVD88 where possible. Parapet wall to 23' NAVD88. 12' high access gate on entry road.
				C	Earthen berm to 7 ft NAVD88. Flood planks 16' high.
5	2020 / 2030	24.50	26	B	Earthen berm to 11 ft NAVD88 where possible. Parapet wall to 26' NAVD88. 15' high access gate on entry road.
				C	Earthen berm to 8 ft NAVD88. Flood planks 18' high.
	2050	25.78	27	B	Earthen berm to 11 ft NAVD88 where possible. Parapet wall to 27' NAVD88. 16' high access gate on entry road.
				C	Earthen berm to 9 ft NAVD88. Flood planks 18' high.
	2070	27.69	29	B	Earthen berm to 11 ft NAVD88 where possible. Parapet wall to 29' NAVD88. 18' high access gate on entry road.
				C	Earthen berm to 11 ft NAVD88. Flood planks 18' high.
	2100	31.69	33	B	Earthen berm to 15 ft NAVD88 where possible. Parapet wall to 33' NAVD88. 18' high access gate on entry road.
				C	Earthen berm to 15 ft NAVD88. Flood planks 18' high.

PERIMETER BERM PRELIMINARY COST ESTIMATE

Hurricane Category	Year	Storm Surge Elevation (ft NAVD88)	Protection Level (ft NAVD88)	A	B	C
3	2020 / 2030	13.91	15	\$12,500,000	\$16,100,000	N/A
	2050	15.19	17	\$13,500,000	\$16,800,000	N/A
	2070	17.10	19	\$14,600,000	\$17,500,000	N/A
	2100	21.10	23	N/A	\$18,900,000	\$25,000,000
5	2020 / 2030	24.50	26	N/A	\$20,000,000	\$27,700,000
	2050	25.78	27	N/A	\$20,400,000	\$27,900,000
	2070	27.69	29	N/A	\$21,000,000	\$28,000,000
	2100	31.69	33	N/A	\$23,100,000	\$30,300,000

BENEFIT/COST FOR OPTION 2 FOR YEAR 2050

Storm Surge Elevation (ft. NAVD88)	Category of Hurricane Protection Level	Total Cost	Preventable Damage Cost ¹	Benefit/Cost Ratio
8.07	1	\$8,000,000	\$10,924,700	1.4
10.06	2	\$12,000,000	\$18,707,250	1.6

¹ Preventable damage cost includes both electrical and mechanical equipment replacement costs.

BENEFIT/COST FOR OPTION 3 FOR YEAR 2030

Storm Surge Elevation (ft. NAVD88)	Category of Hurricane Protection Level	Berm Option	Protection Cost	Preventable Damage Cost ¹	Benefit/Cost Ratio
13.91	3	Earthen berm to 15 ft NAVD88 where possible. Otherwise, parapet wall.	\$12,500,000	\$29,739,550	2.4
		Earthen berm to 11 ft NAVD88 where possible. Parapet wall to 15 ft NAVD88. 4-ft high access gate on entry road.	\$16,100,000		1.8
24.50	5	Earthen berm to 11 ft NAVD88 where possible. Parapet wall to 26 ft NAVD88. 15-ft high access gate on entry road.	\$20,000,000	\$34,800,000	1.7
		Earthen berm to 8 ft NAVD88. Flood planks 18 ft high.	\$27,700,000		1.3

¹ Preventable damage cost includes both electrical and mechanical equipment replacement costs.

BENEFIT/COST FOR OPTION 3 FOR YEAR 2050

Storm Surge Elevation (ft. NAVD88)	Category of Hurricane Protection Level	Berm Option	Protection Cost	Preventable Damage Cost ¹	Benefit/Cost Ratio
15.19	3	Earthen berm to 17 ft NAVD88 where possible. Otherwise, parapet wall.	\$13,500,000	\$30,200,000	2.2
		Earthen berm to 11 ft NAVD88 where possible. Parapet wall to 17 ft NAVD88. 6-ft high access gate on entry road.	\$16,800,000		1.8
25.78	5	Earthen berm to 11 ft NAVD88 where possible. Parapet wall to 27 ft NAVD88. 16-ft high access gate on entry road.	\$20,400,000	\$34,800,000	1.7
		Earthen berm to 9 ft NAVD88. Flood planks 18 ft high.	\$27,900,000		1.2

¹ Preventable damage cost includes both electrical and mechanical equipment replacement costs.

BENEFIT/COST FOR OPTION 3 FOR YEAR 2070

Storm Surge Elevation (ft. NAVD88)	Category of Hurricane Protection Level	Berm Option	Protection Cost	Preventable Damage Cost ¹	Benefit/Cost Ratio
17.10	3	Earthen berm to 19 ft NAVD88 where possible. Otherwise, parapet wall.	\$14,600,000	\$30,213,800	2.1
		Earthen berm to 11 ft NAVD88 where possible. Parapet wall to 19 ft NAVD88. 8-ft high access gate on entry road.	\$17,500,000		1.7
27.69	5	Earthen berm to 11 ft NAVD88 where possible. Parapet wall to 29 ft NAVD88. 18-ft high access gate on entry road.	\$21,000,000	\$34,800,000	1.7
		Earthen berm to 11 ft NAVD88. Flood planks 18 ft high.	\$28,000,000		1.2

¹ Preventable damage cost includes both electrical and mechanical equipment replacement costs.

BENEFIT/COST FOR OPTION 3 FOR YEAR 2100 (2021 DOLLARS)

Storm Surge Elevation (ft. NAVD88)	Category of Hurricane Protection Level	Berm Option	Protection Cost	Preventable Damage Cost ¹	Benefit/Cost Ratio
21.10	3	Earthen berm to 11 ft NAVD88 where possible. Parapet wall to 23 ft NAVD88. 12-ft high access gate on entry road.	\$18,900,000	\$34,600,000	1.8
		Earthen berm to 7 ft NAVD88. Flood planks 16 ft high.	\$25,000,000		1.4
31.69	5	Earthen berm to 15 ft NAVD88 where possible. Parapet wall to 33 ft NAVD88. 18-ft high access gate on entry road.	\$23,100,000	\$34,800,000	1.5
		Earthen berm to 15 ft NAVD88. Flood planks 18 ft high.	\$30,300,000		1.1

¹ Preventable damage cost includes both electrical and mechanical equipment replacement costs.

BENEFIT/COST FOR OPTION 4 FOR YEAR 2100

Storm Surge Elevation (ft. NAVD88)	Category of Hurricane Protection Level	Protection Cost	Preventable Damage Cost ¹	Benefit/Cost Ratio
31.69	5	\$340,548,900	\$34,800,000	0.1

¹ Preventable damage cost includes both electrical and mechanical equipment replacement costs.

RECOMMENDATION

Target Event: 2050

- Provides approximately 30 years of projected “worst case” surge protection

Option: Option 3 Perimeter Wall with Stormwater Pumping System

- Highest B/C ratio
 - 2030 Cat. 3=2.4/Cat. 5=1.7
 - 2050 Cat. 3=2.2/Cat. 5=1.7
- Allows facility protection today against Cat. 5 storm surge
- Provides baseline protection that can be built upon should SLR accelerate
- Defers construction costs to a point in the future where they maybe needed, only if needed

NEXT STEPS!

- ✓ 1. Discuss resilience measures with City staff through a workshop. **COMPLETE**
 2. Seek funding for resilience measures.
 3. Based on workshop, develop plan with appropriate funding for design and installation.
 4. Step resilience measures as appropriate to meet SLR/Surge projections.
 5. Monitor actual SLR vs. projected SLR.
 6. Adjust plan as necessary moving forward.
-

QUESTIONS?



CONTACT US



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