

C2, C3W, C4, C5, C6 Flood Protection Level of Service for Current and Future SLR

September 12, 2023



chen moore and associates



Presentation Outline

1. FPLOS Overview
2. Model Selection
3. Study Area and Model Domain
4. Model Setup
5. Current/Future Conditions Setup
6. FPLOS Metrics
7. Current/Future Results
8. Preliminary Mitigation Strategies



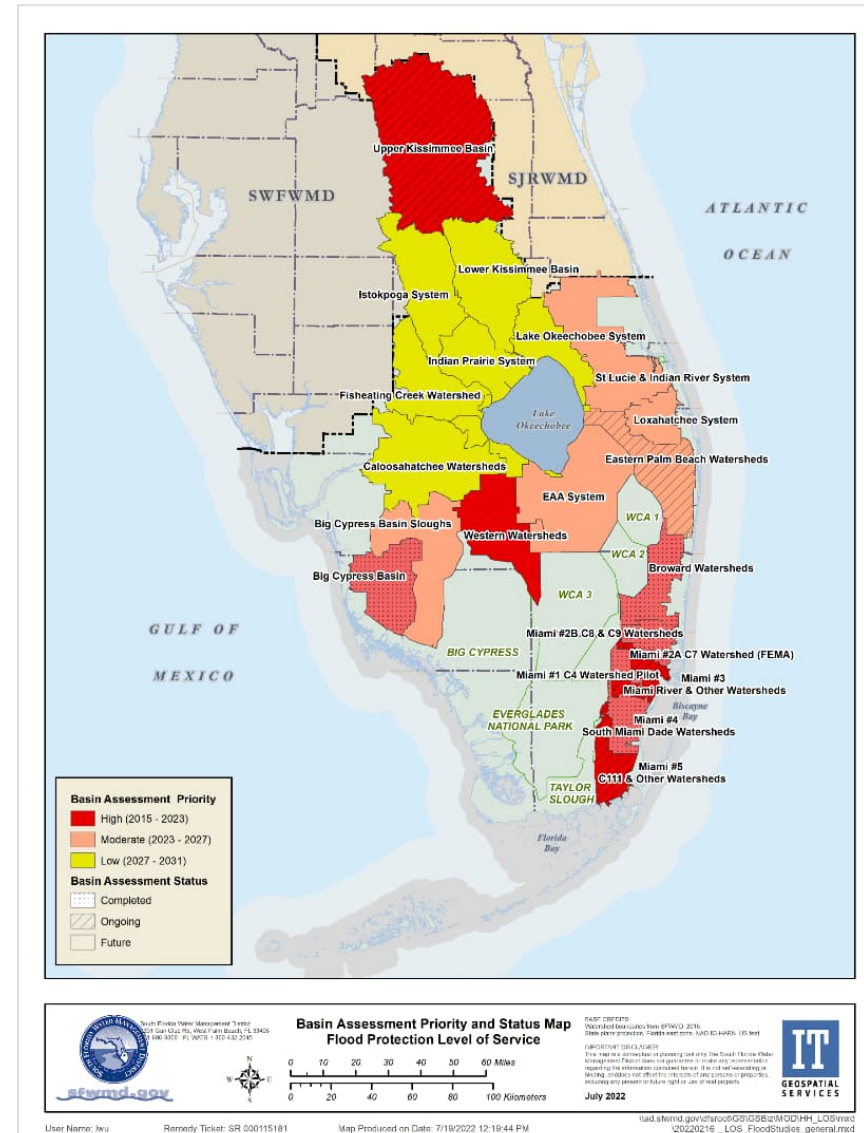
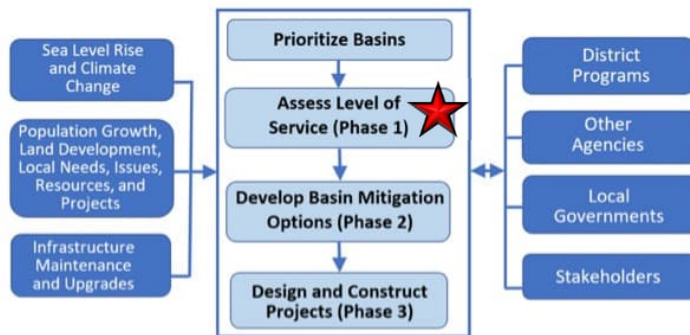
**C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR**



FPLOS Program Overview

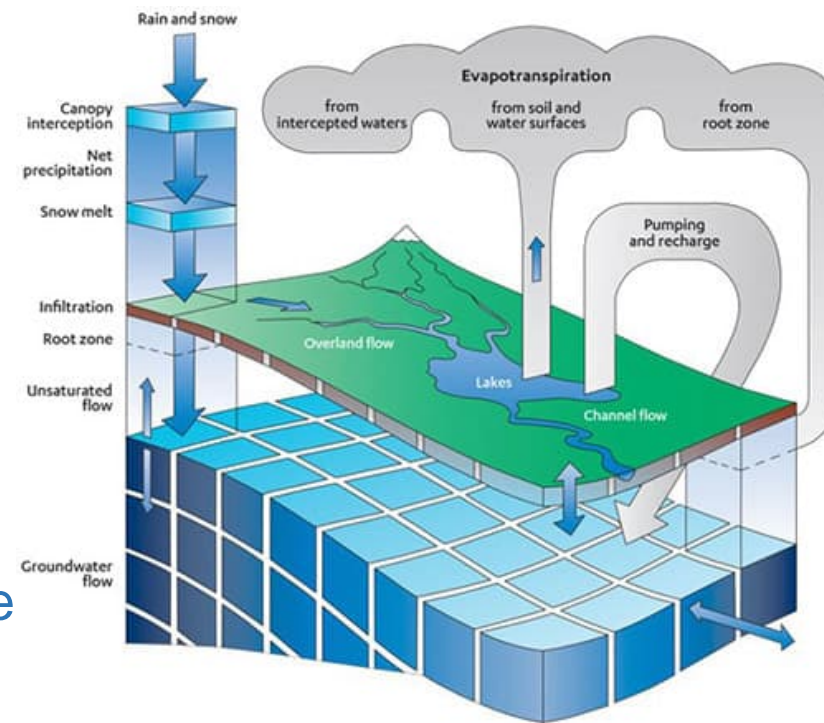
- To fulfill the need of long-term flood protection for basins throughout the 16-county region, a flood protection level of service (FPLOS) program has been established.
- Mission:
 - Identify and prioritize long-term infrastructure improvement needs
 - Develop an implementation strategy
- Goal: to assure that each basin can maintain its designated FPLOS, in a technical and cost-effective manner, in response to population growth, land development, sea level rise and climate conditions change.

Flood Protection Level of Service Program Overview



Model Selection

1. HEC/HMS/HEC-RAS/HEC-RAS2D
2. ICPR4
3. EPA SWMM5/XP-SWMM
4. MIKE SHE/MIKE HYDRO River
 - Hydrology → two-dimensional, physically-based representation of the land surface
 - Hydraulics → allows for control structure operations
 - Groundwater → Interconnectivity with surface water, while accommodating multiple groundwater layers



C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR

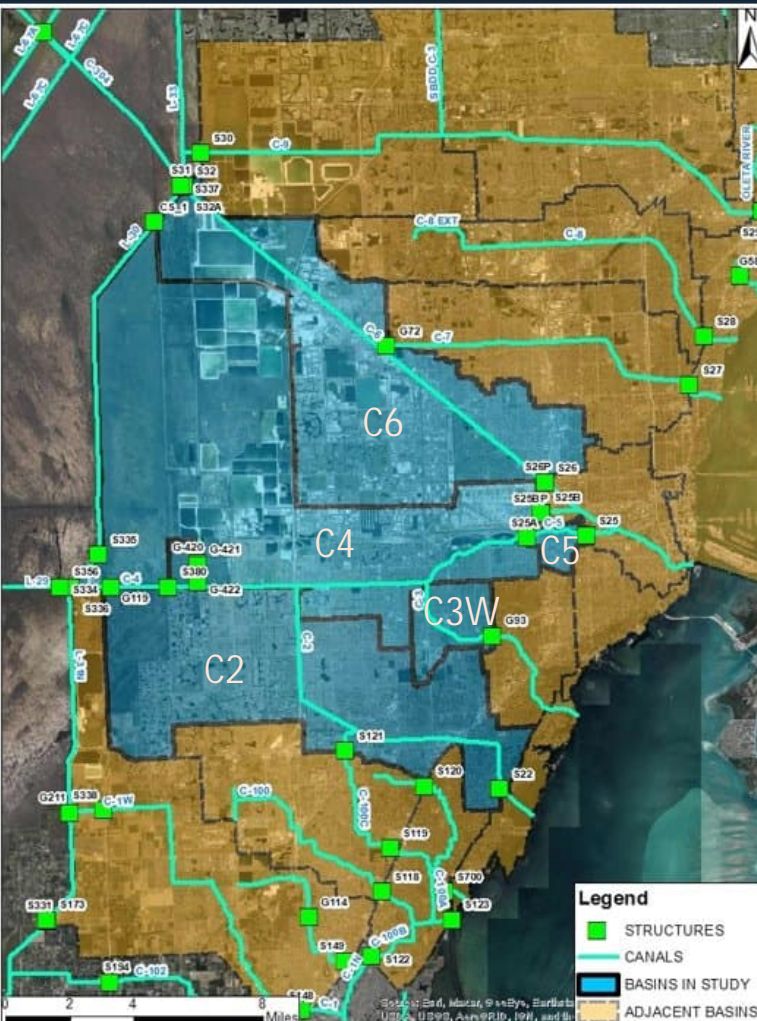
Study Area

Watersheds Evaluated

- **C2 - Snapper Creek**
 - Outfall: S22
- **C3W - Coral Gables Canal**
 - Outfall: G93
- **C4 - Tamiami Canal**
 - Outfall: S25B
- **C5 - Comfort Canal**
 - Outfall: S25
- **C6 - Miami Canal**
 - Outfall: S26

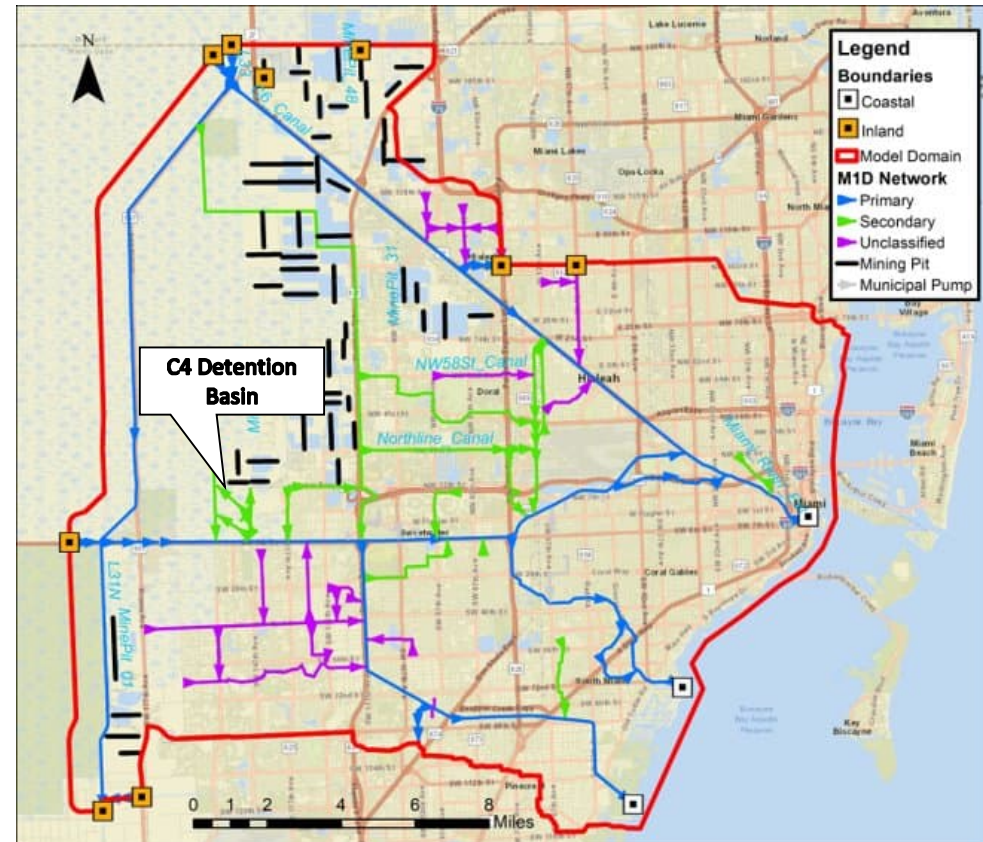
All watersheds were combined in a single model

C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR



Model Setup

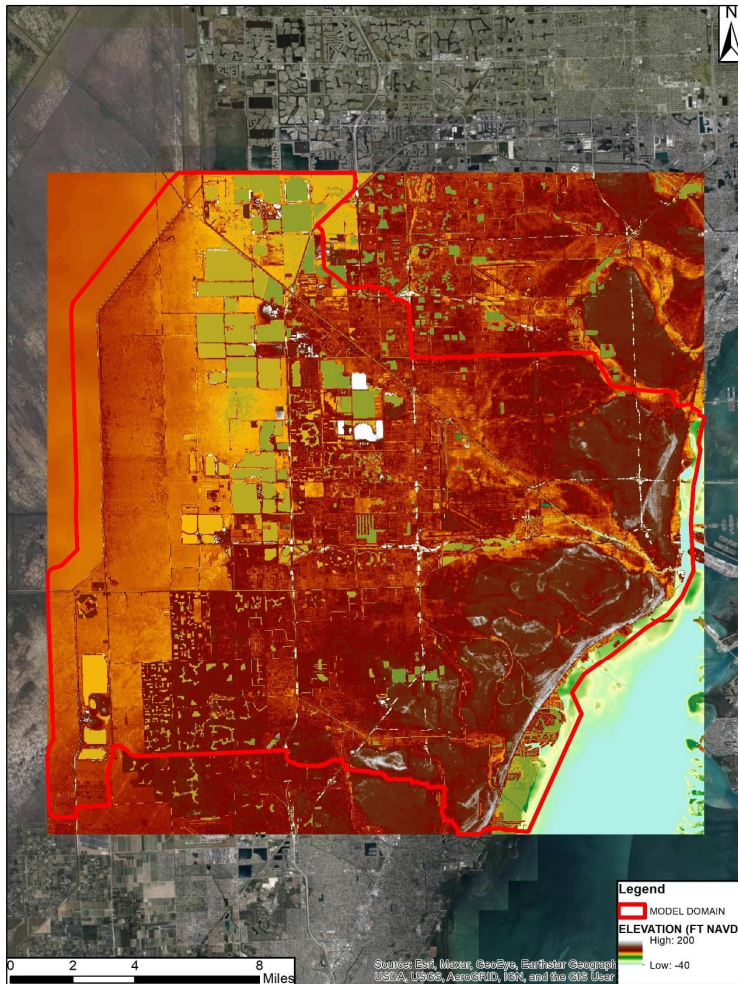
- Model Domain
 - From WCA/ENP to coast
 - From C7 to C2
- Model Resolution
 - 250-ft grid cell
- Calibration (5/10/20-6/1/20)
 - Dry antecedent conditions
 - Recent storm with available data
- Validation (8/20/17-9/22/17) – Irma
 - Very wet antecedent conditions
 - Recent high intensity storm



C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR



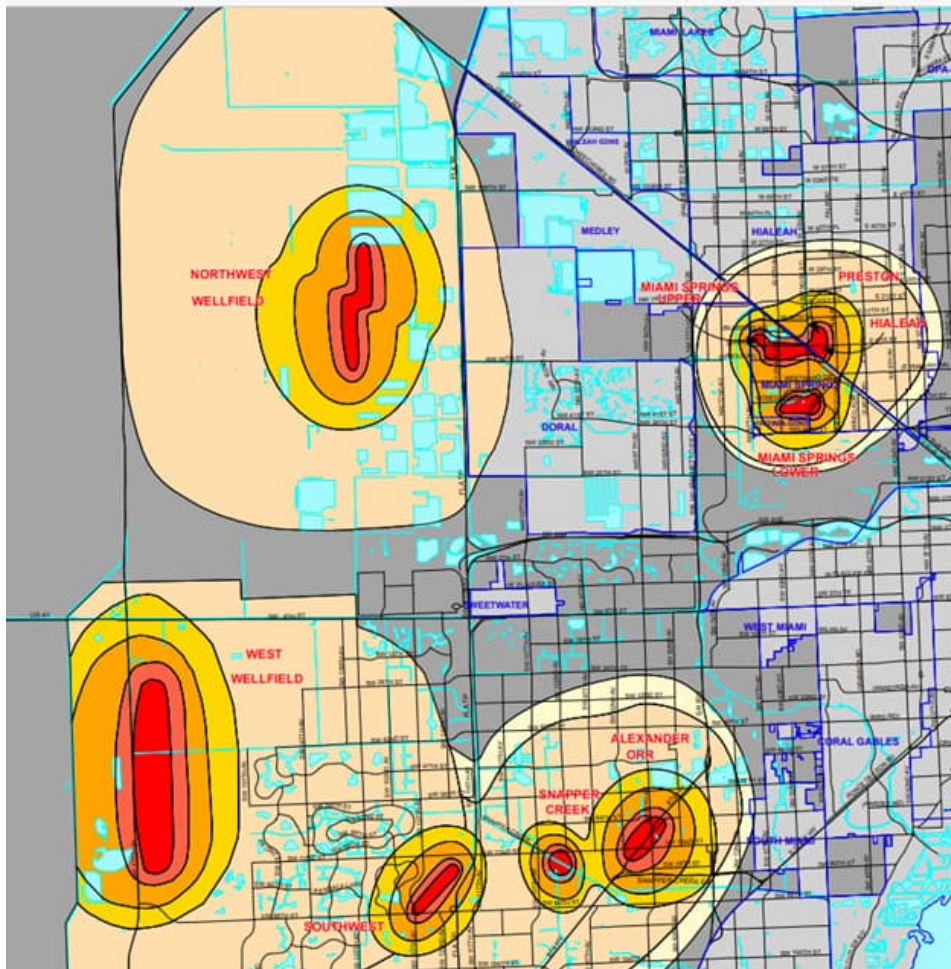
Model Setup – Spatial Data



- Topography – (SFWMD LiDAR)
- Canal geometry – (Existing models)
- Landuse – (FDEP / FLUCCS)
 - ET Parameters
 - Overland Roughness
 - Percent Impervious
- Detention Storage – (Landuse and ERPs)
- Soils Map – (NRCS)
- Groundwater – (From SFWMD / ECSM)

C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR

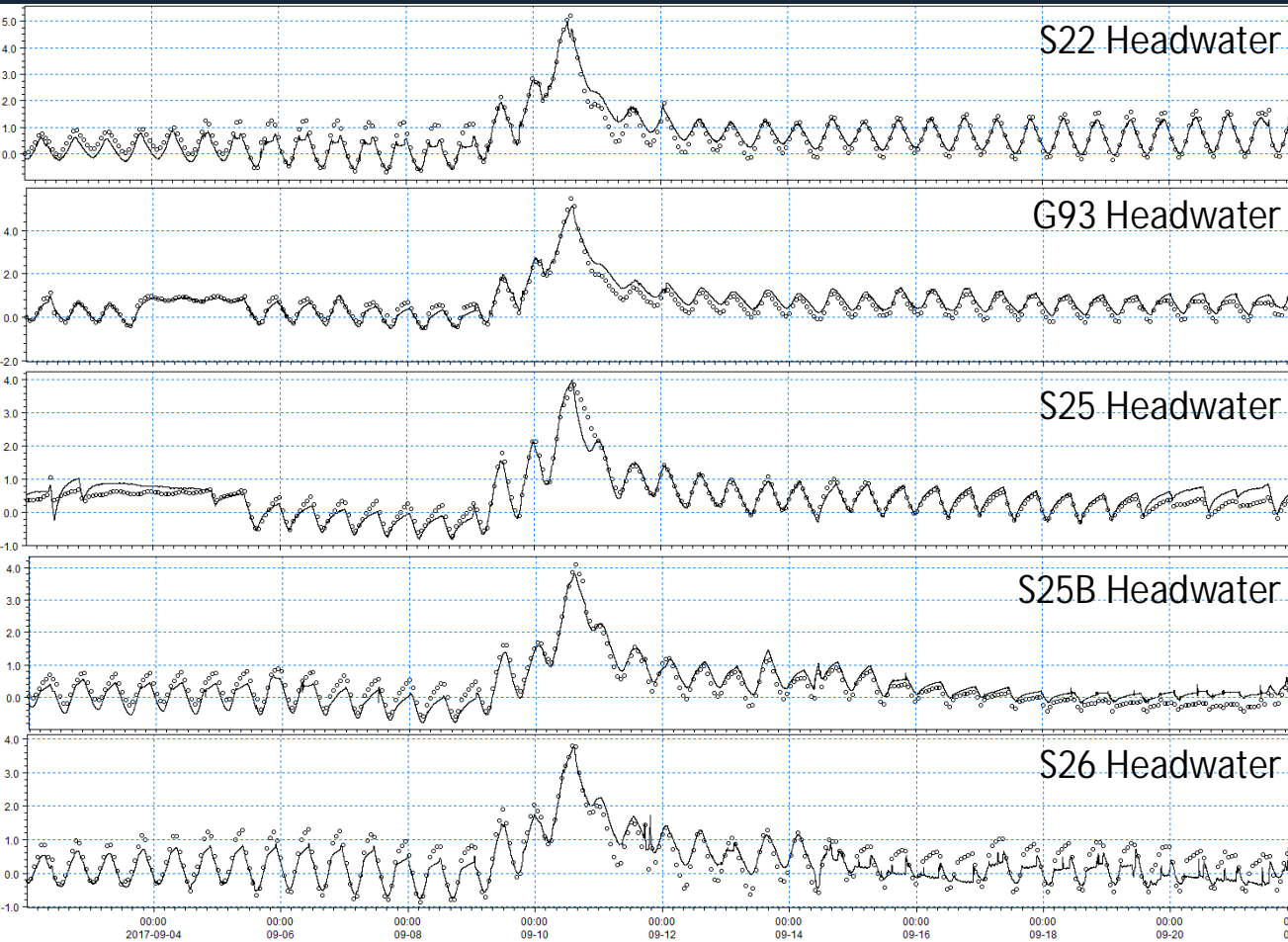
Model Setup – Temporal Data



- Rainfall – NEXRAD @ 15-min
- ET – Measured @ S331W
- GW Pumping – Measured by MD-WASD
- GW Boundaries – Measured by USGS
- Gate Operations – DBHYDRO
- Tidal Data – DBHYDRO
- Canal Stages – DBHYDRO

C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR

Model Calibration and Validation Results



- Good representation of stages throughout each watershed
- Particularly good match-up for the Irma simulation, due to wet antecedent conditions.

C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR

Model Calibration and Validation Results

		Calibration Stages (5/11/2020 - 5/30/2020)				
Watershed	Station	ME (ft)	MAE (ft)	RMSE (ft)	R	NS
C2	C2SW1	0.20	0.32	0.42	0.98	0.56
	C2SW2	0.24	0.36	0.46	0.75	-0.95
	S22_H	0.16	0.46	0.54	0.39	-0.41
C3W	G93_H	0.05	0.33	0.39	0.74	0.19
C4	C4.CORAL	0.32	0.42	0.49	0.95	0.24
	S25B_H	0.14	0.25	0.34	0.78	0.50
	S336_T	-0.03	0.26	0.32	0.97	0.84
	S380_H	0.59	0.62	1.02	0.08	-3.29
	S380_T	0.82	0.85	1.21	0.57	-1.80
	T5W	0.22	0.36	0.44	0.99	0.72
C5	S25_H	-0.26	0.42	0.48	0.82	0.36
C6	S26_H	-0.06	0.23	0.28	0.86	0.72
	S31_T	0.21	0.24	0.28	0.97	0.82

		Validation Stages (9/1/2017 - 9/30/2017)				
Watershed	Station	ME (ft)	MAE (ft)	RMSE (ft)	R	NS
C2	C2SW1	0.19	0.24	0.30	0.97	0.84
	C2SW2	0.18	0.19	0.24	0.98	0.90
	S22_H	0.05	0.18	0.24	0.96	0.92
C3W	G93_H	-0.18	0.25	0.31	0.96	0.88
C4	C4.CORAL	0.01	0.30	0.45	0.70	0.34
	S25B_H	-0.11	0.29	0.35	0.91	0.81
	S336_T	0.11	0.34	0.40	0.51	0.20
	S380_H	1.55	1.55	1.61	0.82	-10.31
	S380_T	1.60	1.60	1.73	0.59	-18.41
	T5W	0.33	0.35	0.43	0.96	0.48
C5	S25_H	-0.09	0.21	0.43	0.84	0.61
C6	S26_H	0.04	0.23	0.29	0.90	0.81
	S31_T	0.30	0.36	0.42	0.92	0.69

- 85% of stage stations within the critical watersheds meet the MAE criteria of 0.5ft for both Calibration and Validation runs
- Simulated peak flows match measured within +/- 20% for all coastal structures during the Irma event

Calibration Peak Flows			
Station	Measured (cfs)	Simulated (cfs)	% Difference
S22	1533.1	1654.5	7.9%
G93	303.3	430.9	42.1%
S25	299.7	412.0	37.5%
S25B	2007.1	1891.5	-5.8%
S26	1426.6	1668.4	16.9%

Validation Peak Flows			
Station	Measured (cfs)	Simulated (cfs)	% Difference
S22	1690.8	1632.0	-3.5%
G93	362.9	362.5	-0.1%
S25	190.9	190.3	-0.3%
S25B	1925.7	2077.3	7.9%
S26	1627.3	1323.8	-18.6%

C2, C3W, C4, C5, C6 FPLOS for Current and Future SLR





Design Storm Simulations - Current and Future Conditions

**C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR**

Design Storm Setup

- Structure Operations

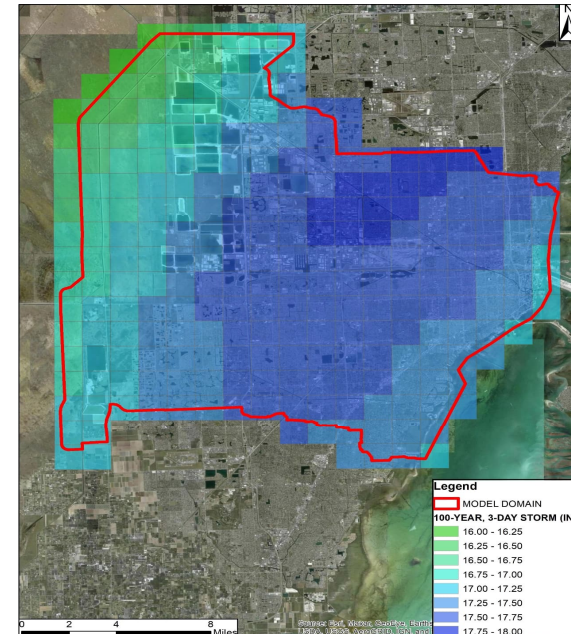
- District's Structure Atlas,
- C4 Watershed Operations Plan
- Water managers

- Rainfall Events

- 5/10/25/100-year, 3-day storms
- Spatially distributed using NEXRAD grid

Branch Name	Name	Structure Type	Logic Language
Coral_Gables_Canal	G93 G1	Sluice, Formula	Unchanged if TSLGLC<6min, Else Closed if dH<0.1, Else Fully Open if Hups>0.76 ft-NAVD AND dH>0.3ft, Else Closed if Hups<-0.54 ft-NAVD, Otherwise Unchanged
Coral_Gables_Canal	G93 G2	Sluice, Formula	Unchanged if TSLGLC<6min, Else Closed if dH<0.1, Else Fully Open if Hups>0.76 ft-NAVD AND dH>0.3ft, Else Closed if Hups<-0.54 ft-NAVD, Otherwise Unchanged
Snapper_Creek_Canal	S22 G1	Sluice, Formula	Unchanged if TSLGLC<6min, Else Closed if dH<0.1ft, Else Fully Open if Hups > 0.96 ft-NAVD AND dH>0.3ft, Else Closed if Hups < -0.04 ft-NAVD, Otherwise Unchanged
Snapper_Creek_Canal	S22 G2	Sluice, Formula	Unchanged if TSLGLC<6min, Else Closed if dH<0.1ft, Else Fully Open if Hups > 0.96 ft-NAVD AND dH>0.3ft, Else Closed if Hups < -0.04 ft-NAVD, Otherwise Unchanged
Comfort_Canal_Southfork	S25	Underflow	Unchanged if TSLGLC<6min, Else Closed if dh<0.1, Else Fully Open if Hups>-0.345 ft-NAVD, Else Closed if Hups<-0.745 ft-NAVD, Else Fully Open if dh>0.3ft, Otherwise Unchanged
Comfort_Canal_Southfork	S25A G1	Underflow	Closed
C4 Canal	S25B G1	Sluice, Formula	Unchanged if TSLGLC<6min, Else Closed if dh<0.1ft, Else Fully Open if Hups>0.451 ft-NAVD, Else Closed if Hups<-0.549 ft-NAVD, Else Fully Open if dh>0.3ft, Otherwise Unchanged

H = head, dH = delta or difference in head between upstream and downstream of the gate,
 Hups = head upstream of structure, TSLGLC – Time Since Last Gate Level Change

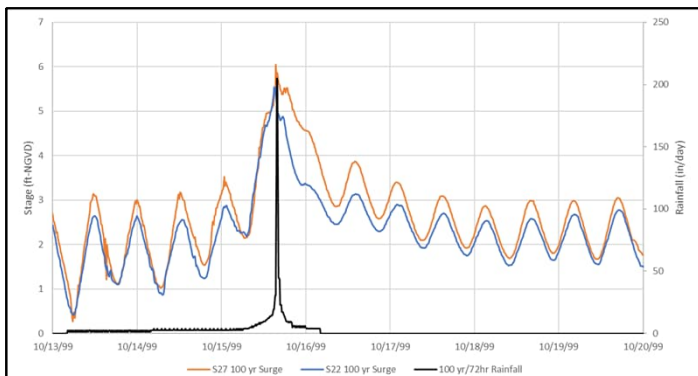
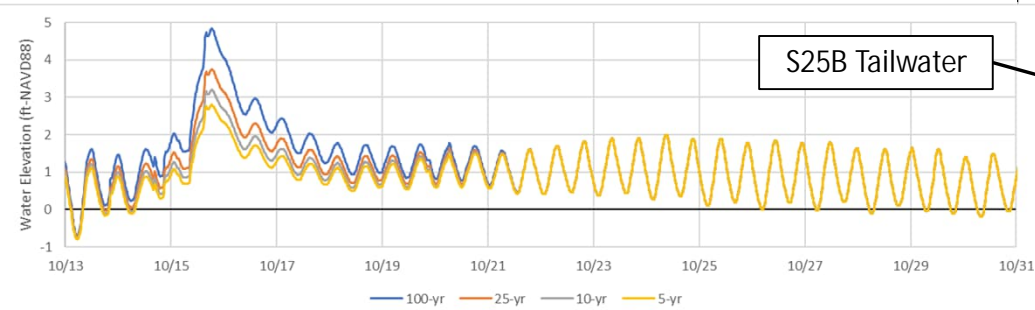


C2, C3W, C4, C5, C6 FPLOS
 for Current and Future SLR

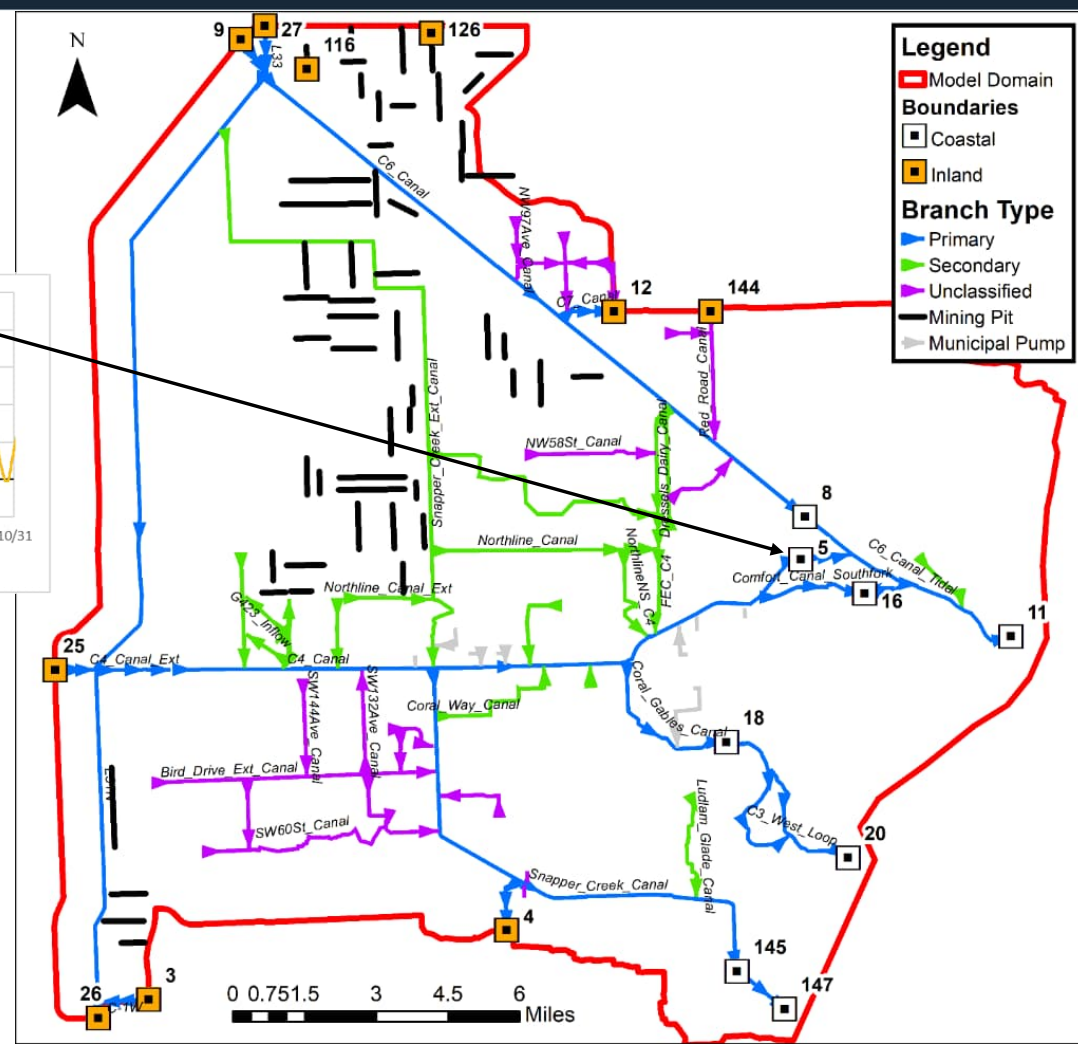


Design Storm Setup

- Surface Water Boundary Conditions
 - TW conditions prescribed at S26, S25B, S25, G93, and S22

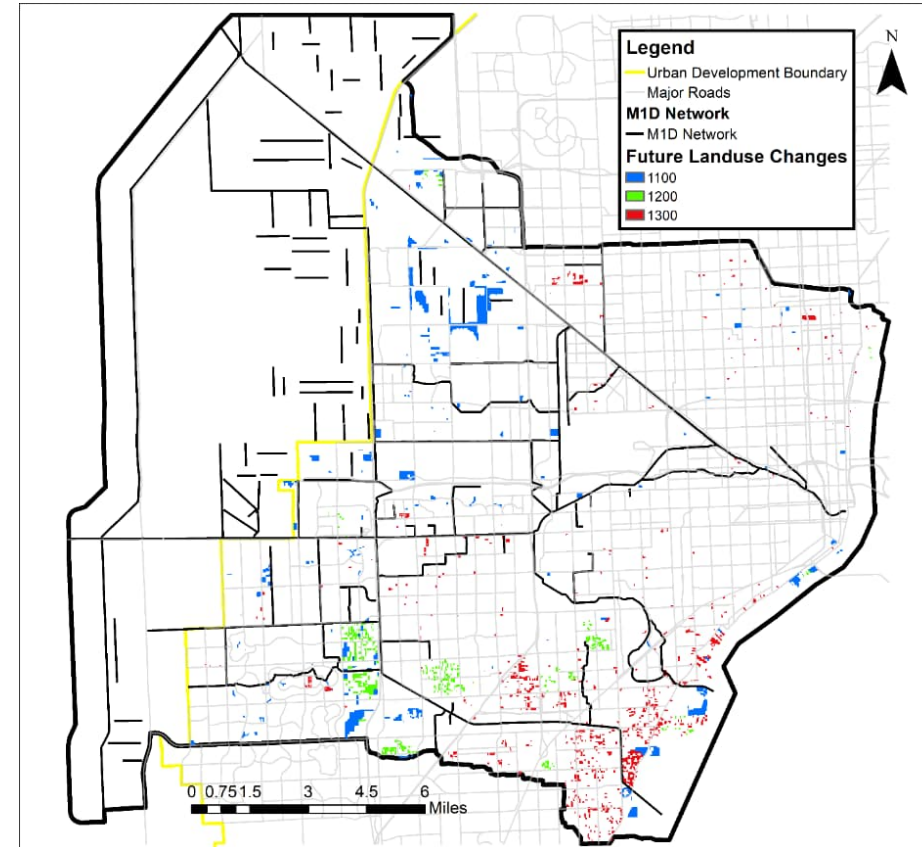


Storm surge peak and rainfall peak are aligned.



Design Storm Setup – Future Conditions

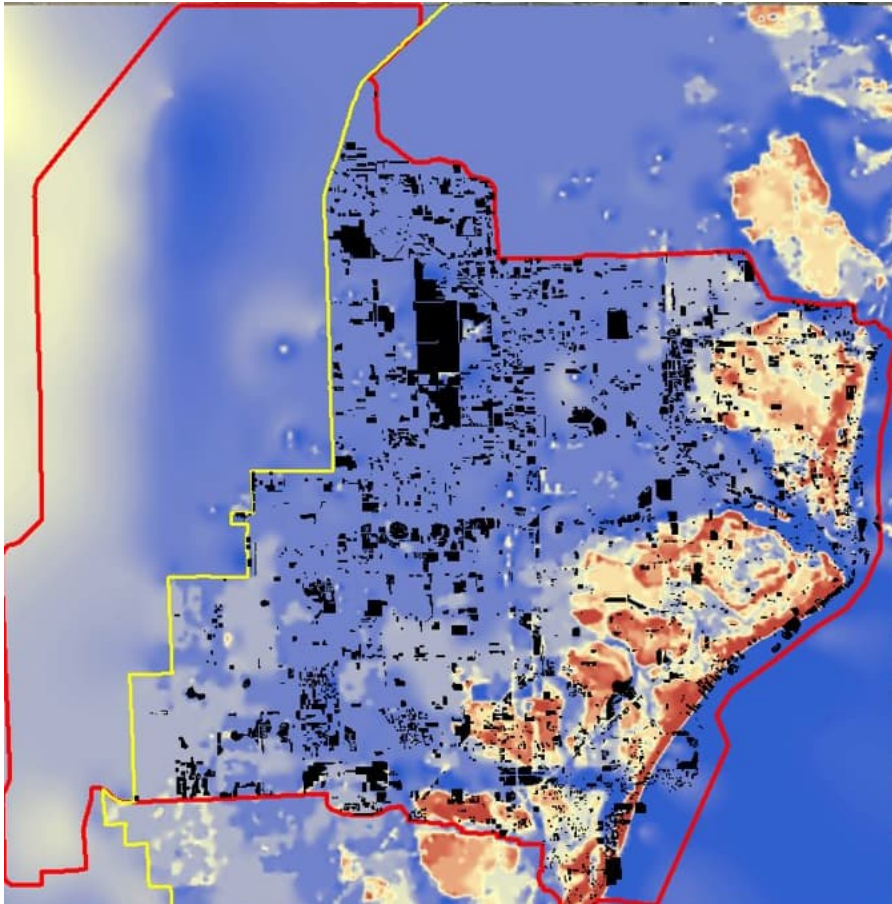
- Land use
 - Increase LU classification
 - Open/Vacant/Ag to Low Density
 - Low Density to Medium Density
 - Medium Density to High Density
- Overland Parameters
 - Adjusted for more development
 - Manning's n
 - Detention storage
 - Runoff coefficient



C2, C3W, C4, C5, C6 FPLoS
for Current and Future SLR



Design Storm Setup – Future Conditions

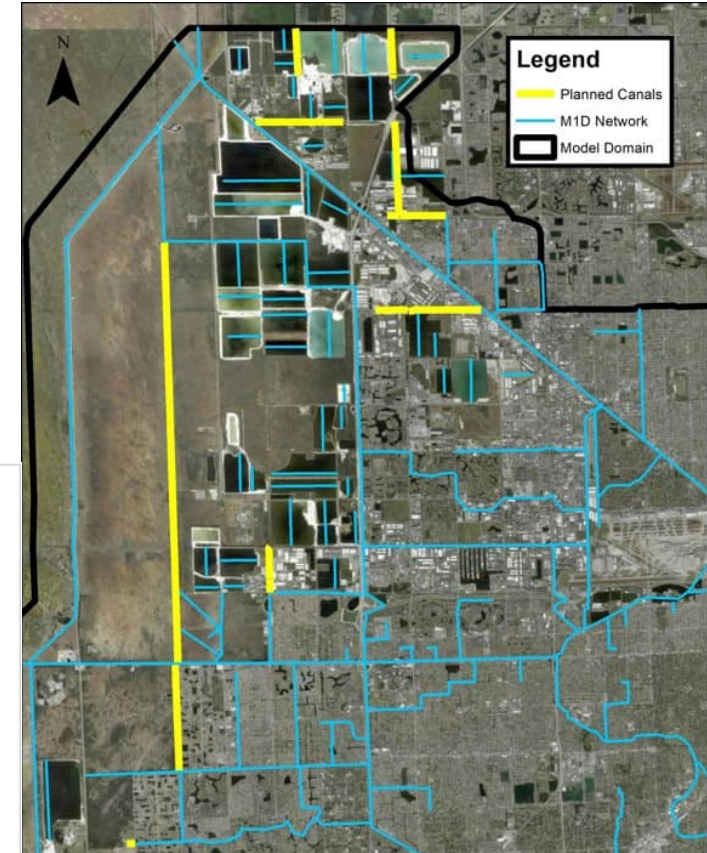
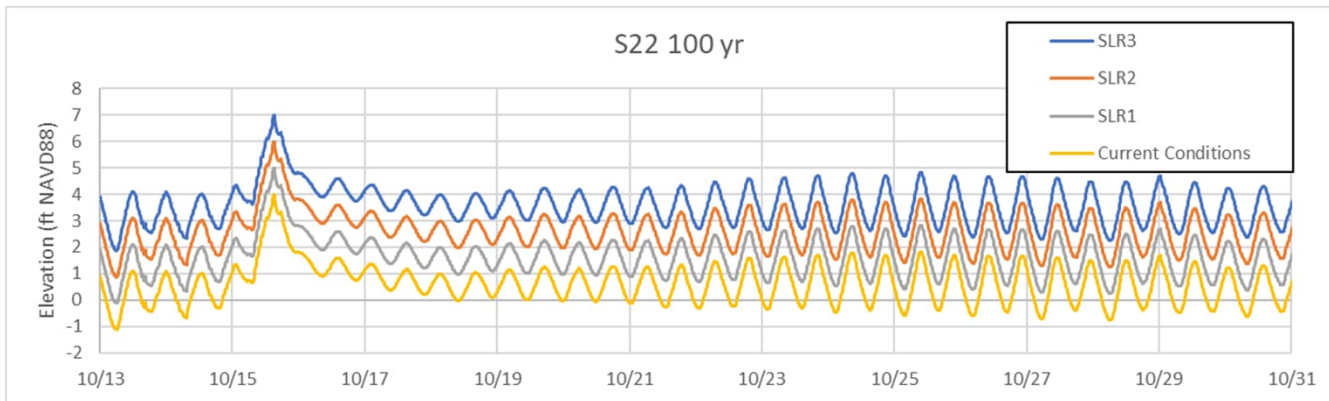


- Topography
 - Raised elevation for 90% of each vacant and old parcel (MDC Flood Criteria)
 - Reduced elevation for 10% of each vacant and old parcel to account for onsite storage

C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR

Design Storm Setup – Future Conditions

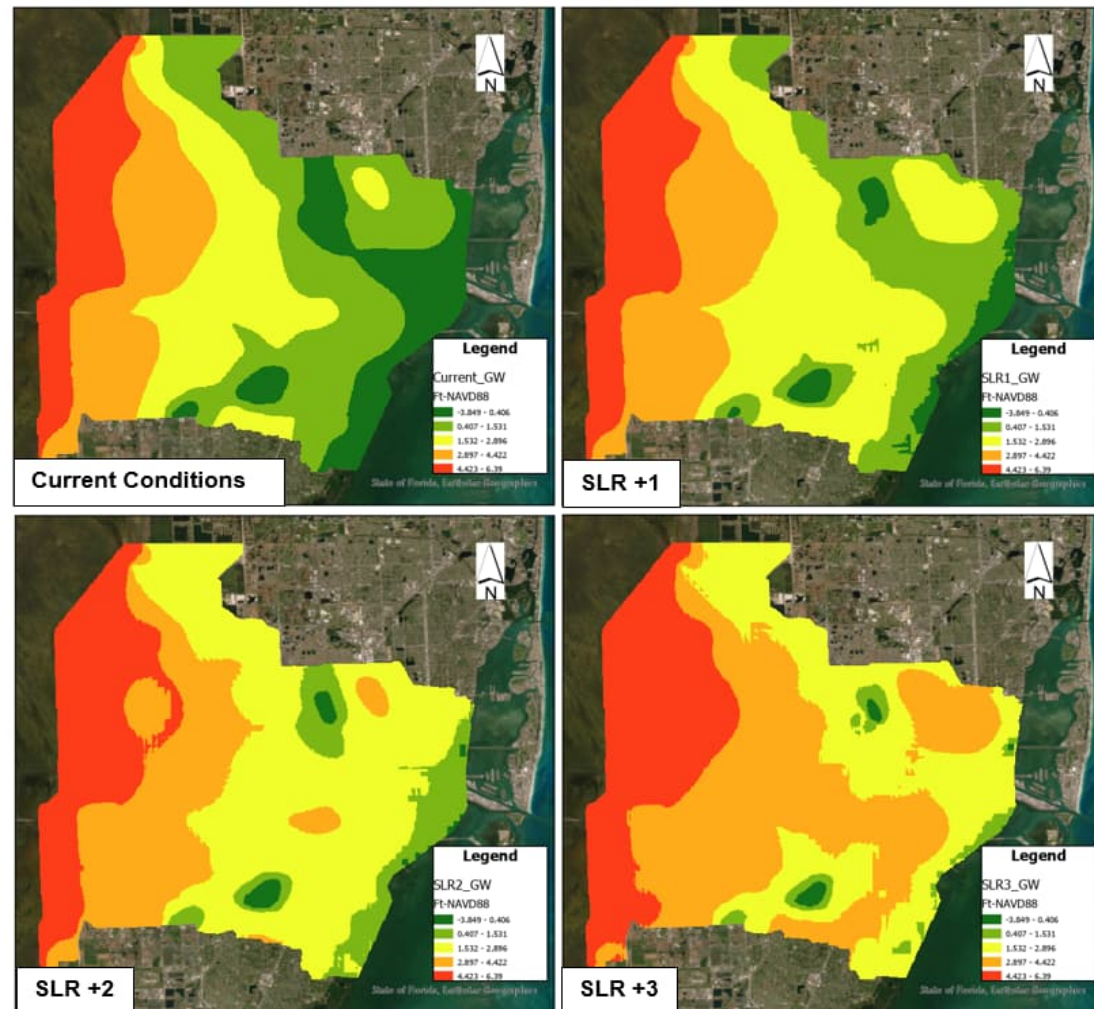
- Surface Water
 - Increased initial conditions and boundary conditions to account for SLR (+1, +2, +3 ft)
 - Added “planned canals” from MDC with cross-sections matching TOB criteria



C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR

Design Storm Setup – Future Conditions

- Groundwater
 - Used MDC's future GW projections for SLR +1 ft (May 2040)
 - Projected future GW for SLR +2 and +3 ft
 - Increased water supply withdrawals based on MD-WASD estimates (+44%)



A photograph of two construction workers in safety gear (hard hats and high-visibility vests) standing on a construction site. They are looking towards a large, flat, light-colored area, possibly a prepared ground surface. In the background, there are piles of earth, some construction equipment, and a cloudy sky. The workers' vests have the 'CMA' logo on them. A semi-transparent blue overlay covers the bottom half of the image, containing the title text.

Modeling Results and Mitigation Strategies

**C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR**

FPLOS Metrics

- SFWMD developed 6 FPLOS performance metrics (PMs)
- Comparison tool for changes in flood protection as a result of SLR

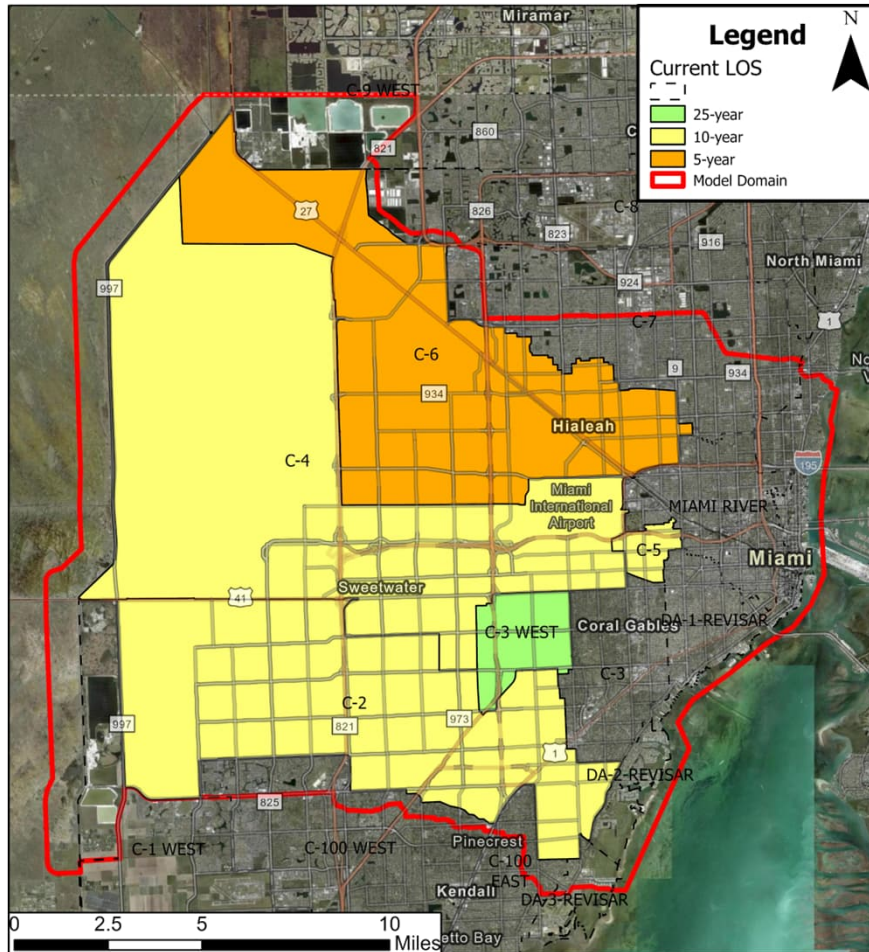
Performance Metric	Description
PM #1	Maximum stage in primary canals
PM #2	Maximum discharge capacity through the primary canals
PM #3	Tidal structure flow performance
PM #4	Peak storm runoff – maximum conveyance capacity of the watershed
PM #5	Frequency of flooding – stage-based LOS for sub-watersheds
PM #6	Duration of flooding

C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR



Design Storm Results – Current and Future Conditions

Overall LOS Rating for Each Watershed



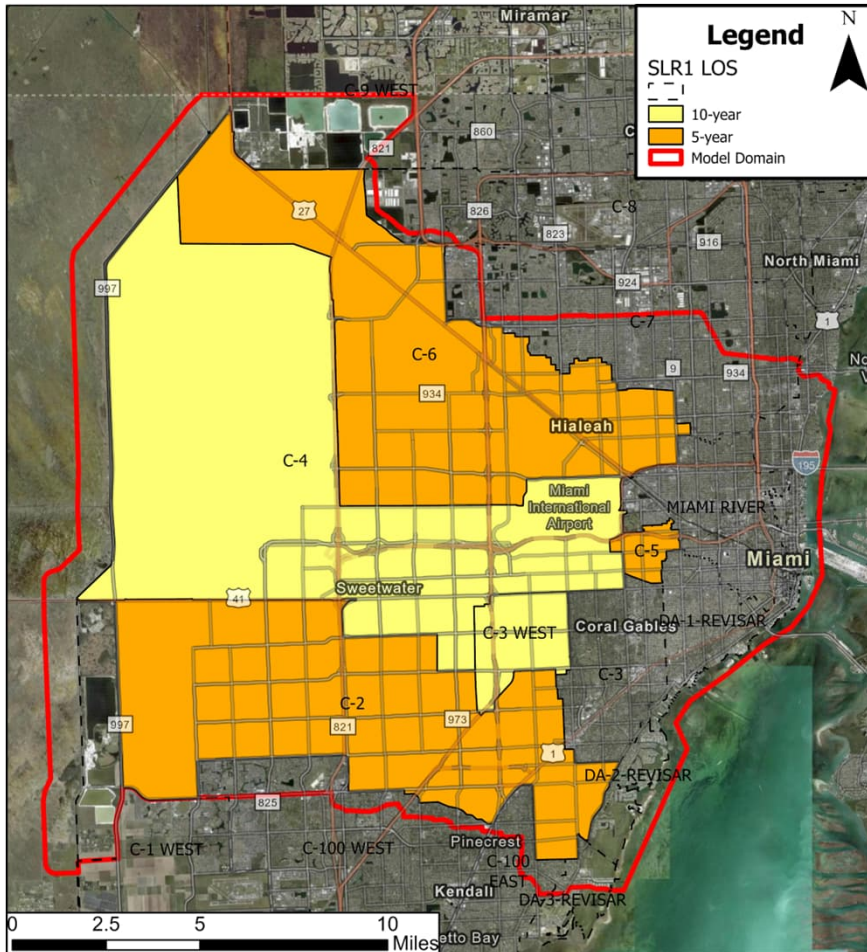
CONDITION	PM	C2	C3W	C4	C5	C6
Current Conditions	PM #1	10-year	25-year	25-year	25-year	25-year
	PM #5	25-year	25-year	10-year	10-year	5-year
	PM #6	25-year	25-year	10-year	25-year	<5-year
	Overall LOS	10-year	25-year	10-year	10-year	5-year
Future Conditions SLR +1 foot	PM #1	5-year	10-year	10-year	10-year	10-year
	PM #5	25-year	25-year	10-year	5-year	5-year
	PM #6	25-year	10-year	10-year	10-year	<5-year
	Overall LOS	5-year	10-year	10-year	5-year	5-year
Future Conditions SLR +2 feet	PM #1	<5-year	5-year	5-year	<5-year	<5-year
	PM #5	10-year	10-year	5-year	5-year	<5-year
	PM #6	10-year	10-year	5-year	5-year	<5-year
	Overall LOS	<5-year	5-Year	5-year	<5-year	<5-year
Future Conditions SLR +3 feet	PM #1	<5-year	<5-year	<5-year	<5-year	<5-year
	PM #5	10-year	10-year	<5-year	<5-year	<5-year
	PM #6	10-year	5-year	<5-year	<5-year	<5-year
	Overall LOS	<5-year	<5-year	<5-year	<5-year	<5-year

C2, C3W, C4, C5, C6 FPLOS for Current and Future SLR



Design Storm Results – Current and Future Conditions

Overall LOS Rating for Each Watershed



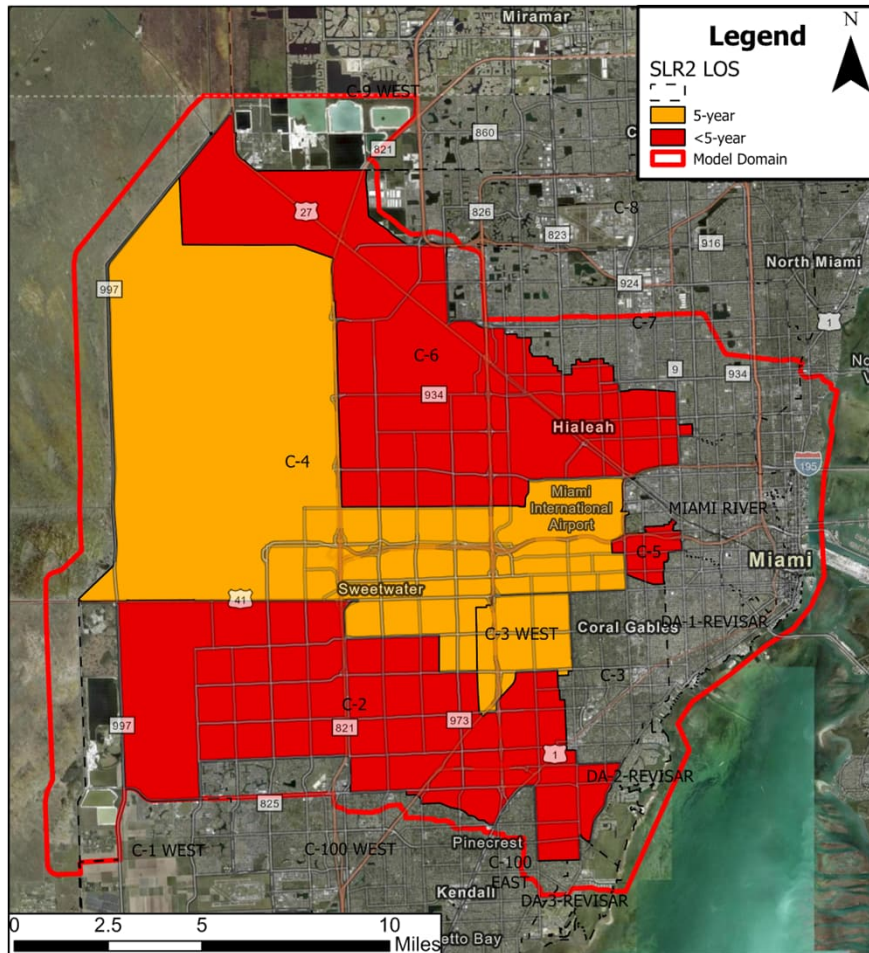
CONDITION	PM	C2	C3W	C4	C5	C6
Current Conditions	PM #1	10-year	25-year	25-year	25-year	25-year
	PM #5	25-year	25-year	10-year	10-year	5-year
	PM #6	25-year	25-year	10-year	25-year	<5-year
	Overall LOS	10-year	25-year	10-year	10-year	5-year
Future Conditions SLR +1 foot	PM #1	5-year	10-year	10-year	10-year	10-year
	PM #5	25-year	25-year	10-year	5-year	5-year
	PM #6	25-year	10-year	10-year	10-year	<5-year
	Overall LOS	5-year	10-year	10-year	5-year	5-year
Future Conditions SLR +2 feet	PM #1	<5-year	5-year	5-year	<5-year	<5-year
	PM #5	10-year	10-year	5-year	5-year	<5-year
	PM #6	10-year	10-year	5-year	5-year	<5-year
	Overall LOS	<5-year	5-Year	5-year	<5-year	<5-year
Future Conditions SLR +3 feet	PM #1	<5-year	<5-year	<5-year	<5-year	<5-year
	PM #5	10-year	10-year	<5-year	<5-year	<5-year
	PM #6	10-year	5-year	<5-year	<5-year	<5-year
	Overall LOS	<5-year	<5-year	<5-year	<5-year	<5-year

**C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR**



Design Storm Results – Current and Future Conditions

Overall LOS Rating for Each Watershed



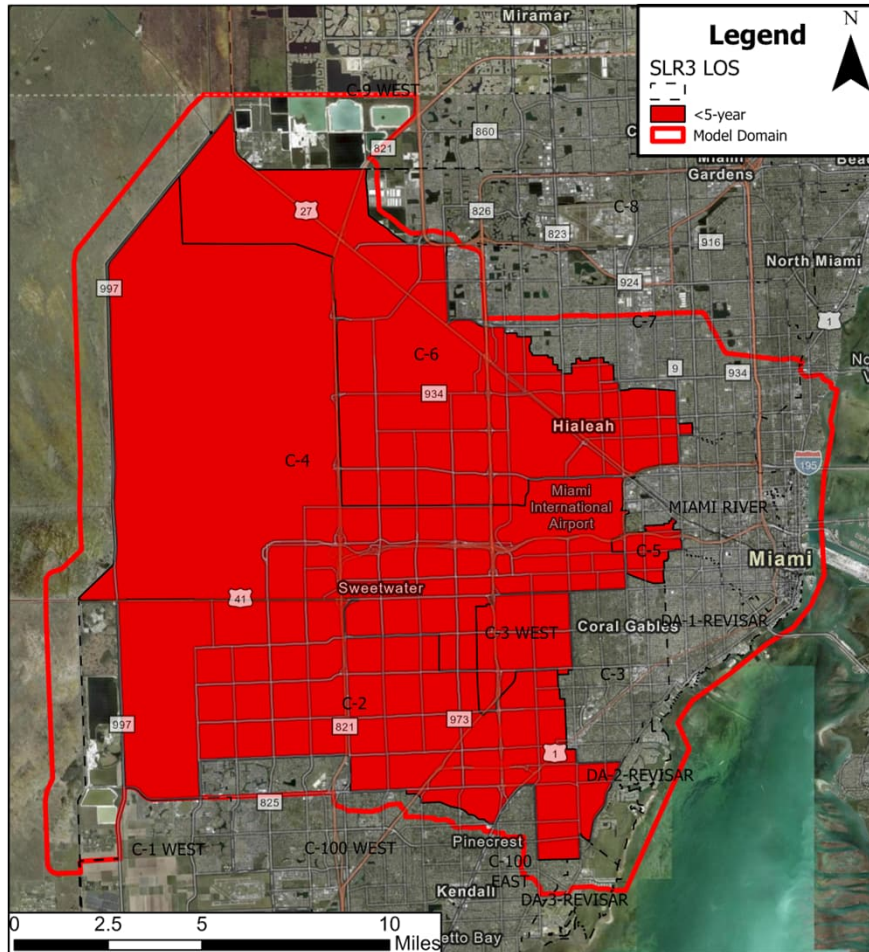
CONDITION	PM	C2	C3W	C4	C5	C6
Current Conditions	PM #1	10-year	25-year	25-year	25-year	25-year
	PM #5	25-year	25-year	10-year	10-year	5-year
	PM #6	25-year	25-year	10-year	25-year	<5-year
	Overall LOS	10-year	25-year	10-year	10-year	5-year
Future Conditions SLR +1 foot	PM #1	5-year	10-year	10-year	10-year	10-year
	PM #5	25-year	25-year	10-year	5-year	5-year
	PM #6	25-year	10-year	10-year	10-year	<5-year
	Overall LOS	5-year	10-year	10-year	5-year	5-year
Future Conditions SLR +2 feet	PM #1	<5-year	5-year	5-year	<5-year	<5-year
	PM #5	10-year	10-year	5-year	5-year	<5-year
	PM #6	10-year	10-year	5-year	5-year	<5-year
	Overall LOS	<5-year	5-Year	5-year	<5-year	<5-year
Future Conditions SLR +3 feet	PM #1	<5-year	<5-year	<5-year	<5-year	<5-year
	PM #5	10-year	10-year	<5-year	<5-year	<5-year
	PM #6	10-year	5-year	<5-year	<5-year	<5-year
	Overall LOS	<5-year	<5-year	<5-year	<5-year	<5-year

**C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR**



Design Storm Results – Current and Future Conditions

Overall LOS Rating for Each Watershed



CONDITION	PM	C2	C3W	C4	C5	C6
Current Conditions	PM #1	10-year	25-year	25-year	25-year	25-year
	PM #5	25-year	25-year	10-year	10-year	5-year
	PM #6	25-year	25-year	10-year	25-year	<5-year
	Overall LOS	10-year	25-year	10-year	10-year	5-year
Future Conditions SLR +1 foot	PM #1	5-year	10-year	10-year	10-year	10-year
	PM #5	25-year	25-year	10-year	5-year	5-year
	PM #6	25-year	10-year	10-year	10-year	<5-year
	Overall LOS	5-year	10-year	10-year	5-year	5-year
Future Conditions SLR +2 feet	PM #1	<5-year	5-year	5-year	<5-year	<5-year
	PM #5	10-year	10-year	5-year	5-year	<5-year
	PM #6	10-year	10-year	5-year	5-year	<5-year
	Overall LOS	<5-year	5-Year	5-year	<5-year	<5-year
Future Conditions SLR +3 feet	PM #1	<5-year	<5-year	<5-year	<5-year	<5-year
	PM #5	10-year	10-year	<5-year	<5-year	<5-year
	PM #6	10-year	5-year	<5-year	<5-year	<5-year
	Overall LOS	<5-year	<5-year	<5-year	<5-year	<5-year

C2, C3W, C4, C5, C6 FPLOS for Current and Future SLR

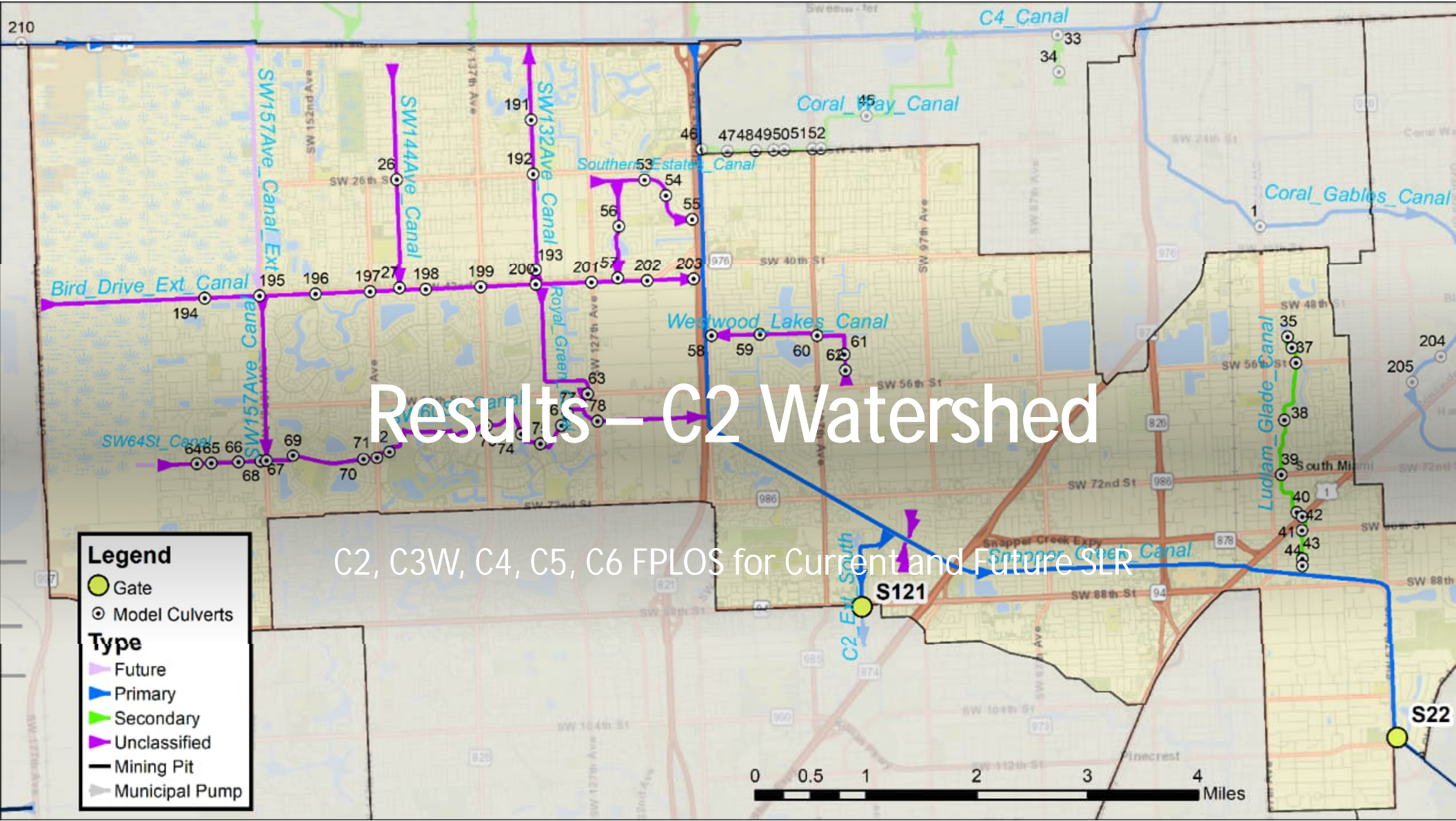
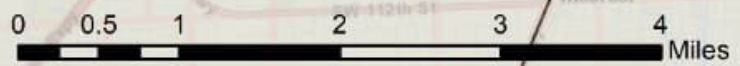


Results – C2 Watershed

C2, C3W, C4, C5, C6 FPLOS for Current and Future SLR

Legend

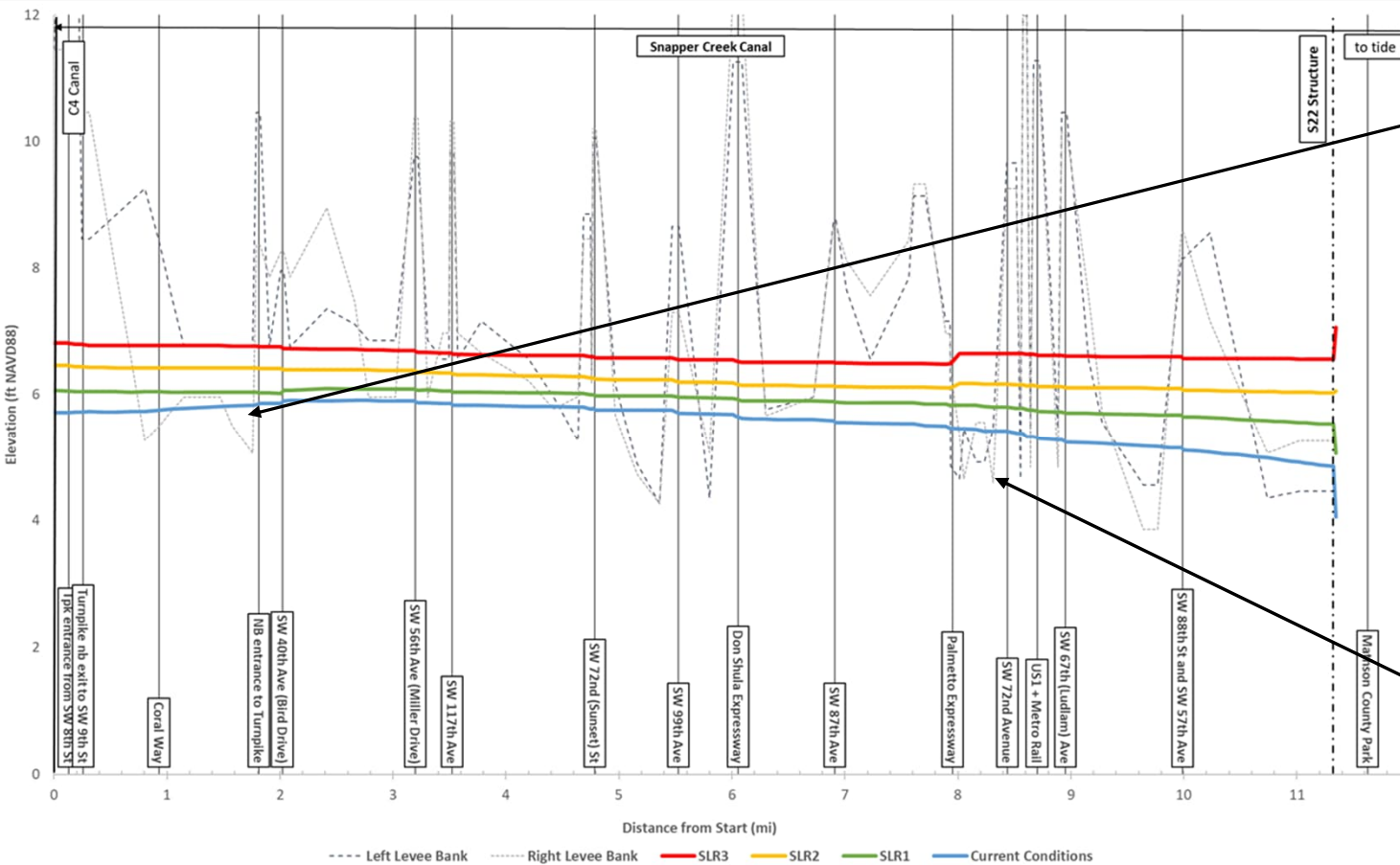
- Gate
- Model Culverts
- Type**
- Future
- Primary
- Secondary
- Unclassified
- Mining Pit
- Municipal Pump



Results – C2 Watershed

PM#1

Maximum Stage in Snapper Creek Canal (100yr/72hr storm)



Results – C2 Watershed

PM#1

Maximum Stage and Bridge Low Chords – Snapper Creek Canal

Location Description			Current Conditions				SLR1				SLR2				SLR3			
	Low Chord	Bridge Top	Elevation (ft-NAVD)															
			100 yr	25 yr	10 yr	5 yr	100 yr	25 yr	10 yr	5 yr	100 yr	25 yr	10 yr	5 yr	100 yr	25 yr	10 yr	5 yr
Turnpike entrance from SW 8th Street	12.16	16.18	5.65	5.08	4.69	4.37	6.06	5.31	5	4.73	6.46	5.81	5.32	5	6.81	6.25	5.87	5.6
Turnpike north bound exit to SW 9th Street	7.26	10.76	5.67	5.15	4.74	4.42	6.04	5.39	5.07	4.77	6.43	5.8	5.36	5.06	6.78	6.22	5.91	5.63
north bound entrance to Turnpike	9.57	13.93	5.78	5.19	4.75	4.44	6.02	5.48	5.09	4.77	6.41	5.8	5.39	5.1	6.75	6.21	5.9	5.64
SW 40th Avenue (Bird Drive)	5.57	7.46	5.78	5.19	4.75	4.44	6.02	5.48	5.09	4.78	6.41	5.8	5.38	5.09	6.75	6.21	5.9	5.64
SW 56th Avenue (Miller Drive)	8.37	12.06	5.82	5.2	4.73	4.41	6.08	5.5	5.1	4.75	6.38	5.82	5.41	5.1	6.7	6.21	5.89	5.63
SW 117th Ave	8.96	12.86	5.78	5.16	4.69	4.35	6.05	5.48	5.07	4.73	6.34	5.79	5.39	5.07	6.66	6.18	5.87	5.6
SW 107th Avenue	8.06	12.26	5.73	5.06	4.6	4.28	6.02	5.45	5.01	4.67	6.29	5.76	5.36	5.04	6.62	6.15	5.84	5.57
SW 72nd (Sunset) Avenue	7.08	10.13	5.68	5	4.53	4.21	5.98	5.4	4.96	4.62	6.24	5.72	5.32	5	6.58	6.12	5.81	5.54
SW 99th Avenue	8.06	10.21	5.67	4.97	4.49	4.15	5.98	5.39	4.94	4.6	6.23	5.72	5.32	4.99	6.57	6.11	5.81	5.53
R/R west of SR 874 Express Way	6.43	9.83	5.61	4.88	4.4	4.05	5.94	5.35	4.88	4.54	6.19	5.68	5.28	4.95	6.55	6.08	5.78	5.5
SR 874	10.9	13.9	5.58	4.85	4.36	4.02	5.92	5.32	4.85	4.51	6.17	5.67	5.26	4.93	6.53	6.07	5.77	5.49
SW87 Avenue	6.96	8.68	5.52	4.75	4.26	3.92	5.89	5.26	4.8	4.45	6.13	5.65	5.22	4.89	6.51	6.05	5.76	5.47
SW 79th (Kings Creek) Avenue	6.68	8.66	5.46	4.67	4.16	3.82	5.87	5.21	4.75	4.4	6.11	5.63	5.19	4.86	6.49	6.03	5.75	5.45
SW 77th Avenue	6.07	10.56	5.42	4.63	4.1	3.76	5.85	5.17	4.71	4.36	6.11	5.61	5.17	4.83	6.48	6.02	5.74	5.44
Palmetto Express Way + Ramp (combined)	7.1	13.76	5.38	4.58	4.04	3.7	5.83	5.14	4.68	4.32	6.18	5.59	5.15	4.81	6.65	6.07	5.73	5.49
Behind Dadeland Mall	7.46	8.11	5.38	4.57	4.03	3.69	5.82	5.13	4.67	4.32	6.17	5.59	5.15	4.81	6.65	6.06	5.73	5.5
SW 72nd Avenue	7.51	12.76	5.34	4.53	3.98	3.64	5.8	5.11	4.64	4.29	6.17	5.58	5.13	4.79	6.65	6.06	5.71	5.48
SW 70th Ave	8.29	13.6	5.3	4.48	3.93	3.59	5.78	5.07	4.61	4.26	6.15	5.56	5.11	4.77	6.64	6.05	5.7	5.46
US1 + Metro Rail (combined)	9.11	11.96	5.2	4.42	3.8	3.46	5.75	5.04	4.58	4.23	6.14	5.54	5.09	4.76	6.63	6.03	5.69	5.44
SW 67th (Ludlam) Avenue	8.78	13.08	5.19	4.29	3.78	3.45	5.72	5	4.55	4.19	6.12	5.53	5.06	4.74	6.62	6.02	5.67	5.42
SW 88th Street and SW 57th Avenue	4.16	8.89	5.03	4.17	3.61	3.3	5.67	4.92	4.46	4.09	6.09	5.48	5.01	4.69	6.59	6	5.65	5.41

*Highlighted cells indicate the stages exceed the bridge low chord

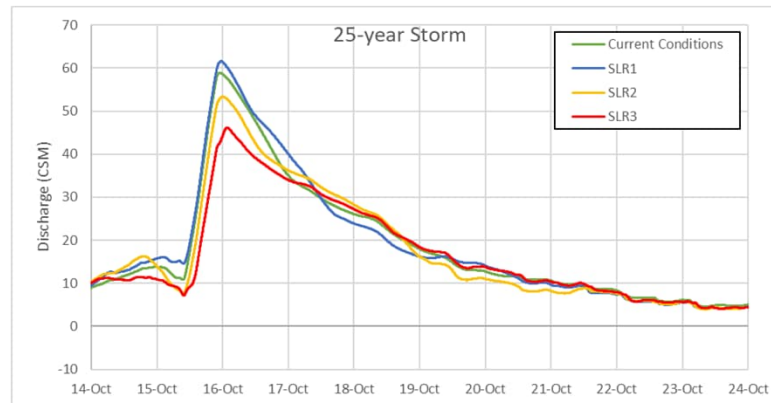
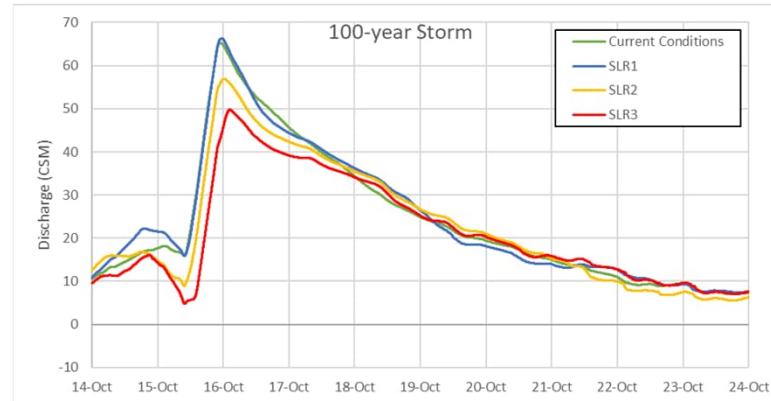


Instantaneous Maximum Discharge Capacity – 100yr

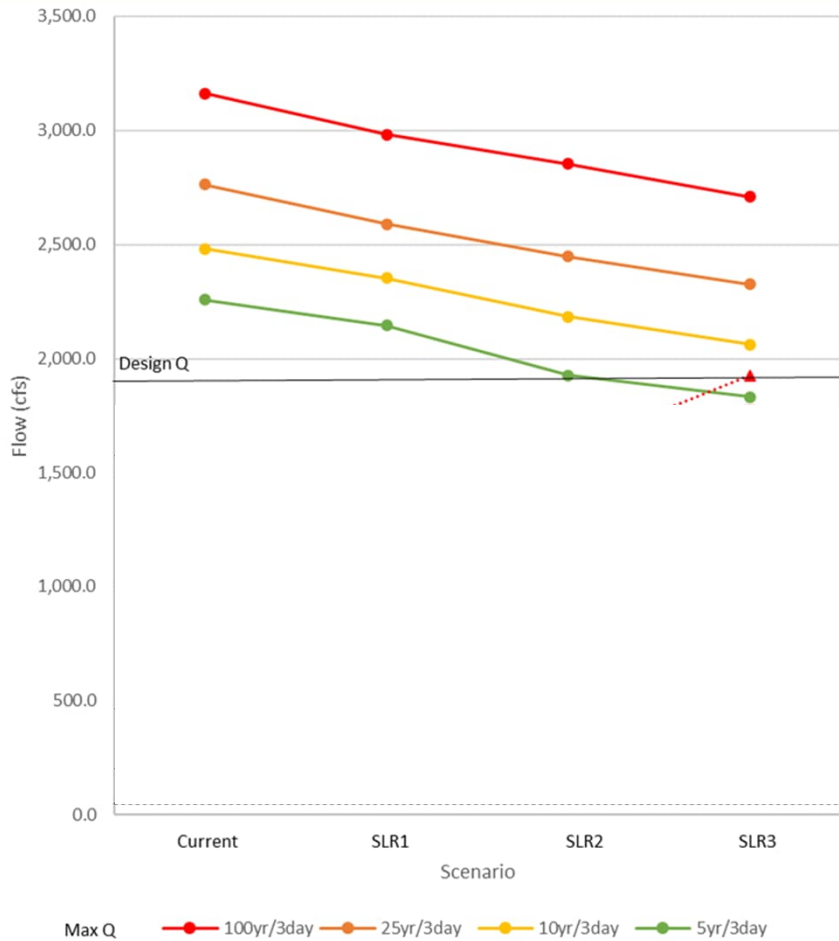
	CURRENT CONDITIONS	SLR1	SLR2	SLR3
Inflow Locations				
Start of Snapper Creek at C4 Canal (CFS)	-566.1	-775.9	-122.2	-66.1
Future Connection at SW 157th Ave (CFS)	–	-403.9	-367.8	-178.7
Outflow Locations				
Coral Way Canal at SW 117th Ave (CFS)	-87.4	-78.2	-18.7	-25.2
SW 132nd Ave Canal into C4 Canal (CFS)	166.4	161.9	106.5	66.3
S112 (CFS)	0	0	0	0
S22 Total Flow (CFS)	3163.5	2831.6	2734.5	2673.6
Watershed Summary				
Basin Area (sq. mi.)	52.6			
Peak Watershed Discharge (C SM)	72.4	77.9	63	56.3

SLR1 discharge capacity increases above current conditions due to future planned canal connections to the C4 Watershed.

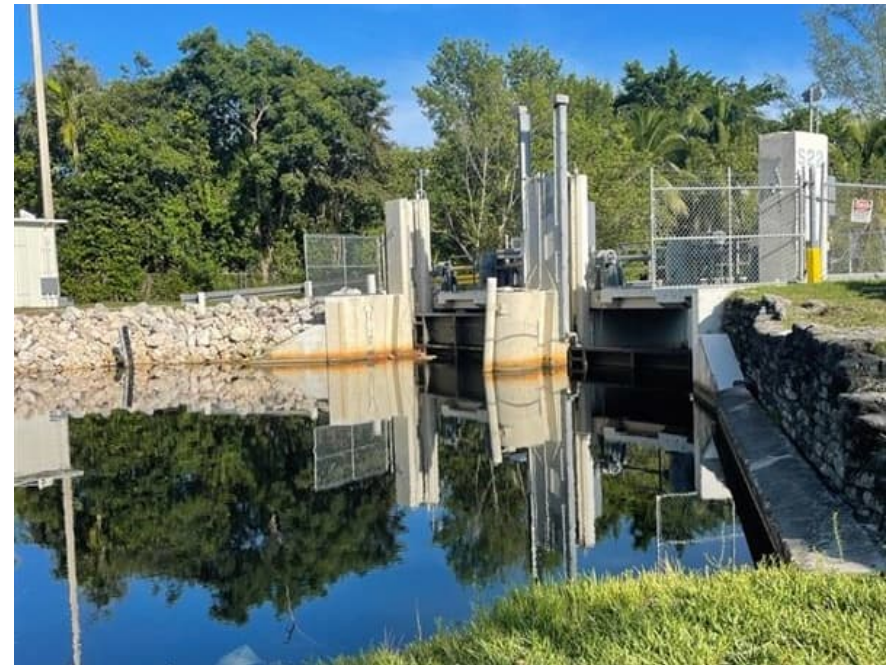
Maximum Discharge Capacity (12-Hour Moving Average)



C2, C3W, C4, C5, C6 FPLOS for Current and Future SLR

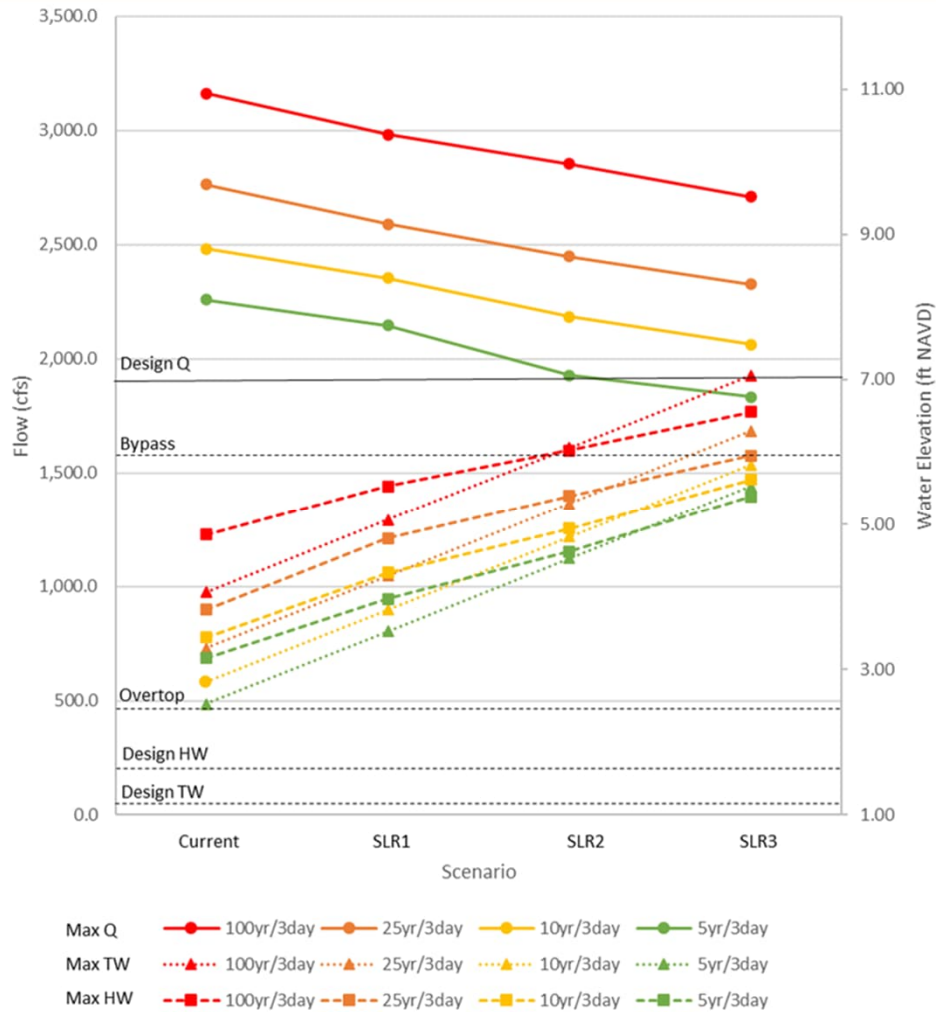


Structure Performance for S-22



C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR





Structure Performance for S-22

The increase in TW levels due to SLR, decreases the head differential at the structure and reduces flow.

C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR

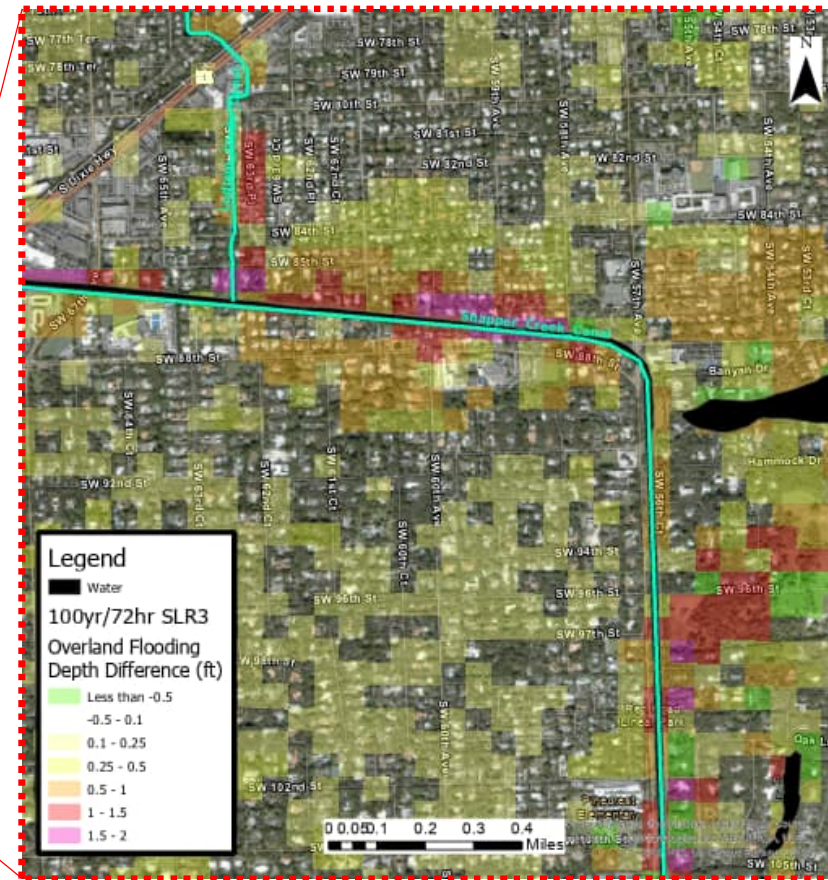


Results – C2 Watershed

PM#5

- PM 5 – Maximum Flood Depth

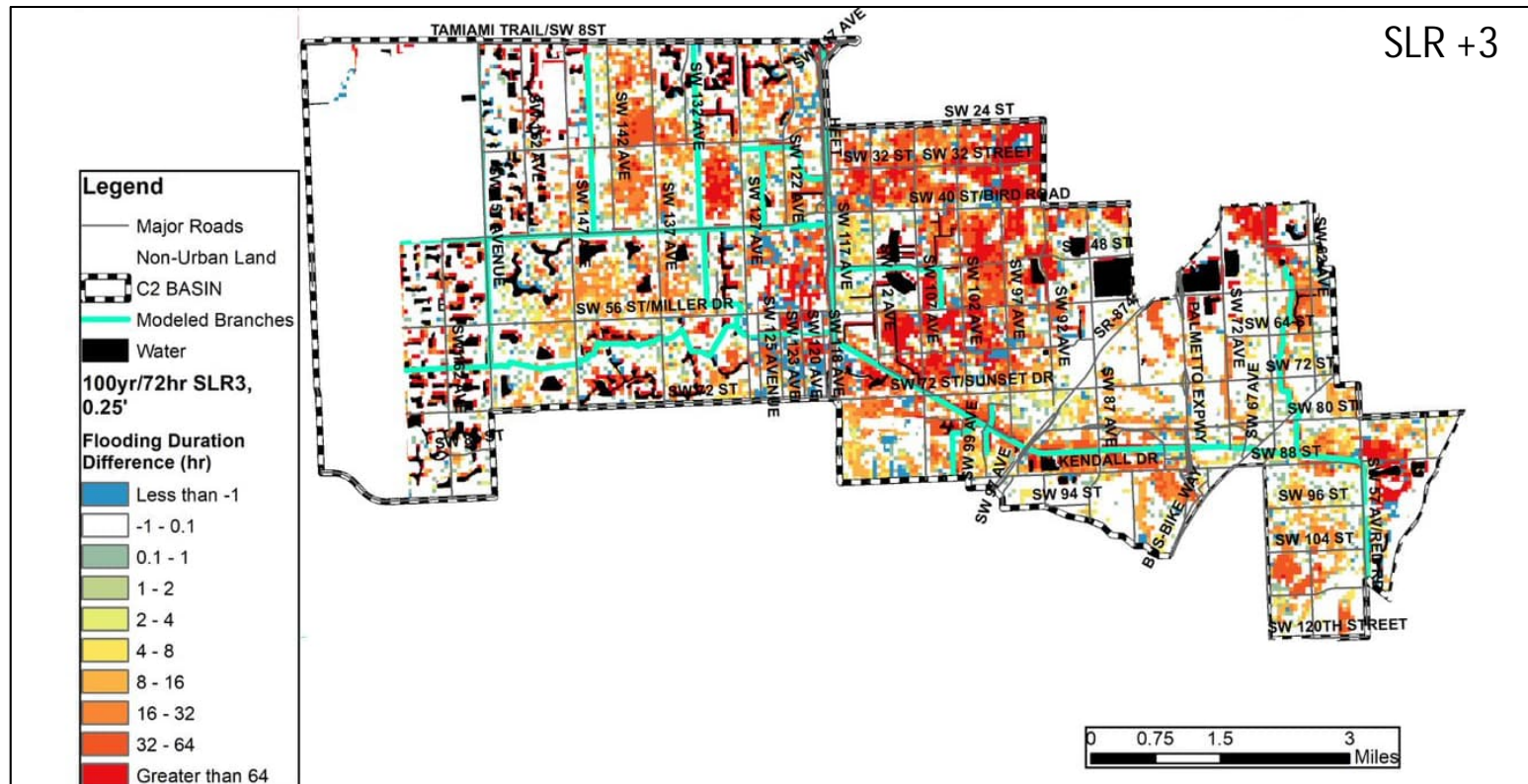
Urban Flooding Depth Difference of SLR +3ft and Current Conditions for the 100-year Storm in the C2 Watershed



C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR



Maximum Flood Duration Difference between SLR and Current Conditions for the 100-year Storm



C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR

Results Summary – C2 Watershed

Increasing vulnerability of bridges.

Future planned canals increase discharge to C4 Watershed.

Extensive canal bank overtopping and overland flooding adjacent to the canals for all SLR conditions even at low storm frequencies.

While flooding depth increases in areas adjacent to canals, flooding duration increases throughout the watershed.

METRIC	NOTES	CURRENT CONDS.	SLR +1 FT	SLR +2 FT	SLR +3 FT
PM #1	<ul style="list-style-type: none"> SLR conditions increase the frequency of bridge low-chord exceedance for the SW 40th Ave and SW 5th Ave bridges. Additionally, the SW 77th Ave bridge low chord is exceeded with the SLR2 condition and the Railroad low chord west of SR874 is exceeded with the SLR3 condition for the 100-year storm. The number of culvert locations where the crown of road is exceeded increases significantly with each SLR condition. For the SLR1 5-year storm the same two (2) culverts are exceeded that were exceeded for the current conditions 10-year storm. The length of Snapper Creek that is overtopped is over a mile for all SLR conditions, with the exception of the SLR1 5-year 	10-year	5-year	<5-year	<5-year
PM #2	<ul style="list-style-type: none"> 25-year Allowable Discharge exceeds the ERP value for the current and SLR1 conditions. With the future canals, a new connection to the C4 Canal increases discharges to the C4 watershed, increasing drainage capacity for SLR1 conditions. SLR2 conditions are similar to current conditions, and SLR3 reduces the discharge capacity at the S22 structure. 	--	--	--	--
PM #3	<ul style="list-style-type: none"> Maximum discharge at S22 falls below design value for the 5-year event with SLR +3. The HW and TW exceed the water level that will bypass S22 for the 100-year design storm for SLR2 and SLR3 future scenarios and for the 25-year design storm for the SLR3 future scenario. 	--	--	--	--
PM #4	<ul style="list-style-type: none"> Peak 12-hour moving discharge ranges from 1,725 CFS to 3,038 CFS (compared to the design discharge of 1,905 CFS) and decreases with increasing SLR for each design storm return period. 	--	--	--	--
PM #5	<ul style="list-style-type: none"> 17.6% of the watershed is flooded with 0.75 ft of depth or greater for the 100-year, 9.7% for the 25-year storm. Inundated areas at these depths are likely not a result of direct canal flooding, but due to slow drainage from flat areas far away from the canal system. Percent increases for the current conditions 25-year are comparable to the SLR1 numbers for the 25-year, while the percentages are similar to the 10-year storms for SLR2 and SLR3. 	25-year	25-year	10-year	10-year
PM #6	<ul style="list-style-type: none"> Canal: Stages at the T5W station recede after 68 hours for the 25-year storm for current conditions, and for more than 3 days for the 100-year storm, which is longer than the duration of the storm event itself. For SLR1, the canal recedes in less than 72 hours for the 10-year storm. For SLR2 and SLR3, the canal takes longer than 4 days to recede for all storm events. Watershed: Percent increases for the current conditions 25-year are comparable to the SLR1 numbers for the 25-year, while the percentages are similar to the 10-year storms for SLR2 and SLR3. 	25-year	25-year	10-year	10-year
Overall Level of Service		10-year	5-year	<5-year	<5-year

C2, C3W, C4, C5, C6 FPLOS for Current and Future SLR



Preliminary Mitigation Strategies – C2 Watershed

Western

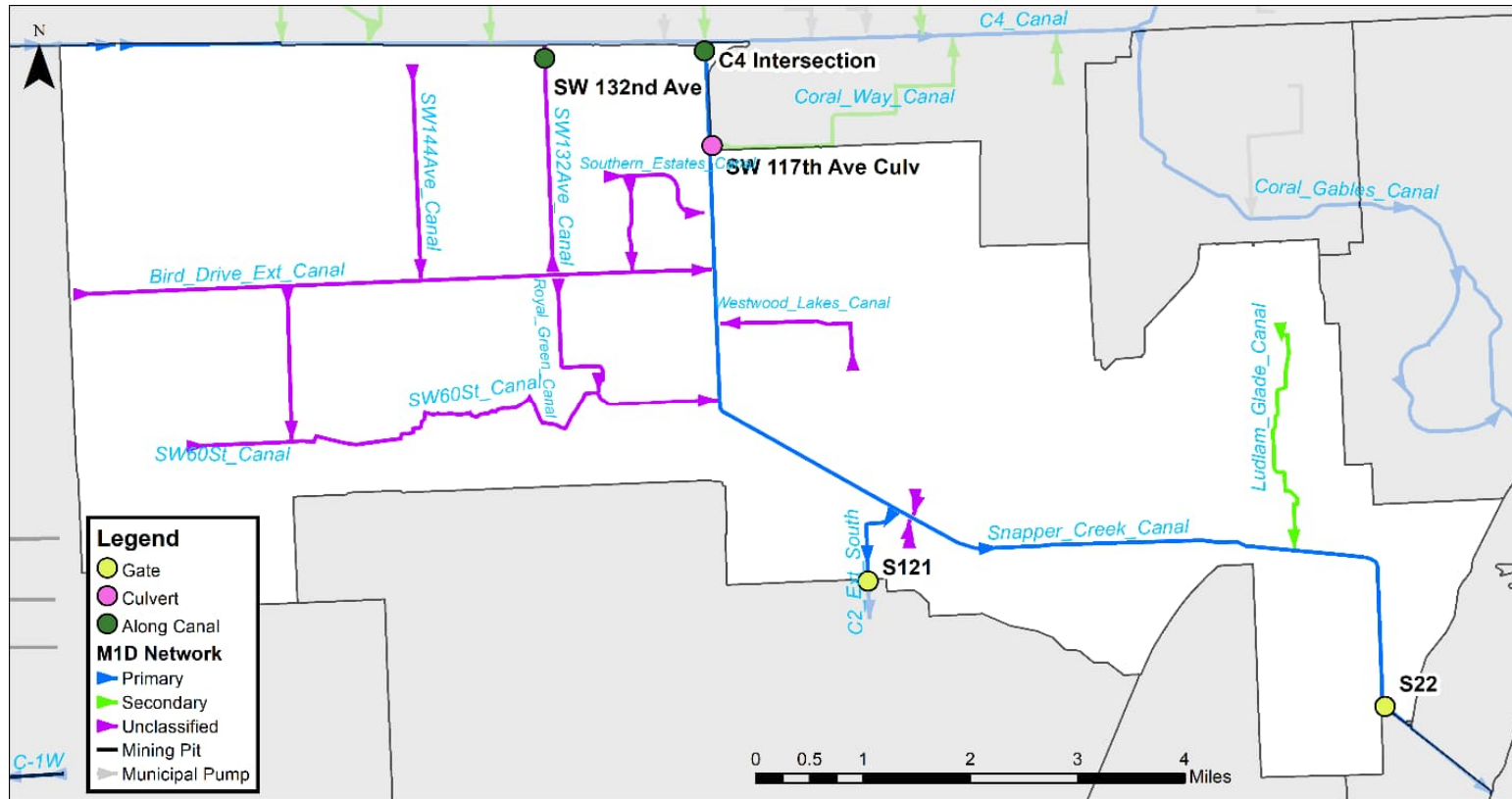
- Acquire storage area

Central

- Raise embankments
- Temporary storage
- Municipal pump stations

Tidal

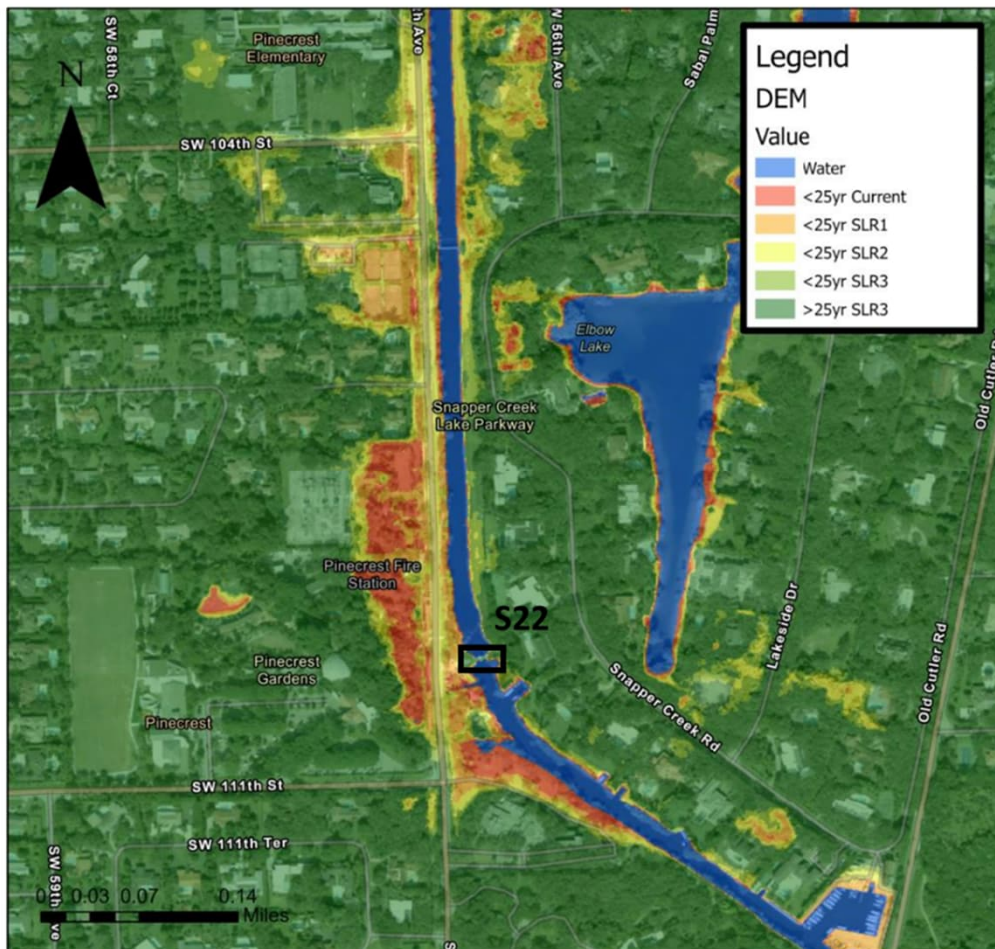
- Structure hardening
- Forward pump station
- Canal Realignment



C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR



Preliminary Mitigation Strategies – C2 Watershed



Tidal Improvements

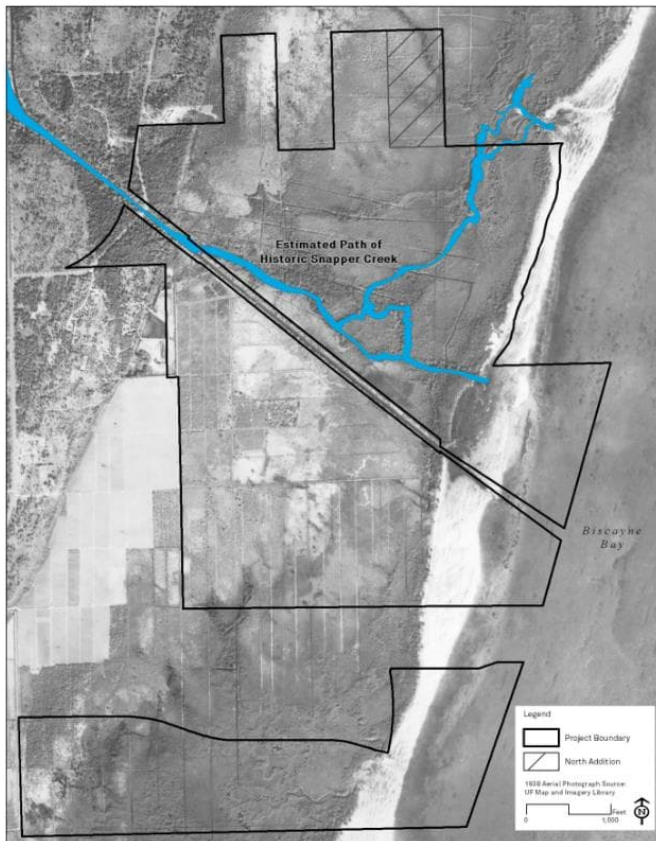
- Increase existing structure elevation to prevent overtopping
- Add tieback levees and floodwalls to prevent short-circuiting around the structure (flanking)
- Install a forward pump station to help reach the design discharge under storm surge or SLR conditions

C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR



Preliminary Mitigation Strategies – C2 Watershed

Historic C2 Canal



Tidal Improvements



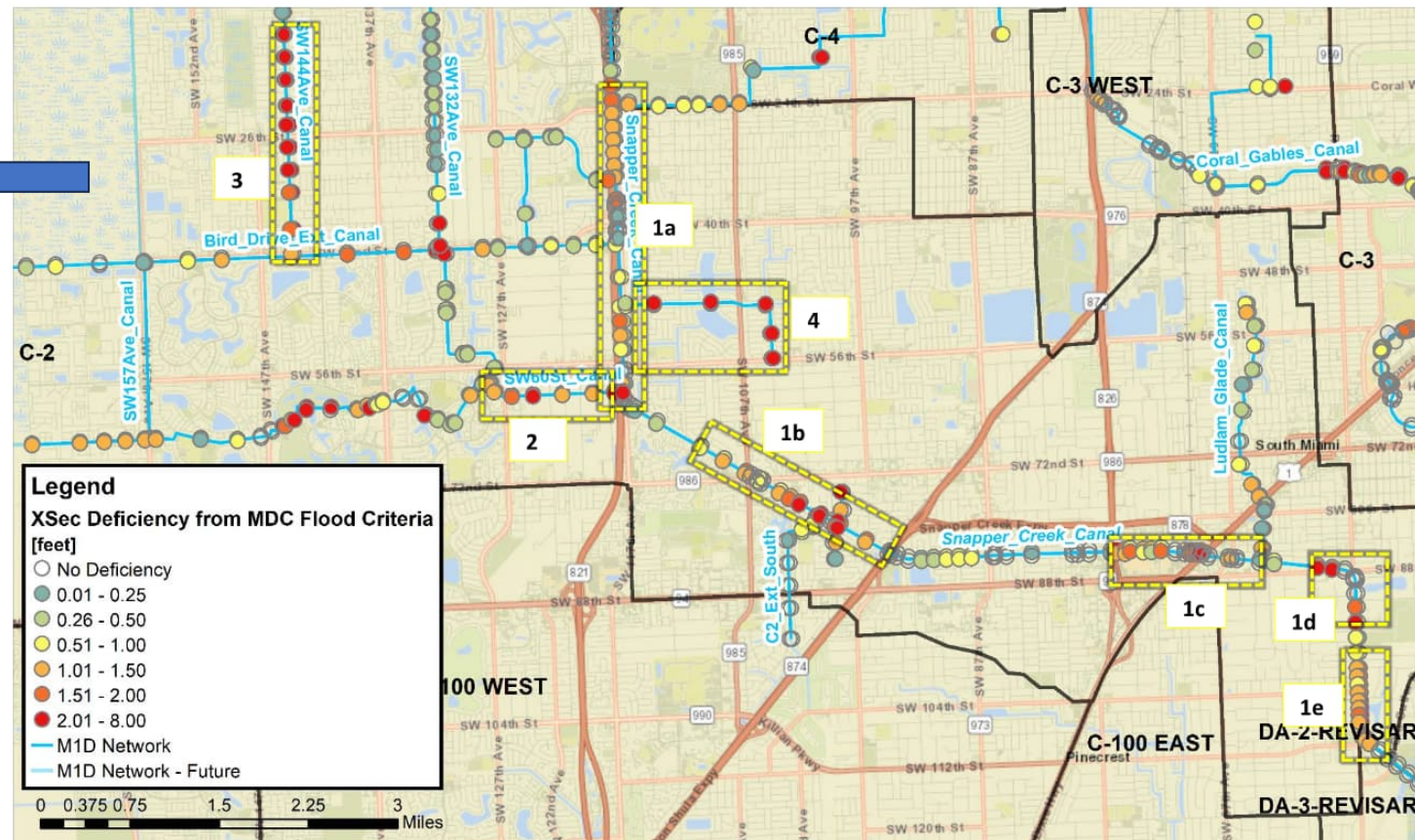
**C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR**



Preliminary Mitigation Strategies – C2 Watershed

Central Improvements

- Raise canal embankments in problem areas
- Use Miami-Dade County parks or golf courses as emergency temporary storage
- Add municipal pumps to subbasins where gravity drainage will be affected by SLR



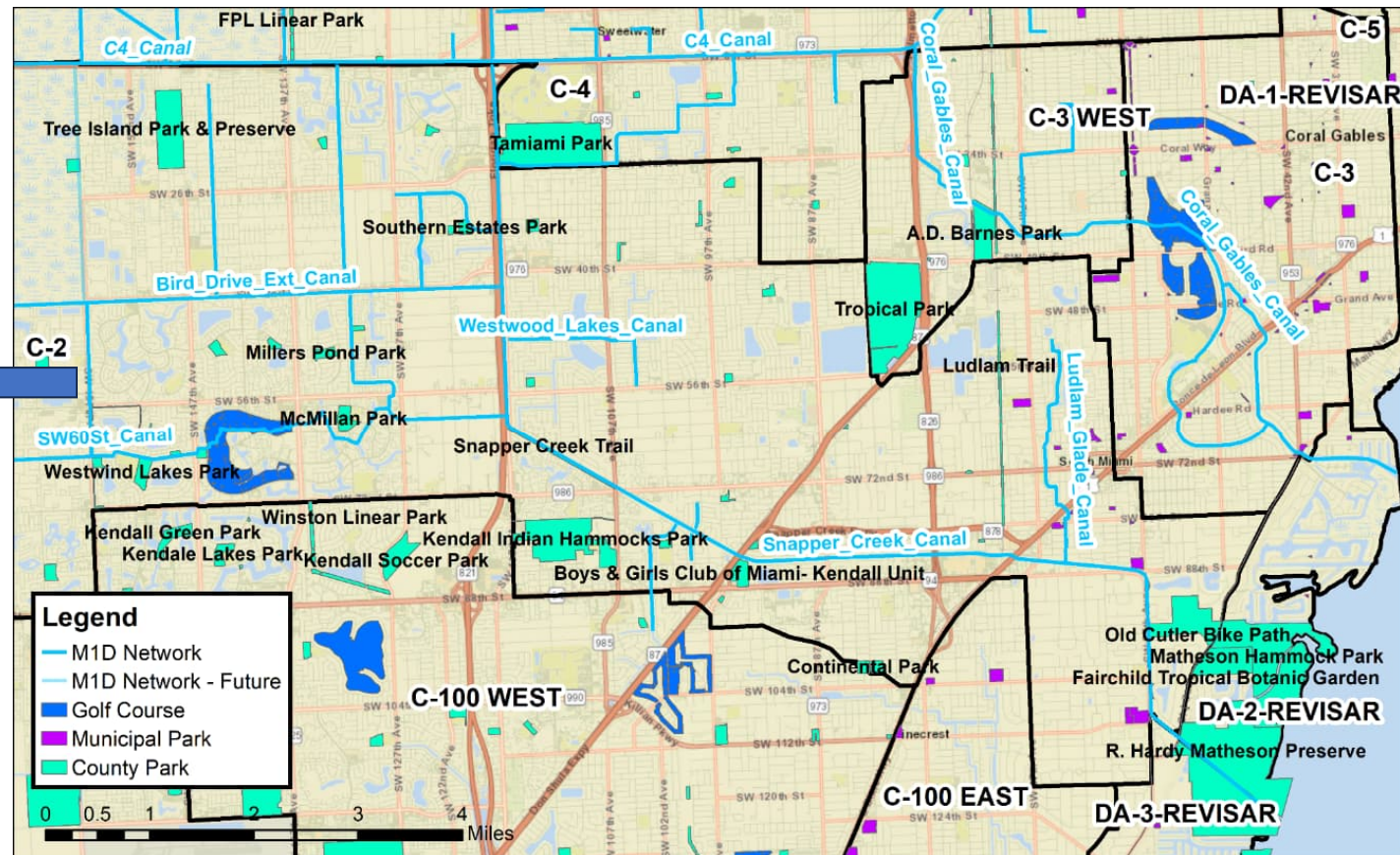
C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR



Preliminary Mitigation Strategies – C2 Watershed

Central Improvements

- Raise canal embankments in problem areas
- Use Miami-Dade County parks or golf courses as emergency temporary storage
- Add municipal pumps to subbasins where gravity drainage will be affected by SLR



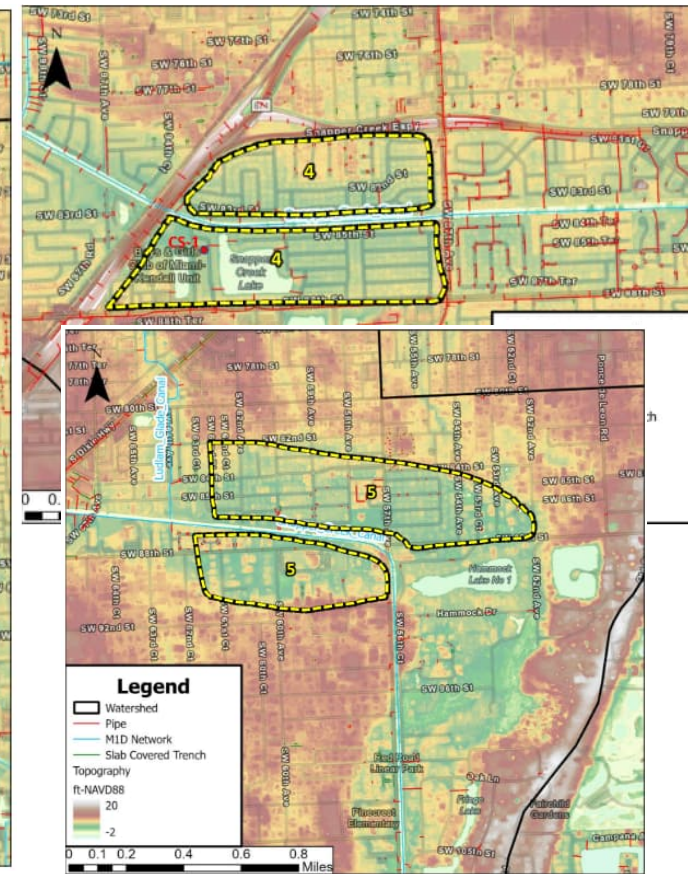
C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR



Preliminary Mitigation Strategies – C2 Watershed

Central Improvements

- Raise canal embankments in problem areas
- Use Miami-Dade County parks or golf courses as emergency temporary storage
- Add municipal pumps to subbasins where gravity drainage will be affected by SLR



C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR

Preliminary Mitigation Strategies – C2 Watershed

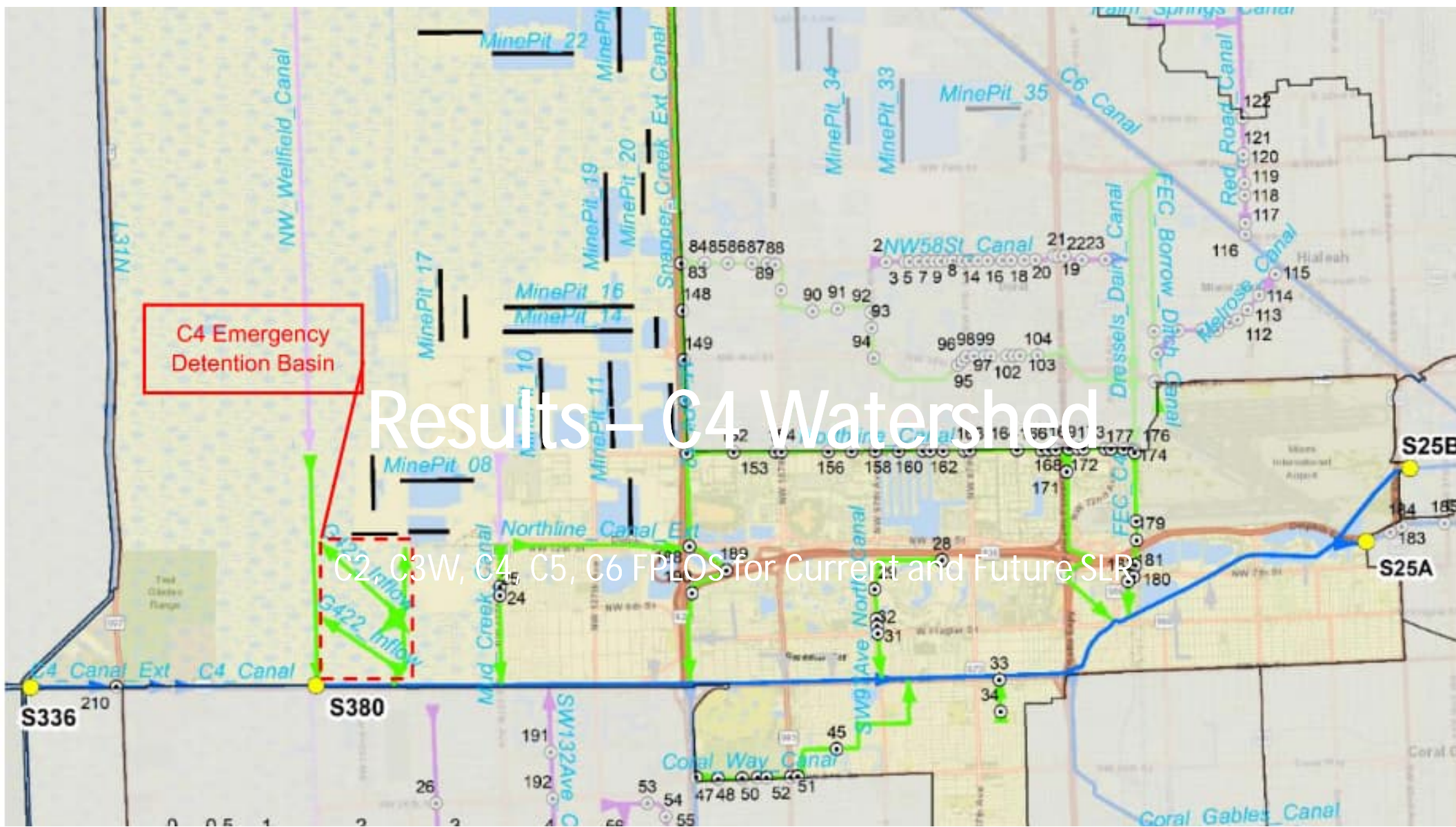
Western Improvements

- Bird Drive Recharge Area could provide flood relief for multiple basins (C2, C3W, C4, and C5)
- Provide relief when C-4 Detention Basin reaches capacity
 - 100-year/72-hour for current conditions
 - 25-year/72-hour for SLR +1 ft



C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR



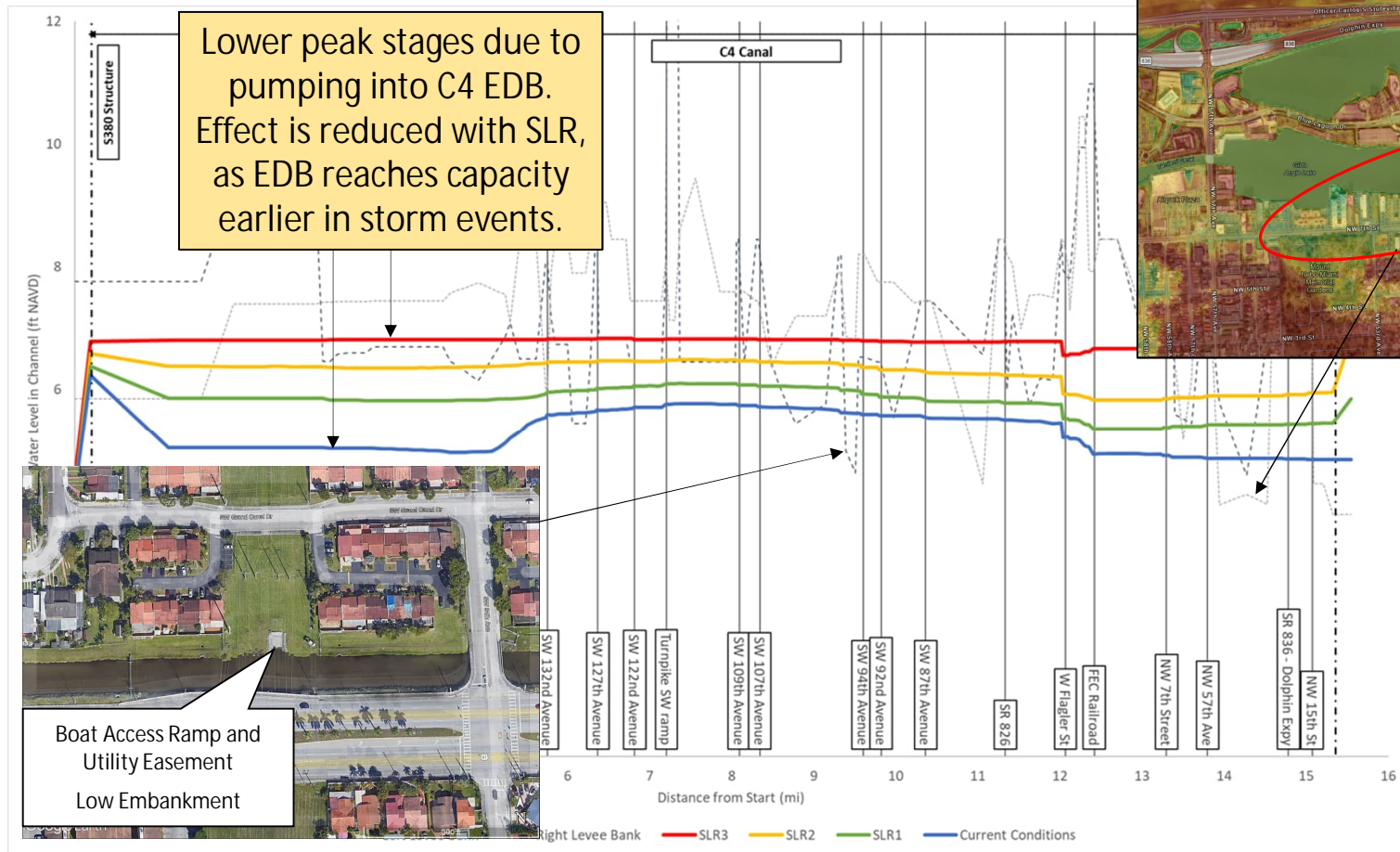


C4 Emergency Detention Basin

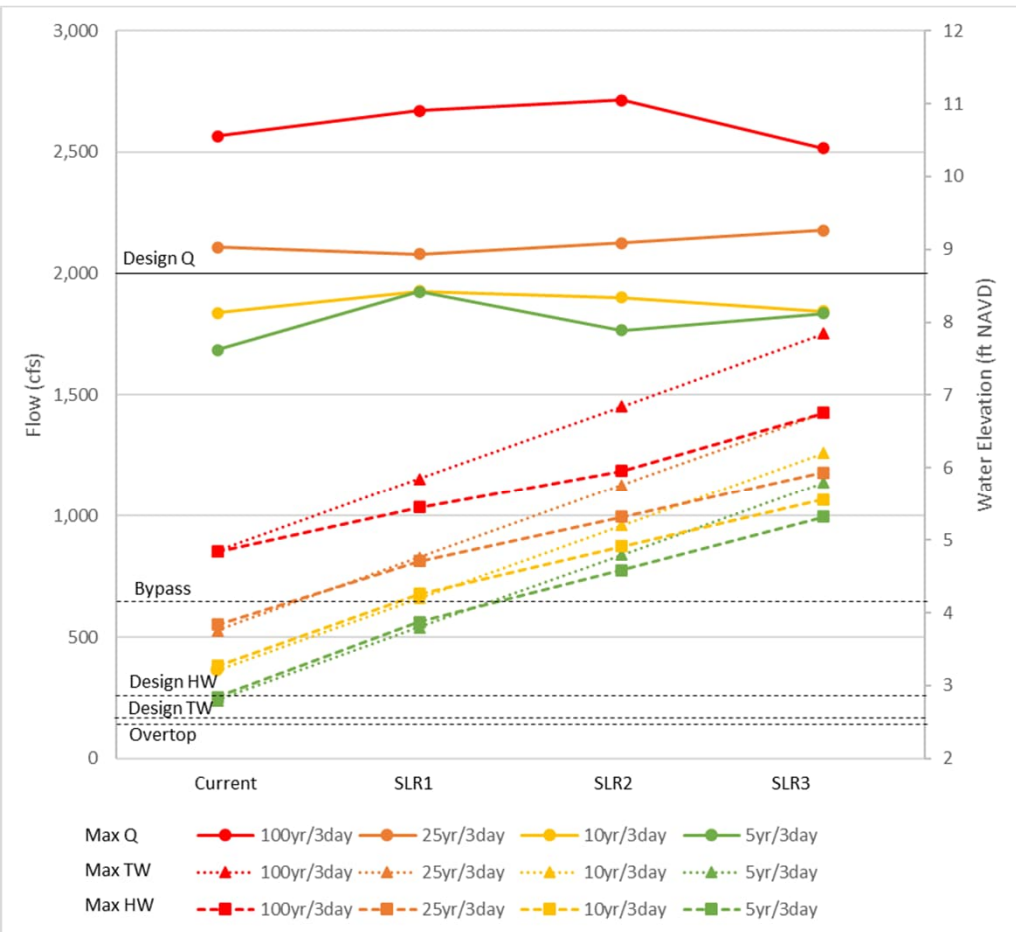
Results – C4 Watershed

C2, C3W, C4, C5, C6 FPLOs for Current and Future SLPS

Maximum Stage in C4 Canal (100yr/72hr storm)



Structure Performance for S-25B

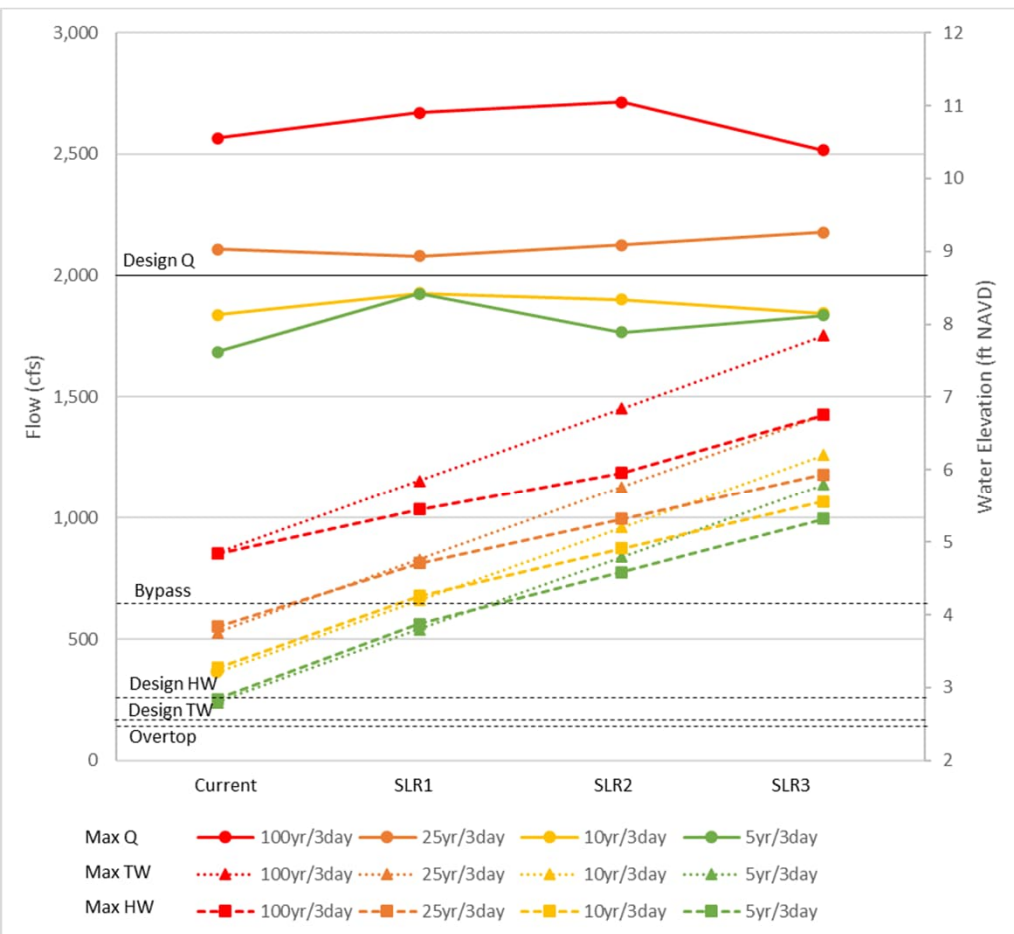


C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR



Structure Performance for S-25B

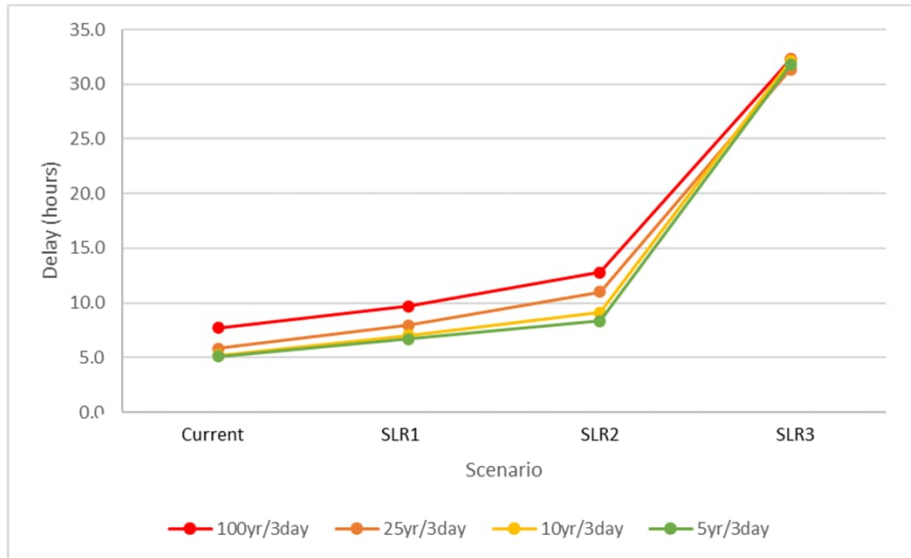
Peak discharge at S-25B does not seem to be affected by SLR.



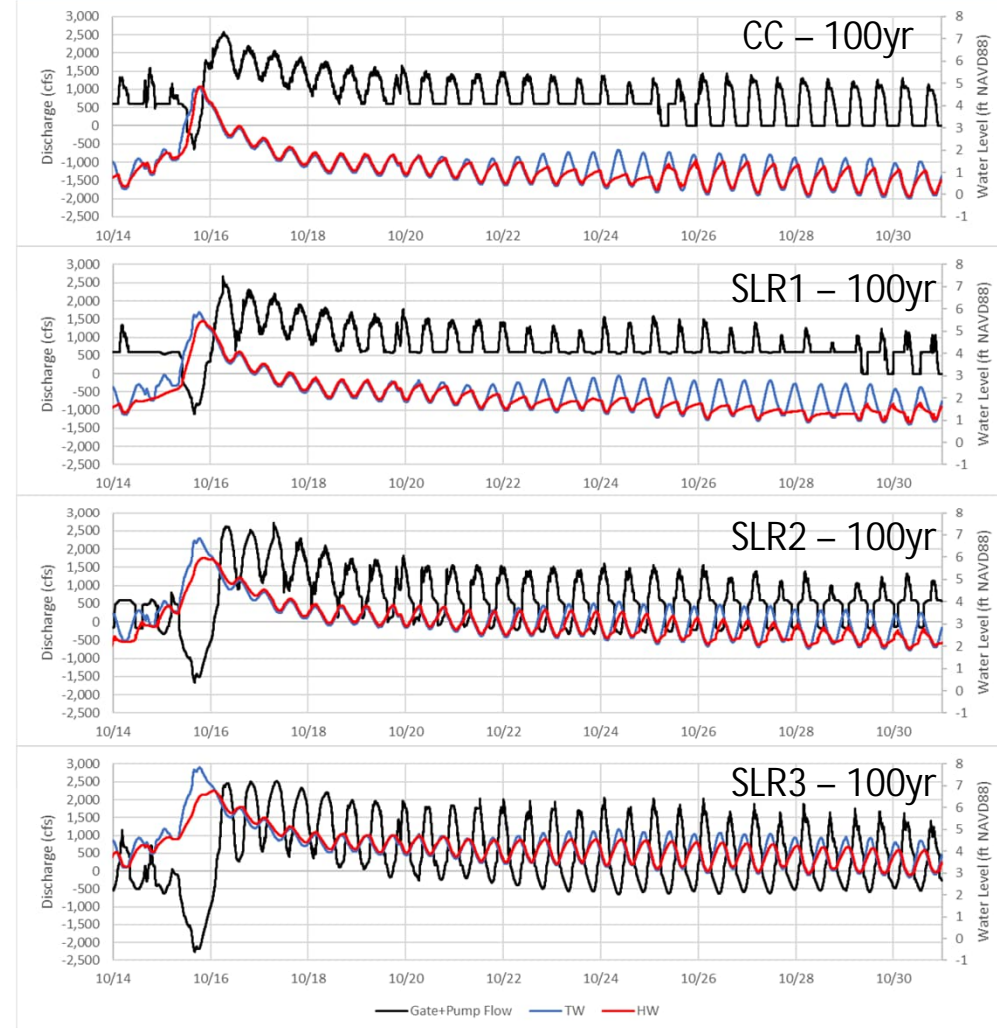
C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR



Time Between Peak HW and Peak Discharge at S-25B



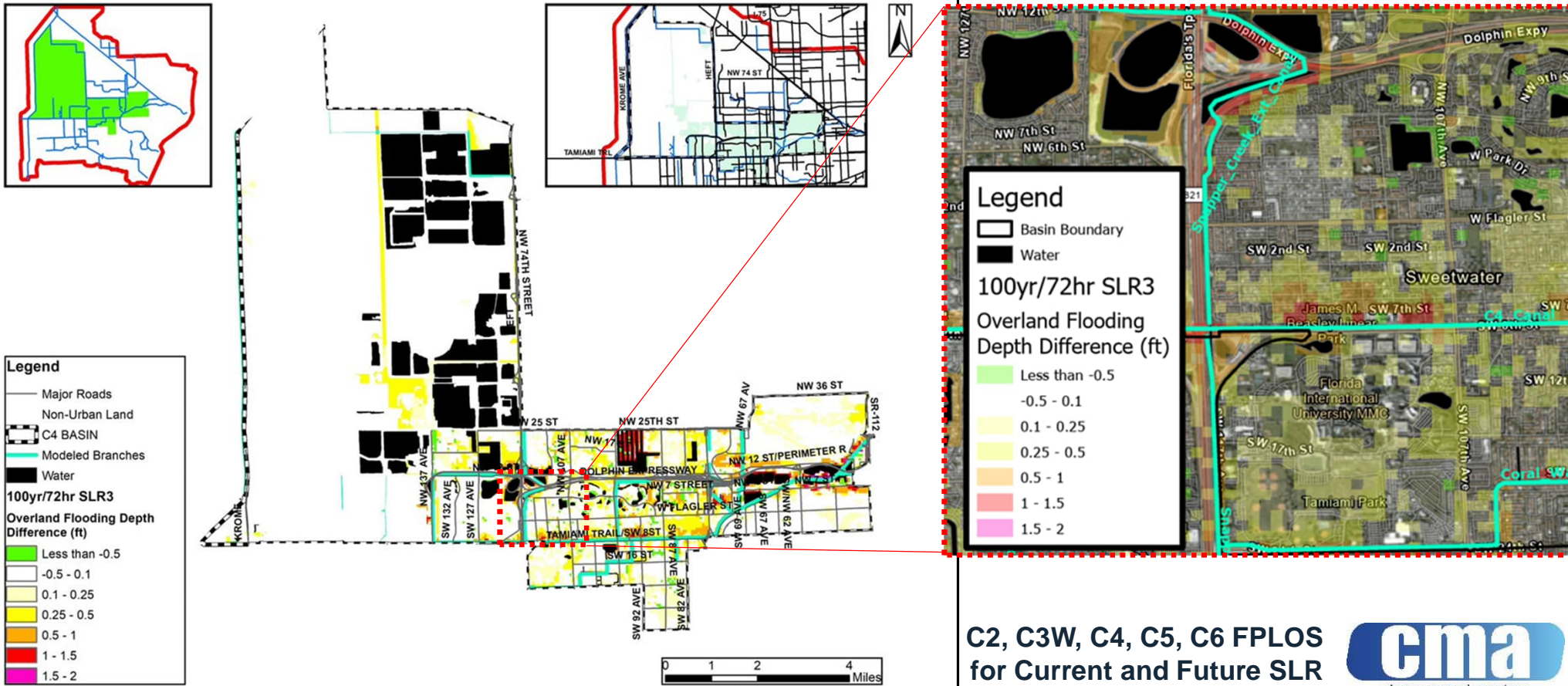
The max delay with respect to the peak discharge at S-25B increases by over two-fold from the current conditions and future SLR1 and SLR2 scenarios to the SLR3 scenario.



Results – C4 Watershed

PM#5

Urban Flooding Depth Difference of SLR +3ft and Current Conditions for the 100-year Storm



C2, C3W, C4, C5, C6 FPLOS for Current and Future SLR

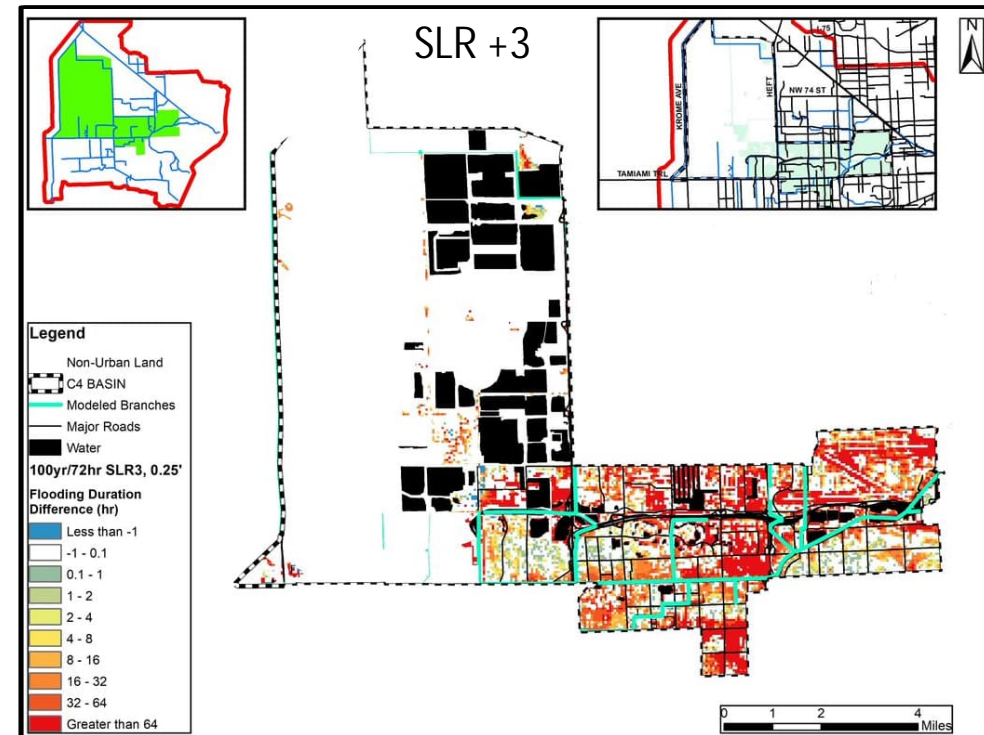
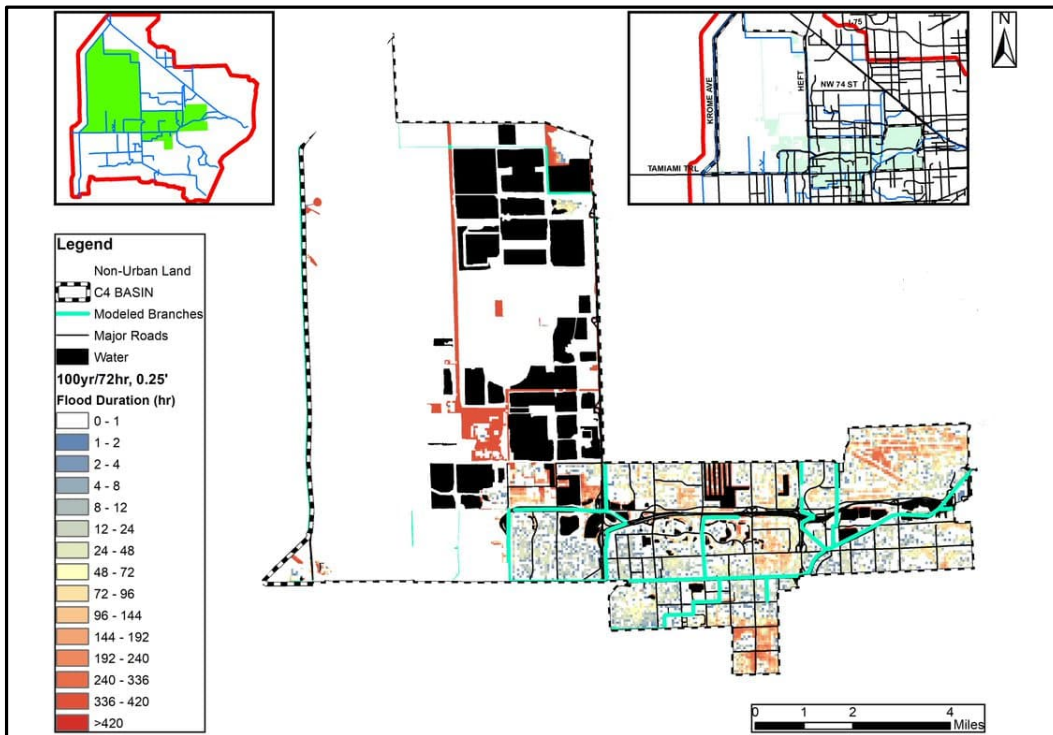


Results – C4 Watershed

PM#6

Urban Flood Duration Map for Current Conditions
100-year Storm

Urban Flooding Duration Difference of SLR and Current
Conditions for the 100-year Storm

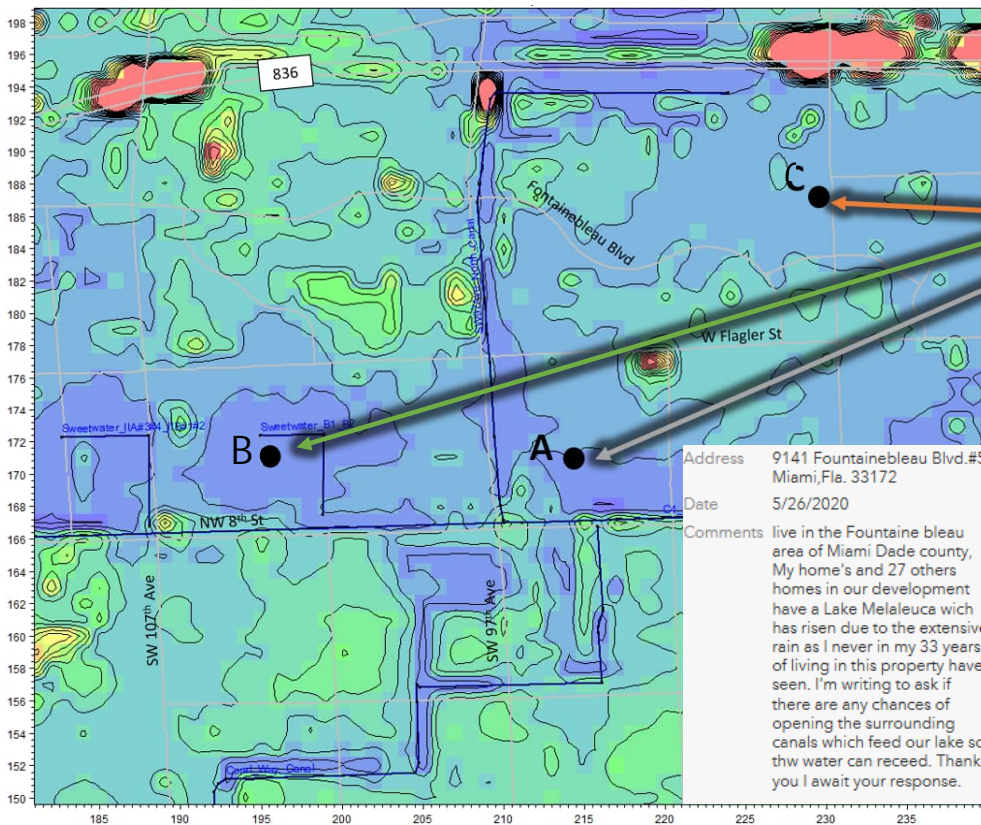


C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR

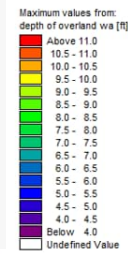
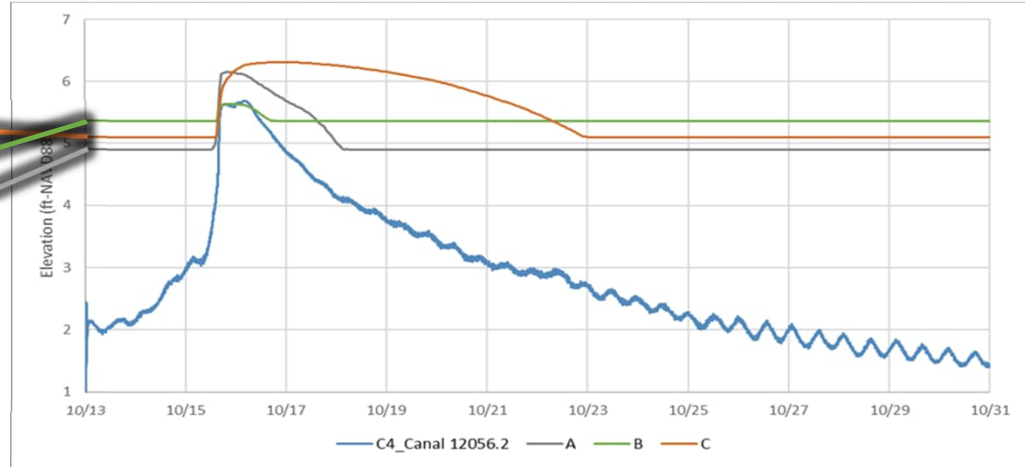


Results – C4 Watershed

PM#6



Point B, which represents an area serviced by a municipal pump stations, experiences lower flooding depth and reduced flood duration for the storm event than Point A or C, which do not have municipal pumping.



C2, C3W, C4, C5, C6 FPLOS for Current and Future SLR



Results Summary – C4

Increasing canal bank overtopping with SLR scenarios.

Discharge capacity of the watershed is maintained with increasing SLR. However, discharge is delayed and extended in duration.

Flooding depth and duration increases in areas adjacent to primary and secondary canals.

Municipal pumping appears to reduce flooding duration.

METRIC	NOTES	CURRENT CONDS.	SLR +1 FT	SLR +2 FT	SLR +3 FT
PM #1	<ul style="list-style-type: none"> No design storms exceeded bridge low chords in the C4 Canal. Five (5) of 61 culvert locations in the watershed were overtopped for the 25-year storm during current conditions, this doubled for SLR1. Three (3) culvert locations were overtopped for the 10-year storm for SLR1, but this increased to nine (9) for SLR2. Three (3) culvert locations were overtopped for the 5-year storm for SLR2, but this increased to 15 for SLR3. The C4 Canal is overtopped for less than a mile for the current conditions 25-year storm, for the SLR1 and SLR2 conditions for 10-year storm, and for the SLR3 condition for the 5-year storm. Problem areas include Fountainbleau, Westchester, and Doral East. 	25-year	10-year	5-year	< 5-year
PM #2	<ul style="list-style-type: none"> No comparable value found for this basin. With the future canals, a new connection to the C4 Canal increases discharges from the C2 watershed, reducing drainage capacity for SLR1 conditions. Peak discharge capacity is delayed a full day for SLR2 and SLR3, when tailwater conditions have improved and pumping returns at S25B. 	--	--	--	--
PM #3	<ul style="list-style-type: none"> Maximum discharge at S25B falls below design value for the 5-year and 10-year storm for all current and future conditions. Max discharge is not affected by SLR. HW exceeds the water level that will bypass S25B for the 100-year and 25-year current conditions scenarios and all future SLR scenarios (SLR1, SLR2, SLR3) except for the 5-year SLR1 scenario. The TW exceeds this bypass elevation during the 100-year current conditions scenario and all future SLR scenarios (SLR1, SLR2, SLR3) except for the 5-year SLR1 scenario. 	--	--	--	--
PM #4	<ul style="list-style-type: none"> Peak 12-hour moving discharge ranges from 771 CFS to 2,159 CFS, compared to the design discharge of 2,000 CFS, and decreases with SLR. 	--	--	--	--
PM #5	<ul style="list-style-type: none"> 26.4% of the watershed is flooded with 0.75 in of depth or greater for the 100-year, 17.3% for the 25-year storm. Inundation at some of these locations is likely related to the canal stages overtopping the canal banks, however, some areas farther away from canals are also experiencing flooding at depths greater than 0.75ft. Difference maps suggest that OL flooding will increase primarily in areas adjacent to the C4 Canal such as Sweetwater and Fountainbleau. 	10-year	10-year	5-year	< 5-year
PM #6	<ul style="list-style-type: none"> Canal: Stages at the T5W station recede after 68 hours for the 25-year storm for current conditions, and for more than 3 days for the 100-year storm, which is longer than the duration of the storm event itself. For SLR1, the canal recedes in less than 72 hours for the 10-year storm. For SLR2 and SLR3, the canal takes longer than 4 days to recede for all storm events. Watershed: Percent of area inundated for more than 48 hours for the current conditions 25-year is over 15% and this increases with SLR. 	10-year	10-year	5-year	< 5-year
Overall Level of Service		10-year	10-year	5-year	<5-year

Preliminary Mitigation Strategies – C4 Watershed

Western

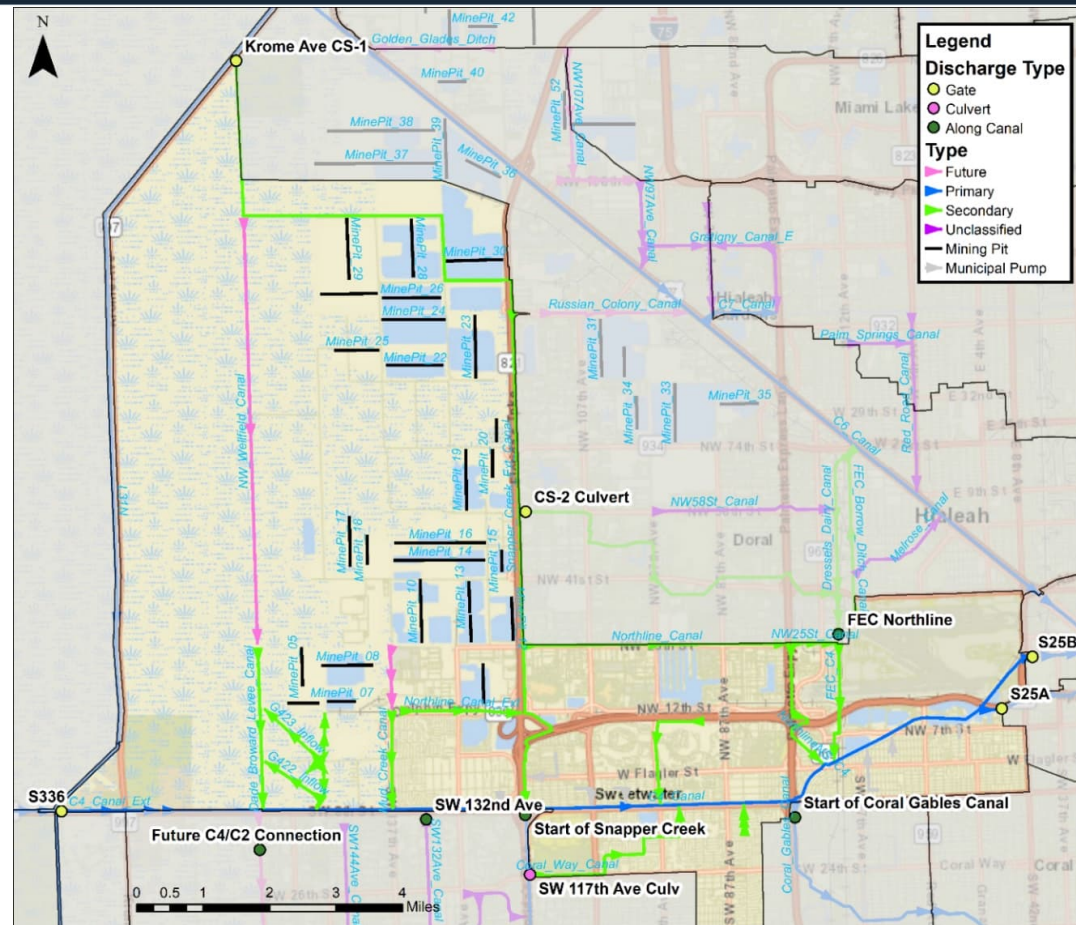
- Improvements to S380
- C4 EDB expansion
- Acquire storage area

Central

- Raise embankments
- Temporary storage
- Municipal pump stations
- Evaluate undersized culverts
- Additional control structures

Tidal

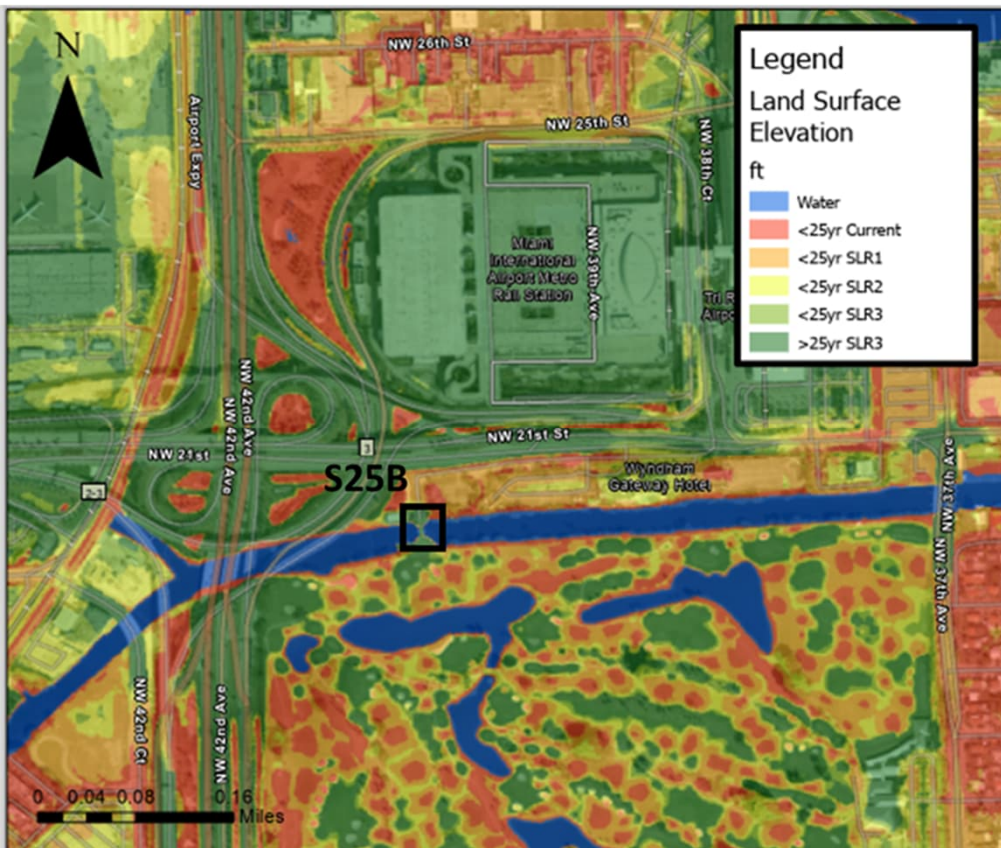
- Structure hardening
- Adjust Forward Pump Operations



C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR

Preliminary Mitigation Strategies – C4 Watershed

Tidal Improvements



- Increase existing structure elevation to prevent overtopping
- Add tieback levees and floodwalls to prevent short-circuiting around the structure (flanking)
- Re-evaluate protocols at S25B_P to allow for pumping during higher downstream conditions
- Pump capacity increases at S25B will be evaluated when downstream impacts are further analyzed in Phase 2

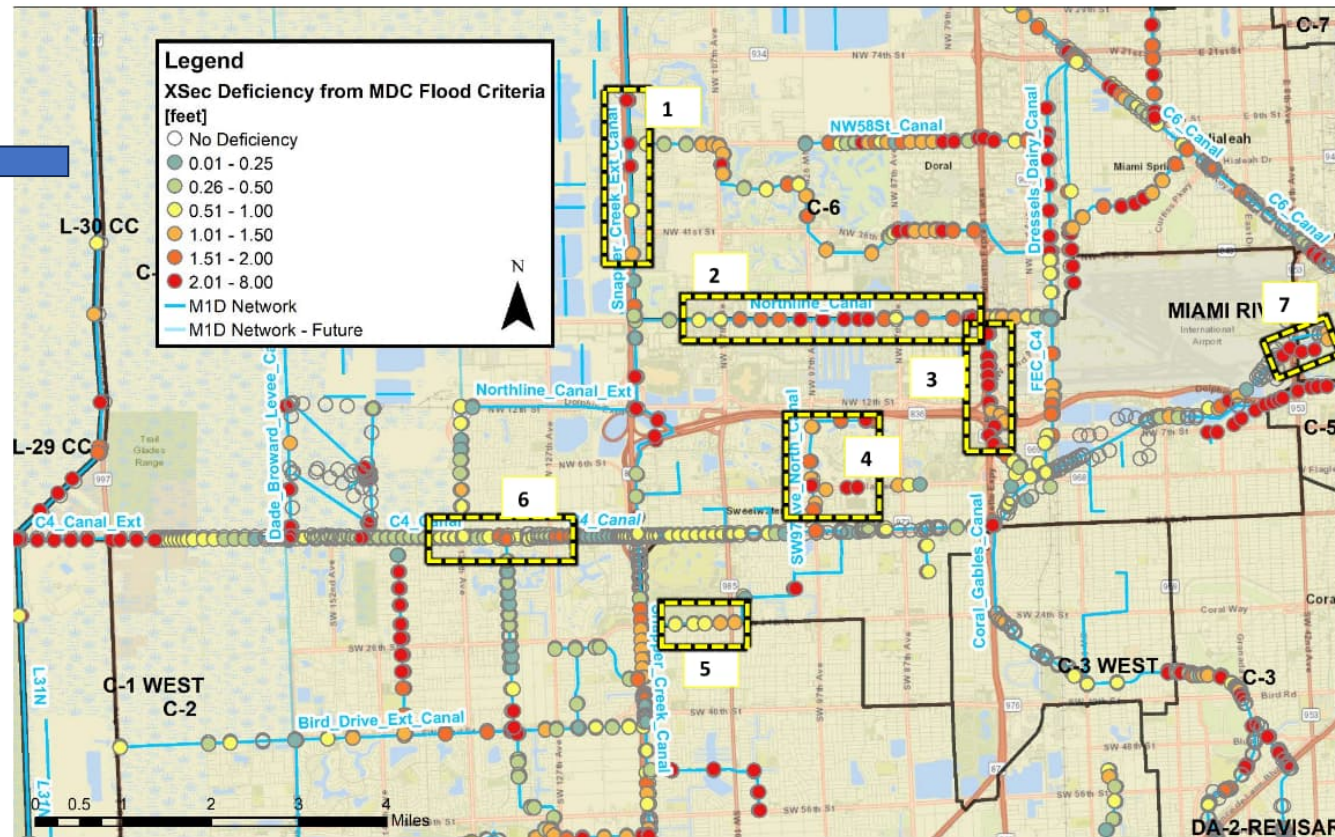
C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR



Preliminary Mitigation Strategies – C4 Watershed

Central Improvements

- Raise canal embankments in problem areas
- Use Miami-Dade County parks or golf courses as emergency temporary storage
- Add municipal pumps to subbasins where gravity drainage will be affected by SLR
- Evaluate undersized culverts
- Add control structures to connections with Snapper Creek Canal and Coral Gables Canal
- Separate C4 Canal from adjoining lakes to increase storage



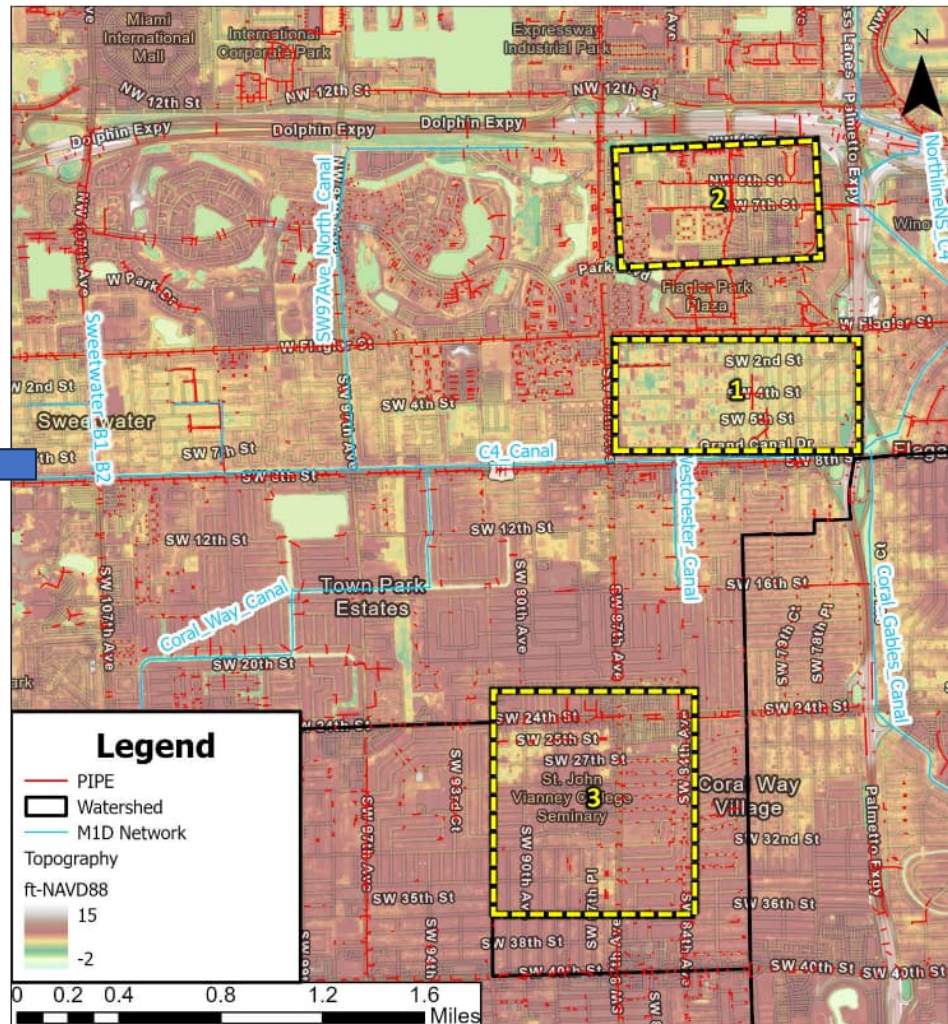
C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR



Preliminary Mitigation Strategies – C4 Watershed

Central Improvements

- Raise canal embankments in problem areas
- Use Miami-Dade County parks or golf courses as emergency temporary storage
- Add municipal pumps to subbasins where gravity drainage will be affected by SLR
- Evaluate undersized culverts
- Add control structures to connections with Snapper Creek Canal and Coral Gables Canal
- Separate C4 Canal from adjoining lakes to increase storage



Preliminary Mitigation Strategies – C4 Watershed

Central Improvements

- Raise canal embankments in problem areas
- Use Miami-Dade County parks or golf courses as emergency temporary storage
- Add municipal pumps to subbasins where gravity drainage will be affected by SLR
- Evaluate undersized culverts
- Add control structures to connections with Snapper Creek Canal and Coral Gables Canal
- Separate C4 Canal from adjoining lakes to increase storage



C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR



Preliminary Mitigation Strategies – C4 Watershed

Central Improvements

- Raise canal embankments in problem areas
- Use Miami-Dade County parks or golf courses as emergency temporary storage
- Add municipal pumps to subbasins where gravity drainage will be affected by SLR
- Evaluate undersized culverts
- Add control structures to connections with Snapper Creek Canal and Coral Gables Canal
- Separate C4 Canal from adjoining lakes to increase storage



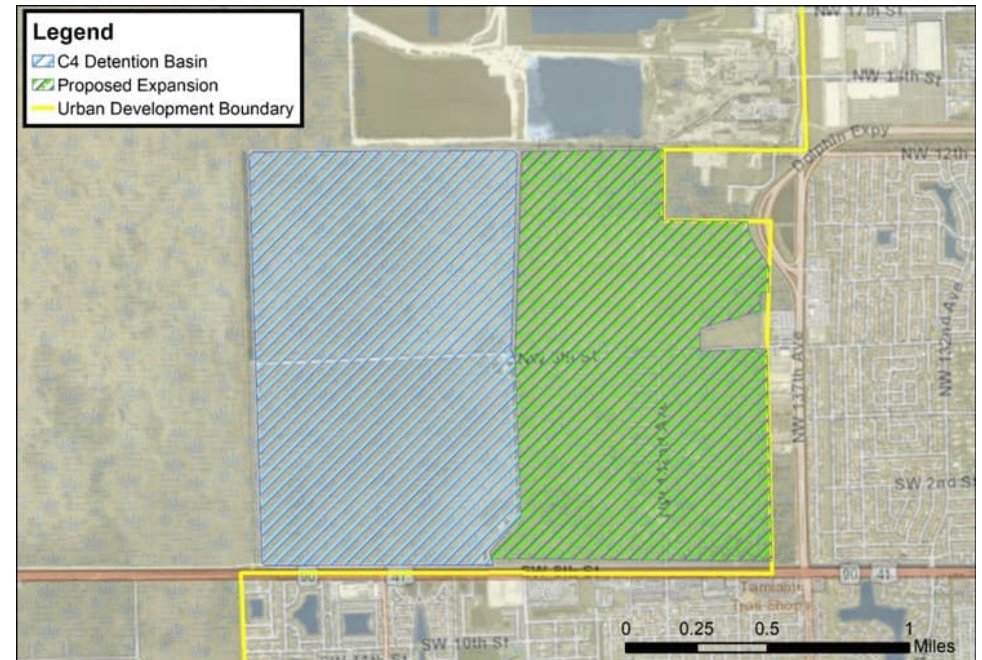
C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR



Preliminary Mitigation Strategies – C4 Watershed

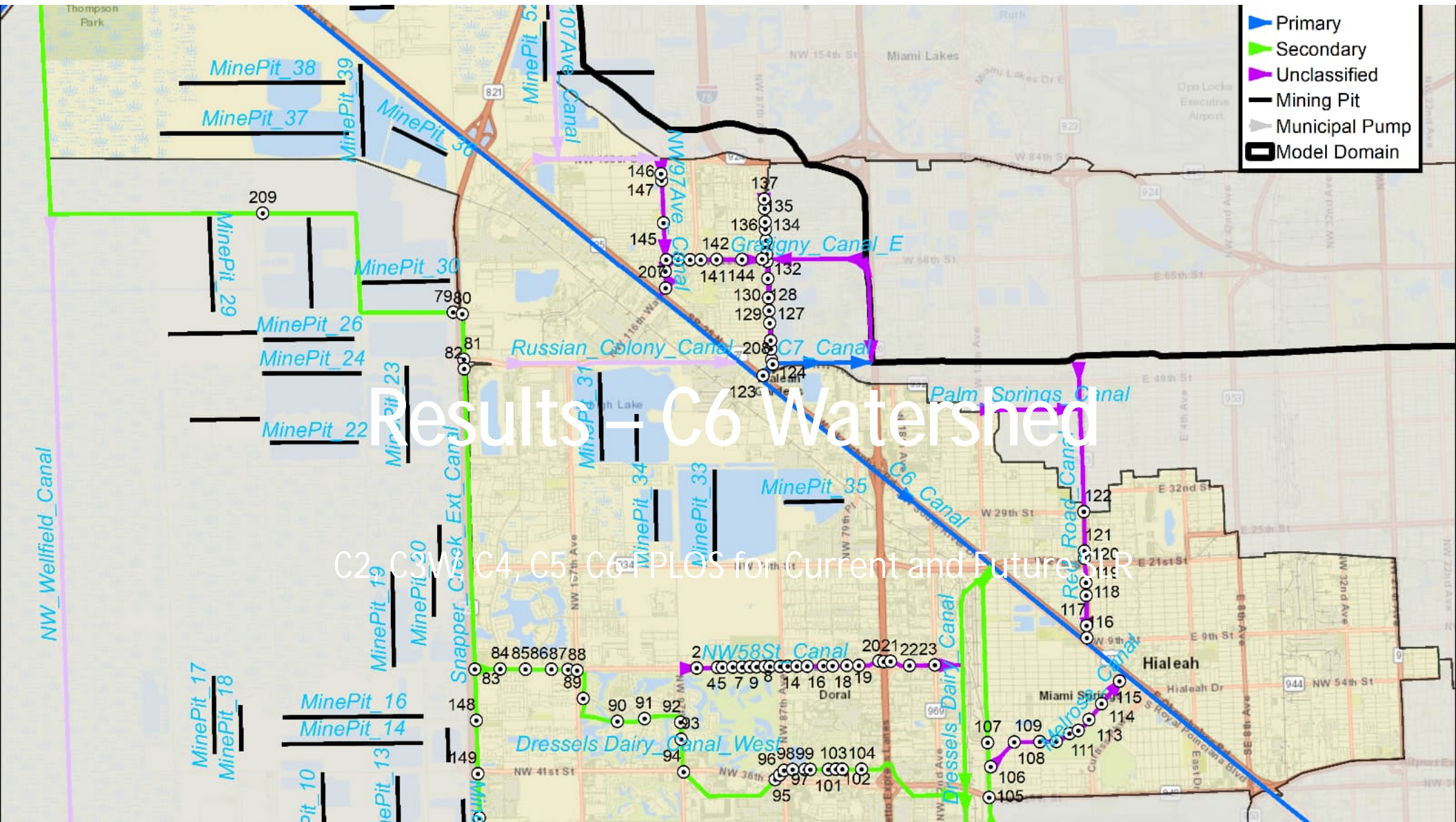
Western Improvements

- Structure upgrades to S380
- Expand C-4 Detention Basin
- Utilize Central Lake Belt Storage Area as additional storage during storm events



C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR

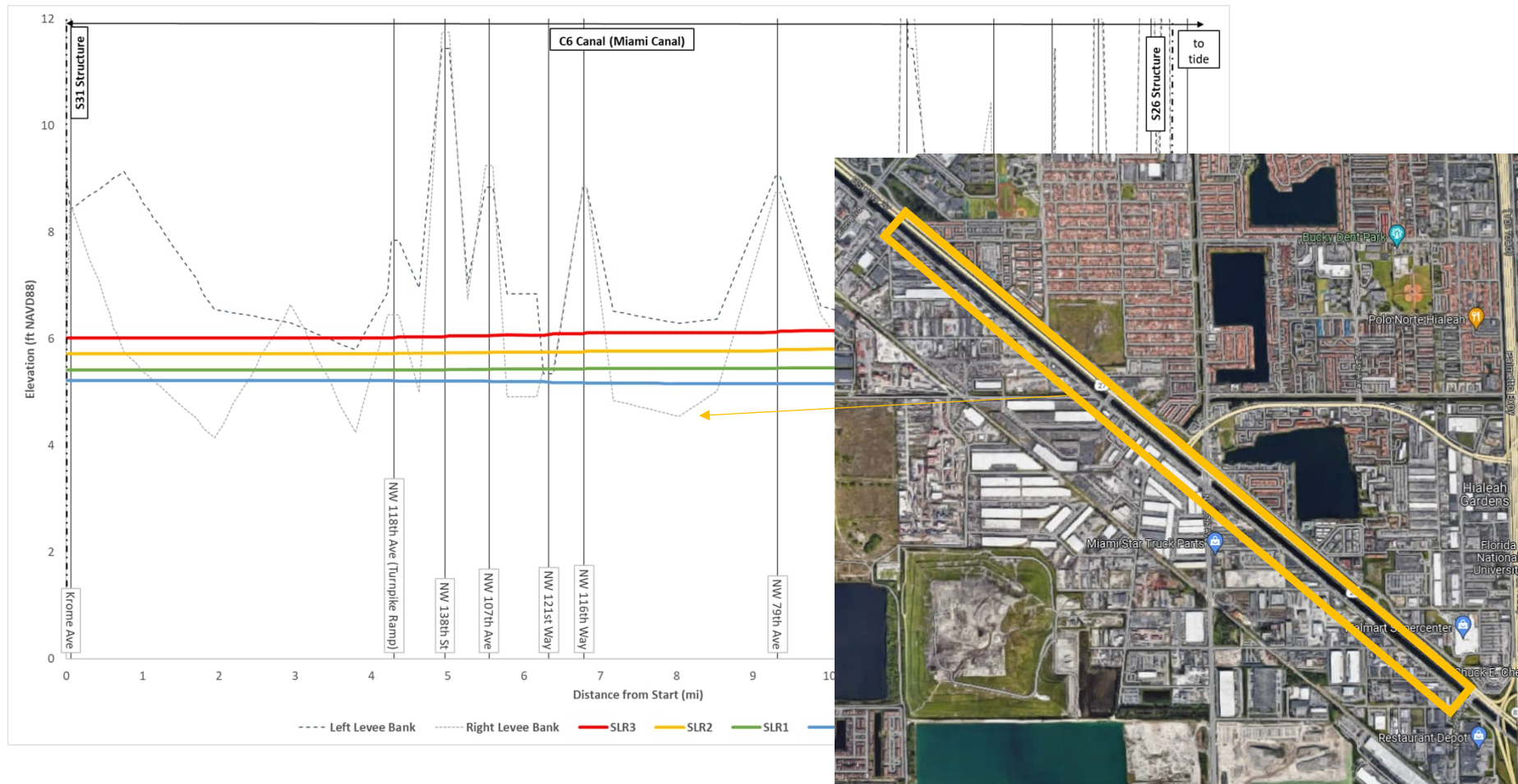




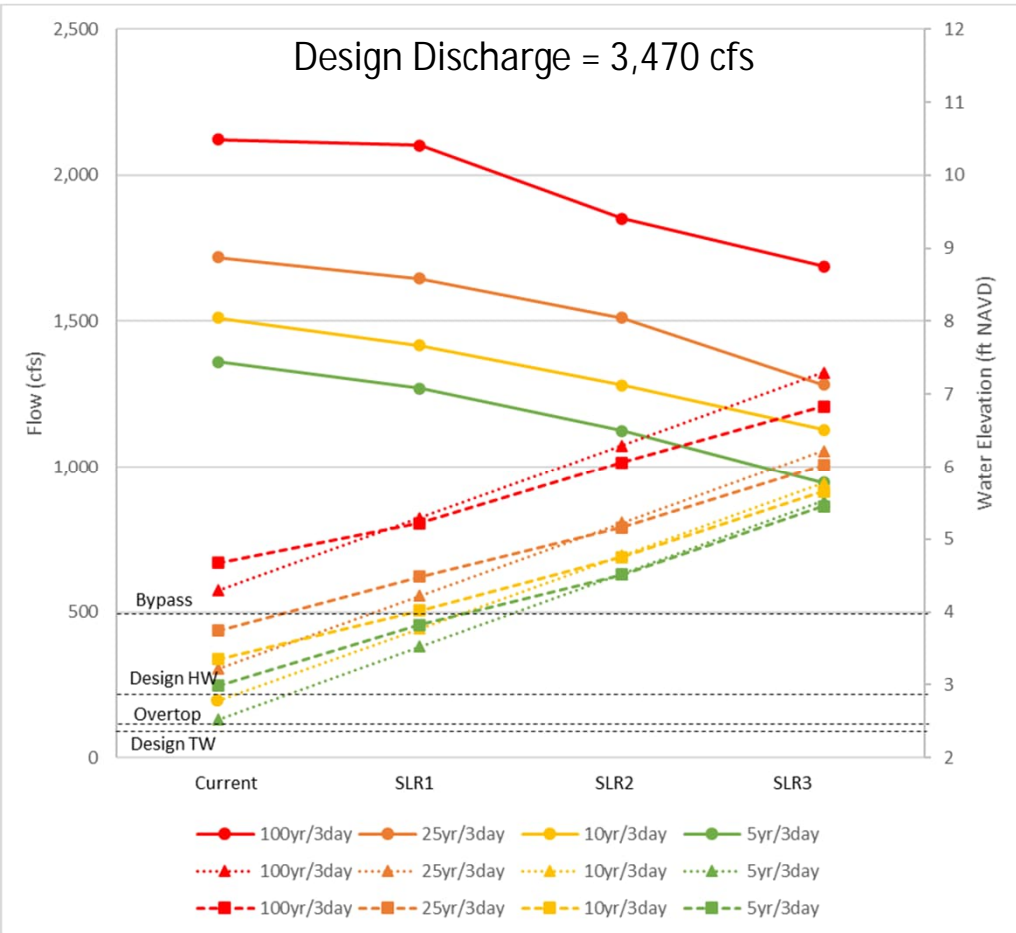
Results – C6 Watershed

C2, C3, C4, C5, C6 PLOS for Current and Future

Maximum Stage in Miami Canal (100yr/72hr storm)



Structure Performance for S-26

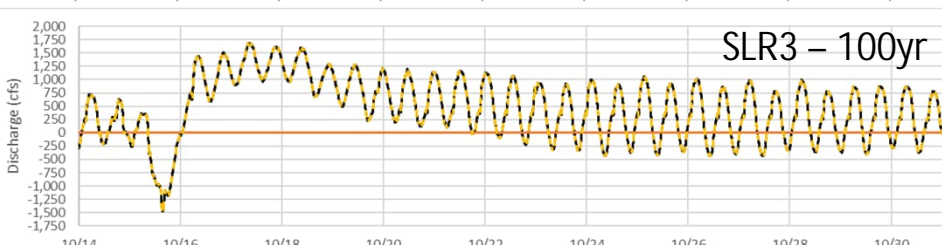
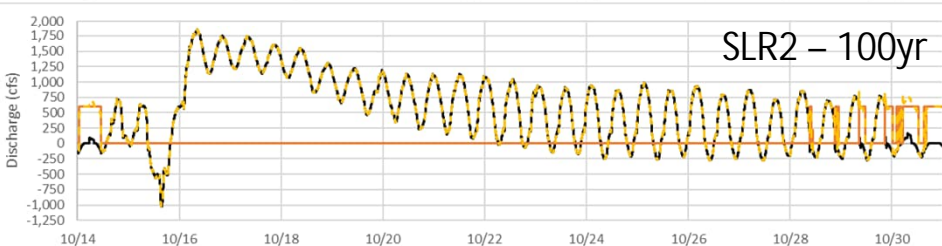
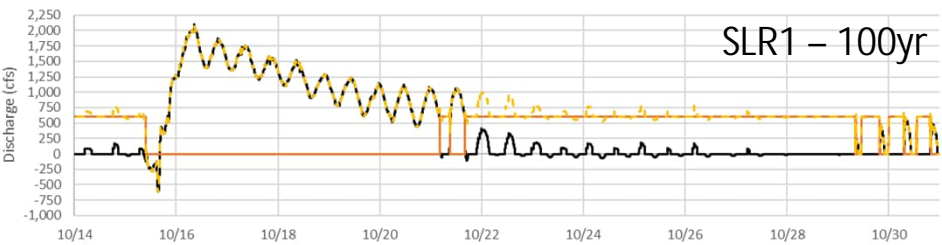
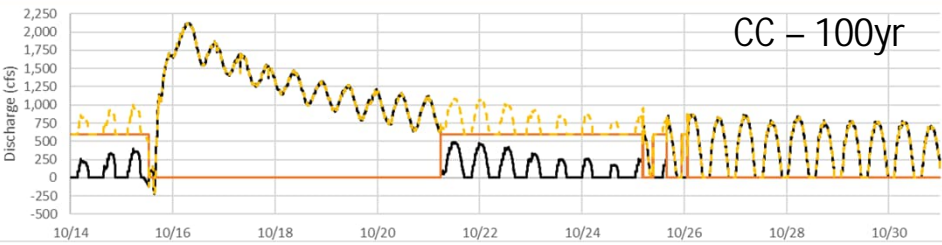


C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR



Results – C6 Watershed

PM#3



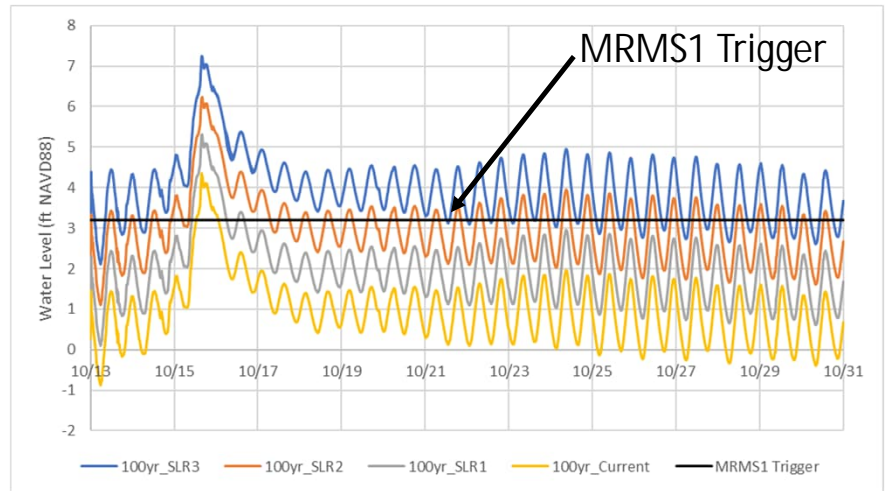
— Gate Flow — Pump Flow - - - Total Flow

S-26 Pump does not turn on if the following conditions are met:

- Stage Upstream < -0.54 ft-NAVD
- Flow through S-26 gate
- S-25B Pump is off

S-25B Pump does not turn on unless all three of the following conditions are met:

- Stage at T5W > 2.25 ft-NAVD
- Stage Upstream > -0.55 ft-NAVD
- Stage at MRMS1 < 3.2 ft-NAVD



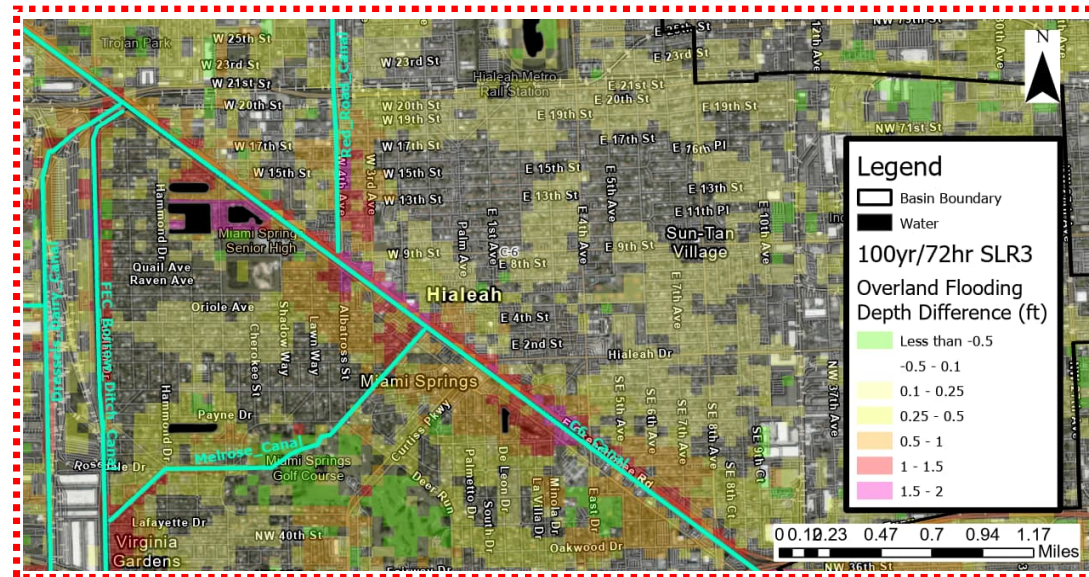
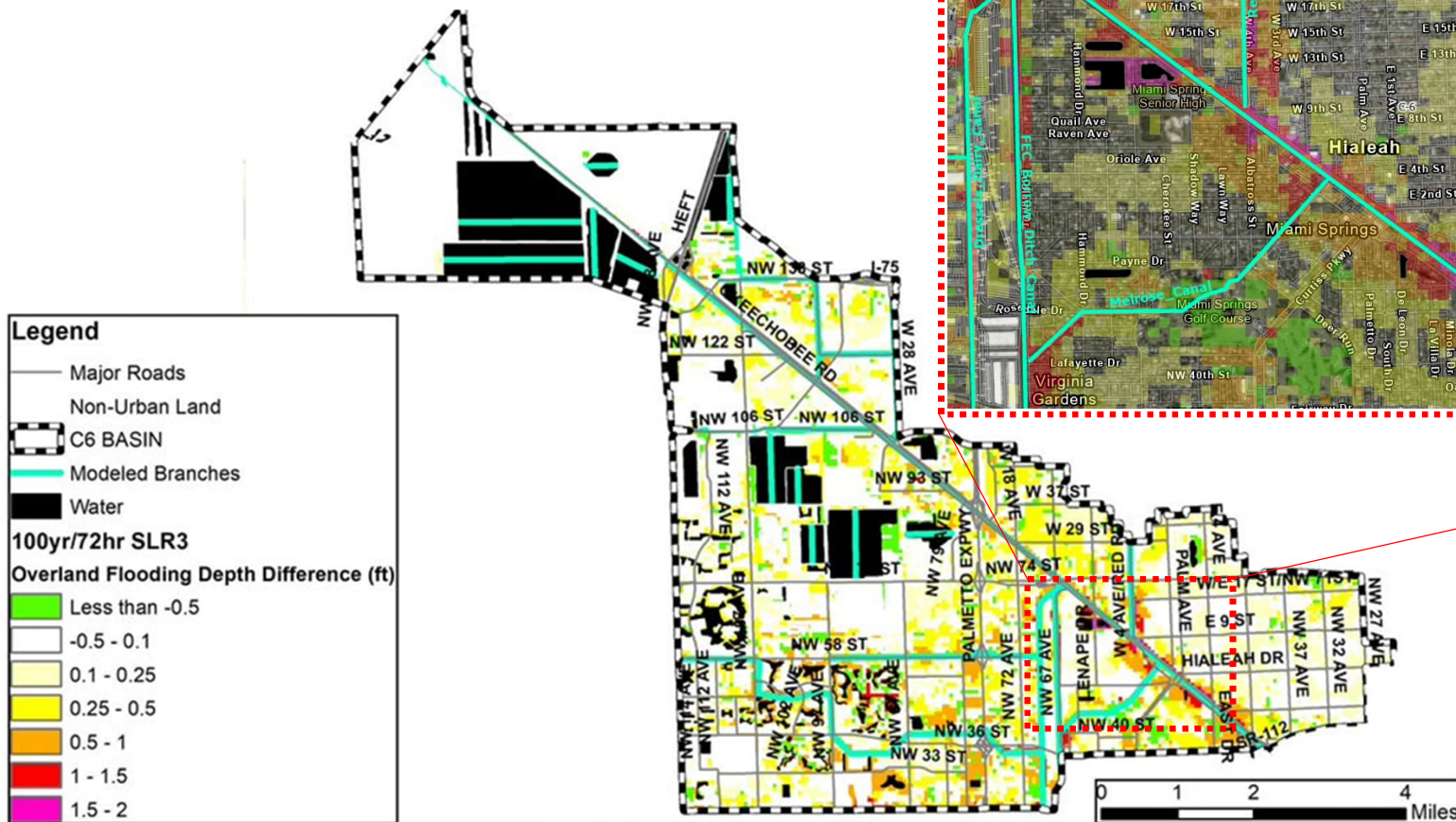
C2, C3W, C4, C5, C6 FPLOS for Current and Future SLR



Results – C6 Watershed

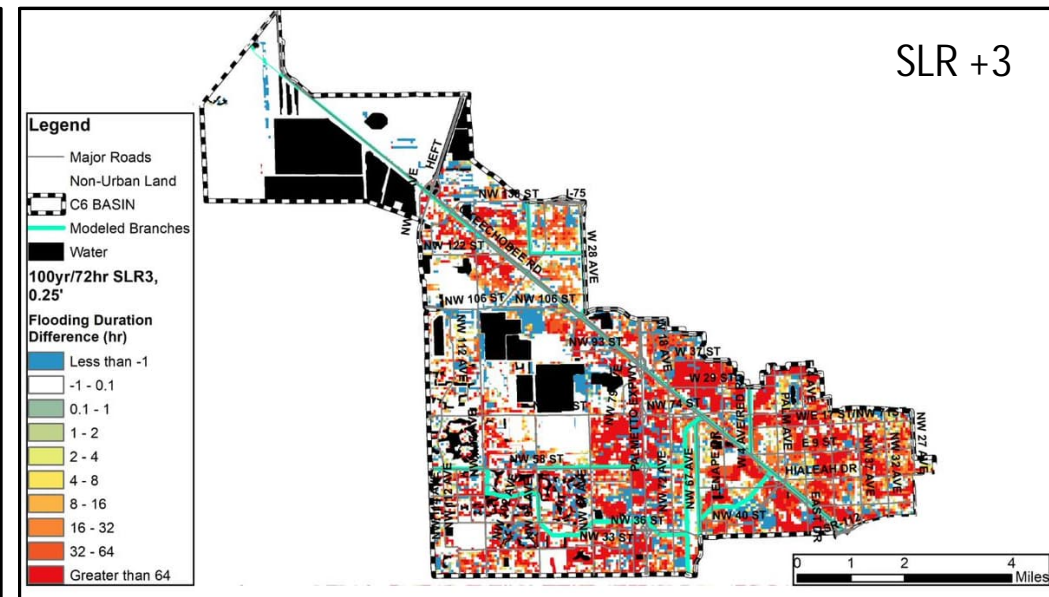
PM#5

Urban Flooding Depth Difference of SLR +3ft and Current Conditions for the 100-year Storm



Urban Flood Duration Map for Current Conditions 100-year Storm

Urban Flooding Duration Difference of SLR and Current Conditions for the 100-year Storm



C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR



Results – C6 Watershed

PM#6

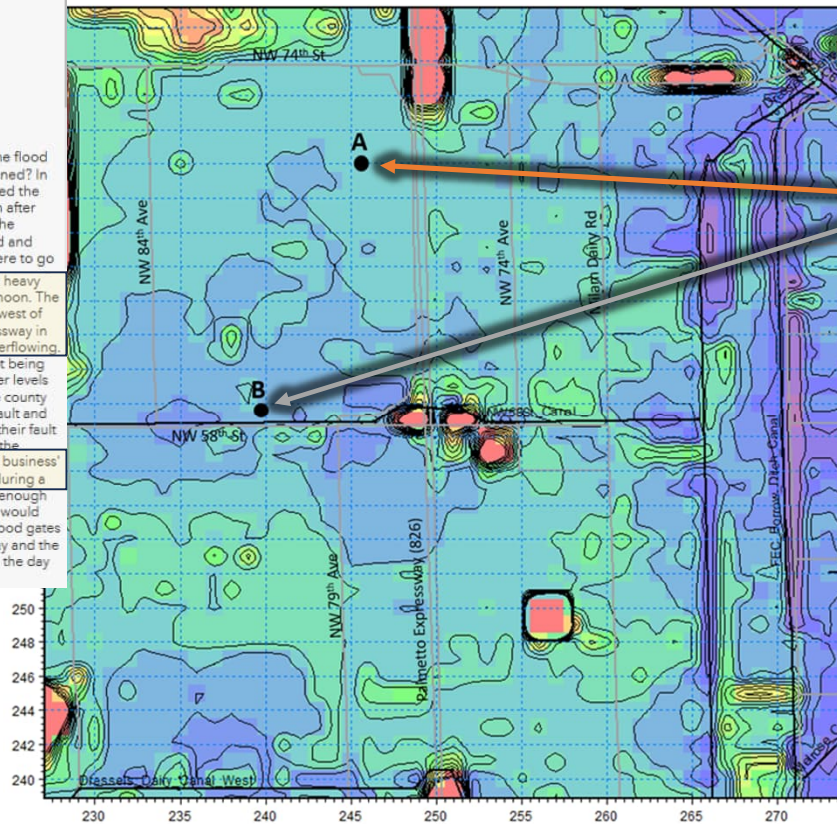
Flooding Complaints: Oscar

Watershed C-6
 Name Oscar
 Phone Number 305-803-9696
 Email ov24@aol.com
 Address N/A
 Date 5/26/2020
 Comments How do we know if the flood gates have been opened? In the area we are located the canals were very high after last weekend rains. The ground was saturated and the water had no where to go

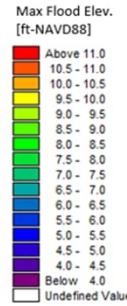
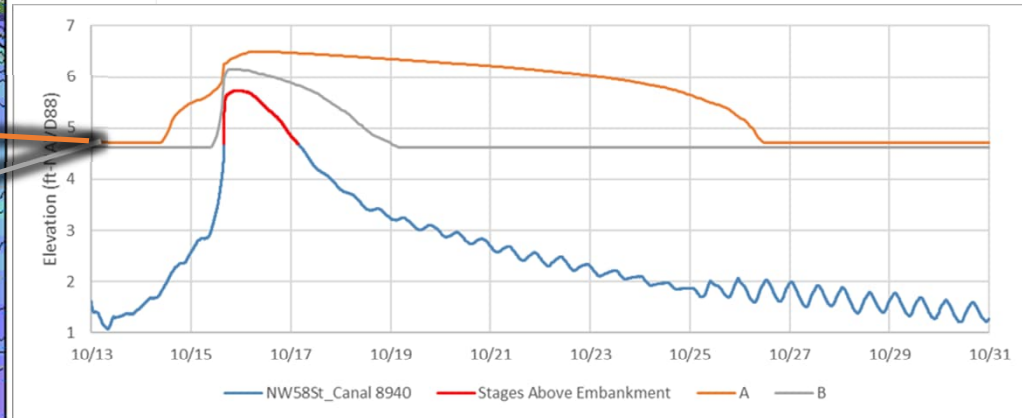
when we received a heavy rain yesterday afternoon. The Canal on NW 56 St west of the palmetto expressway in Miami Dade was overflowing.

These canals are not being maintained at proper levels and all we get is the county saying its SFWMD fault and you guys saying its their fault for not maintaining the

canals. All the while business are being flooded during a time that is difficult enough as it is. That is why I would like to know if the flood gates were open yesterday and the day before that and the day before that?



Both locations are at or below canal embankment elev. Point A takes much longer to recede due to low topography and distance from canal.



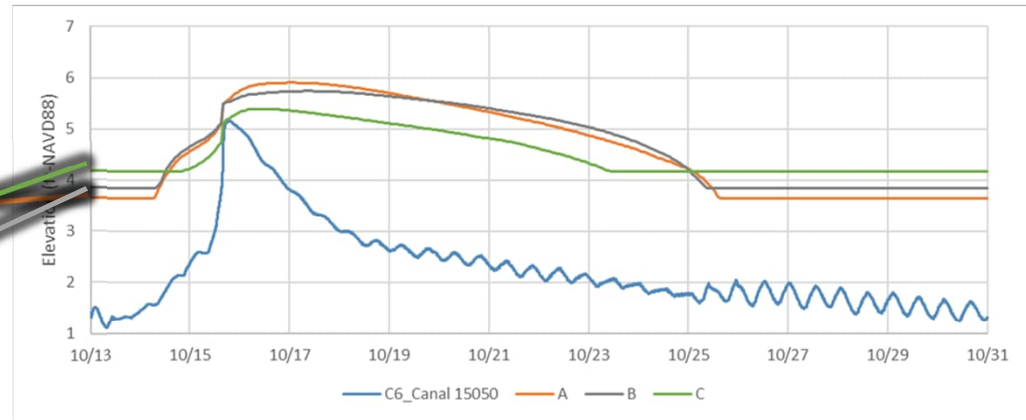
C2, C3W, C4, C5, C6 FPLOS for Current and Future SLR



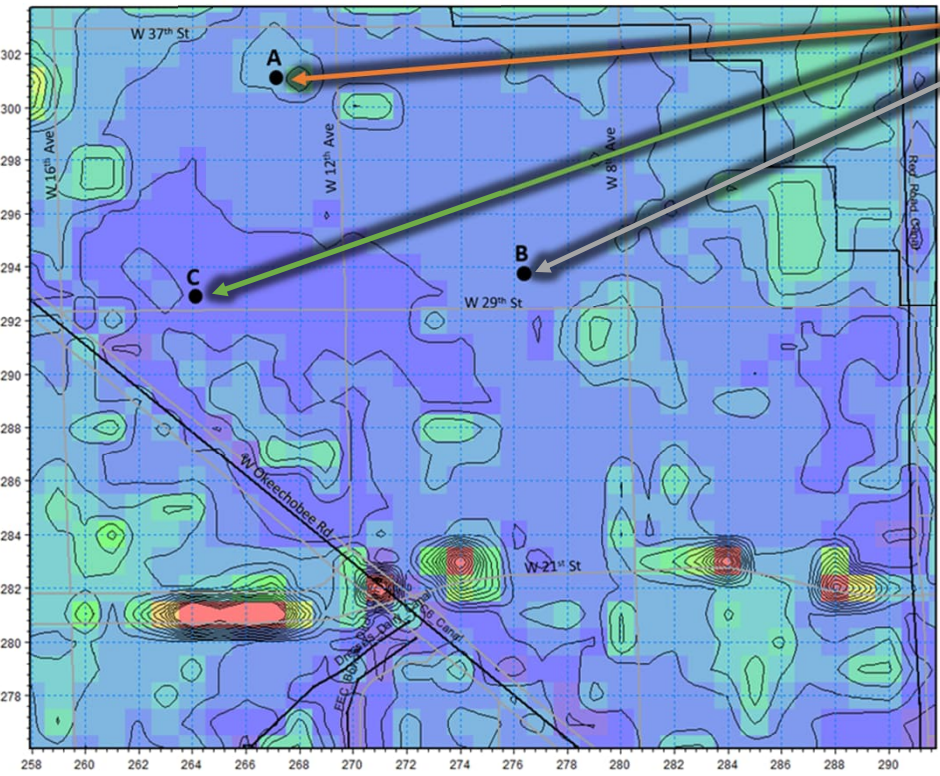
Results – C6 Watershed

PM#6

- PM 6 – Maximum Flood Duration



All three locations have surface elev that are lower than canal stages during 100-year event. Point C, which is closest to the canal, recedes faster than Point A and B. All locations are flooded for almost a week.



Results Summary – C6 Watershed

Increasing canal bank overtopping for some secondary canals and culvert locations.

Pumping at S26_P helps maintain basin discharges for SLR1, but pumping is reduced for SLR2 and SLR3 conditions due to MRMS1 trigger.

Some areas of Hialeah and Doral show extensive flooding depth and duration even during current conditions low frequency storm events.

While flooding depth increases in areas adjacent to the canal, flooding duration increases throughout the watershed.

METRIC	NOTES	CURRENT CONDS.	SLR +1FT	SLR +2FT	SLR +3FT
PM #1	<ul style="list-style-type: none"> Two bridge low chords are exceeded only for the SLR3 100-year simulation (Hook Square/Curtiss Pkwy & S Hook Square). For current conditions, 18 of 61 culverts experienced overtopping during the 100-year storm. Only two (2) experienced overtopping during the 25-year design storm. The number of culvert locations where the crown of road is exceeded increases significantly with each SLR condition, with the exception of the 5-year storm event that doesn't increase significantly until SLR3. 29% of the top-of-bank elevations along the C6 Canal were overtopped during the 100-year design storm, and only 5% during the 25-year. However, secondary canals such as NW 58th St Canal experience overtopping in some areas for all storm events, with majority of the canal passing the 25-year. Overtopping is comparable (and less than one mile) to the 25-year for current conditions for the SLR1 10-year. (See Table 9-83) 	25-year	10-year	< 5-year	< 5-year
PM #2	<ul style="list-style-type: none"> No comparable value found for this basin. There is a general decrease in discharge capacity for the watershed with each higher SLR condition due to reduced discharge at the S26 structure. However, SLR1 shows similar discharge capacity as the current conditions, due to increased pumping at S26_P 	--	--	--	--
PM #3	<ul style="list-style-type: none"> Maximum discharge at S26 falls significantly below design value for all current and future conditions. HW exceeds the water level that will bypass S22 for 100-year current conditions and all future SLR scenarios except for the 5-year SLR1 scenario. The TW exceeds this bypass elevation during 100-year current conditions and all future SLR except for the 5-year and 10-year SLR1 scenarios. 	--	--	--	--
PM #4	<ul style="list-style-type: none"> Peak 12-hour moving discharge ranges from 664 CFS to 1903 CFS, compared to the design discharge of 3,470 CFS, and decreases with increasing SLR for each design storm return period. 	--	--	--	--
PM #5	<ul style="list-style-type: none"> The percentage of the watershed that is inundated with 3 inches or greater is still relatively high for the 5-year storm at 23.2% of the total urban area, however, this number drops rapidly to 15.0% for areas inundated with 6 inches or more. Areas such as Hialeah near W 12th Ave are low-lying and experience flooding due to peak stages in the C6 Canal for all storms except the 5-year for current conditions, however, inundation is comparable to the SLR1 5-year for higher depths. No other storms have comparable inundation. 	5-year	5-year	<5-year	< 5-year
PM #6	<ul style="list-style-type: none"> Canal: Using the new Reference Elevation, stages at the S26_H recede during the current conditions, SLR1, and SLR2 in less than 72 hours for all storm events. For SLR 3 this lasts for a week or more. Watershed: Portions of the watershed (such as Hialeah) show high flooding duration (i.e., > 72 hours) for all storm events. 	<5-year	<5-year	<5-year	< 5-year
Overall Level of Service		5-year	5-year	<5-year	<5-year

C2, C3W, C4, C5, C6 FPLOS for Current and Future SLR



Preliminary Mitigation Strategies – C6 Watershed

Western

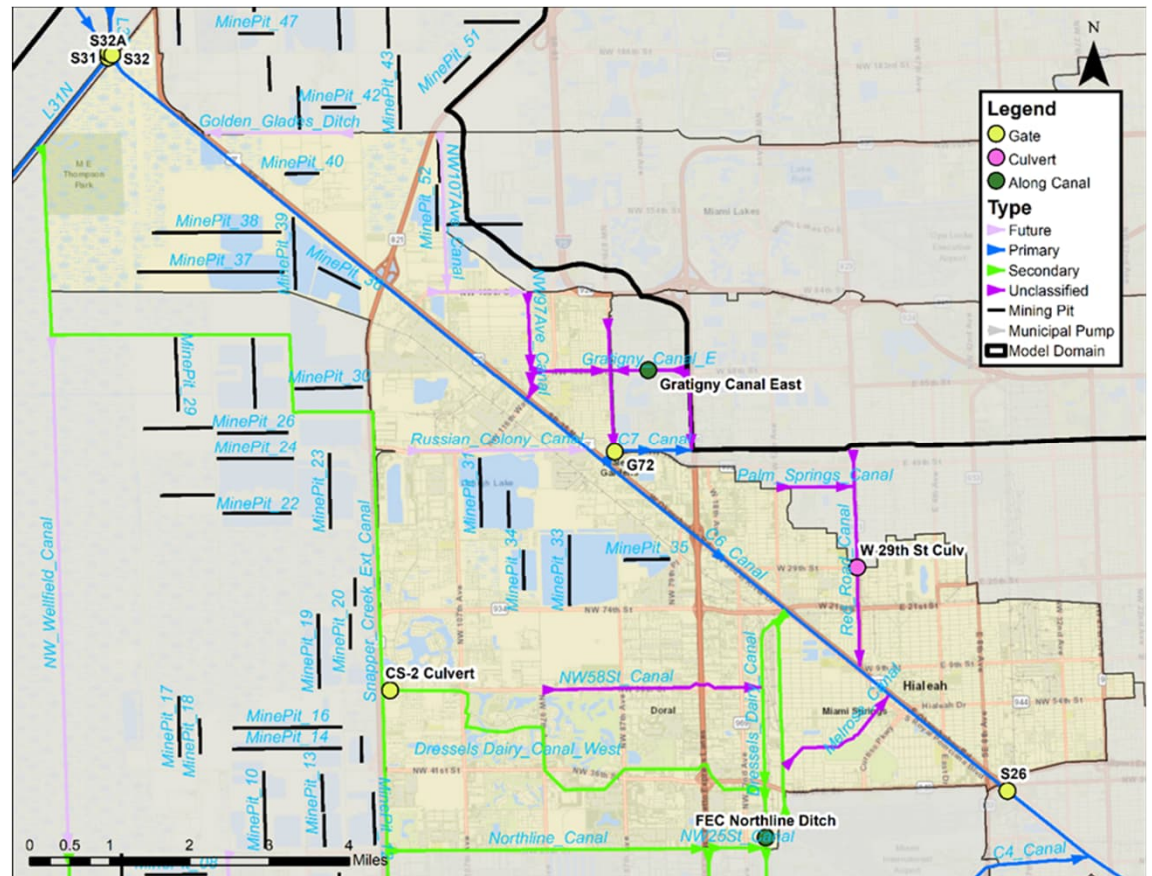
- Acquire storage area

Central

- Raise embankments
- Temporary storage
- Municipal pump stations
- Widen canal
- Undersized culverts
- G72 improvements

Tidal

- Structure hardening
- Adjust Forward Pump Operations
- Additional structure at mouth of canal



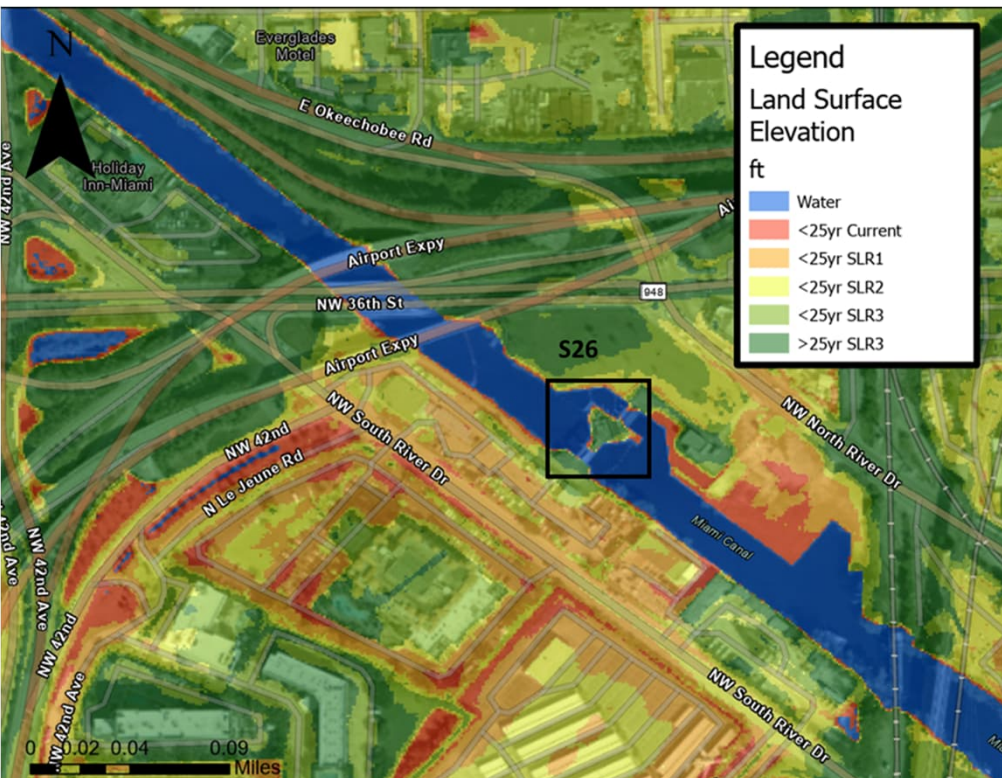
C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR

Preliminary Mitigation Strategies – C6 Watershed

Tidal Improvements

- Increase existing structure elevation to prevent overtopping
- Add tieback levees and floodwalls to prevent flanking
- Re-evaluate protocols at S25B P to allow for pumping during higher downstream conditions
- Retrofit existing forward pumps to increase pump capacity and operability. Downstream impacts will be evaluated in Phase 2.
- Sector gate and pump at mouth of Miami River (recommended in Back Bay Study)

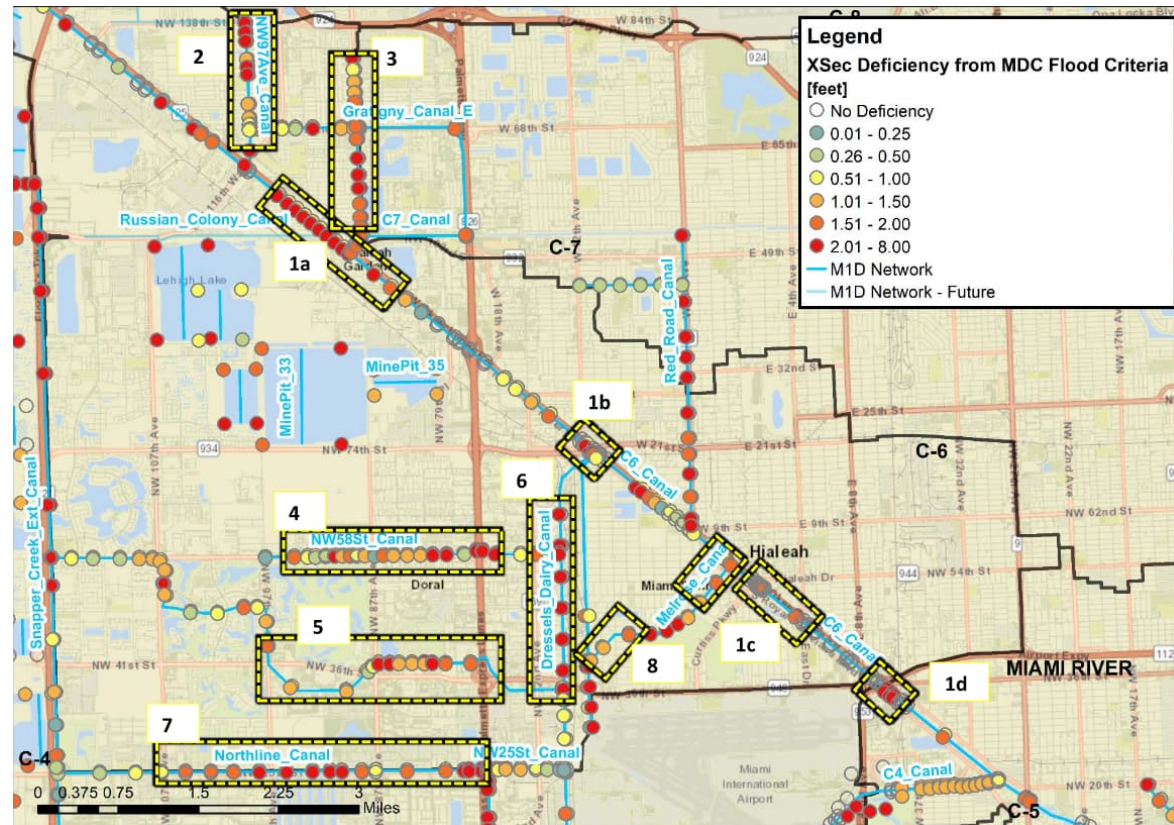
C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR



Preliminary Mitigation Strategies – C6 Watershed

Central Improvements

- Raise canal embankments in problem areas
- Add municipal pumps to subbasins where gravity drainage will be affected by SLR
- Use Miami-Dade County parks or golf courses as emergency temporary storage
- Widen C6 canal to be able to meet design discharge at S26
- Evaluating undersized culverts
- G72 improvements and connection to C7 Canal



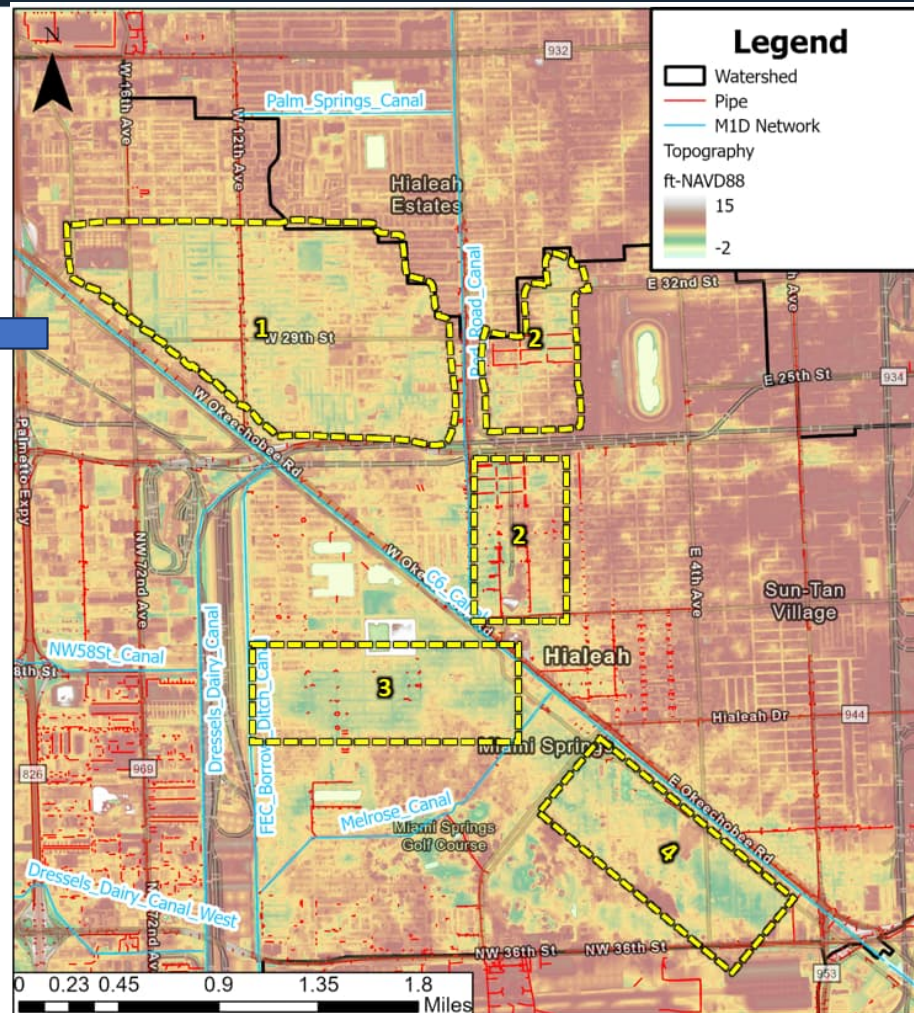
C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR



Preliminary Mitigation Strategies – C6 Watershed

Central Improvements

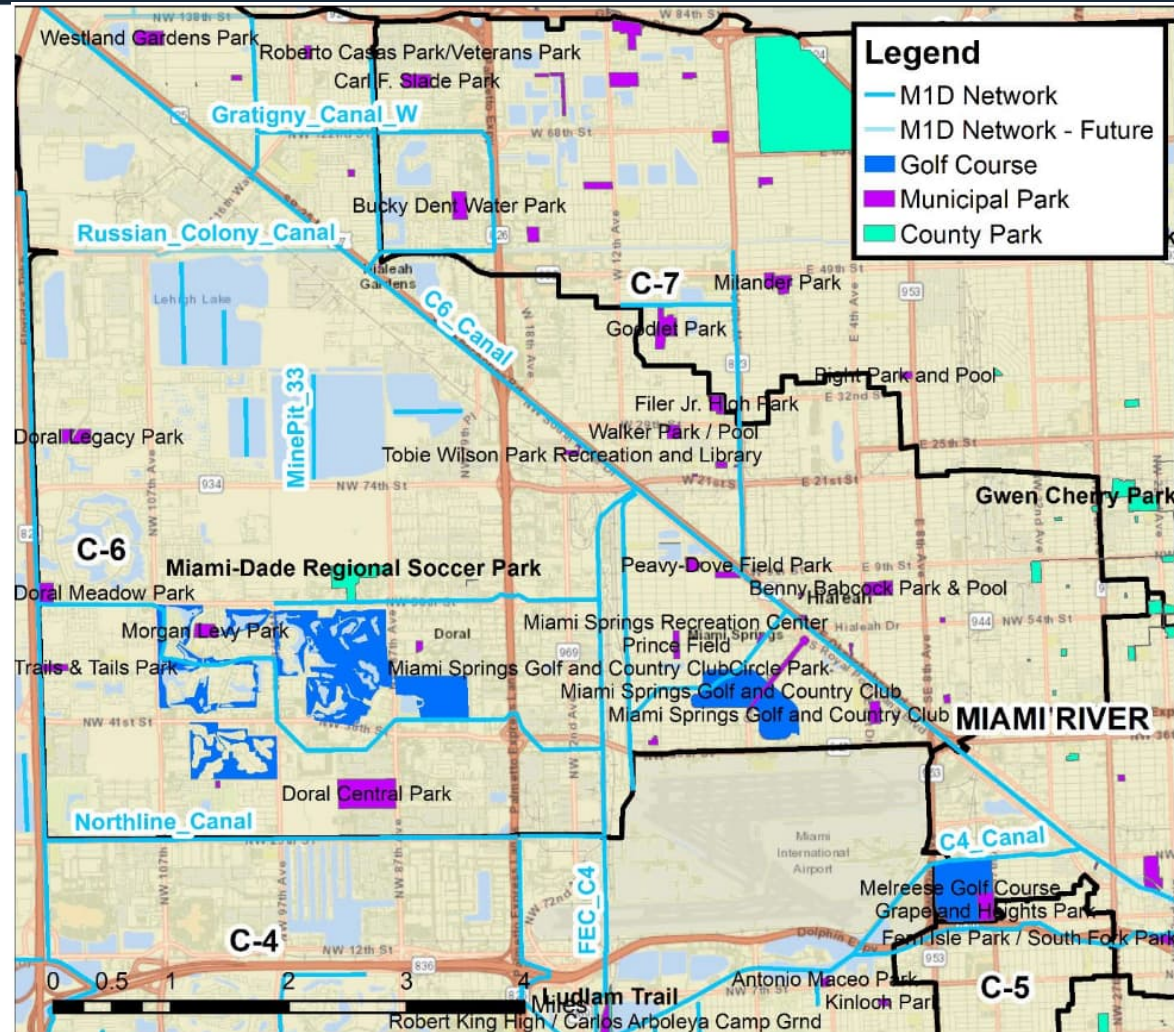
- Raise canal embankments in problem areas
- Add municipal pumps to subbasins where gravity drainage will be affected by SLR
- Use Miami-Dade County parks or golf courses as emergency temporary storage
- Widen C6 canal to be able to meet design discharge at S26
- Evaluating undersized culverts
- G72 improvements and connection to C7 Canal



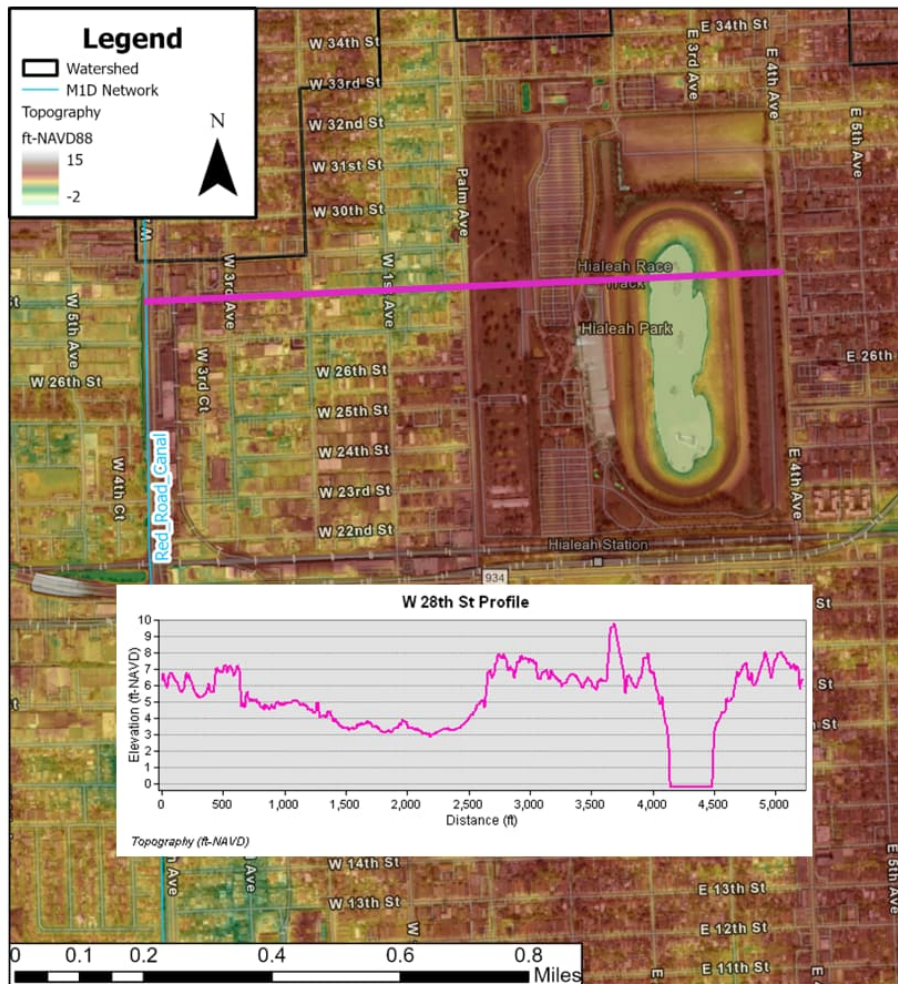
Preliminary Mitigation Strategies – C6 Watershed

Central Improvements

- Raise canal embankments in problem areas
- Add municipal pumps to subbasins where gravity drainage will be affected by SLR
- Use Miami-Dade County parks or golf courses as emergency temporary storage
- Widen C6 canal to be able to meet design discharge at S26
- Evaluating undersized culverts
- G72 improvements and connection to C7 Canal



Preliminary Mitigation Strategies – C6 Watershed



Central Improvements

- Use Miami-Dade County parks or golf courses as emergency temporary storage
- Hialeah Park Casino
 - Provide controlled storage using naturally high landscape as levees
 - Degrade the natural areas to provide additional floodplain storage during high rainfall events

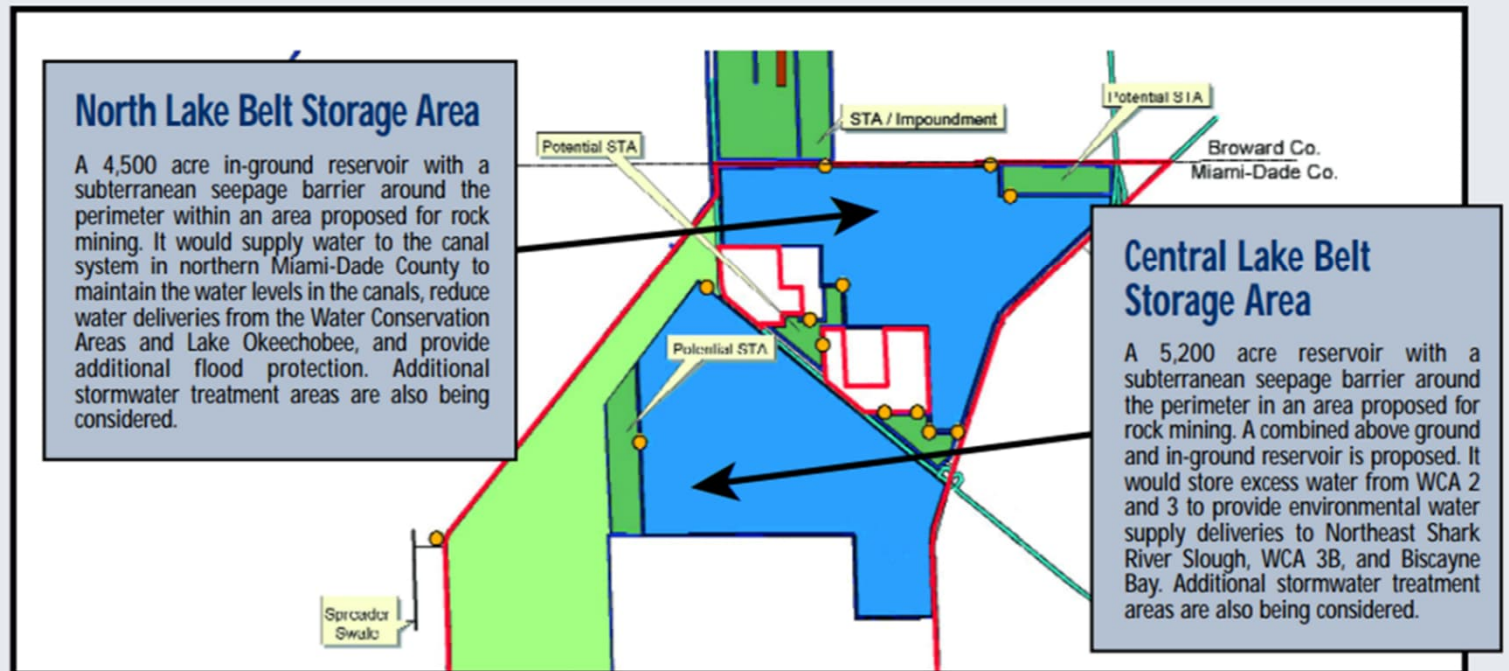
C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR

Preliminary Mitigation Strategies – C6 Watershed

Western Improvements

- Utilize North Lake Belt Storage Area as additional storage during storm events

CERP COMPONENTS MAP



C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR



Future Studies

- SFWMD's Resiliency Plan
 - Develop Conceptual Costs for Mitigation Strategies
- US Army Corps of Engineers
 - 216 Study
- Phase 2
 - Model select mitigation strategies
 - Evaluate downstream impacts of adding or increasing pump stations at coastal structures
 - Work with stakeholders



C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR



Thank You!

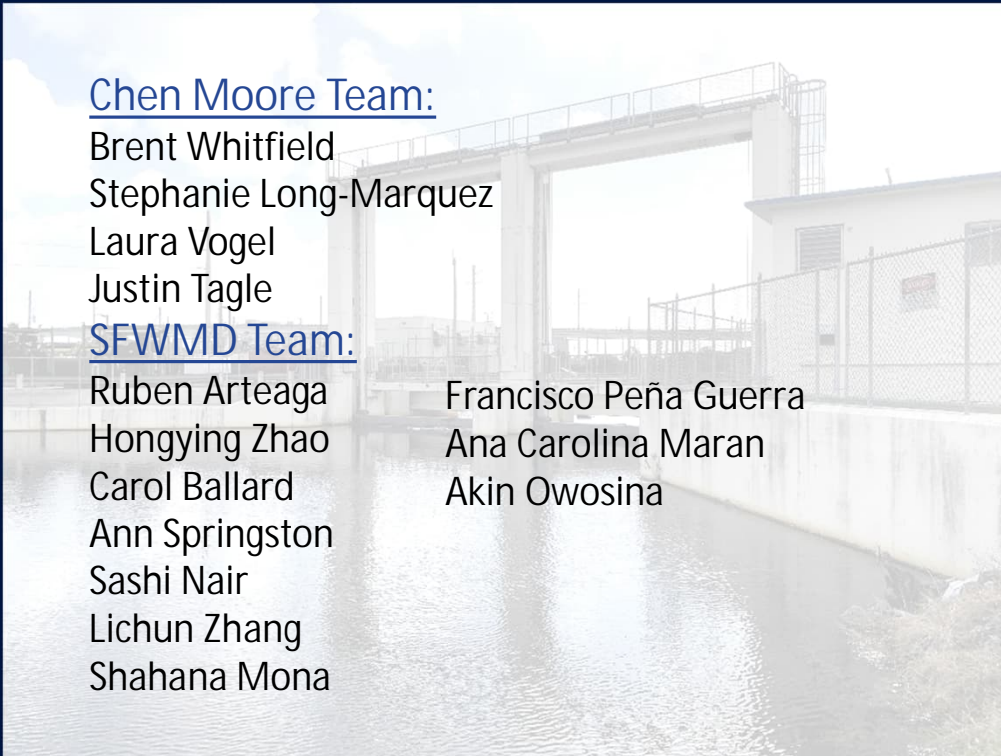
Chen Moore Team:

Brent Whitfield
Stephanie Long-Marquez
Laura Vogel
Justin Tagle

SFWMD Team:

Ruben Arteaga
Hongying Zhao
Carol Ballard
Ann Springston
Sashi Nair
Lichun Zhang
Shahana Mona

Francisco Peña Guerra
Ana Carolina Maran
Akin Owosina

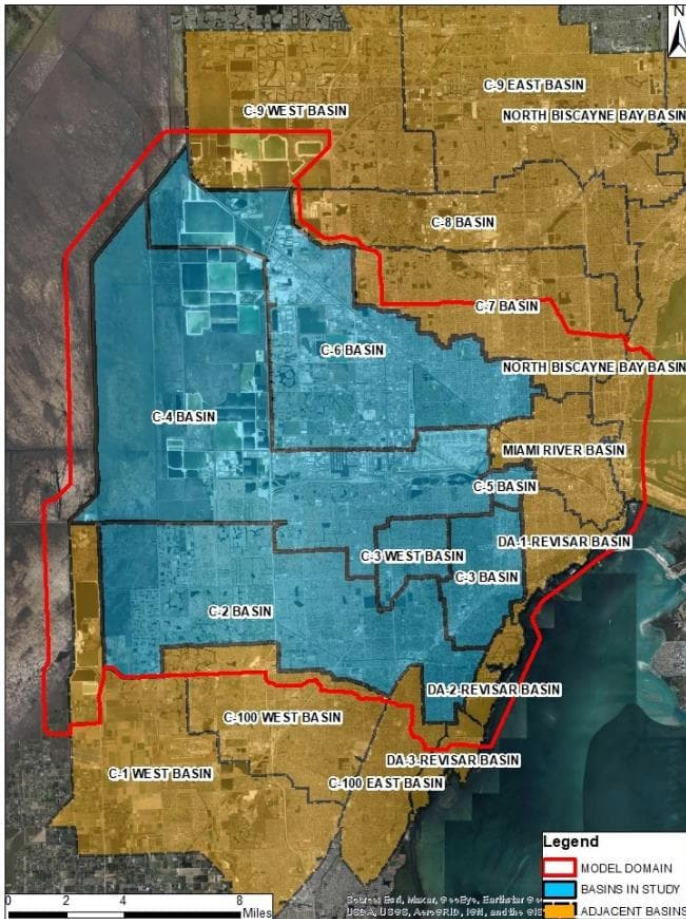


Preliminary Mitigation Strategies - Summary

8 tidal structure improvement/ mitigation projects

20 mitigation projects
13 District owned/
co-owned solutions

6 basin headwater mitigation projects



BASIN	EASTERN (TIDAL)	CENTRAL (UPLAND)	WESTERN (ROCK MINES)
C2	<ol style="list-style-type: none"> S22 hardening (Raise the overtopping and bypass elevations, add tie-back levees/floodwalls) Forward pump station Canal re-alignment 	<ol style="list-style-type: none"> Raising canal embankments in problem areas Temporary storage in parks/golf courses Municipal pump station (including pumping from Ludlam Glade contributing basin up to Coral Gables Canal) Extend SW 157th Avenue Canal to the C4 Canal Sub-dividing the C2 Watershed to increase discharge potential 	<ol style="list-style-type: none"> Acquire storage in western mining lakes with water control structures in Bird Drive Extension Canal to convey water to storage facilities
C3W	<ol style="list-style-type: none"> G93 hardening (Raise the overtopping elevation) Additional salinity structure or storm surge/tidal barrier at the end of the C3 Canal (potentially with navigational accessibility) 	<ol style="list-style-type: none"> Raising canal embankments in problem areas Temporary storage in parks/golf courses 	
C4	<ol style="list-style-type: none"> S25B Structure Upgrades – raising the overtopping elevation, adding tie-back levees Adjust forward pump operations to allow for discharge under higher downstream conditions 	<ol style="list-style-type: none"> Raising canal embankments in problem areas Temporary storage in parks/golf courses Municipal pump station improvements Evaluating undersized culverts Control structures at C2 and C3W watersheds Separating storage areas from main canal 	<ol style="list-style-type: none"> Improved operations for S380 to keep water west C4 Emergency Detention Basin Expansion Acquire storage areas in western mining lakes (Central Lake Belt Storage Area)
C5	<ol style="list-style-type: none"> S25 replacement (construct spillway in same location with tie-back levees/floodwalls) S25 relocation (construct spillway in location with higher elevation and with tie-back levees/floodwalls) Forward pump station at S25 	<ol style="list-style-type: none"> Raising canal embankments in problem areas Municipal pump stations 	<ol style="list-style-type: none"> Improvements to S25A to allow inter-basin connection with C4 Canal
C6	<ol style="list-style-type: none"> S26 Hardening (Raise the overtopping and bypass elevations, add tie-back levees/floodwalls) Adjust forward pump operations for SLR scenarios Potential retrofit of existing forward pump stations Floodwalls, sector gate, and pump station at the mouth of Miami River 	<ol style="list-style-type: none"> Raising canal embankments in problem areas Widen canal to improve conveyance capacity Construct municipal pumps for Hialeah and Doral Temporary Storage in parks/golf courses Improvements and operational changes to G72 to discharge to C7 Canal during storm events 	<ol style="list-style-type: none"> Acquire storage areas in western mining lakes (North Lake Belt Storage Area) with conveyance structures connecting to C6 Canal