

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

June 15, 2023



chen moore and associates

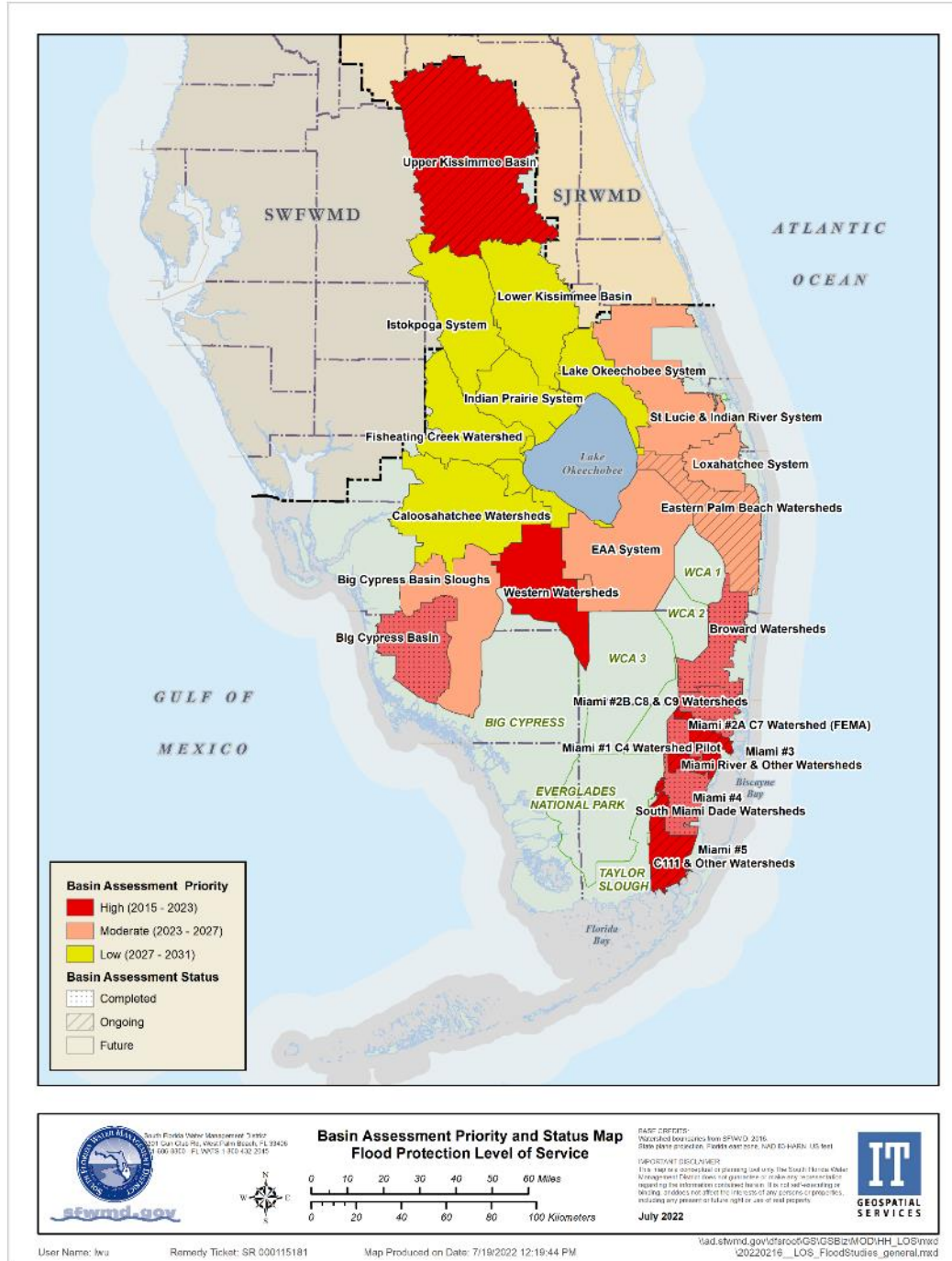
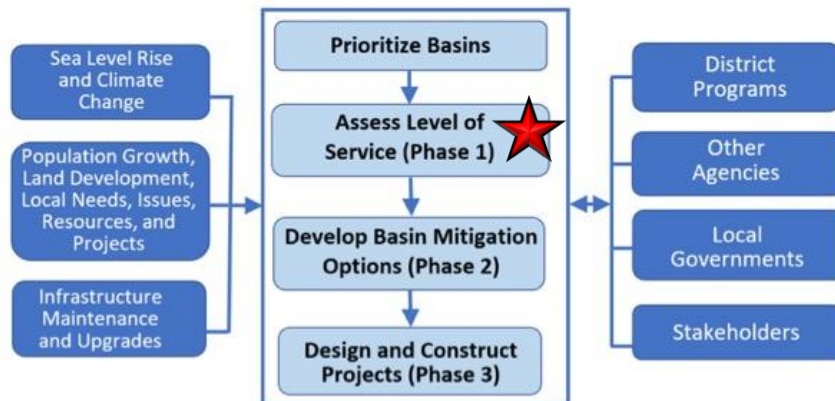


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Laura Vogel, PhD, PE

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



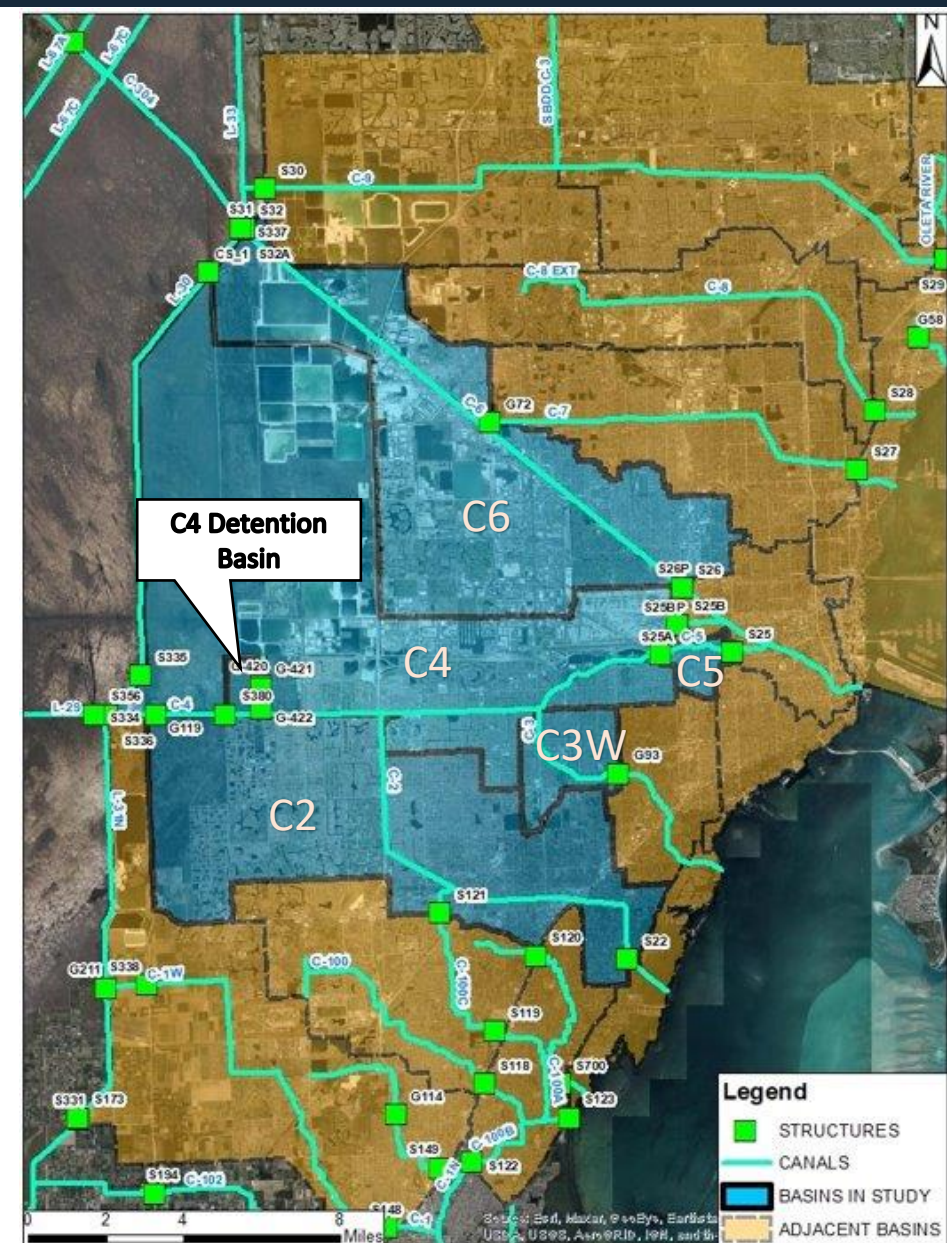
South Florida Water Management District
221 East Kissimmee Way, Winter Haven, FL 32906
888.932.FLWMSD | 352.432.2540

Basin Assessment Priority and Status Map
Flood Protection Level of Service

DATE PREPARED: 7/19/2022
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DATE OF REVIEW: 7/19/2022

IT
GEO SPATIAL SERVICES

Study Area

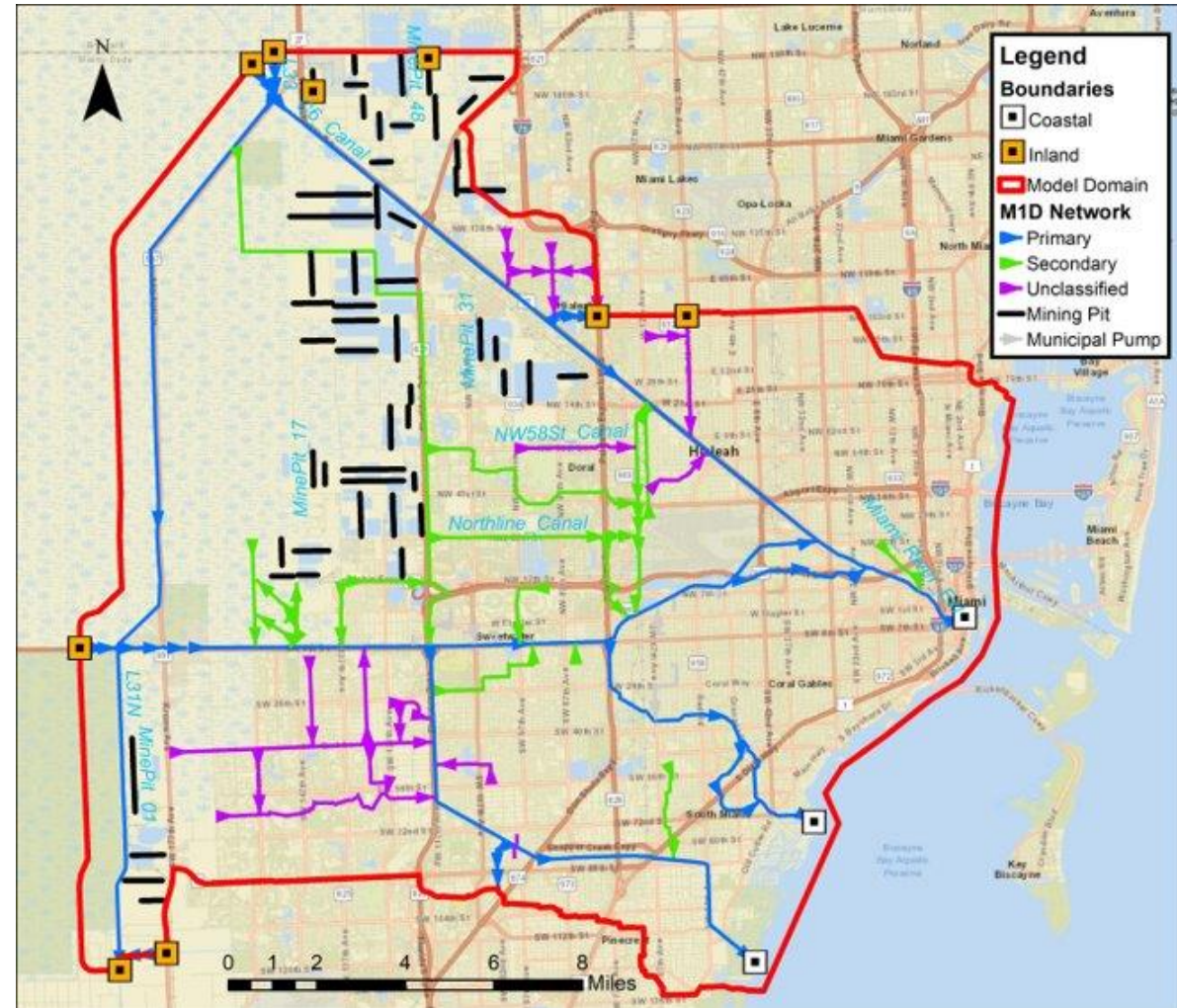


- Primary Areas of interest for this FPLOS are the C2, C3W, C4, C5, and C6 watersheds
 - C2:
 - Primary Canal: Snapper Creek
 - Primary Outfall: S22
 - C3W:
 - Primary Canal: Coral Gables Canal
 - Primary Outfall: G93
 - C4:
 - Primary Canal: C4 Canal (Tamiami Canal)
 - Primary Outfall: S25B
 - C5:
 - Primary Canal: Comfort Canal Southfork
 - Primary Outfall: S25
 - C6:
 - Primary Canal: C6 Canal (Miami Canal)
 - Primary Outfall: S26
- Considering significant interconnectivity of these watersheds and capability of MIKE SHE/MIKE 1D as a regional modeling platform, all watersheds were combined in a single model

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

Model Setup

- Model Domain
 - Covers C2 through C6 Watersheds
 - From WCA/ENP wetlands to coast
 - From C7 Canal to boundary of C2 Basin
 - 250ft model resolution
- Calibration Period
 - 2020 Memorial Weekend Event
- Validation Period
 - 2017 Hurricane Irma Event



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

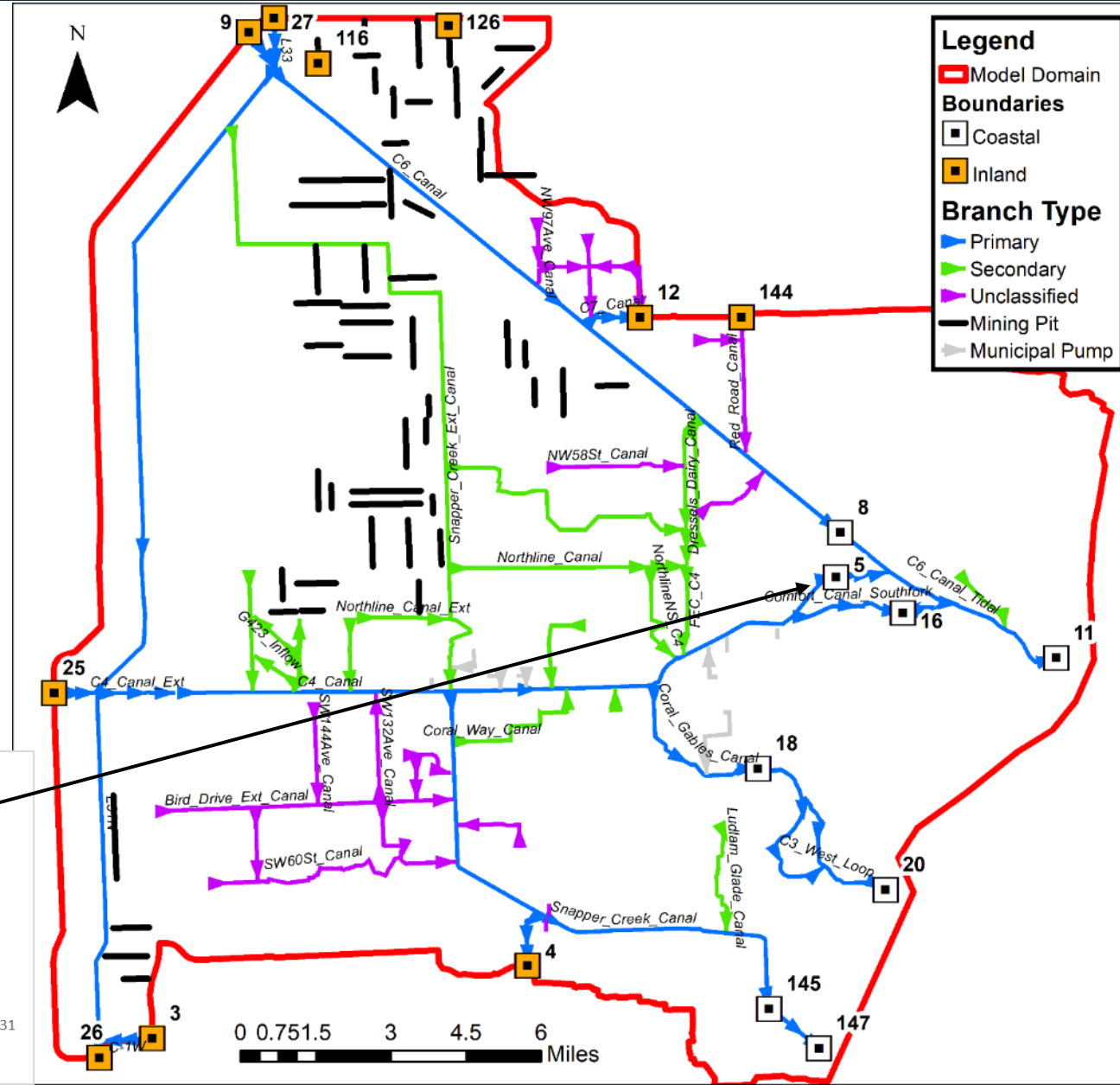
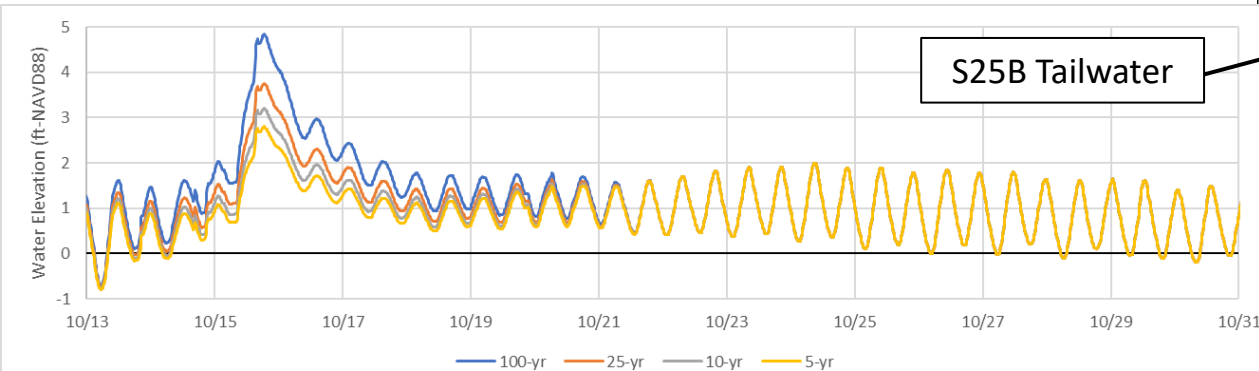


Design Storm Simulations - Current and Future Conditions

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

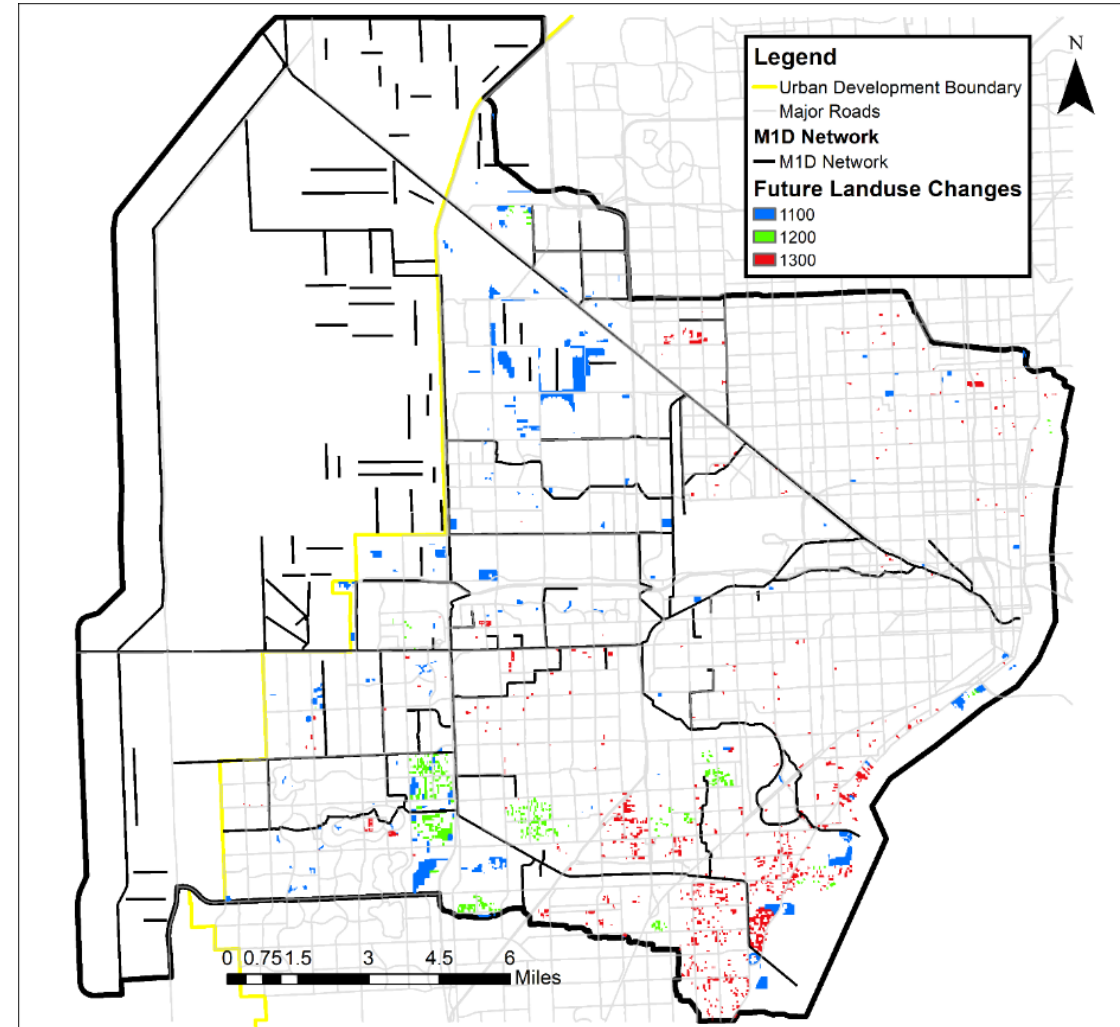
Design Storm Setup

- Rainfall Events
 - 100-, 25-, 10-, and 5-year 3-day storms
- Surface Water Boundary Conditions
 - TW conditions were prescribed at the structures S26, S25B, S25, G93, and S22



Design Storm Setup – Future Conditions

- Land use
 - Increase LU classification for vacant and old parcels
- Overland Parameters
 - Adjusted Manning's n, detention storage, runoff coefficient based on LU classification
- Topography
 - Raised vacant and old parcels to match MDC Flood Criteria map
 - Reduced 10% of raised parcel to account for onsite storage
- Groundwater
 - Added MDC's future GW increase projections for 1ft SLR (May 2040) to existing GW levels
 - Increased public water supply GW withdrawals based on MDC WASD estimates
- 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



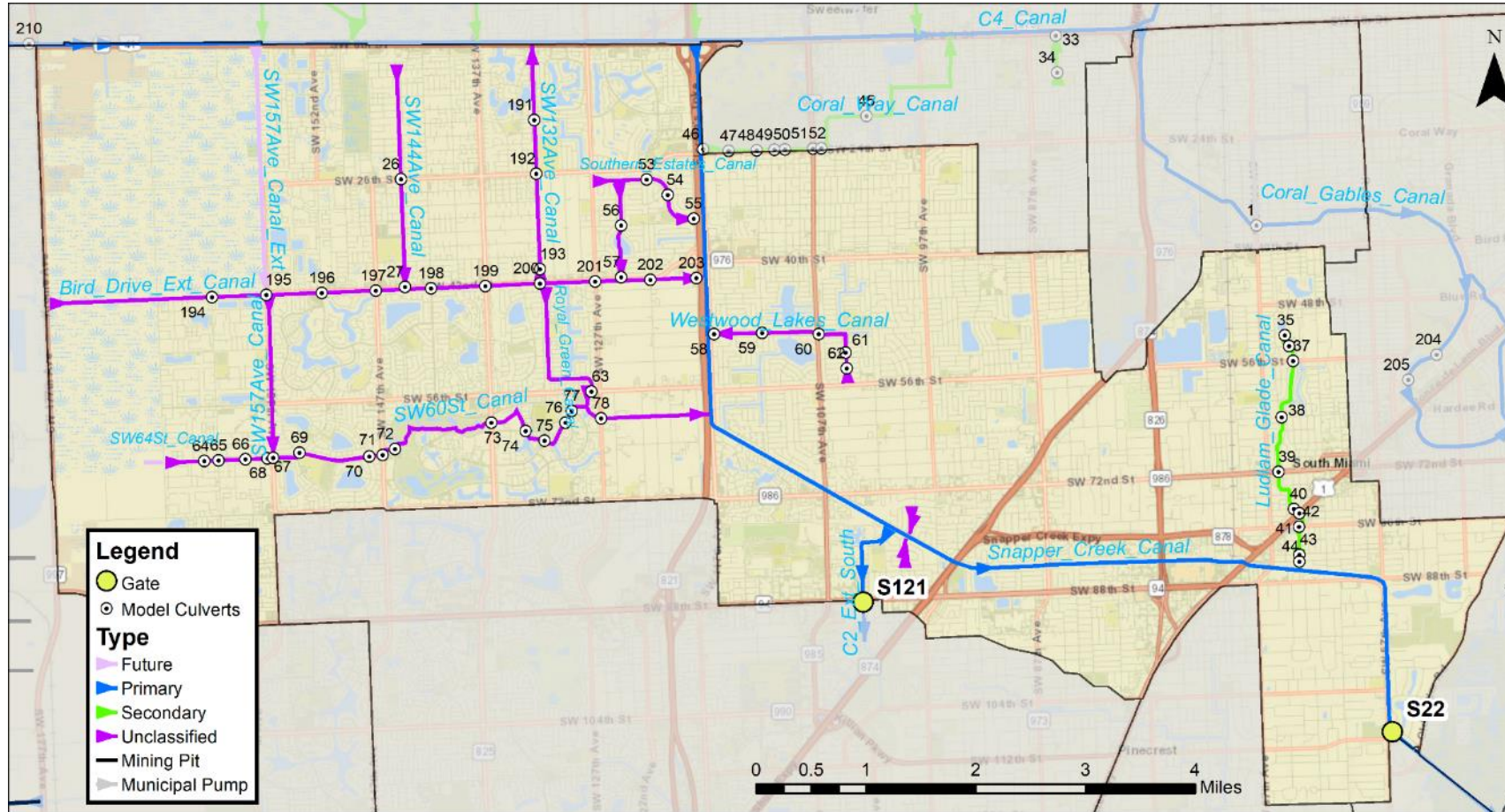
C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR

FPLOS Metrics

- SFWMD developed 6 FPLOS performance metrics (PMs) to quantify the level of flood protection provided within a watershed for current and future conditions
- Provides ability to quantify changes in flood protection as a result of SLR

Performance Metric	Description
PM #1	Maximum stage in primary canals
PM #2	Maximum daily 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

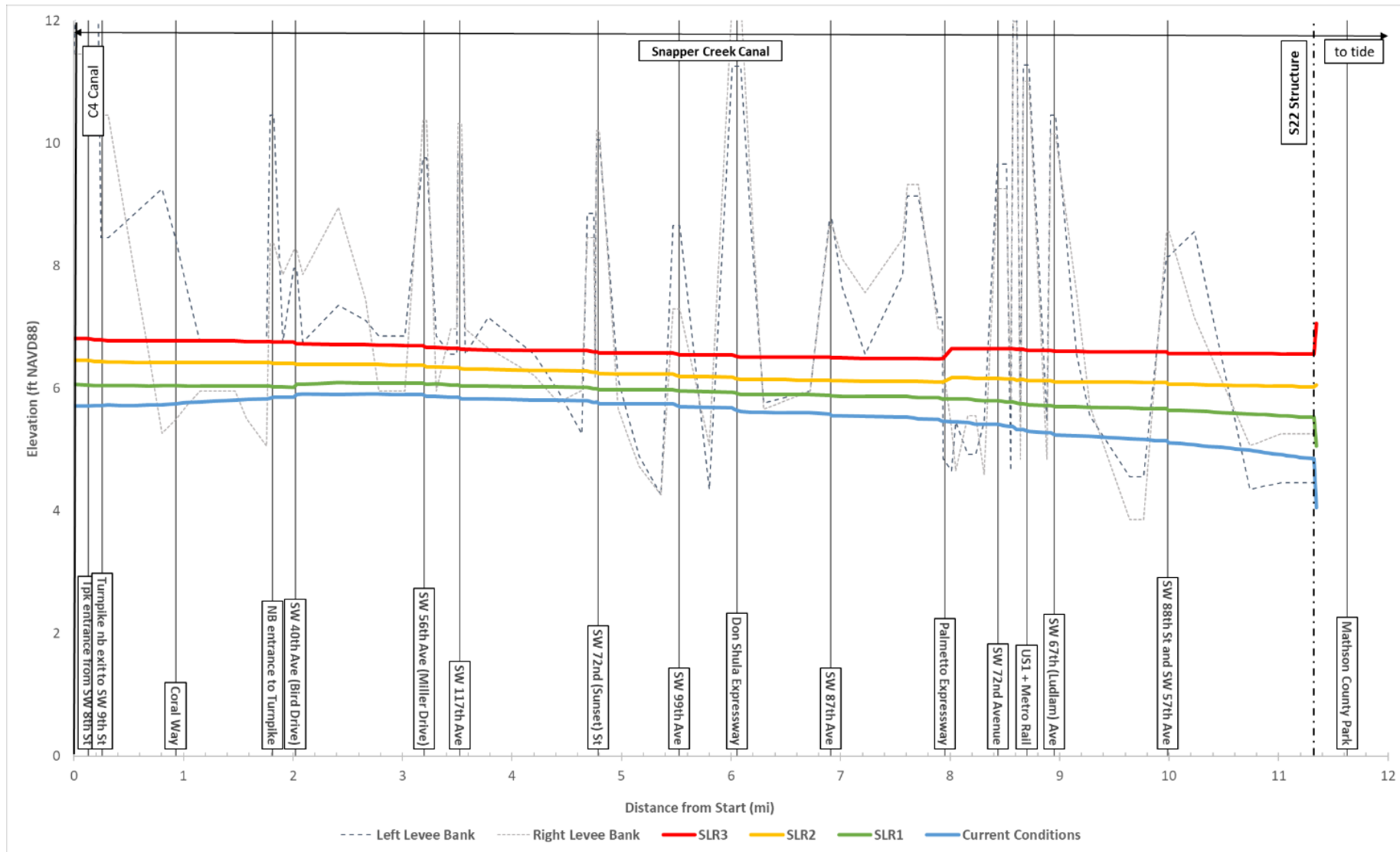
Results – C2 Watershed



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

Results – C2 Watershed

- PM1 – Maximum Stage in Snapper Creek Canal (100yr/72hr storm)



Results – C2 Watershed

- PM1 – Maximum Stage and Bridge Low Chords – Snapper Creek Canal

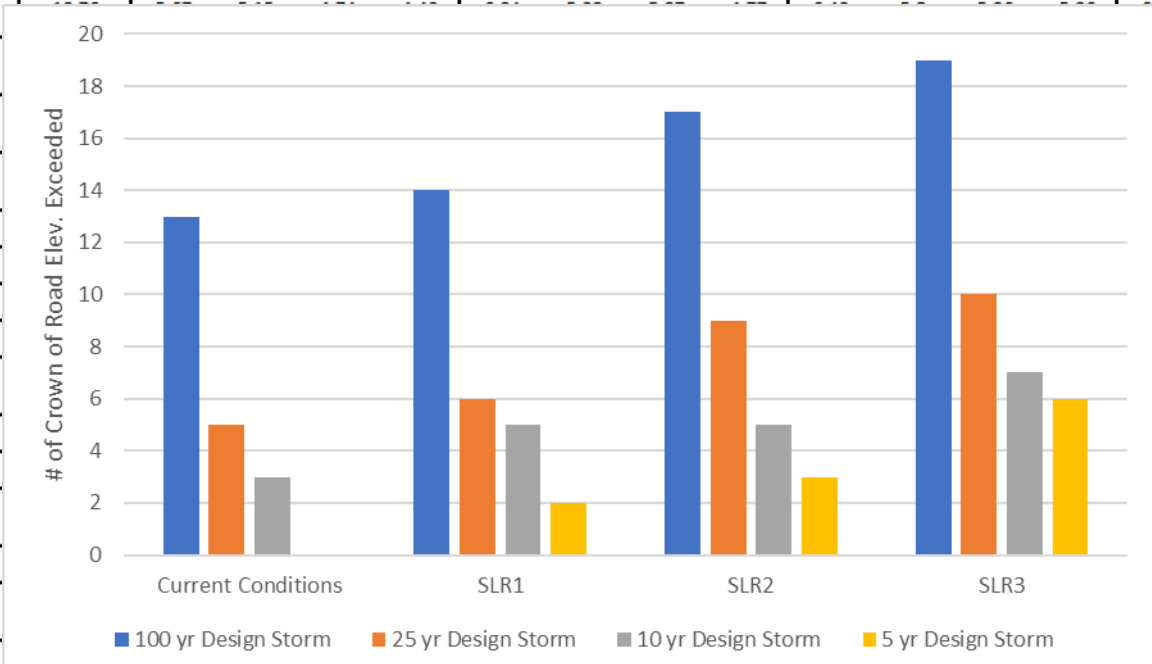
Location Description			Current Conditions				SLR1				SLR2				SLR3			
	Low Chord	Bridge Top	Elevation (ft-NAVD)															
			100 yr	25 yr	10 yr	5 yr	100 yr	25 yr	10 yr	5 yr	100 yr	25 yr	10 yr	5 yr	100 yr	25 yr	10 yr	5 yr
Turnpike entrance from SW 8th Street	12.16	16.18	5.65	5.08	4.69	4.37	6.06	5.31	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

Results – C2 Watershed

- PM1 – 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
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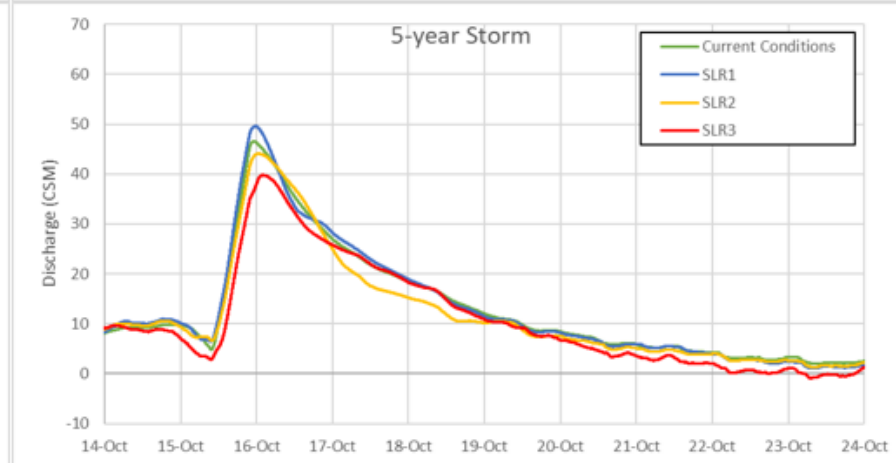
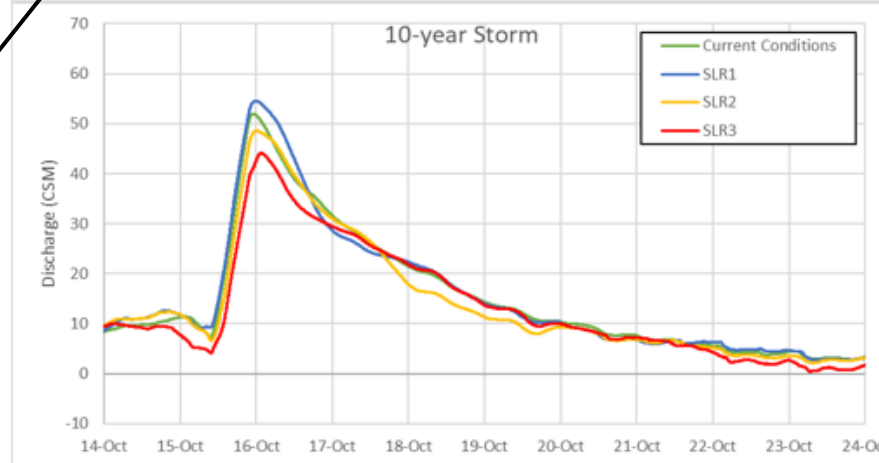
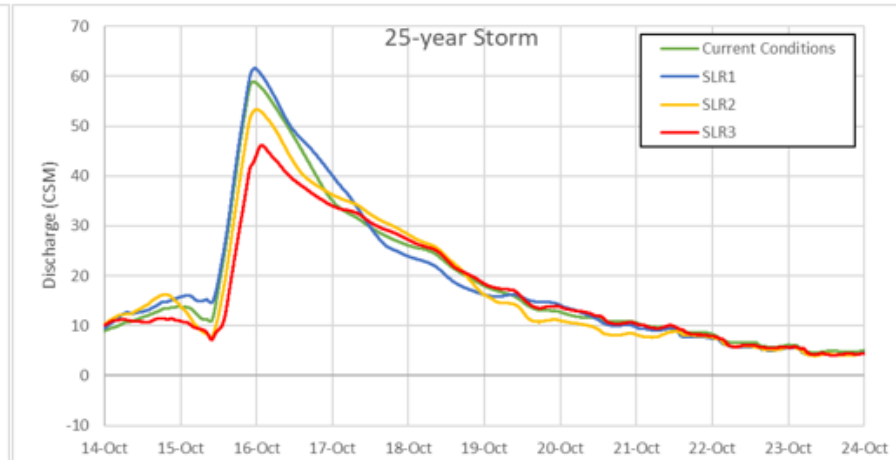
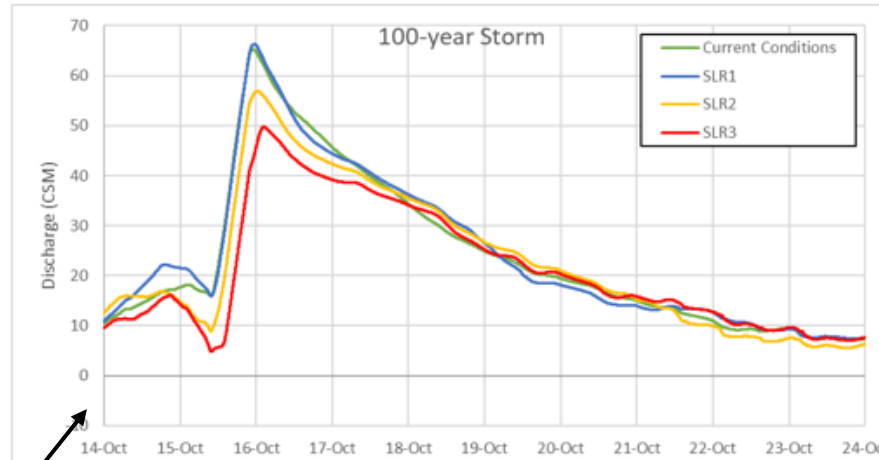


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Results – C2 Watershed

- PM2 – Maximum Discharge Capacity (12-Hour Moving Average)

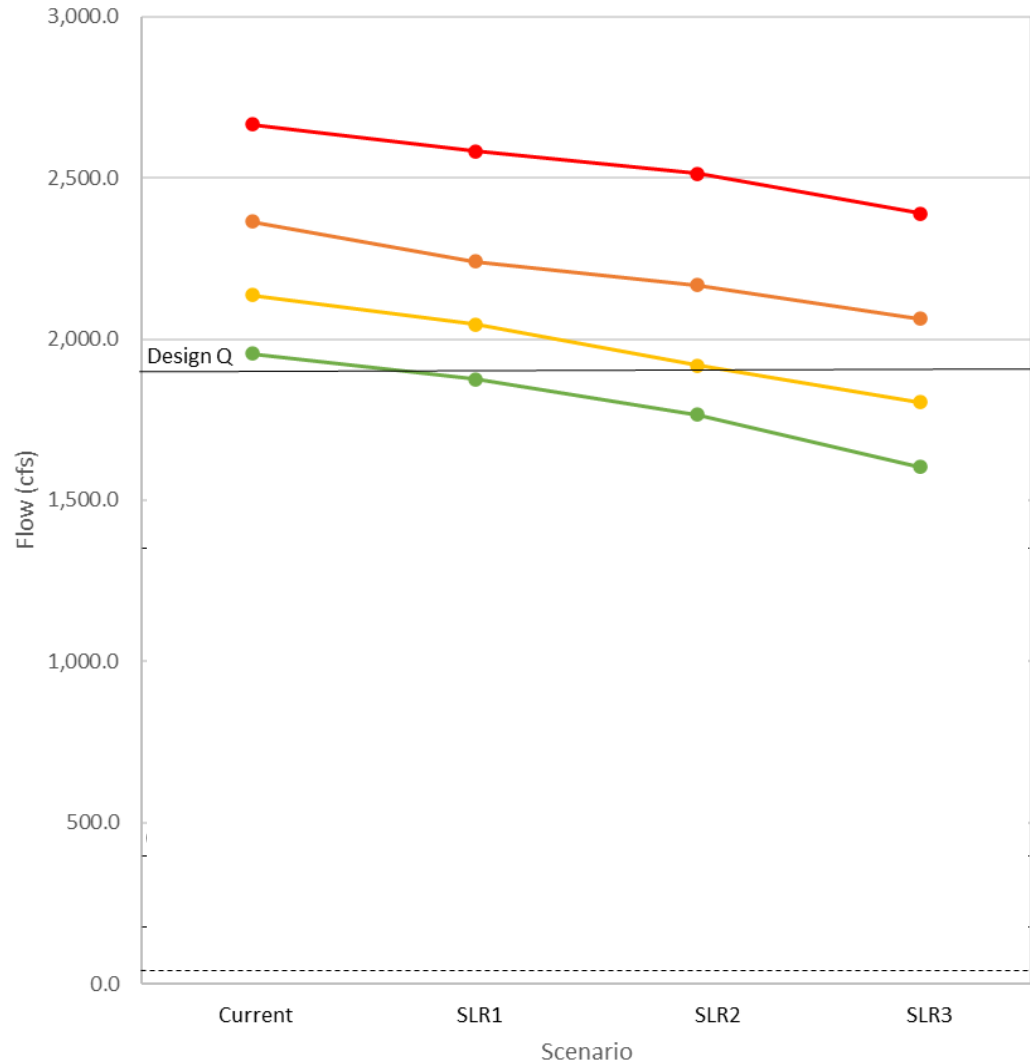
	Current Conditions	SLR1	SLR2	SLR3
	100-yr	100-yr	100-yr	100-yr
Inflow Locations				
Start of Sna	-566.1	-775.9	-122.2	-66.1
Future Con	--	-403.9	-367.8	-178.7
Outflow Locations				
Coral Way	-87.4	-78.2	-18.7	-25.2
SW 132nd	166.4	161.9	106.5	66.3
S112 (cfs)	0	0	0	0
S22 Total F	3163.5	2831.6	2734.5	2673.6
Watershed Summary				
Basin Area (sq. mi.)	52.6	52.6	52.6	52.6
Peak Wate	72.4	77.9	63	56.3



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



Results – C2 Watershed



Max Q ● 100yr/3day ● 25yr/3day ● 10yr/3day ● 5yr/3day

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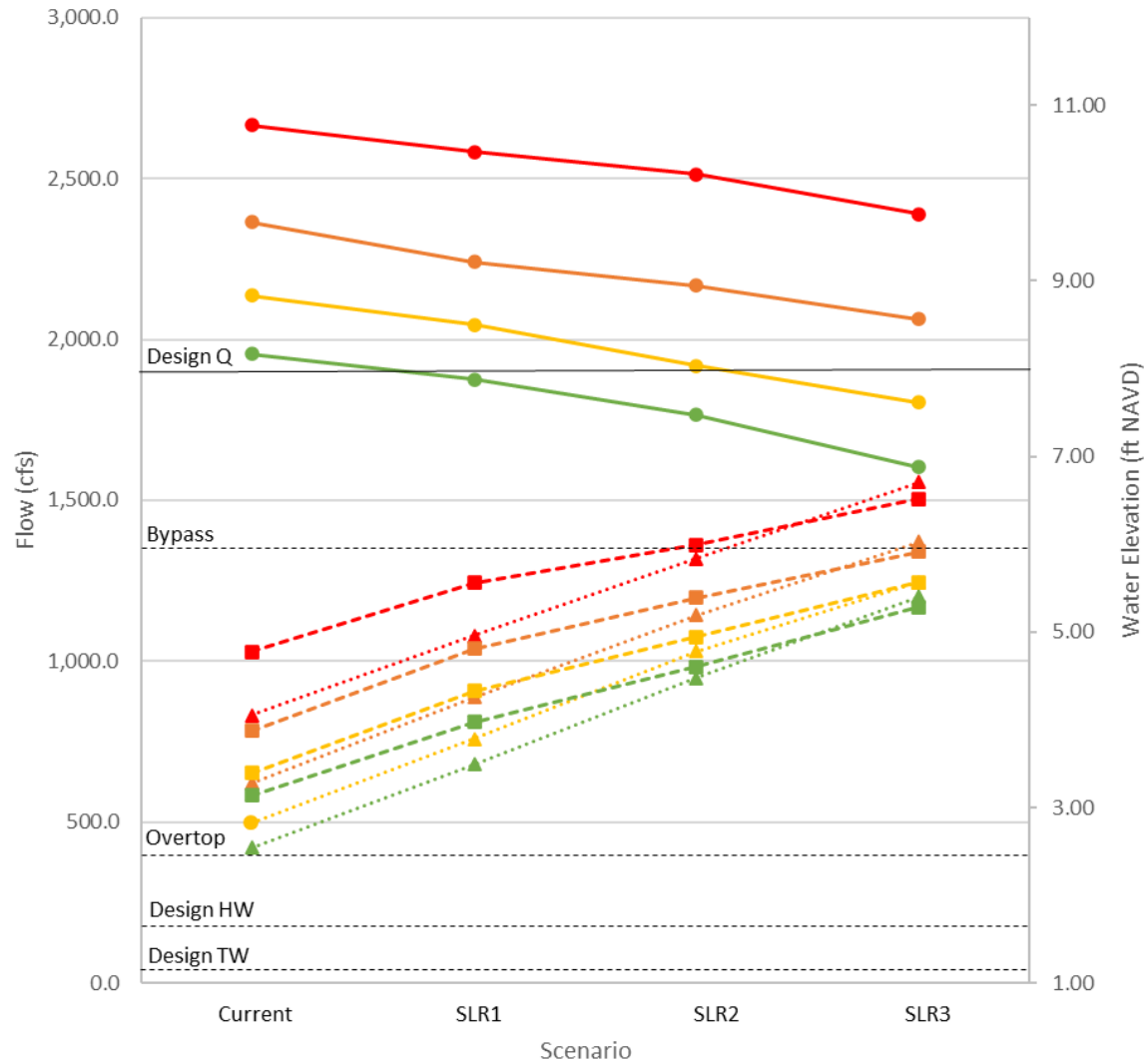
- PM3 – Structure Performance (S22)



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



Results – C2 Watershed



- PM3 – Structure Performance (S22)

The increase in TW levels due to SLR, decreases the head differential at the structure and inhibits the flow out of the basin, potentially creating additional flooding upstream of the structure as shown in PM #1.

Max Q ● 100yr/3day ● 25yr/3day ● 10yr/3day ● 5yr/3day
 Max TW ▲ 100yr/3day ▲ 25yr/3day ▲ 10yr/3day ▲ 5yr/3day
 Max HW ■ 100yr/3day ■ 25yr/3day ■ 10yr/3day ■ 5yr/3day

DRAFT

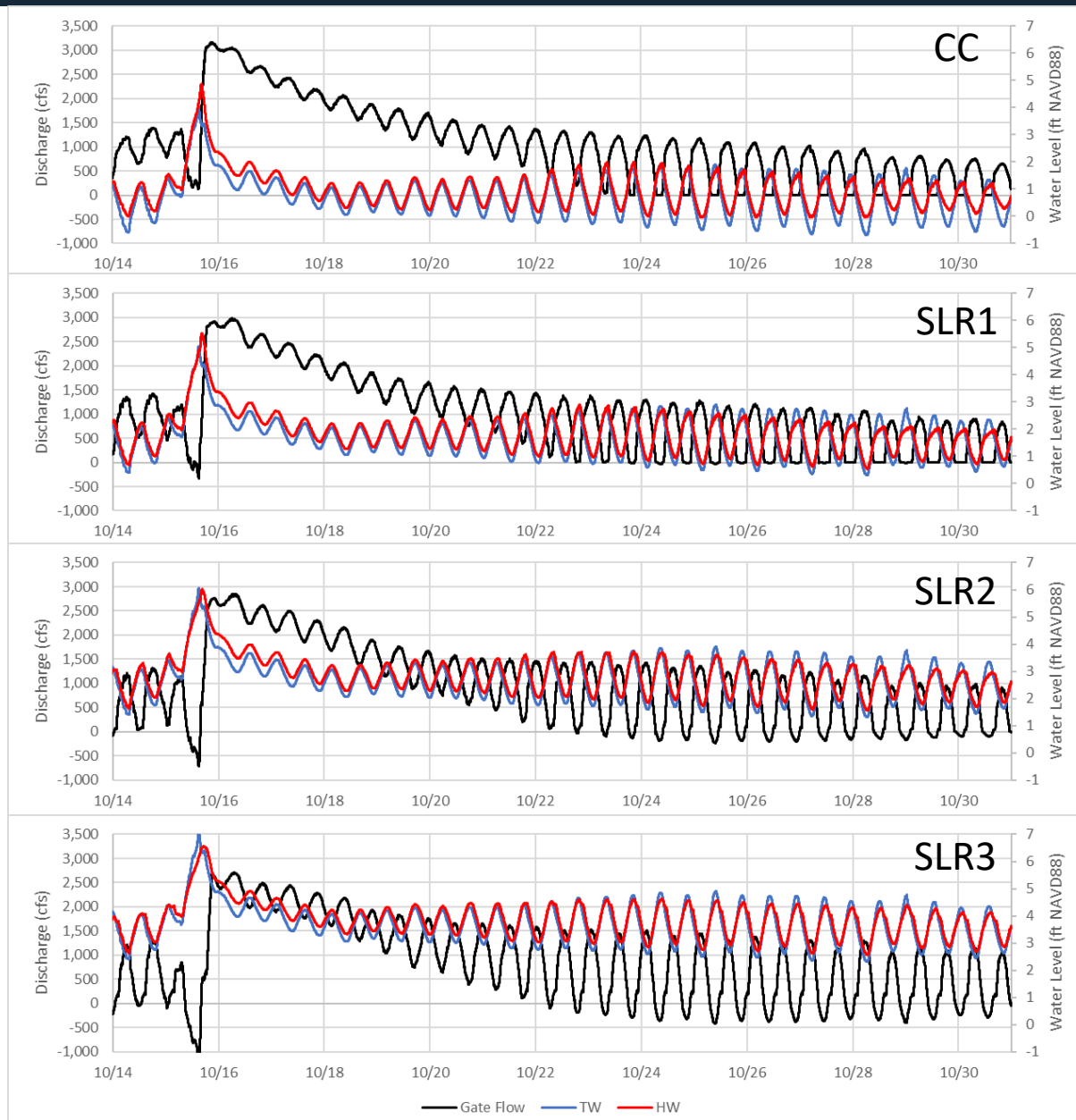
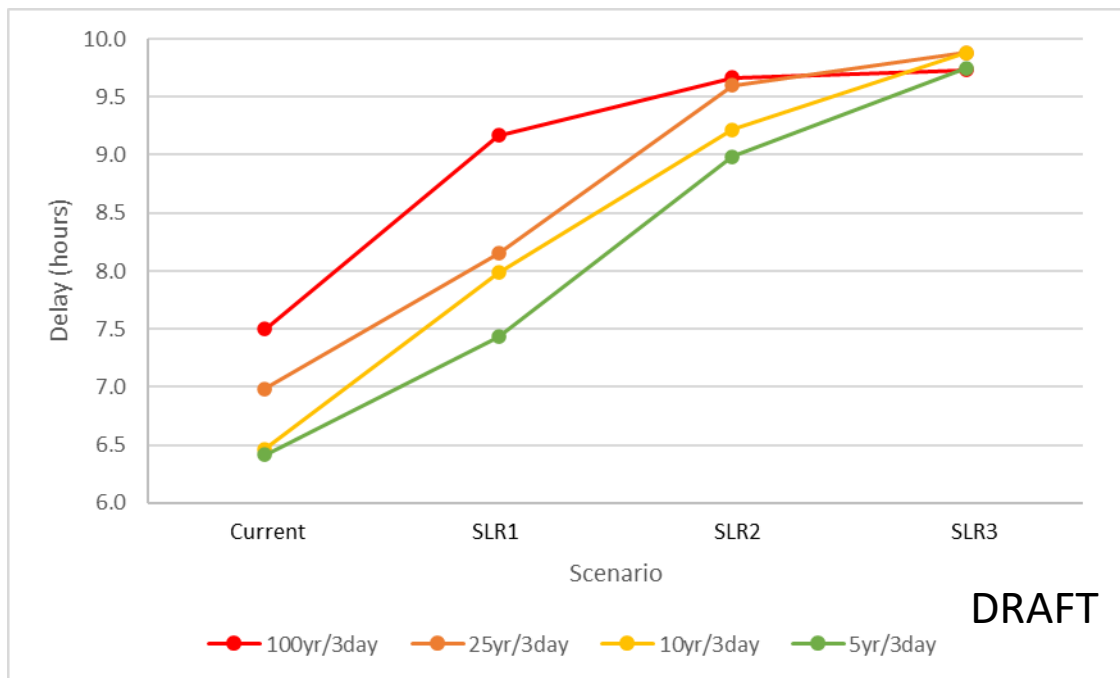
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for Current and Future SLR



Results – C2 Watershed

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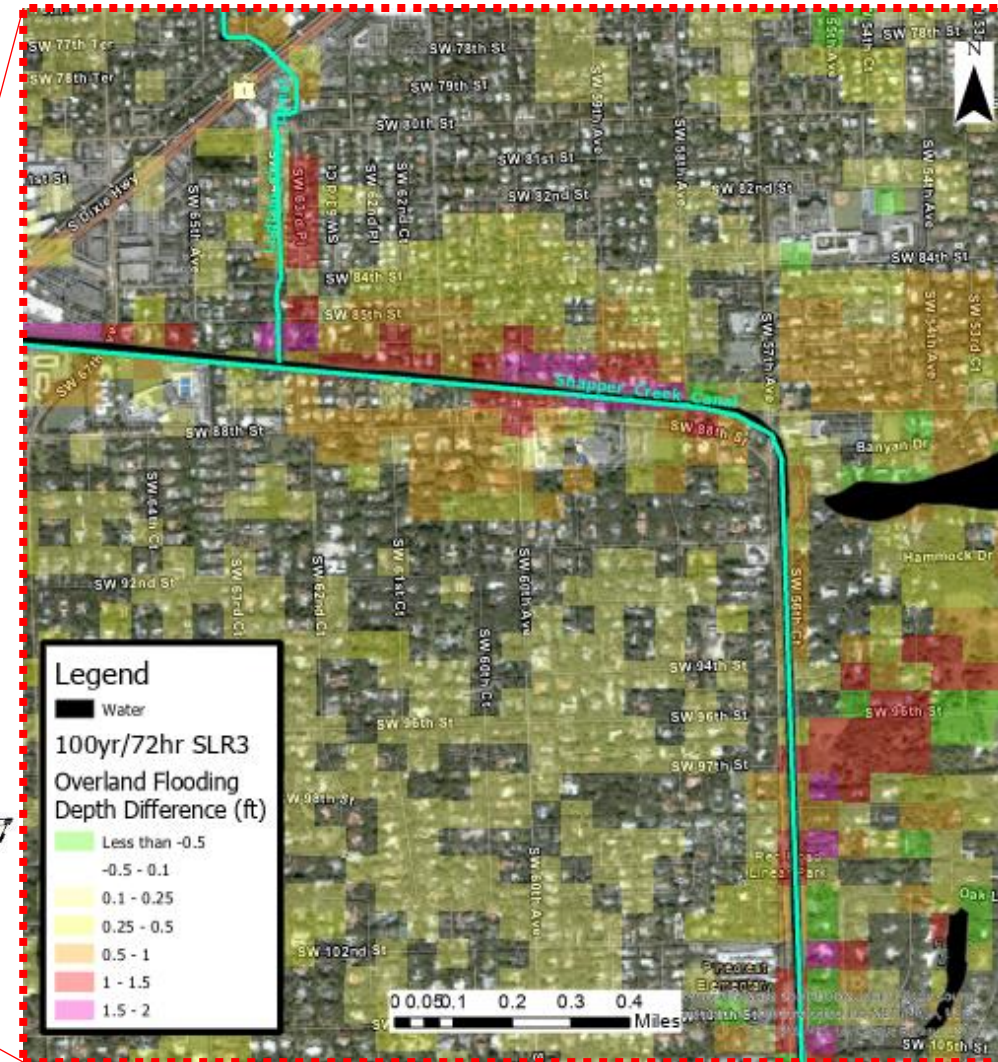
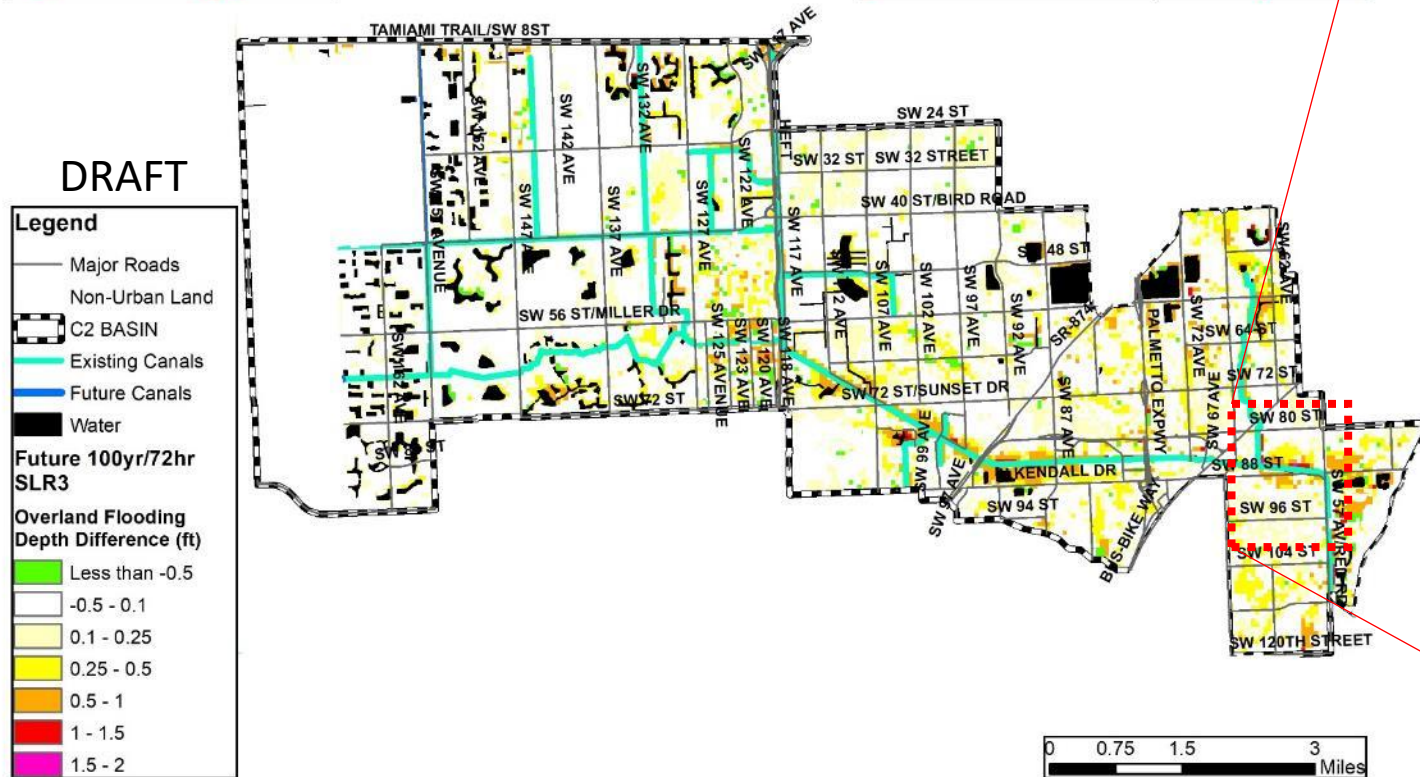
Time Between Peak HW and Peak Discharge at S22



Results – C2 Watershed

• 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

Results – C2 Watershed

• PM 6 – Maximum Flood Duration

Urban Flooding Duration Difference of SLR and Current Conditions for the 100-year Storm in the C2 Watershed

Canal flood duration determined using reference elevation of municipal pump off trigger elevation (5 ft-NGVD/3.43 ft-NAVD).

Design Storm	Duration (hours)				
	Current Conditions w/ 2.23 ft-NAVD Reference Elev.	Current Conditions w/ 3.43 ft-NAVD Reference Elev.	SLR1	SLR2	SLR3
100-yr	281.8	119.6	162.1	282.6	420.6*
25-yr	184.3	67.6	108.2	217.7	410.4*
10-yr	140.3	40.8	68.6	149.8	408.3*
5-yr	101.6	24.9	47.1	120.1	398.1*

*Canal stages do not recede past the Reference Elevation after the storm and therefore the storm duration is longer than the values provided.



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

Results – C2 Watershed

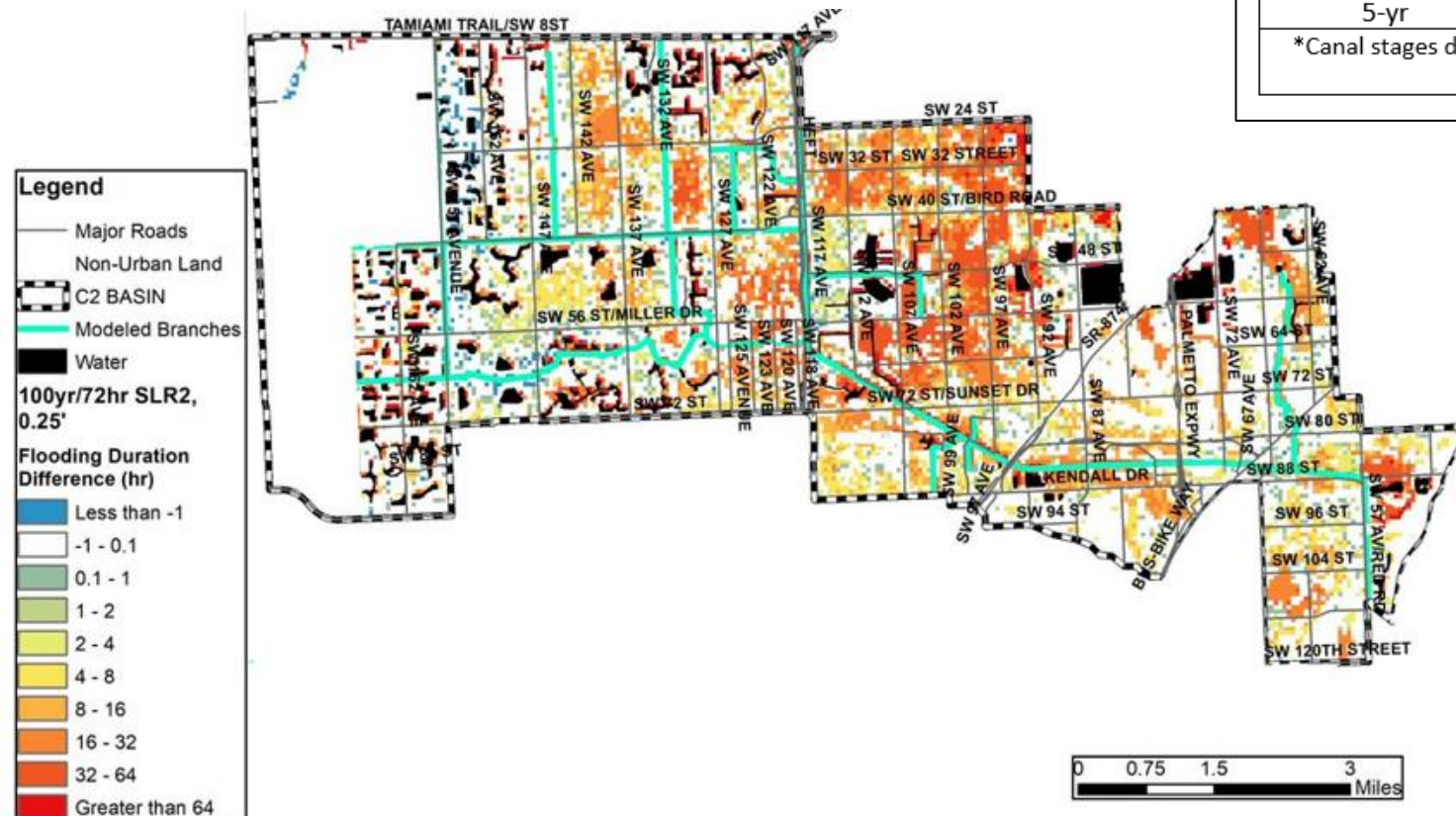
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Results – C2 Watershed

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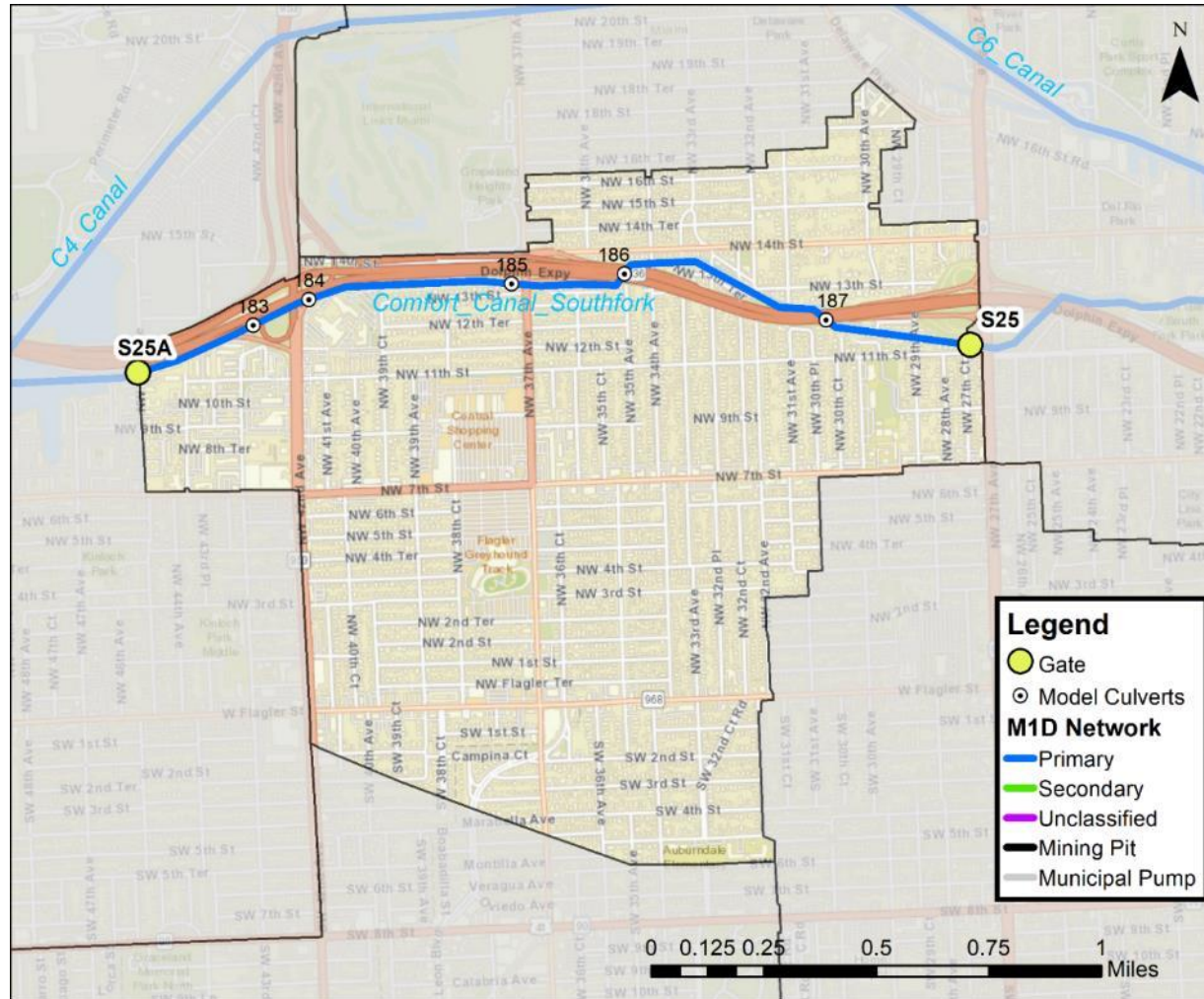
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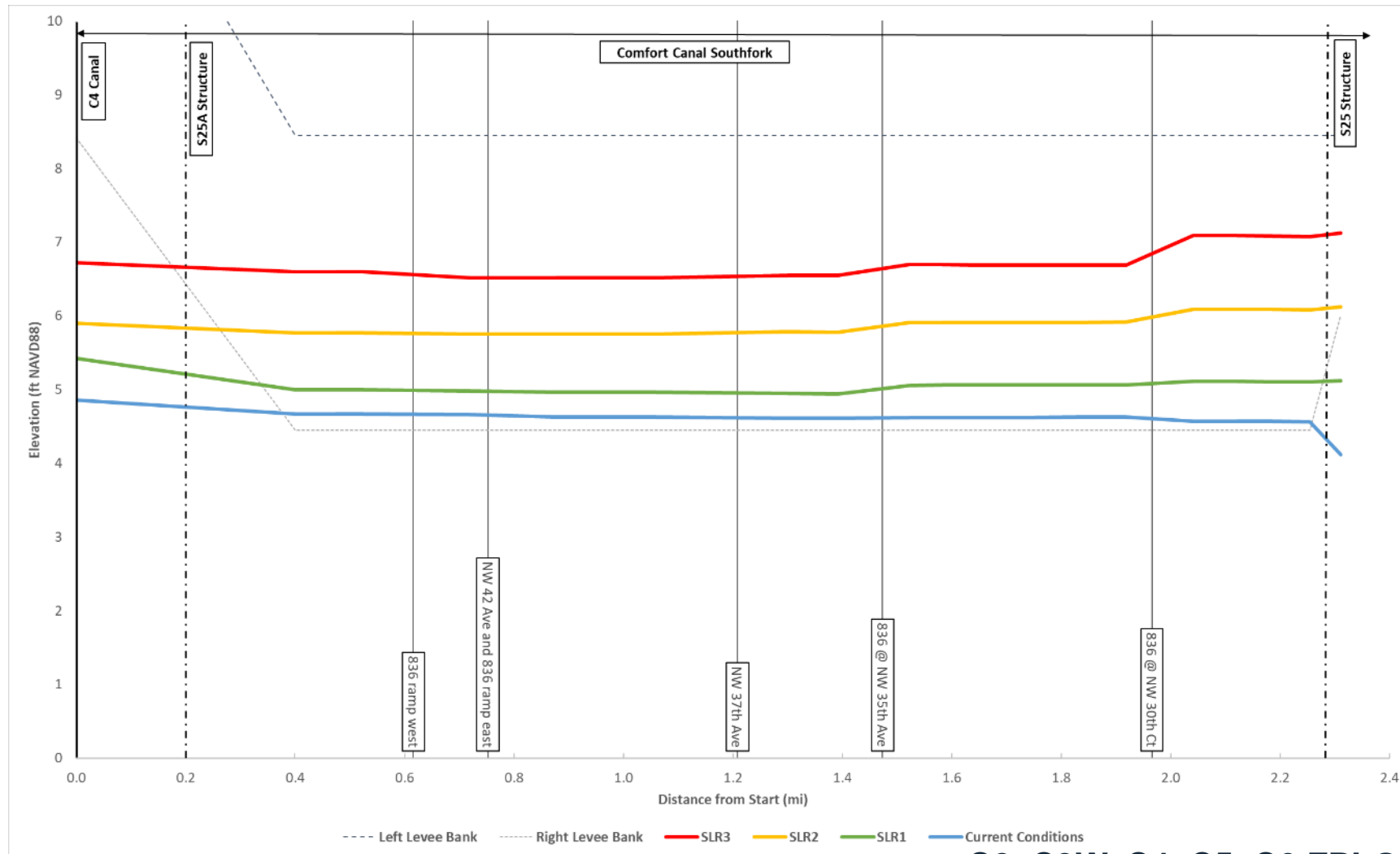
Results – C5 Watershed



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

Results – C5 Watershed

- PM1 – Maximum Stage in Comfort Canal Southfork (100yr/72hr storm)

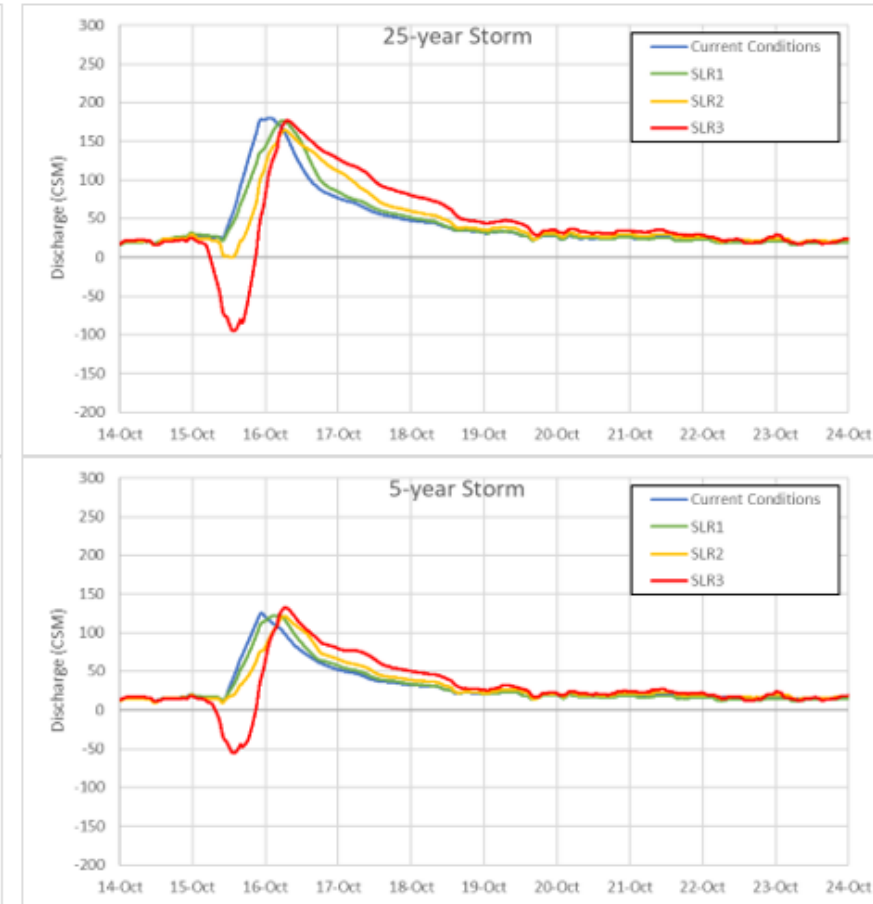
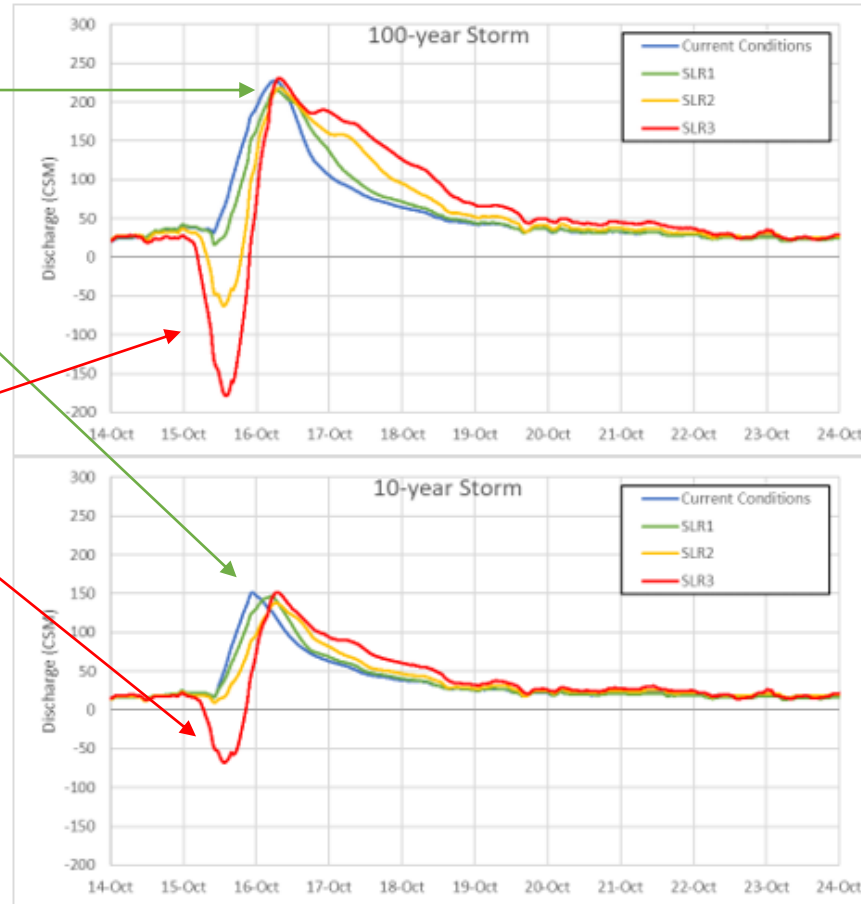


C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR

Results – C5 Watershed

- PM2 – Maximum Discharge Capacity (12-Hour Moving Average)

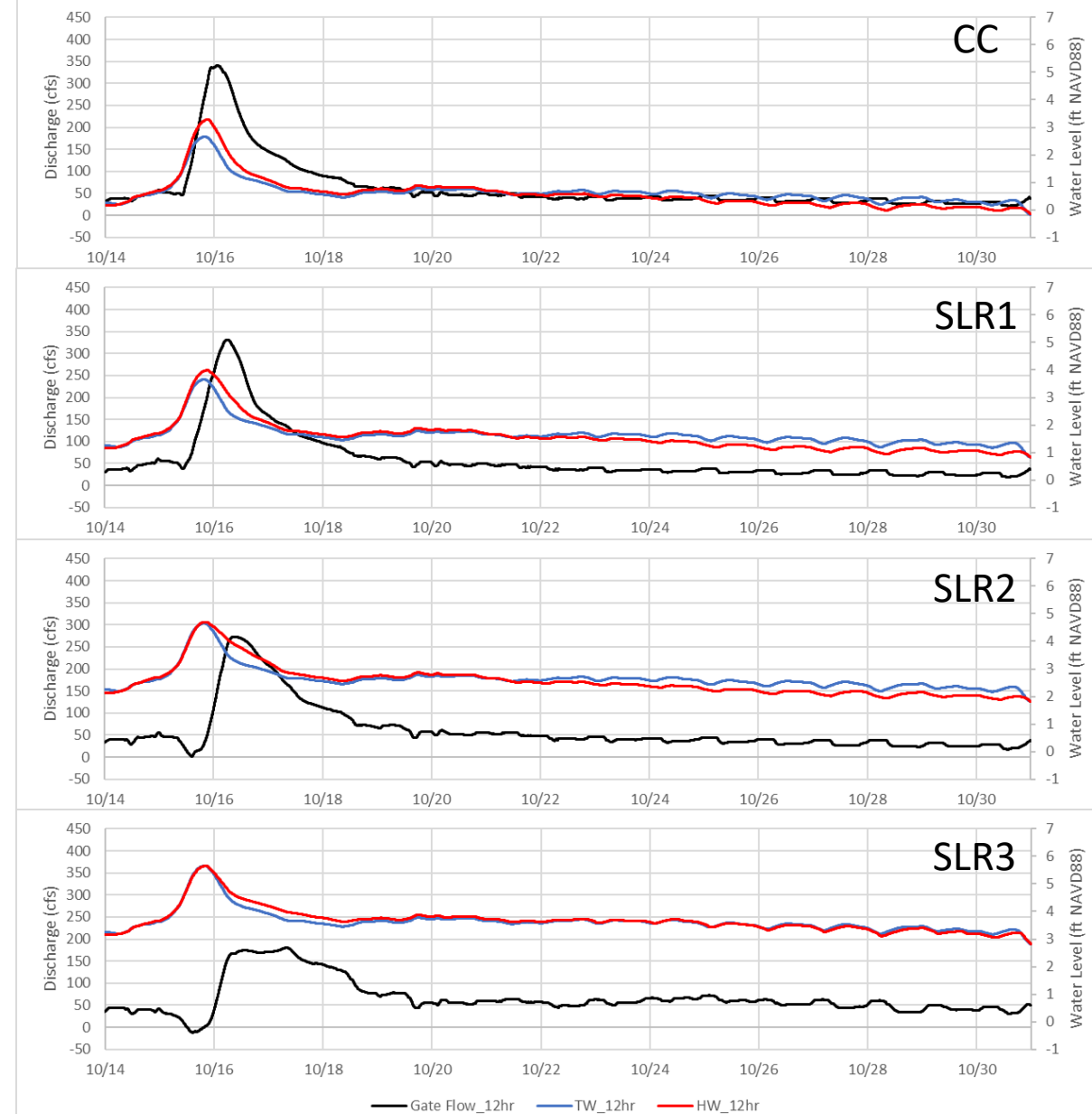
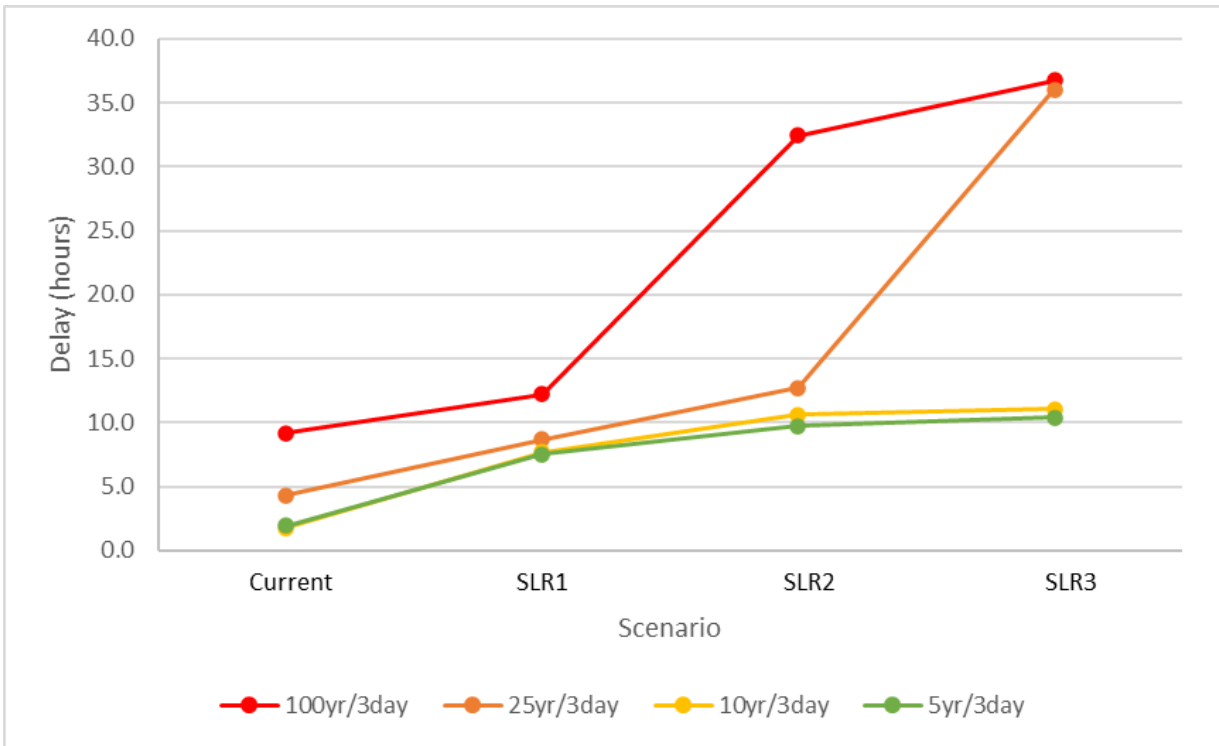
- Little to **no reduction** in the basins ability to discharge.
- Shifting of the peaks with increasing SLR.
 - Caused by **increasing overtopping** of the structure during the peak of the surge event



Results – C5 Watershed

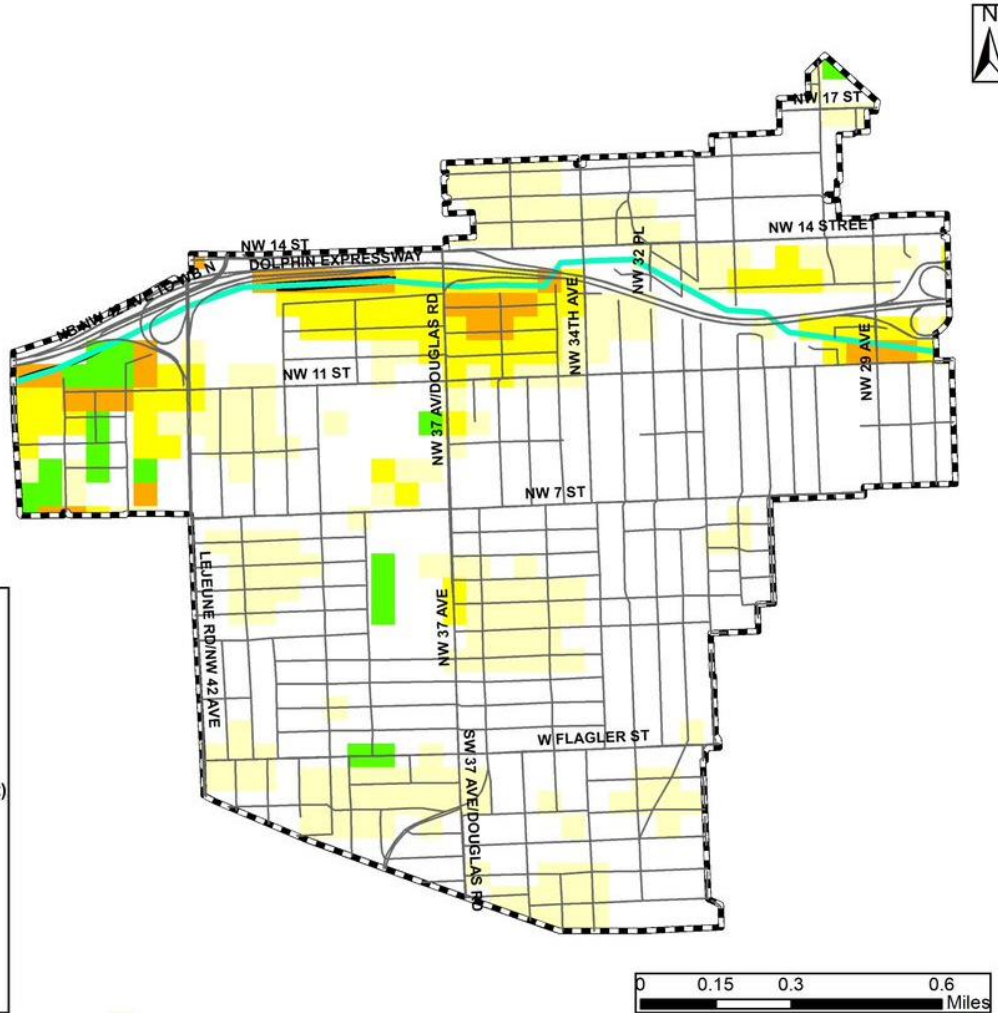
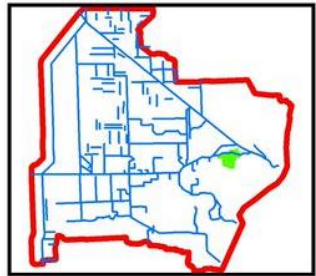
- PM3 – Structure Performance (S25)

Time Between Peak HW and Peak Discharge at S25

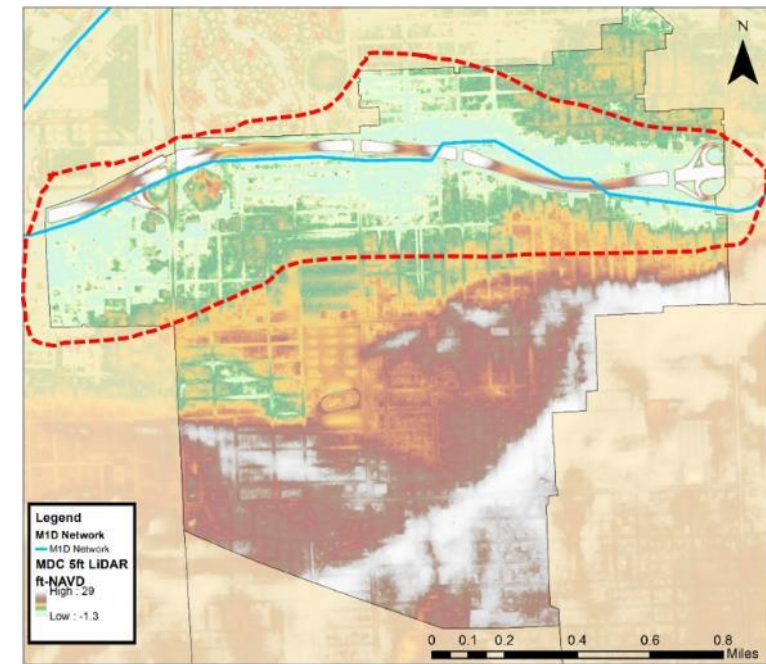


Results – C5 Watershed

- PM 5 – Maximum Flood Depth



Urban Flooding Depth Difference of SLR and Current Conditions for the 100-year Storm in the C5 Watershed

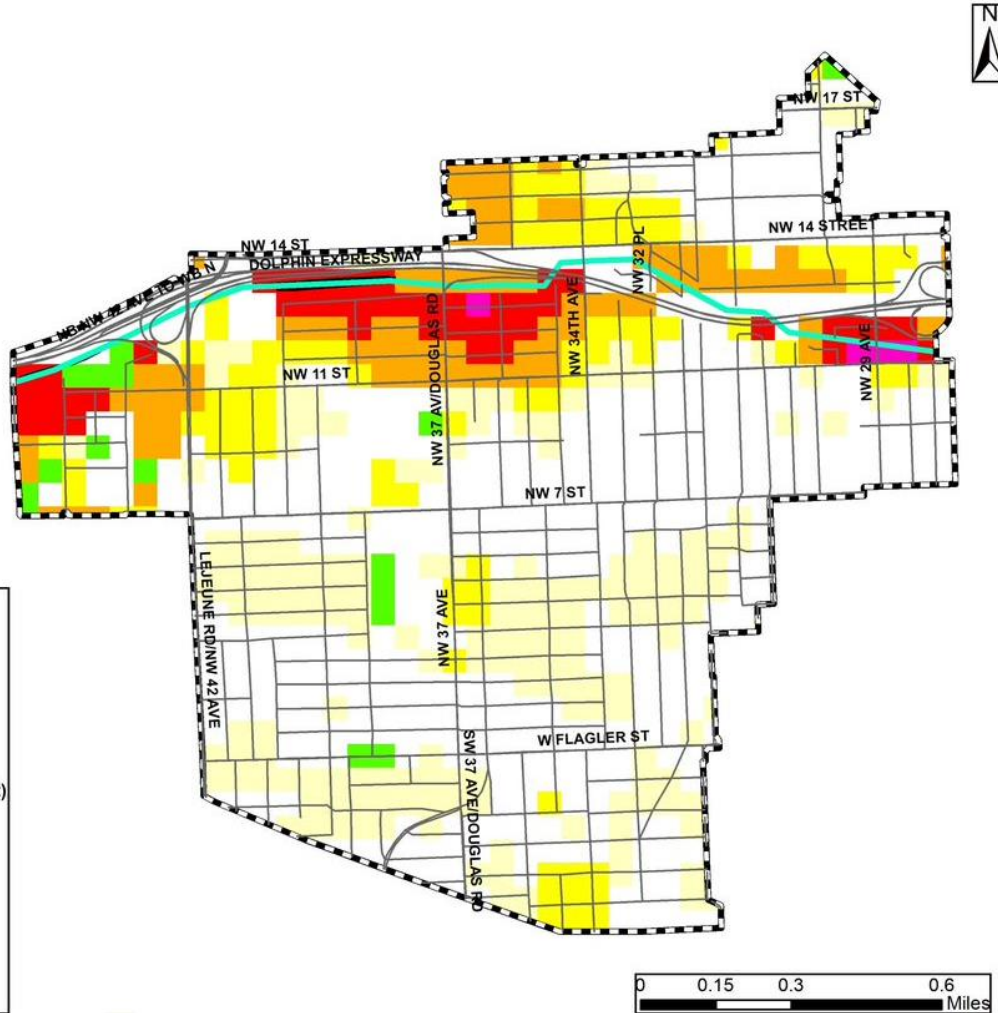
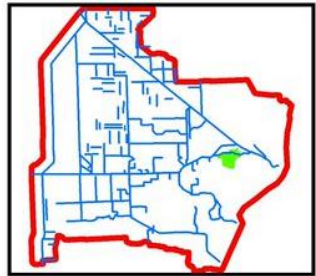


C2, C3W, C4, C5, C6 FPLOS for Current and Future SLR

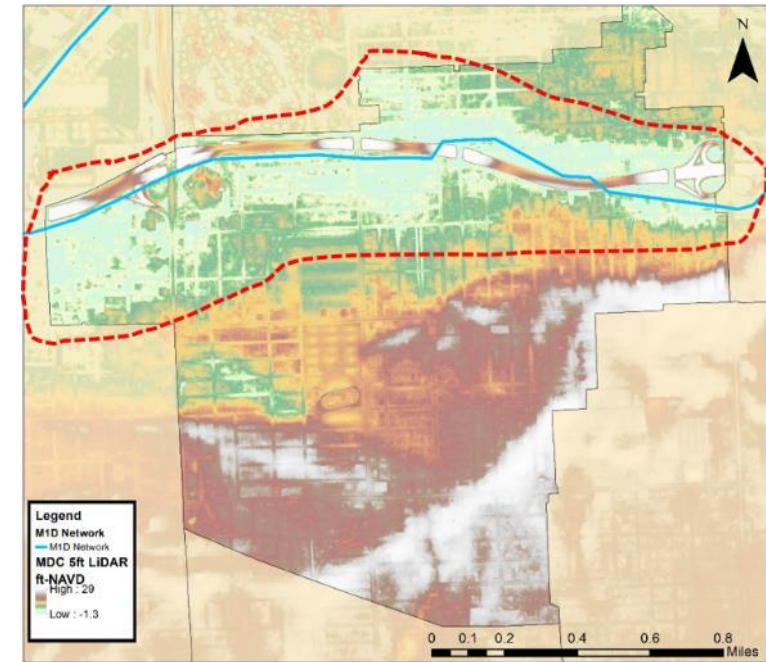


Results – C5 Watershed

- PM 5 – Maximum Flood Depth



Urban Flooding Depth Difference of SLR and Current Conditions for the 100-year Storm in the C5 Watershed

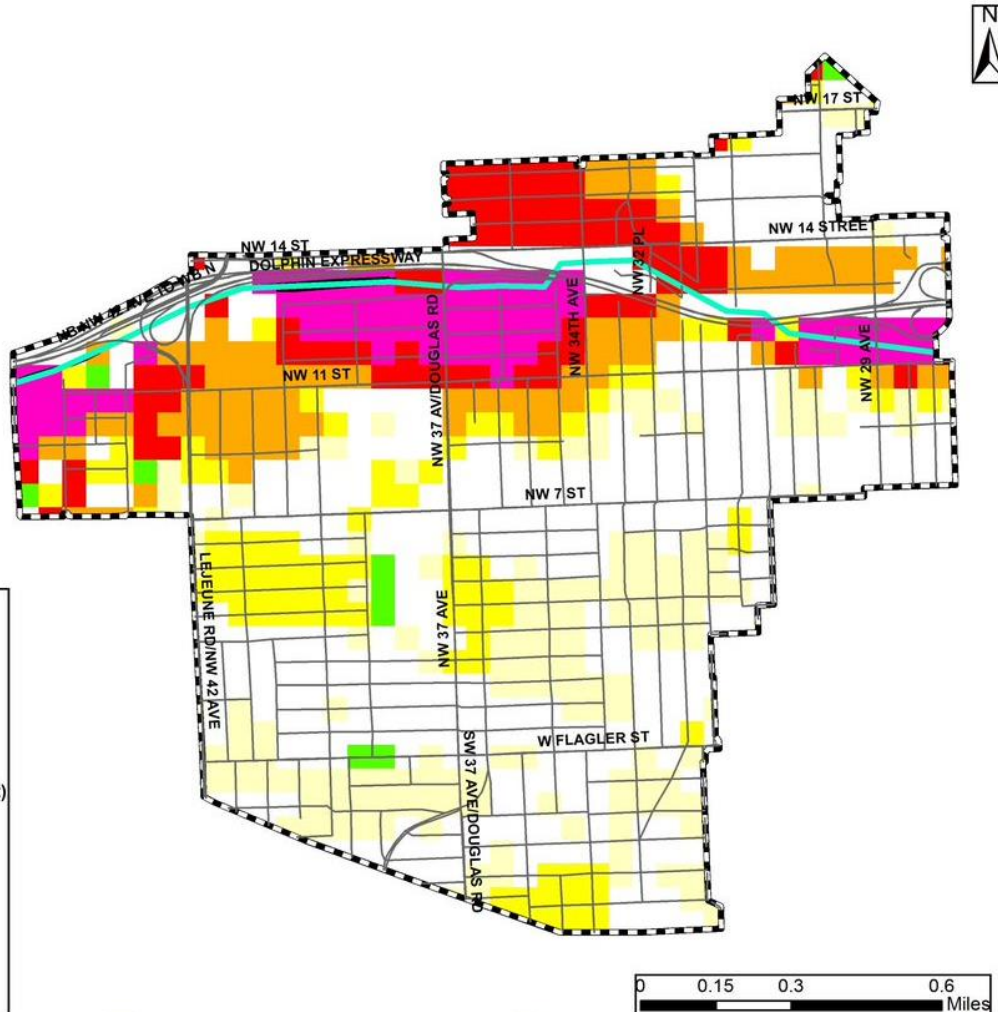
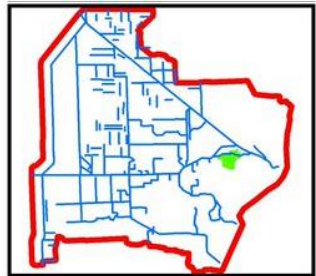


C2, C3W, C4, C5, C6 FPLOS for Current and Future SLR

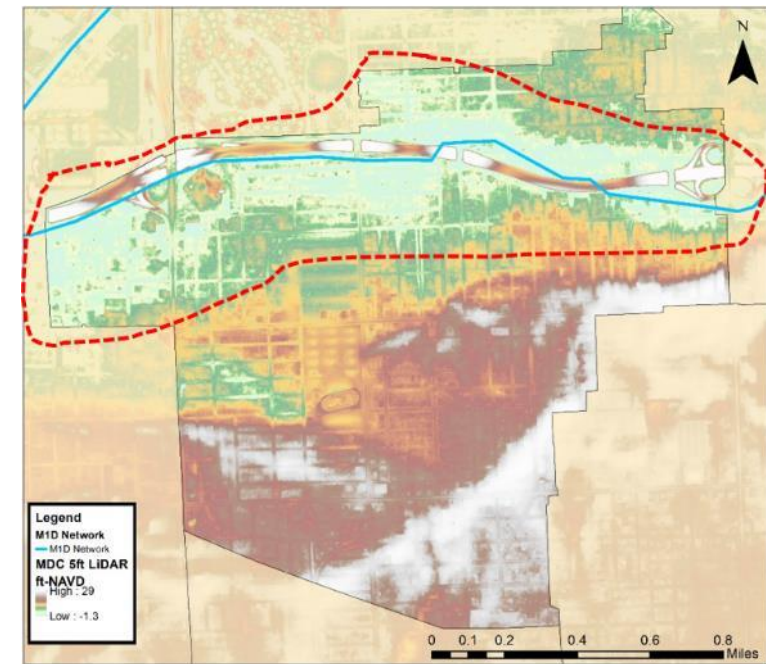


Results – C5 Watershed

- PM 5 – Maximum Flood Depth



Urban Flooding Depth Difference of SLR and Current Conditions for the 100-year Storm in the C5 Watershed



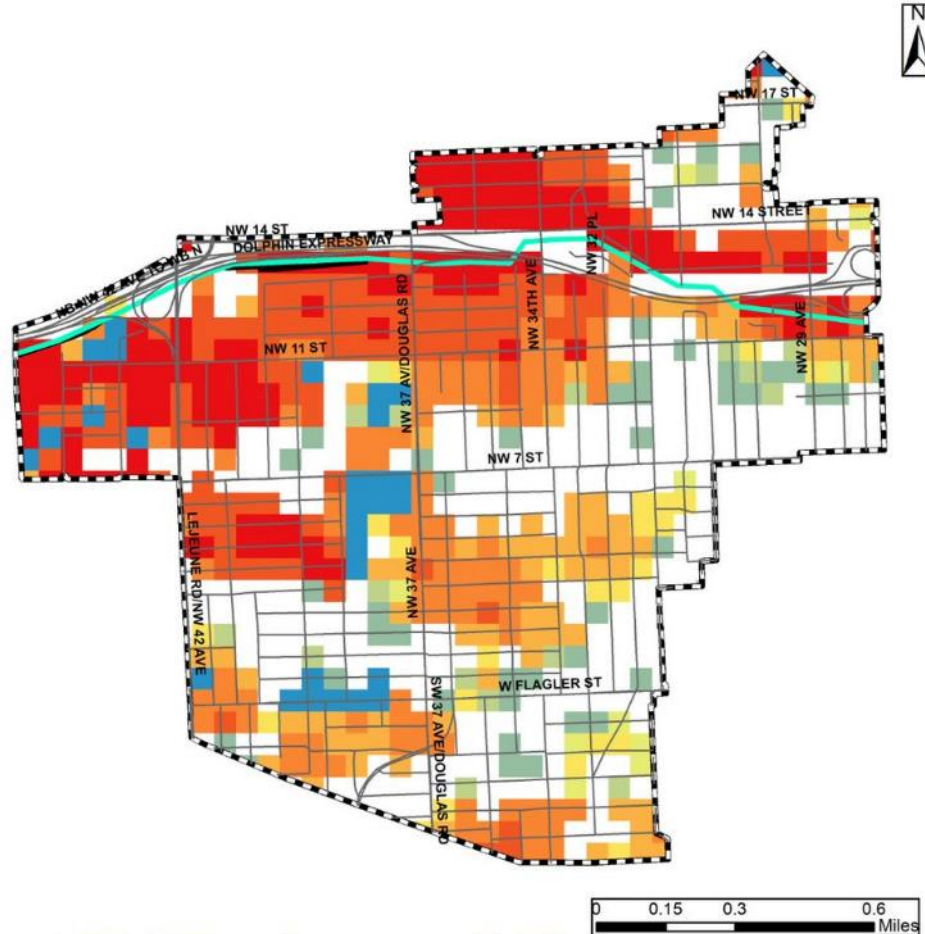
C2, C3W, C4, C5, C6 FPLOS for Current and Future SLR



Results – C5 Watershed

- PM 6 – Maximum Flood Duration

Urban Flooding Duration Difference of SLR +3ft and Current Conditions for the 100-year Storm in the C5 Watershed



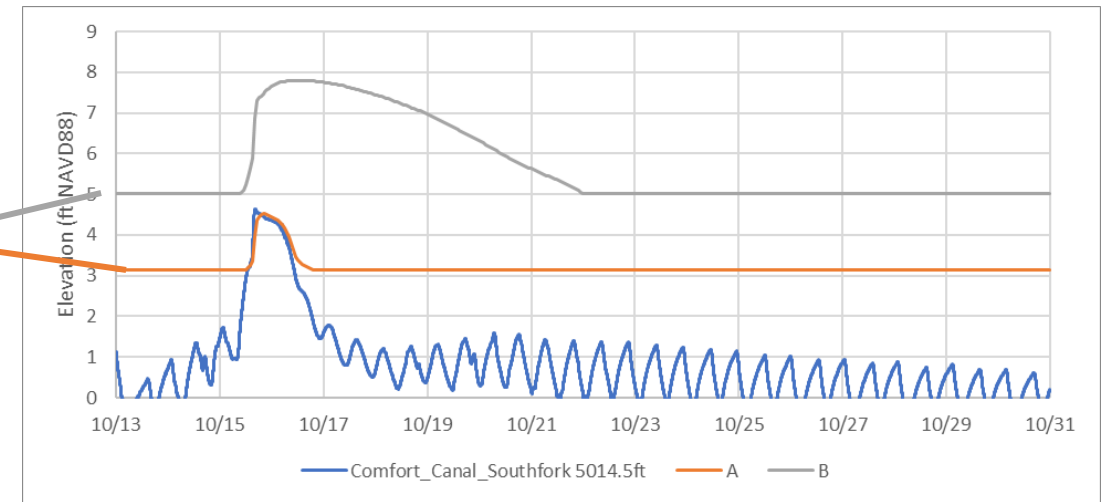
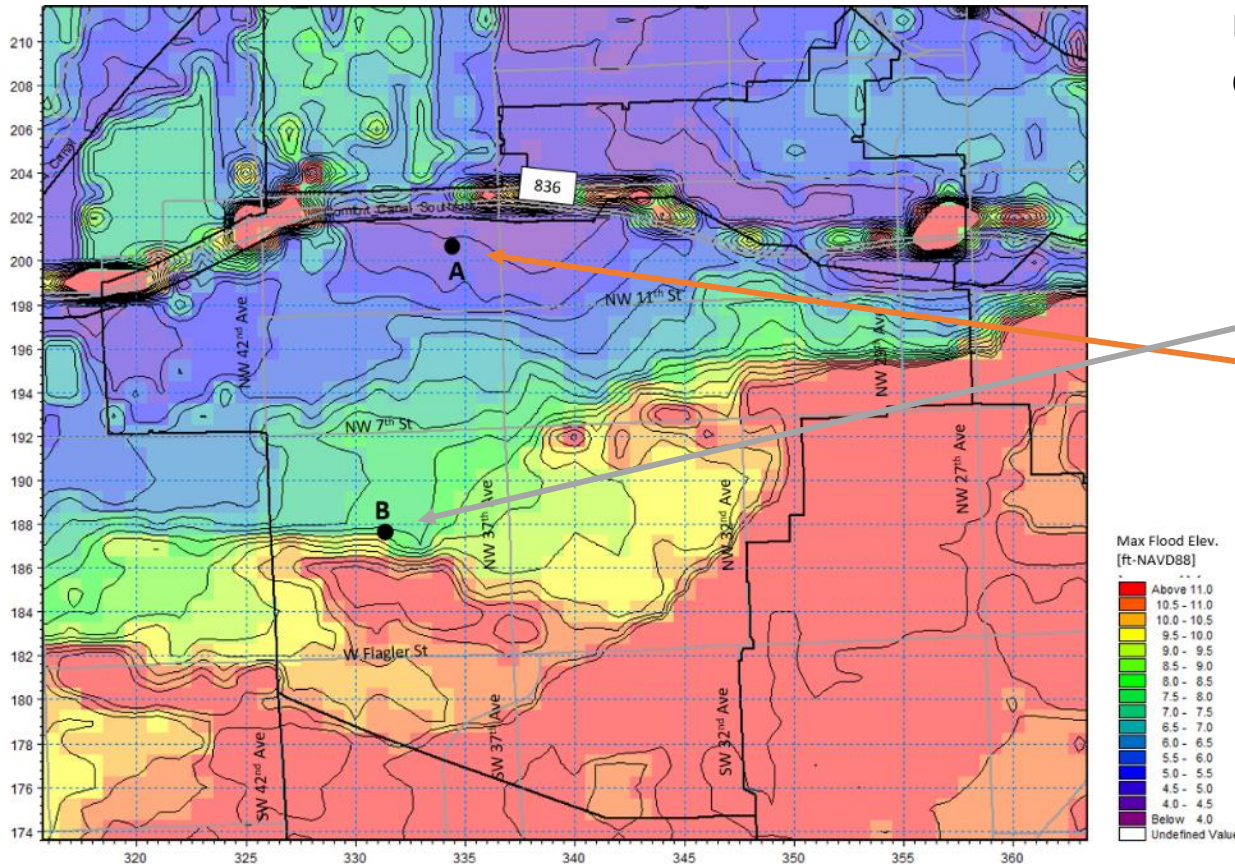
C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR



Results – C2 Watershed

- PM 6 – Maximum Flood Duration

While overtopping of the Comfort Canal presents a major flooding concern, it also provides drainage that reduces duration for areas directly adjacent to the canal.



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

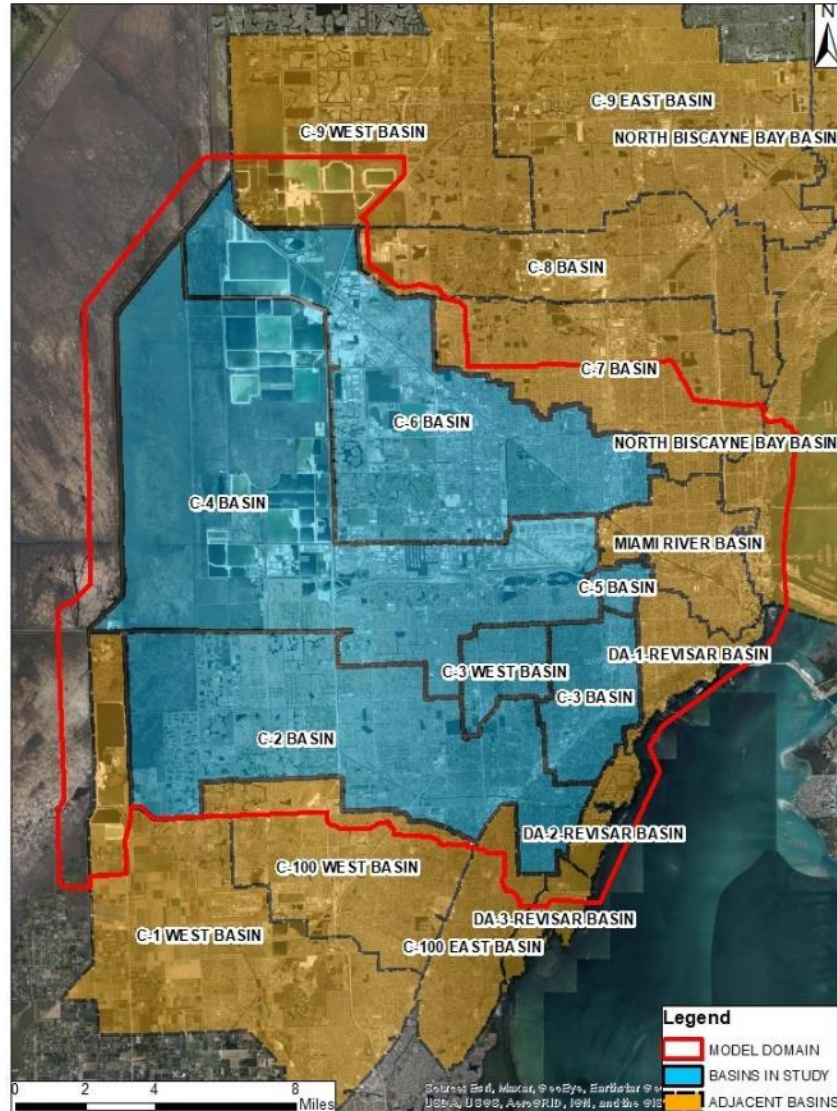
A photograph of two construction workers in safety gear (hard hats and high-visibility vests) standing on a construction site. They are looking towards a large, flat, light-colored area, possibly a prepared surface or a large pit. In the background, there is a yellow construction vehicle (a loader) and some industrial structures under a cloudy sky. The text 'Preliminary Mitigation Strategies' is overlaid in a large, bold, black font across the center of the image.

Preliminary Mitigation Strategies

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



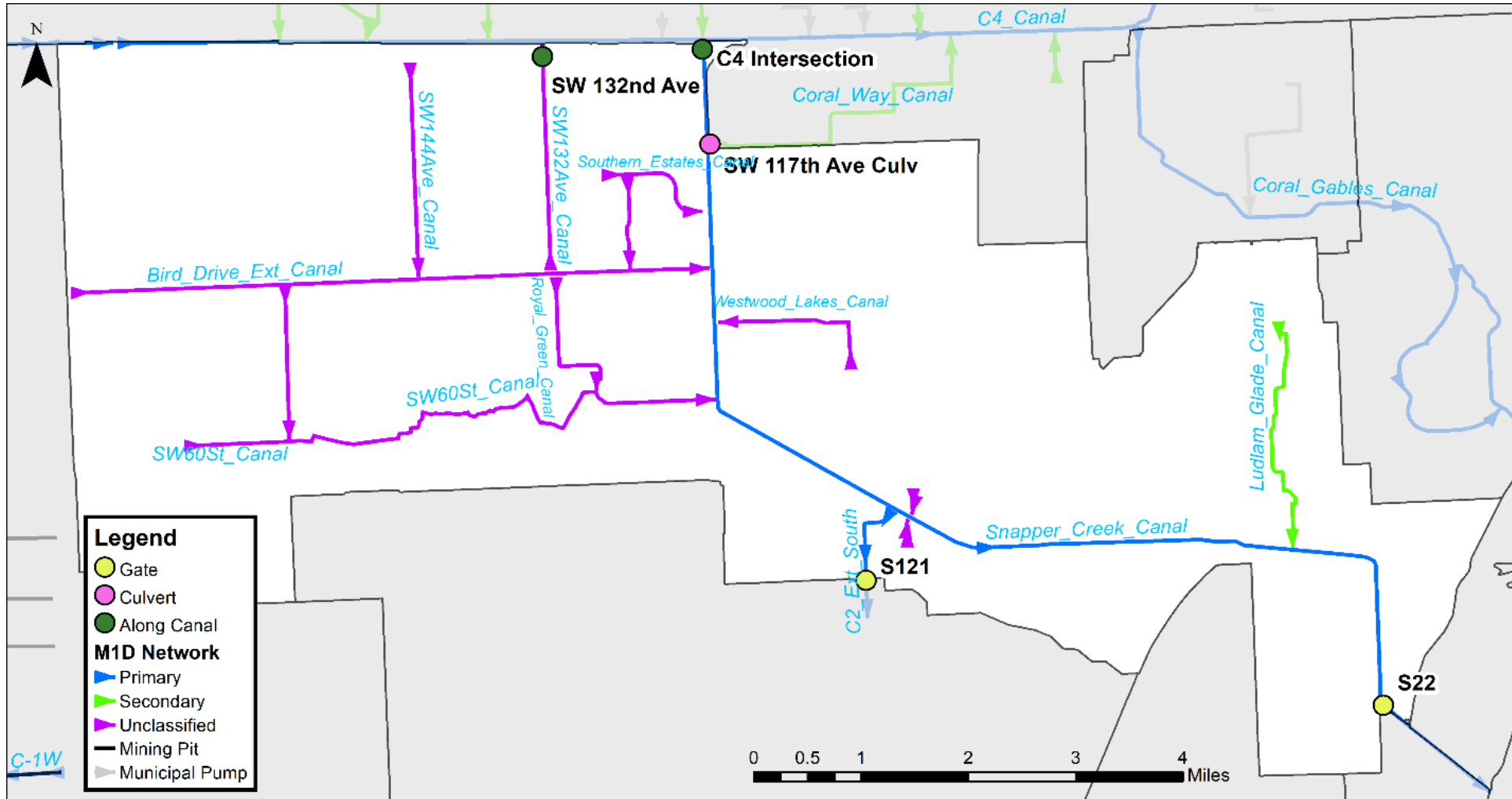
Preliminary Mitigation Strategies



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 – increasing pump capacity Improved operations for S380 to keep water west 	<ol style="list-style-type: none"> C4 Emergency Detention Basin Expansion Acquire storage areas in western mining lakes (Central Lake Belt Storage Area) with conveyance structures connecting to C4 Canal
C5	<ol style="list-style-type: none"> S25 replacement (Remove culvert and construct spillway in same location with tie-back levees/floodwalls) S25 replacement (Remove culvert and construct spillway in location with higher elevation and with tie-back levees/floodwalls) Forward pump station 	<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 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

Preliminary Mitigation Strategies – C2 Watershed

Western
Acquire storage area



Central
Raise embankments

Temporary storage

Municipal pump stations

Tidal

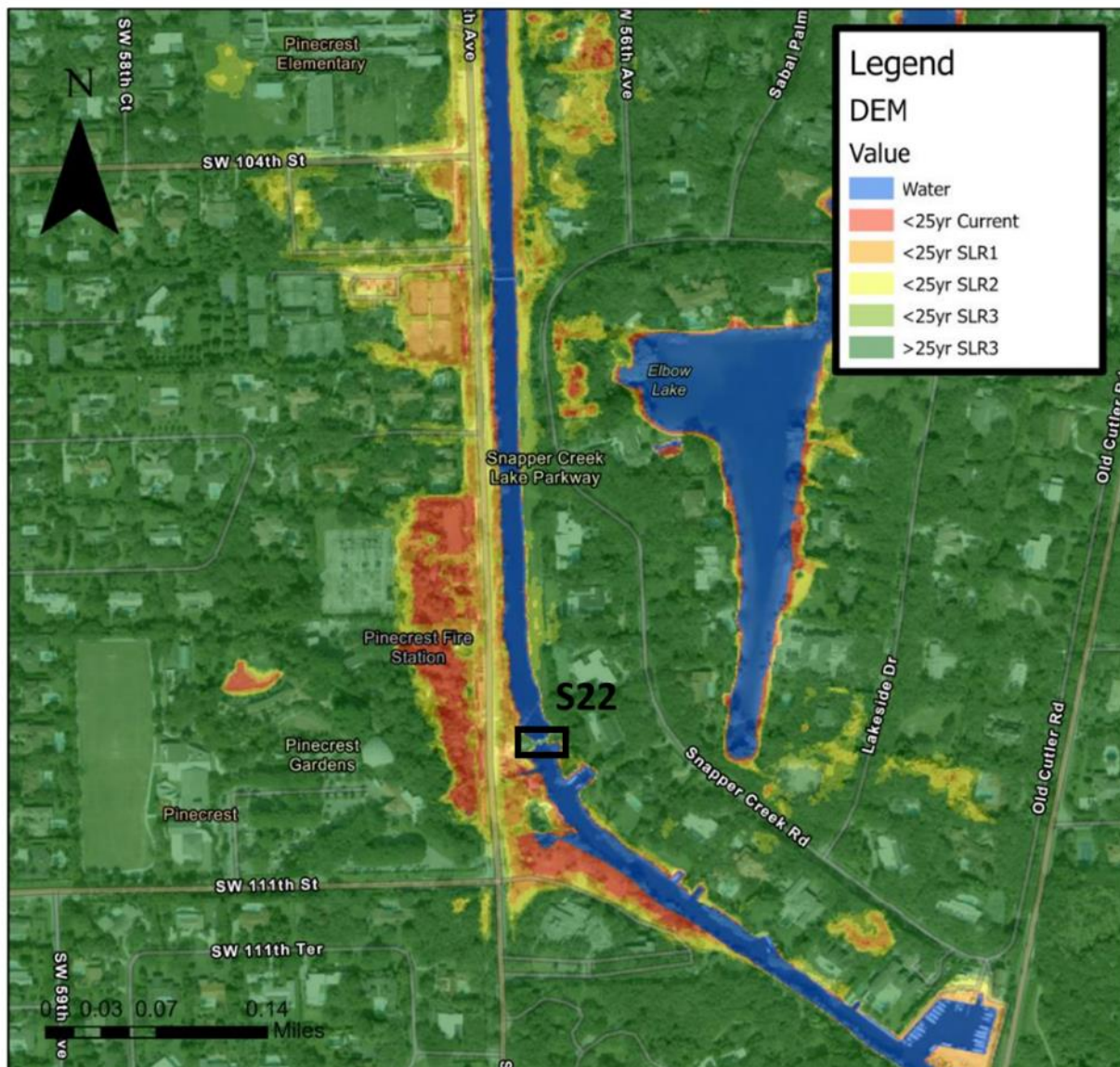
Structure hardening

Forward pump station

Canal Realignment

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

Preliminary Mitigation Strategies – C2 Watershed



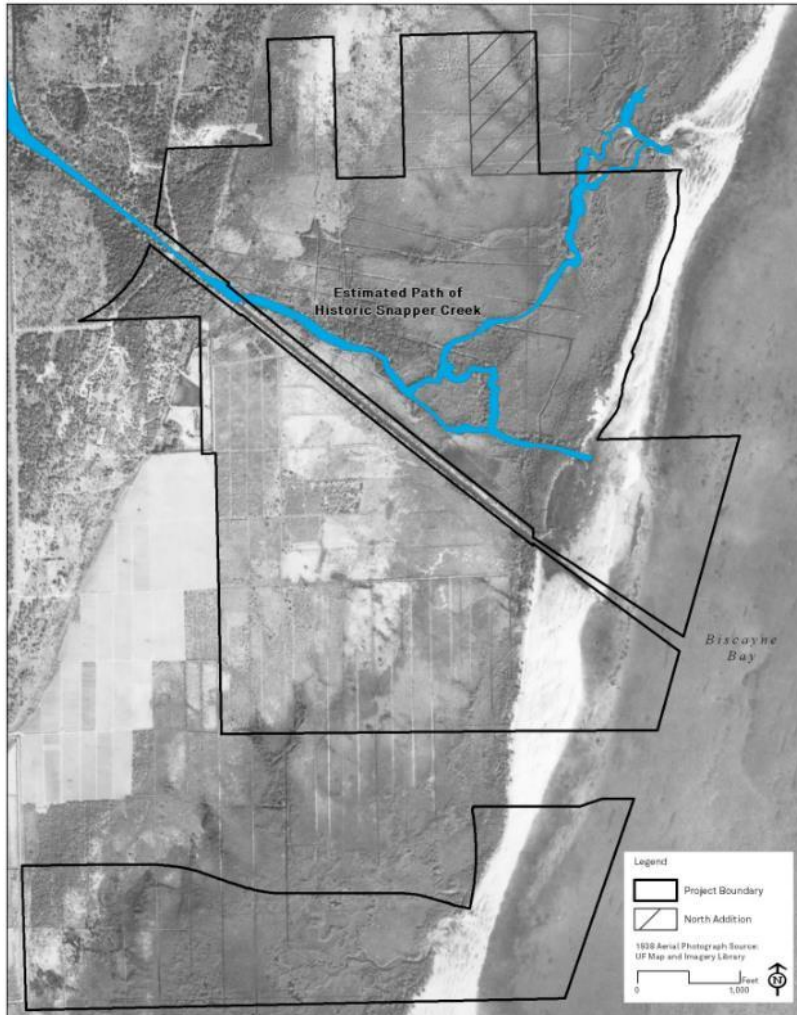
Tidal Improvements

- Increase existing structure elevation to prevent overtopping
- Add tieback levees and floodwalls to prevent flooding of the area and short-circuiting of the water around the structure (flanking)
- Install a forward pump station to help reach the design discharge while gravity discharge is limited under storm surge and SLR conditions

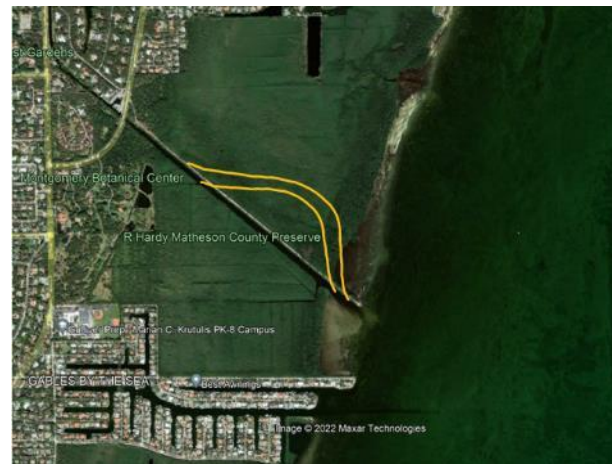
C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR

Preliminary Mitigation Strategies – C2 Watershed

Historical C2 Canal



Tidal Improvements

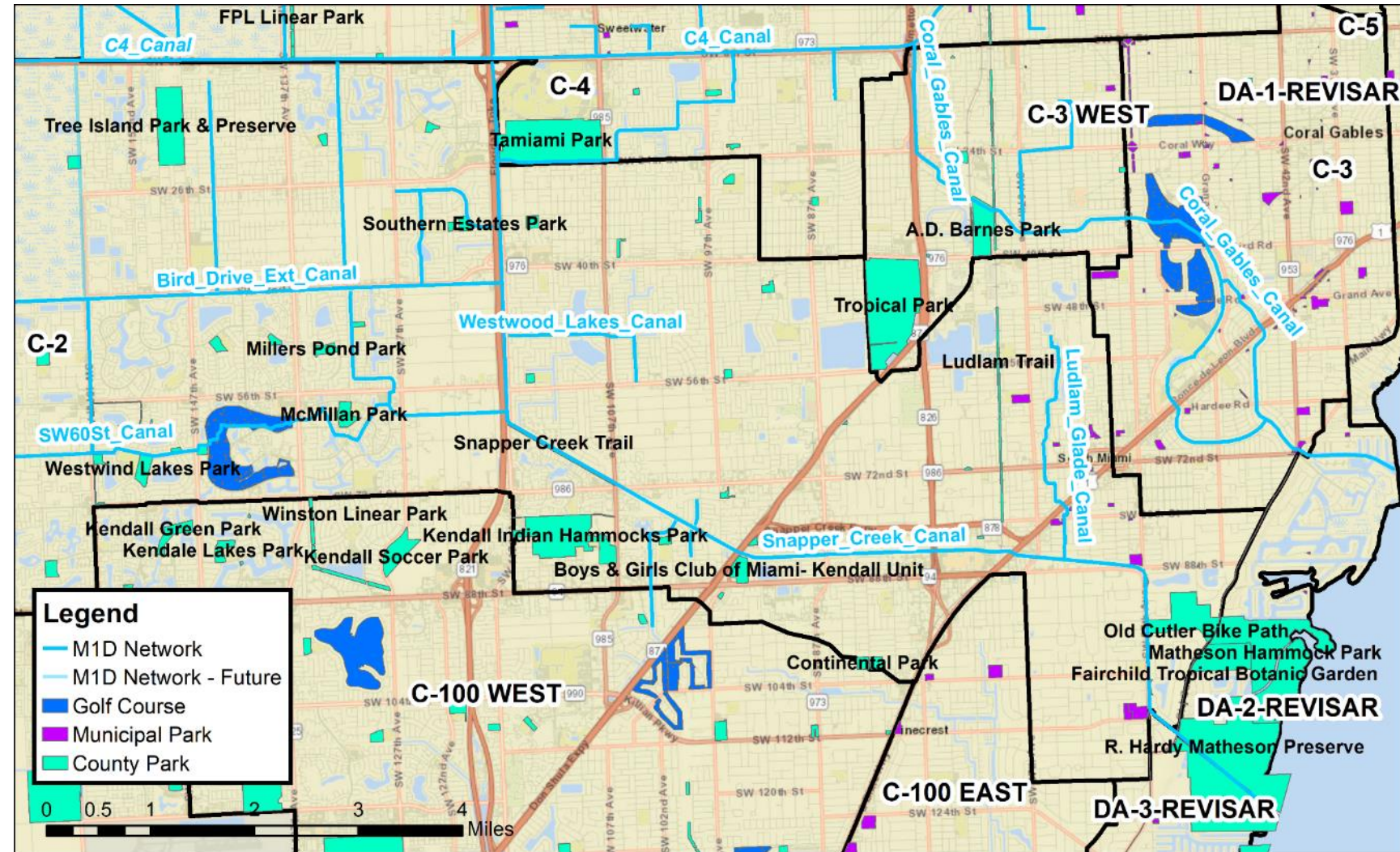


**C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR**

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

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

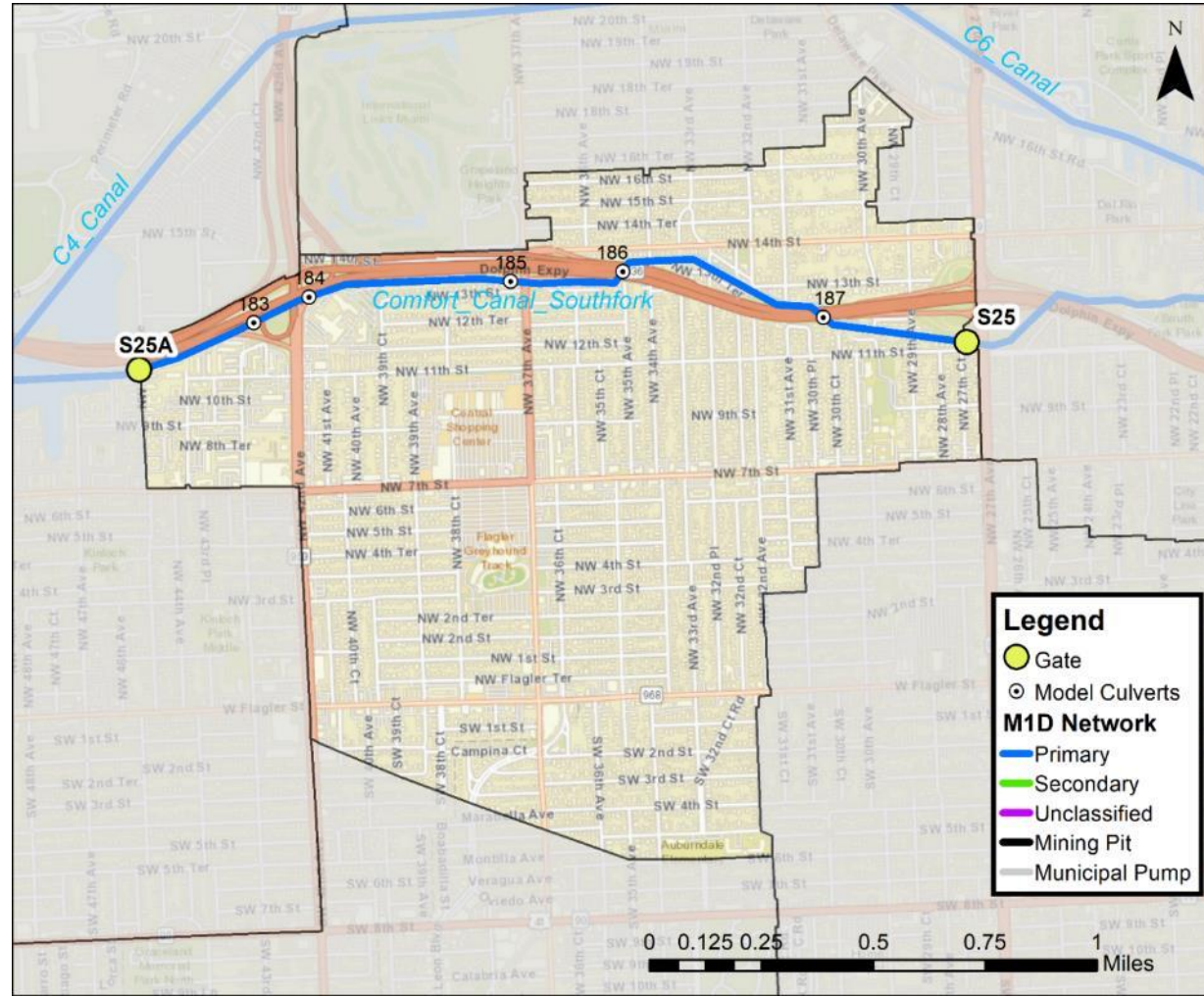


C2, C3W, C4, C5, C6 FPLOS
for Current and Future SLR

Preliminary Mitigation Strategies – C5 Watershed

Western

- Connection with the C4 Basin



Central

- Raise embankments
- Municipal pump stations

Tidal

- Structure hardening
- Forward pump station

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

Preliminary Mitigation Strategies – C5 Watershed



Tidal Improvements

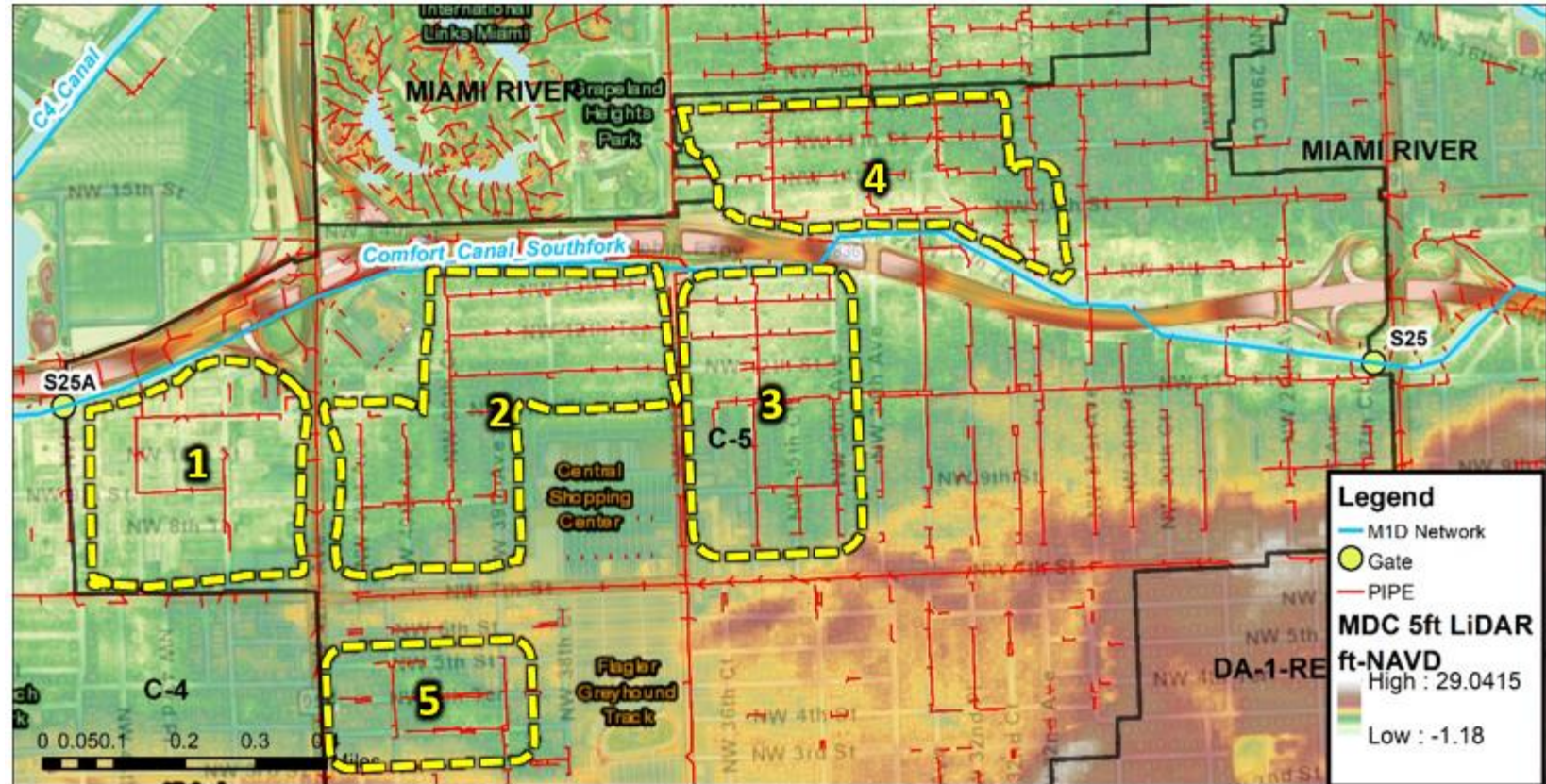
- Replace structure at current location
 - Add tieback levees and floodwalls to prevent flooding of the area and short-circuiting of the water around the structure (flanking)
- Relocate and replace structure at alternate location
 - Add tieback levees and floodwalls to prevent flooding of the area and short-circuiting of the water around the structure (flanking)
- Install a forward pump station to help reach the design discharge while gravity discharge is limited under storm surge and SLR conditions

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

Preliminary Mitigation Strategies – C5 Watershed

Central Improvements

- Raise canal embankments in problem areas
- 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 – C5 Watershed

Western Improvements

- Reconsider connection with the C4 Canal under certain conditions:
 - While western storage is being utilized (i.e. pumping into the C4 EDB)
 - If no overtopping of the C5 structure is occurring (i.e. no saltwater intrusion)
 - If stages in the C4 are not at critical stages (less than pump-off trigger for municipal pump stations)
- Would require replacement of the existing S25A structure



Next Steps

- Initial cost estimation of mitigation strategies
- Phase 2
 - Evaluate the mitigation strategy projects with modeling
 - Working with municipalities/stakeholders



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

Thank You!

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