



Shark River Slough Appendix A Water Quality Analysis

Edward C. Smith

Office of Water Policy and Ecosystems Restoration
Florida Department of Environmental Protection

Technical Oversight Committee | December 2023



1

Water Quality Analysis – Outline

History of Exceedances

Exceedance Frequency and Magnitude
Water Management Changes

Hydrodynamics of WCA-3A

Western Inflows – S190 & S140
Miami Canal Inflows – S8, S339, S340
Eastern Inflows – S150, S11A-C, S9/S9A

Local Drivers

S333HW Stage – TP Concentration Relationship
Low-Stage Water Deliveries



2

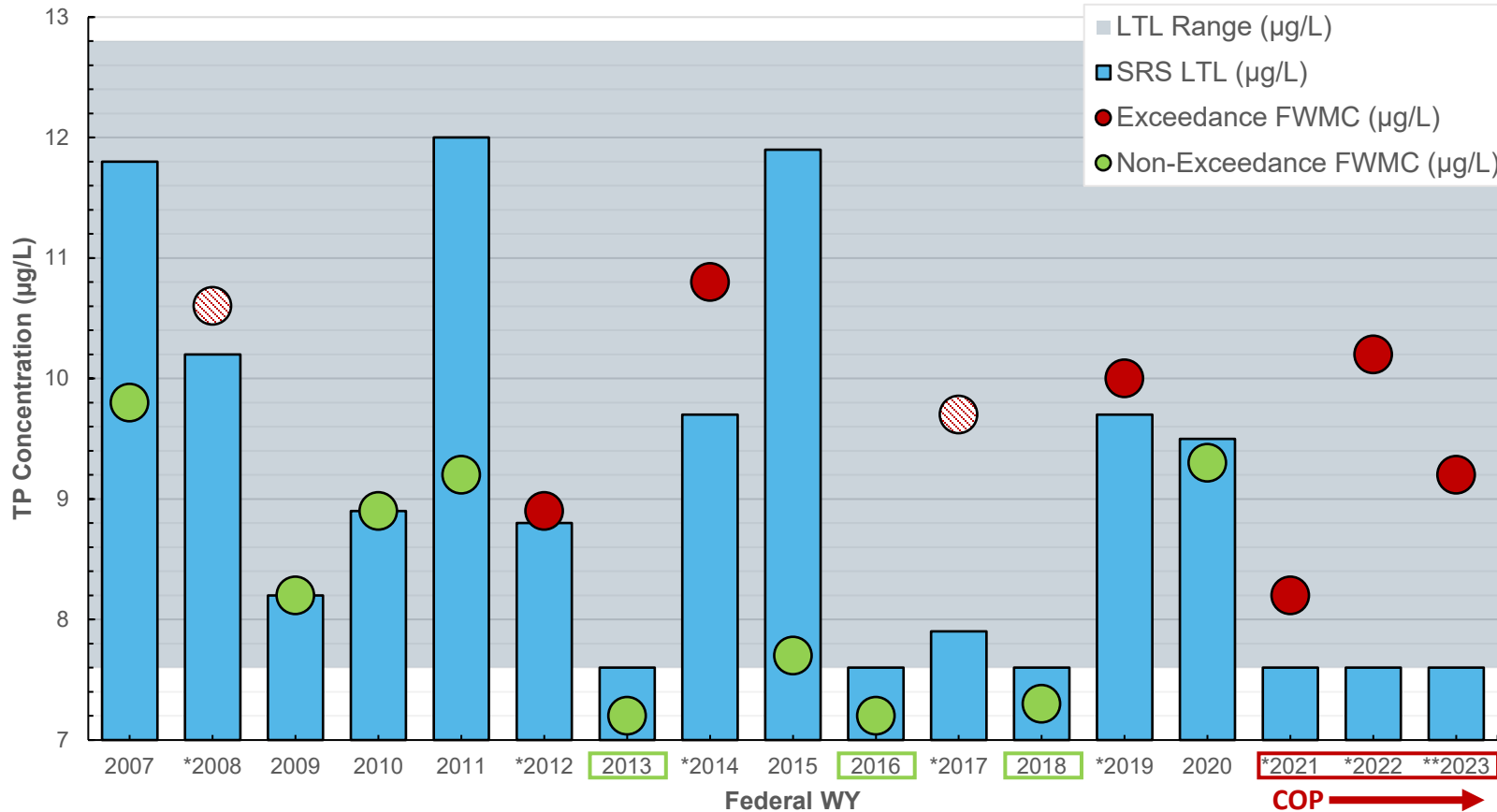
History of Exceedances

Dec. 2023 TOC



3

LTL Trending Down, FWMC Not Increasing



Series	Kendall's τ	p-value ***	Sen's slope (µg/L/yr)
LTL	-0.42	0.0225	-0.119
FWMC	-0.02	0.9341	<0.001

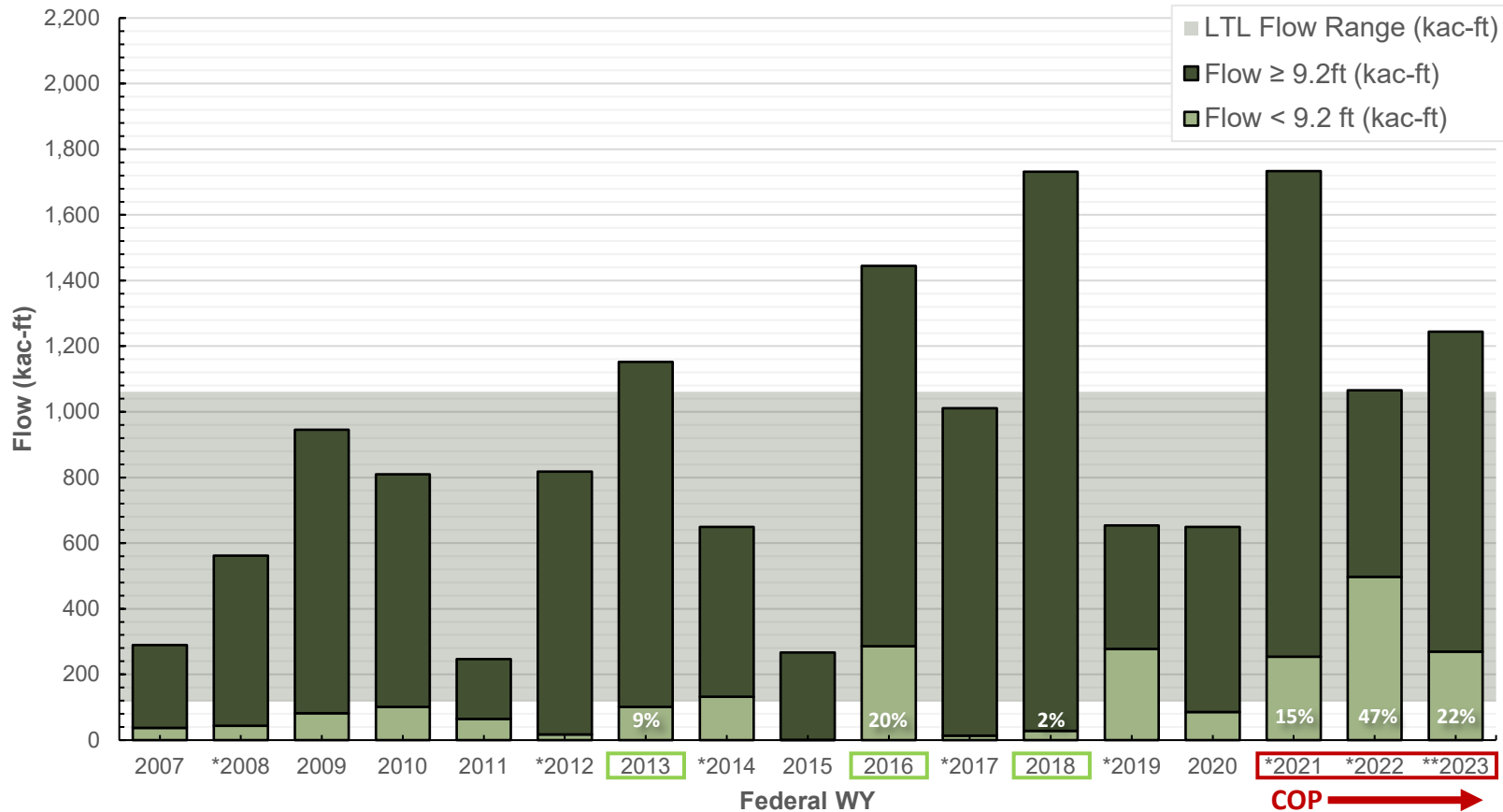
- TP FWMCs have no trend
- LTL has trended significantly downward (p=0.02)
 - At minimum limit (7.6 µg/L) since FWY 2021

Increased flows as a result of COP have driven the LTL down to the minimum and the frequency of exceedances has increased

* Exceedance year; ** Provisional data; *** Significance determined at 0.05; Kendall's tau and Sen's slope calculated in R. Note: WY2008 & WY2017 exceedances excused by the TOC.



SRS Total Flows & Flows Under 9.2 ft Increasing



Series	Kendall's τ	p-value	Sen's slope (kac-ft/yr)
Total Flow	0.40	0.0273	51
Low-Stage Flow	0.35	0.0518	15

- Total flow has trended upward (p=0.03)
 - Above maximum LTL equation input (1,061 kac-ft) for 5 of last 8 years
- S333HW stage < 9.2 ft flow has also trended upward (p=0.05)***
 - Associated with higher TP concentrations

The lower the stage, the higher the FWMC – recent years had significant flow at lower stages

* Exceedance year; ** Provisional data; *** Not significant at 0.05 but is significant at 0.1; Kendall's tau and Sen's slope calculated in R.



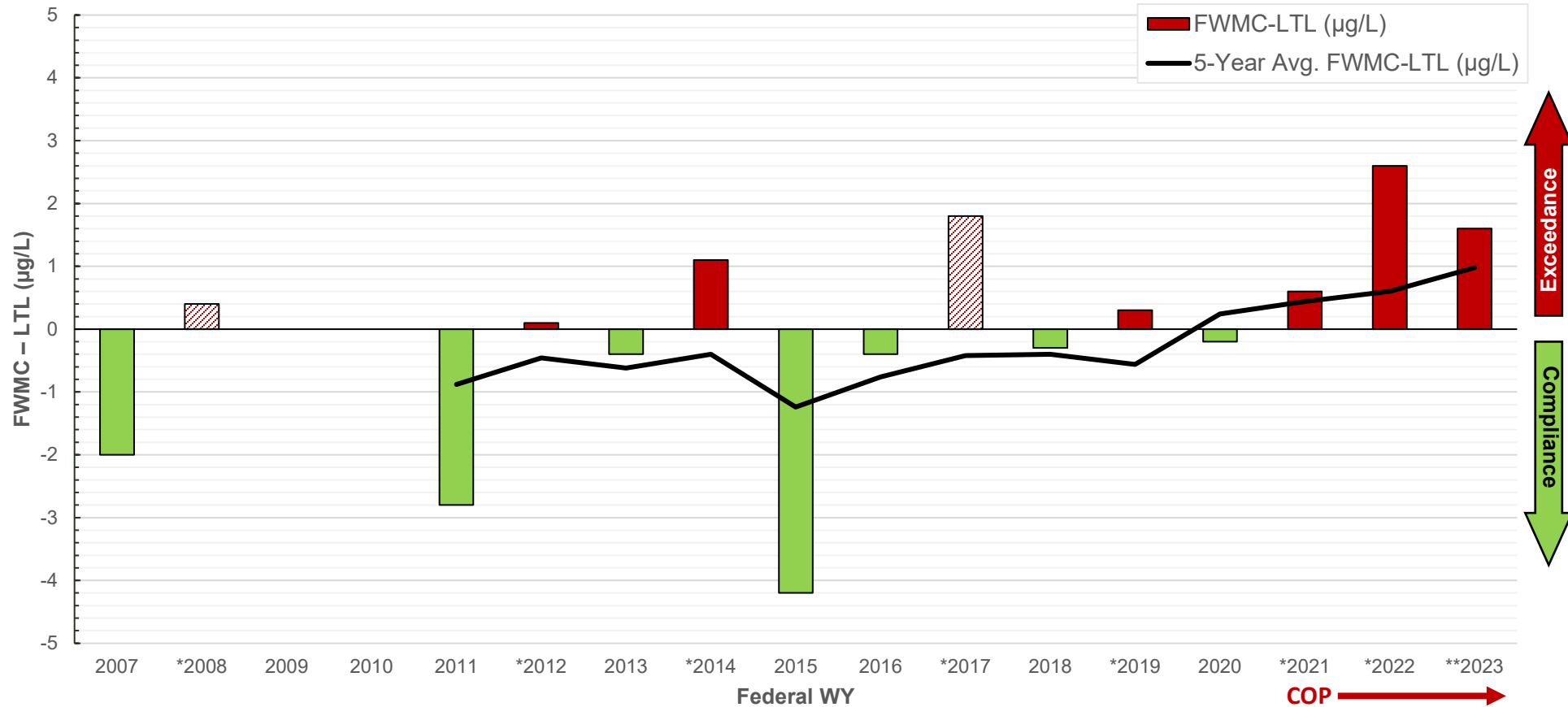
Combined Operational Plan (COP)

- **COP was designed to...**
 - Improve water deliveries (timing, location, volume) into ENP.
 - Increase flows through Taylor Slough and coastal creeks.
 - Increase dry season flows into eastern Shark River Slough to improve ecological health.
- **COP Final Environmental Impact Statement acknowledged that changed operations would...**
 - Result in increased TP FWMC and decreased LTL.
 - Increase the risk of LTL exceedances.
- **As anticipated...**
 - Dry season water deliveries have been extremely beneficial ecologically to SRS.
 - Exceedances of Appendix A have occurred with increased frequency since COP implementation.

Exceedances of Appendix A have occurred annually since COP implementation



Exceedance Magnitude Increasing Since WY 2019



The rolling 5-year average FWMC was less than the LTL until WY 2020

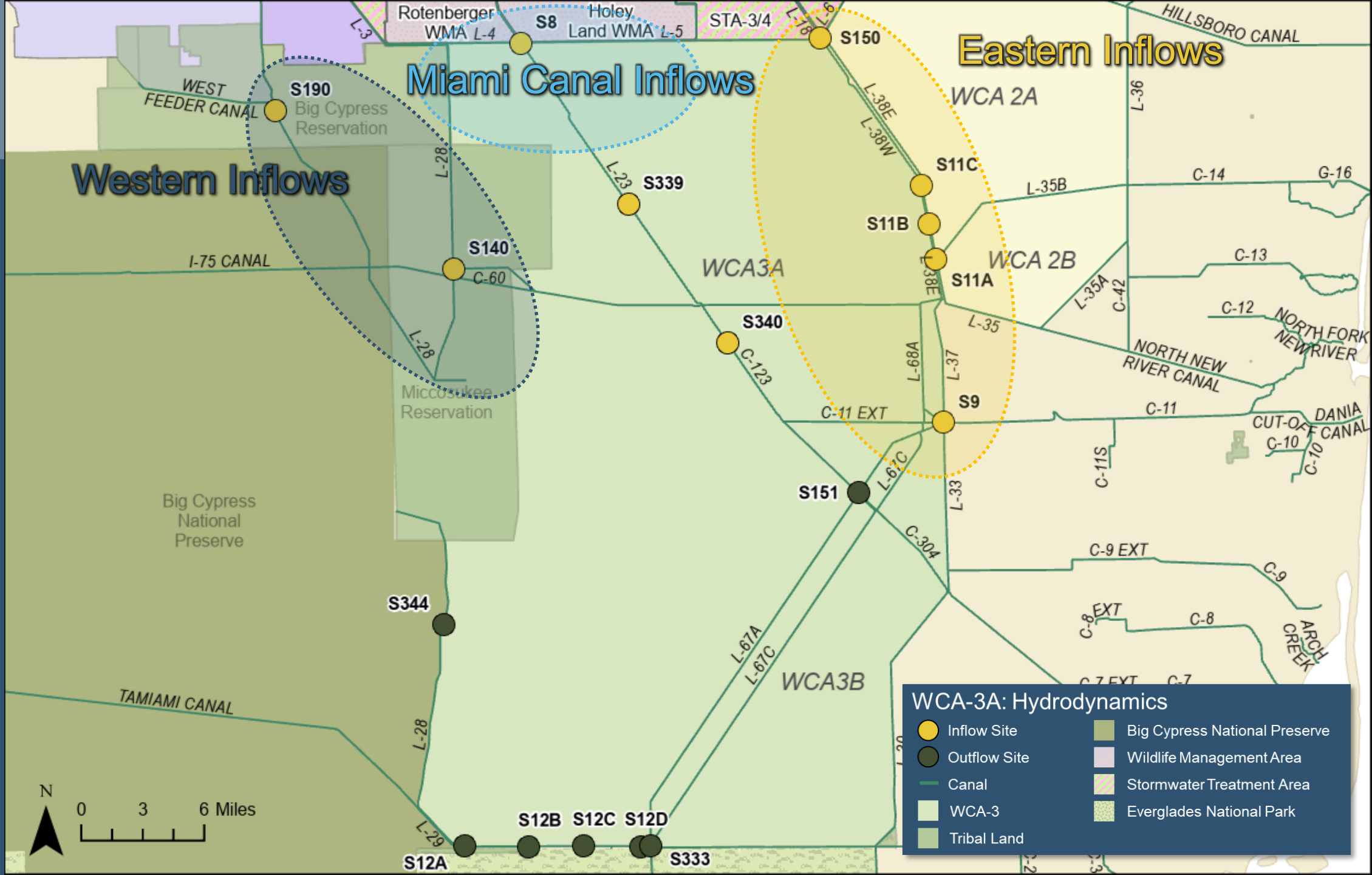
* Exceedance year; ** Provisional data; Note: WY2008 & WY2017 exceedances excused by the TOC.



7

Hydrodynamics of WCA-3

Dec. 2023 TOC



Eastern Inflows

Miami Canal Inflows

Western Inflows

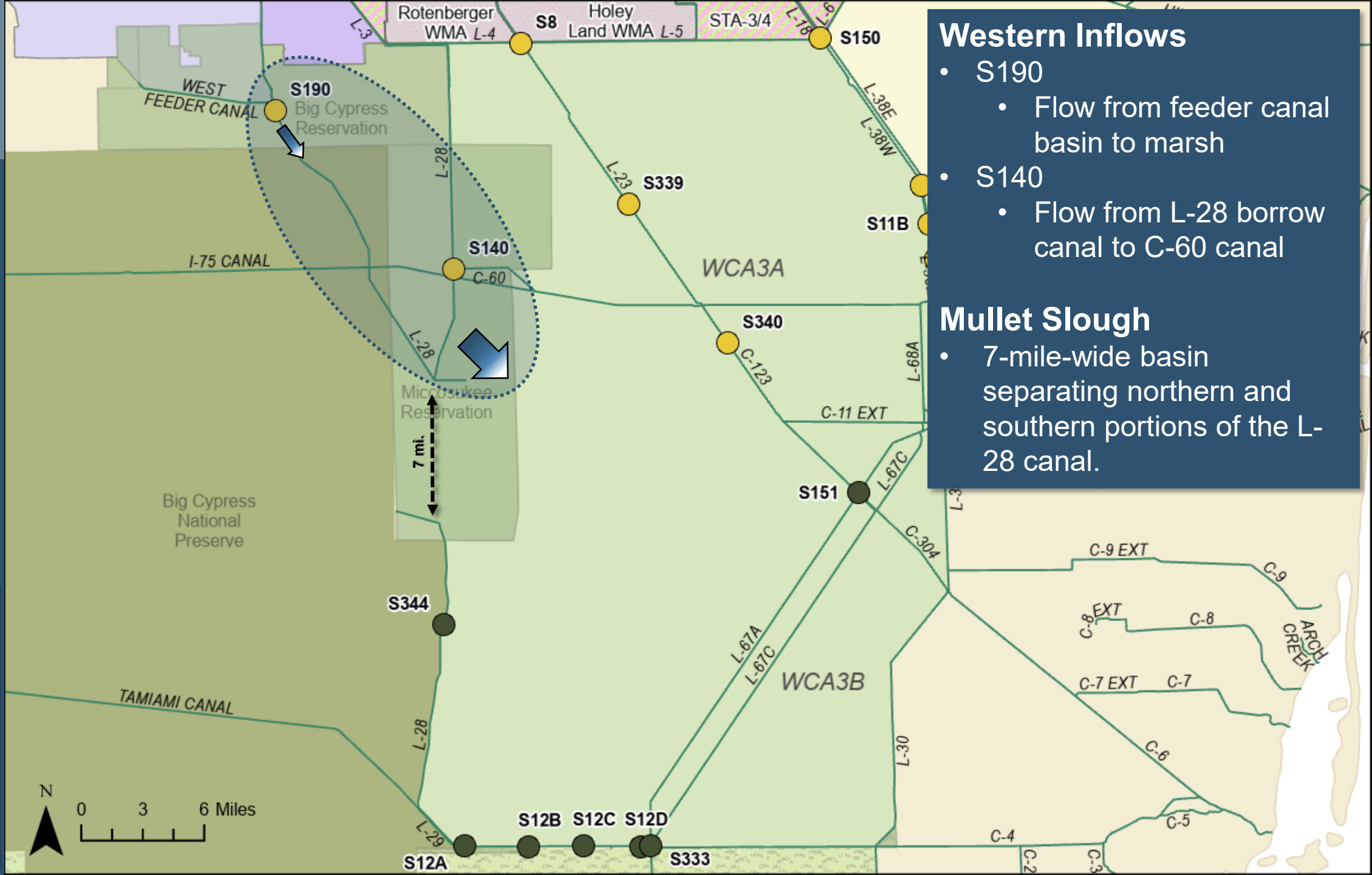
WCA-3A: Hydrodynamics

Inflow Site	Outflow Site	Big Cypress National Preserve
Canal	Wildlife Management Area	Stormwater Treatment Area
WCA-3	Everglades National Park	Tribal Land





Western Inflows



- ### Western Inflows
- S190
 - Flow from feeder canal basin to marsh
 - S140
 - Flow from L-28 borrow canal to C-60 canal
- ### Mullet Slough
- 7-mile-wide basin separating northern and southern portions of the L-28 canal.

WCA-3A

- Inflow Site
- Outflow Site
- Canal
- Flow Vector
- WCA-3
- Tribal Land
- BCNP
- WMA
- STA
- ENP





10

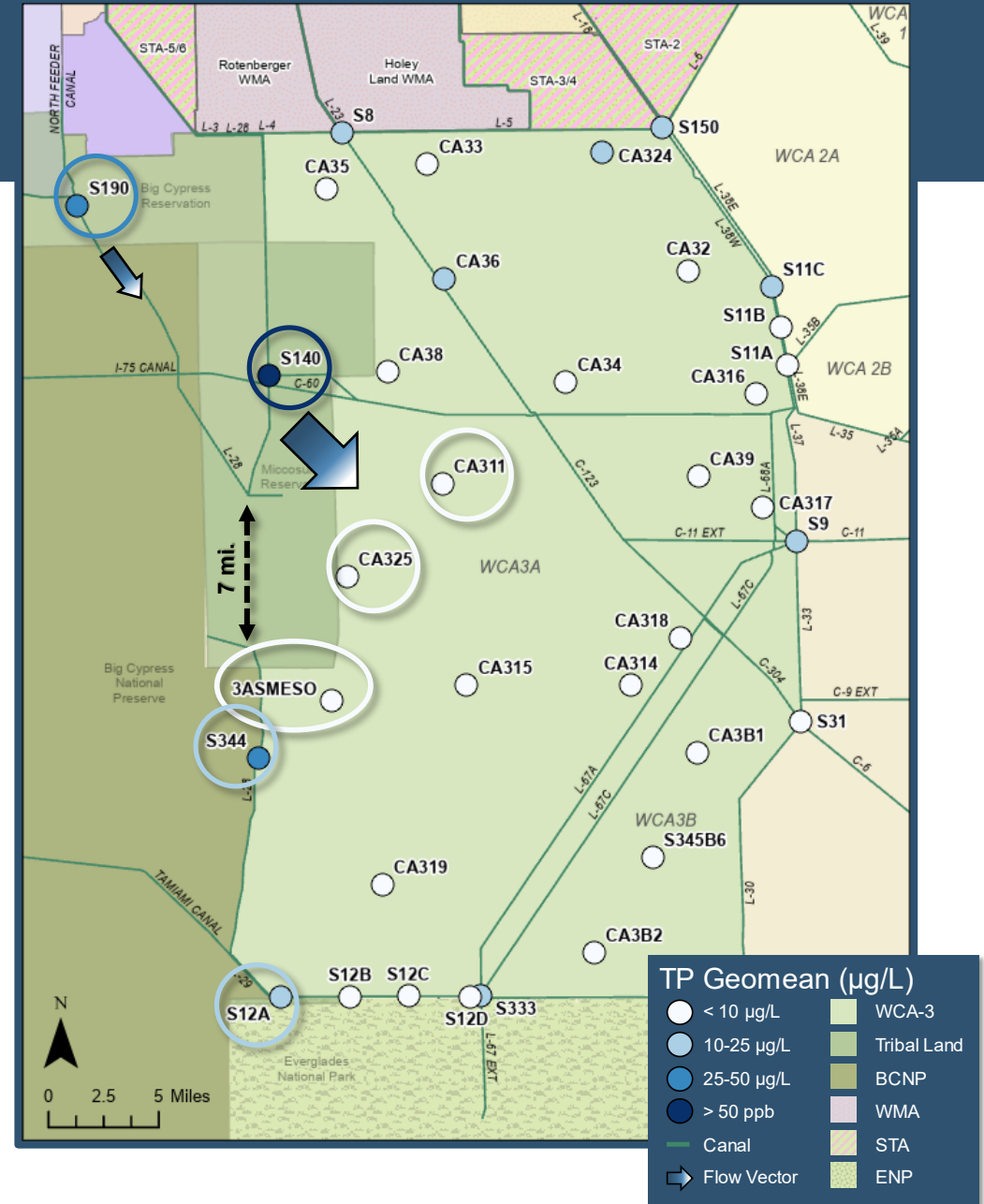
Western Inflows: Marsh Interaction

Mullet Slough

- 7-mile-wide gap within the L-28 canal.
- **S-190 and S-140**
- High-TP inflows that enter the marsh via S190 and S140 reduced after a short distance.

Station	Class	5-Yr Avg TP Conc. (µg/L)
S190	Inflow	40.0 ± 24.9
S140	Inflow	52.2 ± 21.5
CA311	Marsh	4.4 ± 1.3
CA325	Marsh	4.7 ± 1.7
3ASMESO	Marsh	4.2 ± 1.7
S344	Outflow	25.1 ± 17.2
S12A	Outflow	18.0 ± 10.2

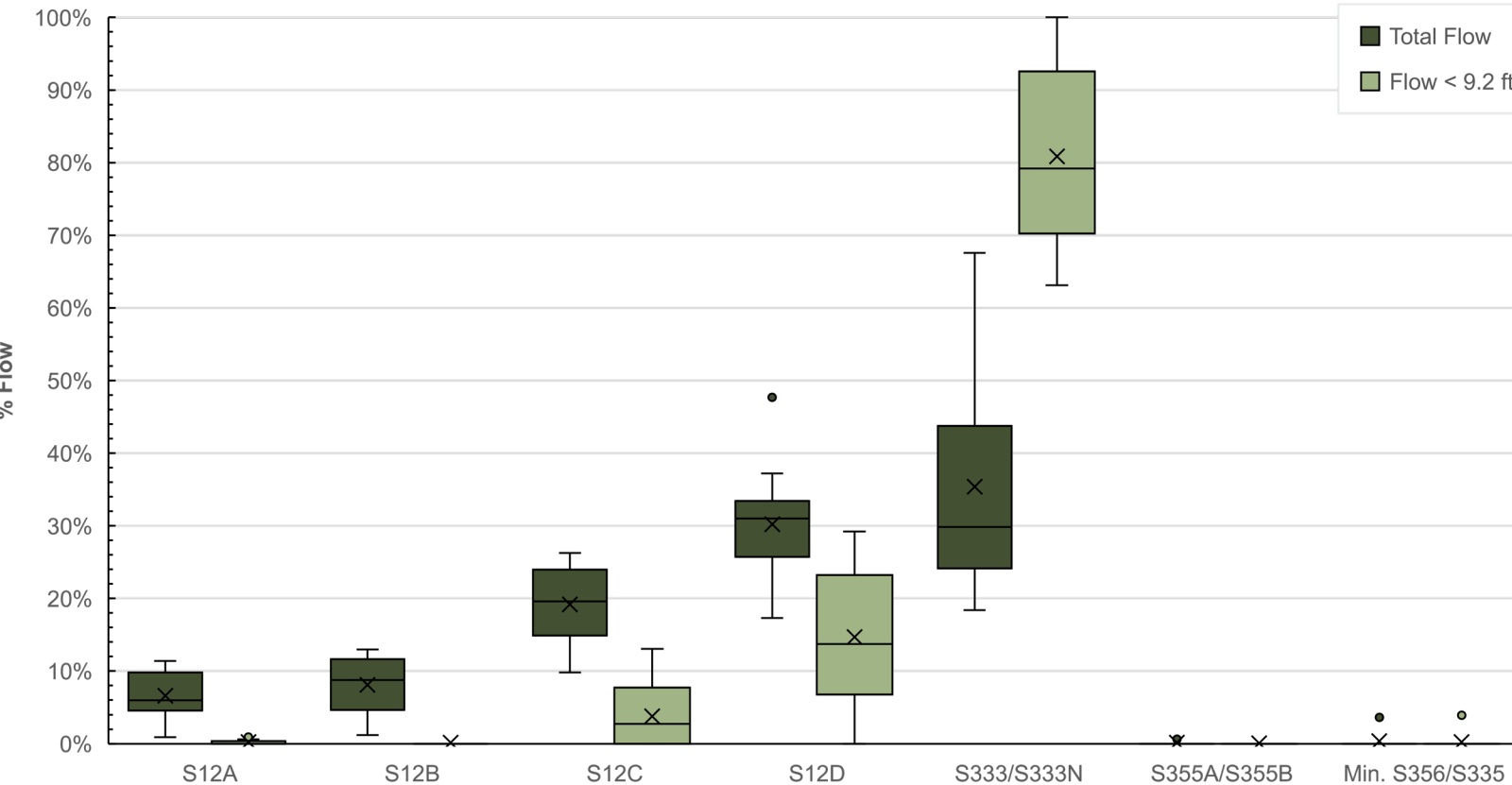
Data from WY 2019-2023





Western Inflows: S12A has Minimal Flow

Annual SRS Flow Contributions by Site (WY 2007-2023)



- S12A flows make up a small proportion of total flows to SRS.
- S12A is closed during the dry season and does not contribute flow when S333HW < 9.2 ft.
 - Vast majority of low-stage flows are through S333 & S333N

**S12A contributes a small proportion of flow to the LTL equation
When flowing, it typically has good WQ; thus any effect on compliance is de minimis**

Note: Flows from S356/S335 were only counted for years using App. A SRS Method 1.5 (WY2021-2023).

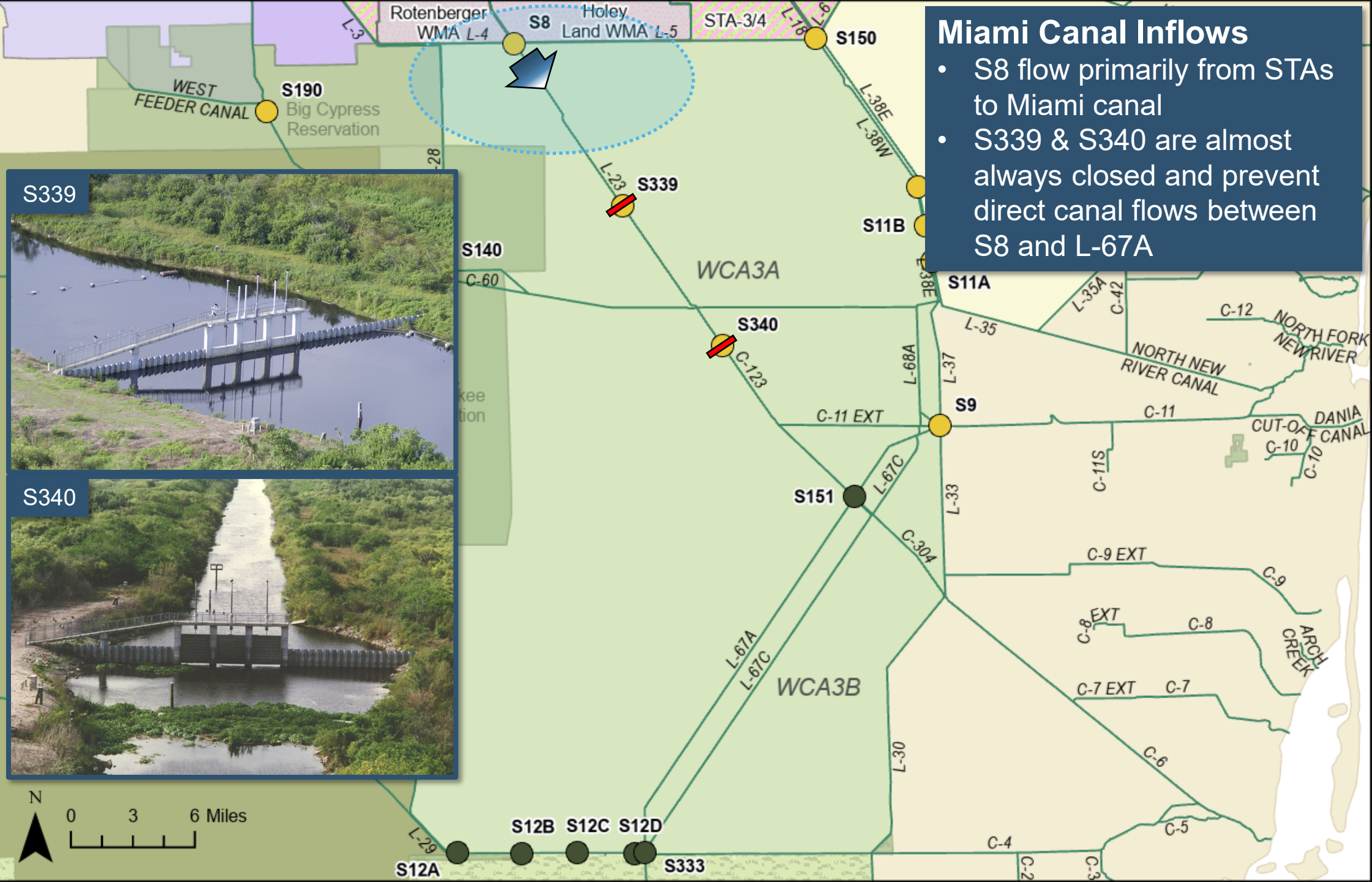


12

Miami Canal Inflows

Miami Canal Inflows

- S8 flow primarily from STAs to Miami canal
- S339 & S340 are almost always closed and prevent direct canal flows between S8 and L-67A



WCA-3A

- Inflow Site
- Outflow Site
- Canal
- ➔ Flow Vector
- Barrier to Flow
- WCA-3
- Tribal Land
- BCNP
- WMA
- STA
- ENP

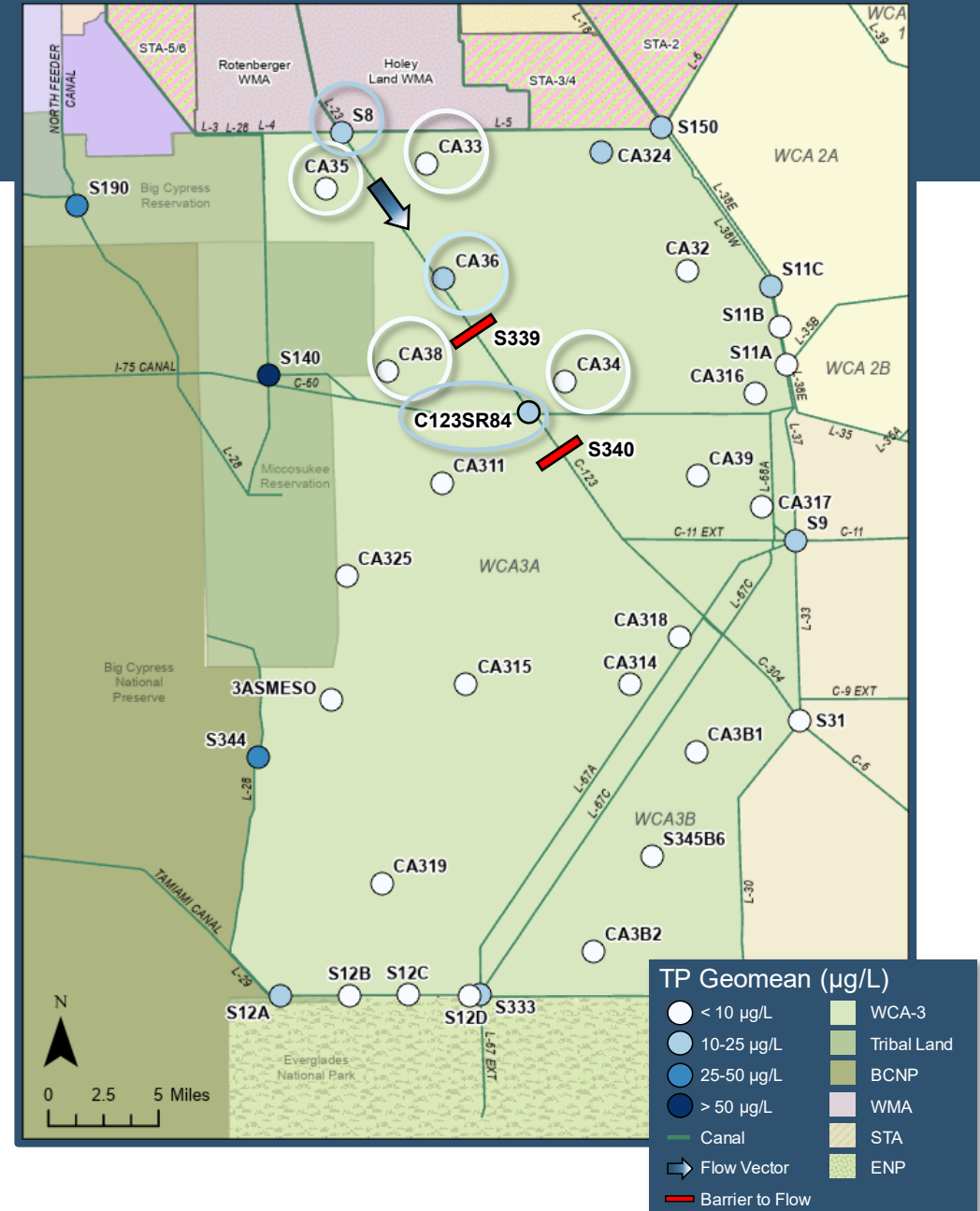


Miami Canal Inflows: Marsh Interaction

Miami Canal

- Cut nearly perpendicular to topographical contours through WCA-3A
 - High canal-marsh interaction

Station	Class	5-Yr Avg TP Conc. (µg/L)
S8	Inflow	15.1 ± 4.6
CA35	Marsh	5.7 ± 1.3
CA33	Marsh	9.2 ± 2.8
CA36	Marsh	13.2 ± 5.2
CA38	Marsh	5.0 ± 1.9
CA34	Marsh	7.3 ± 2.3
C123SR84*	Inflow	20.4 ± 7.4



Seasonally screened data from WY 2019-2023; * C123SR84 WQ surrogate for S339 & S340



14

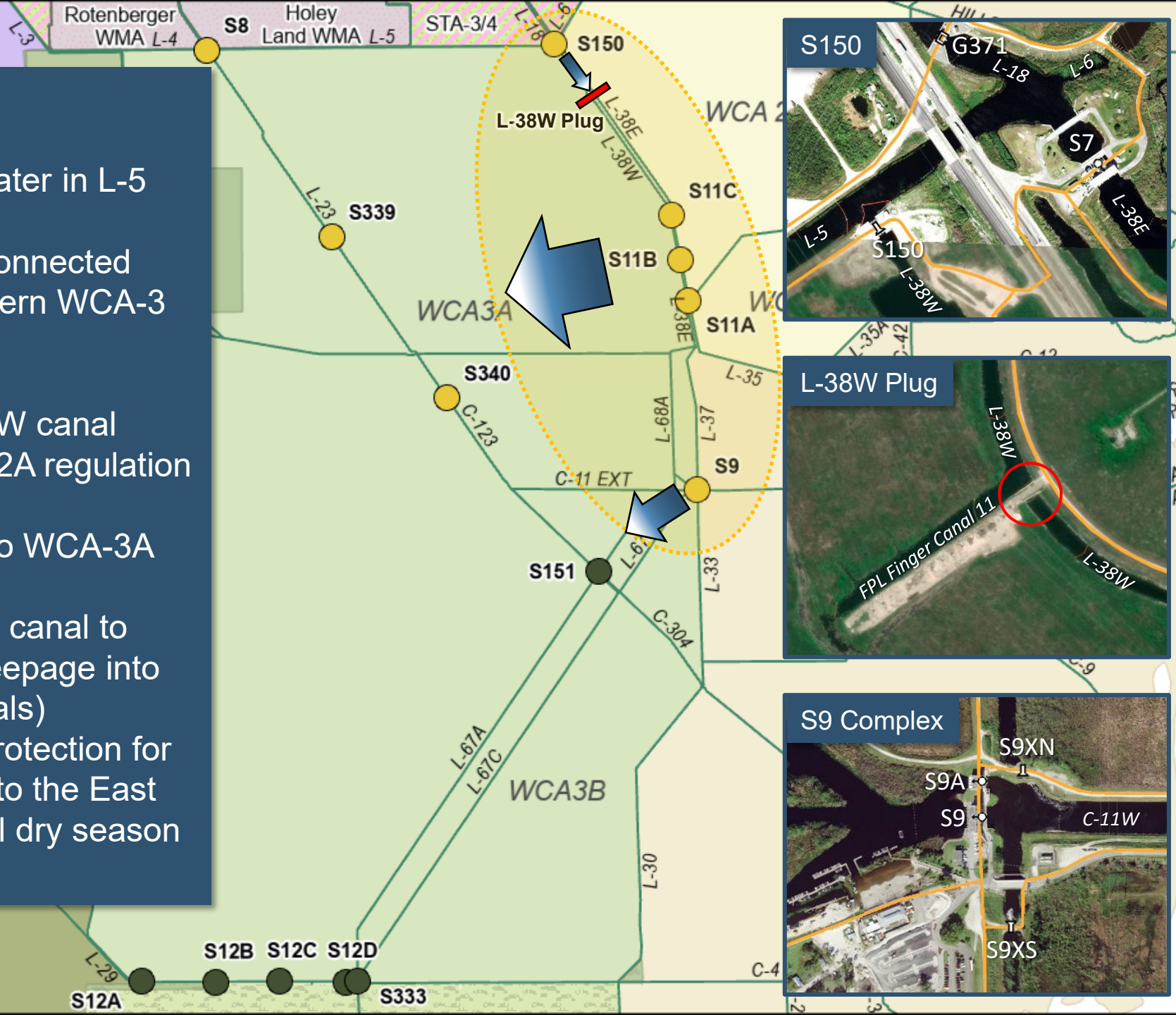
Eastern Inflows

Eastern Inflows

- S150
 - Receives STA water in L-5 canal
 - L-38W plug disconnected S150 from southern WCA-3 canals in 2020
- S11A-C
 - Located on L-38W canal
 - Maintains WCA-2A regulation schedule stage
 - Principal inflow to WCA-3A
- S9 & S9A
 - Flow from C11W canal to WCA-3A (and seepage into L-37 & L-33 canals)
 - Provides flood protection for Broward county to the East
 - Typically minimal dry season discharges

WCA-3A

- Inflow Site
- Outflow Site
- Canal
- ➔ Flow Vector
- Barrier to Flow
- WCA-3
- Tribal Land
- BCNP
- WMA
- STA
- ENP





Eastern Inflows: S9 & S9A

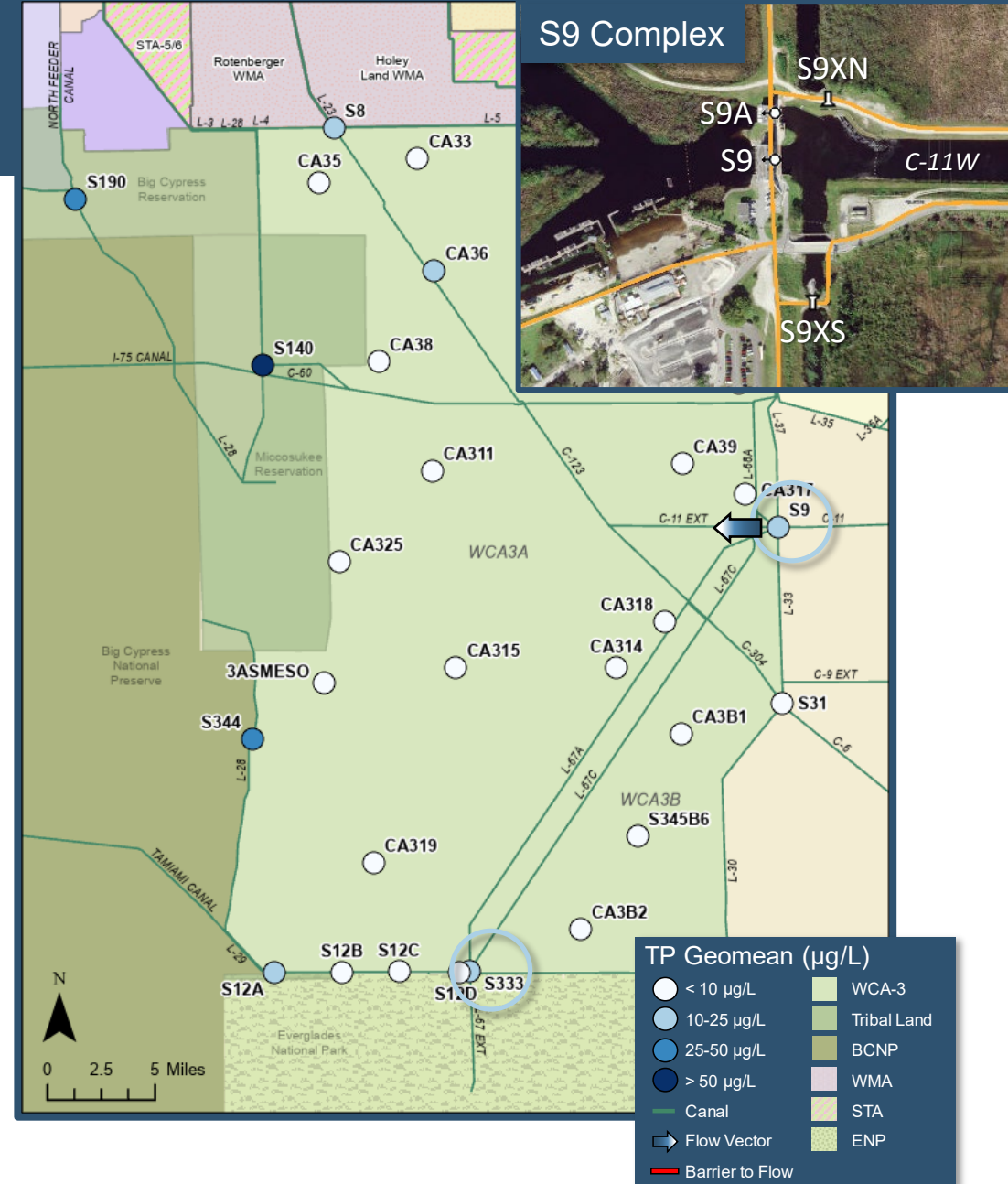
16

S9 & S9A

- Flood control pump stations
- Operations generally occur during wet periods when WCA-3A stages are elevated.
- TP concentrations slightly lower and less variable than at S333 & S333N.

Station	Class	5-Yr Avg TP Conc. (µg/L)
S9	Inflow	12.5 ± 4.0
S9A	Inflow	13.0 ± 4.8
S333	Outflow	14.0 ± 6.4
S333N	Outflow	15.3 ± 7.7

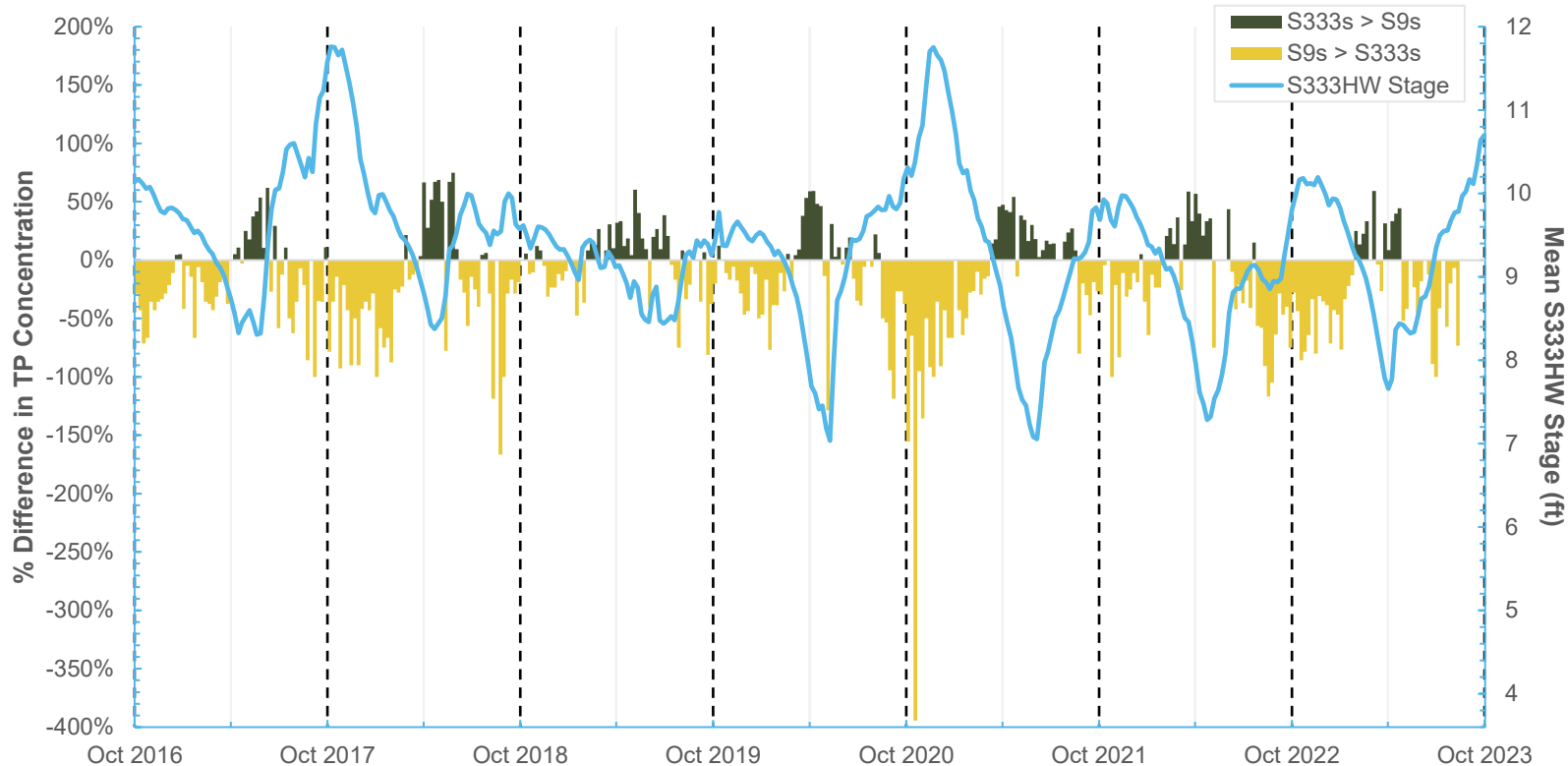
Seasonally screened data from WY 2019-2023





TP Concentrations at S333s & S9s

Difference in Weekly S333s & S9s Mean TP Concentrations with Weekly Mean S333HW Stage



TP Grab Concentrations by Stage

- Above 9.2 ft, S333s TP grabs are on average 36% lower than S9s TP grabs.
- Below 9.2 ft, S333s TP grabs are on average 9% higher than S9s TP grabs.

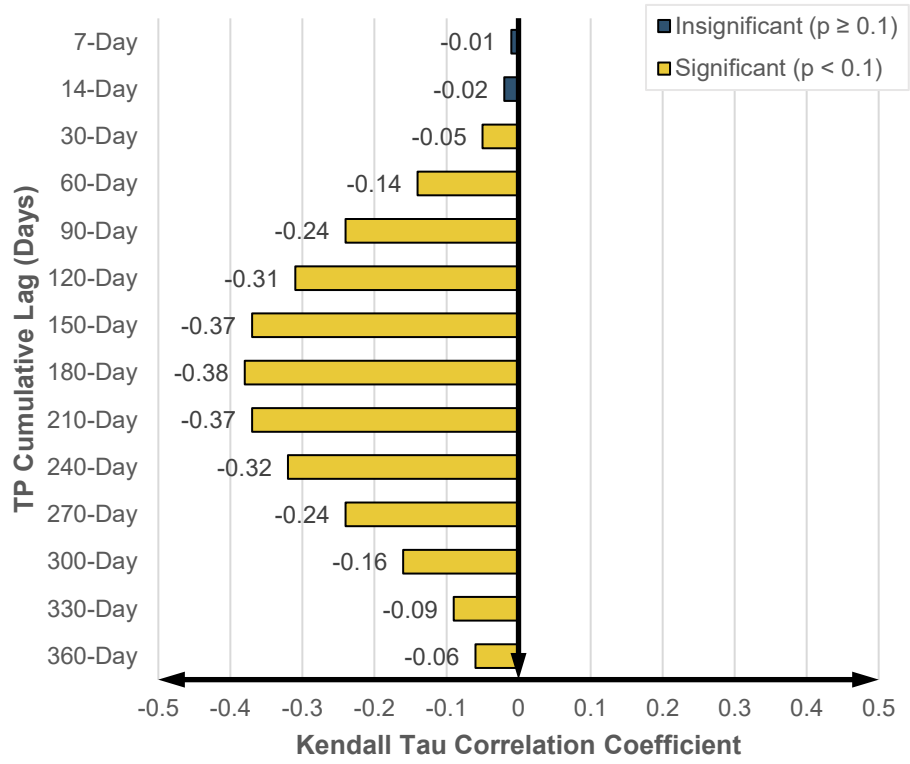
TP concentrations at S333s tend to be higher than at S9s when stage is low (the critical period) – when stage is high, concentrations at S9s tend to be higher than at S333s



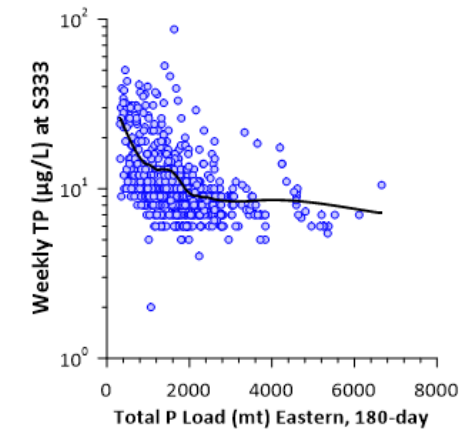
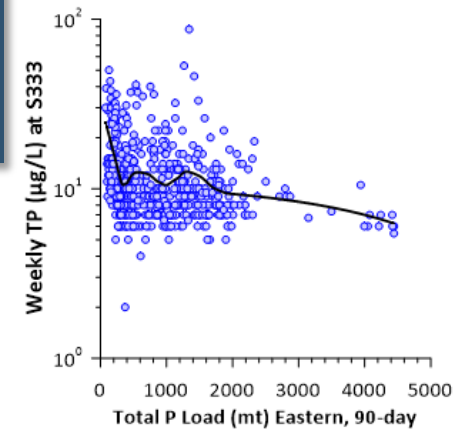
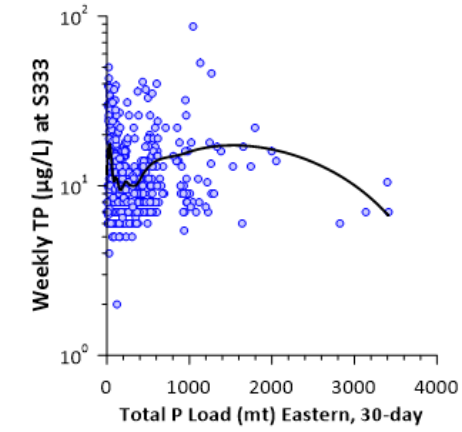
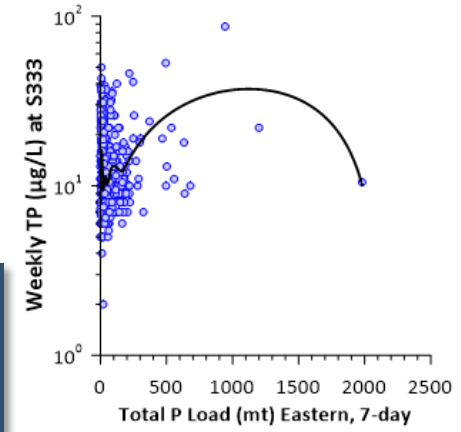
Inverse Correlation between S9 TP Load & S333 FWMC

18

S9 Cumulative TP Load vs. S333 TP FWMC Correlation



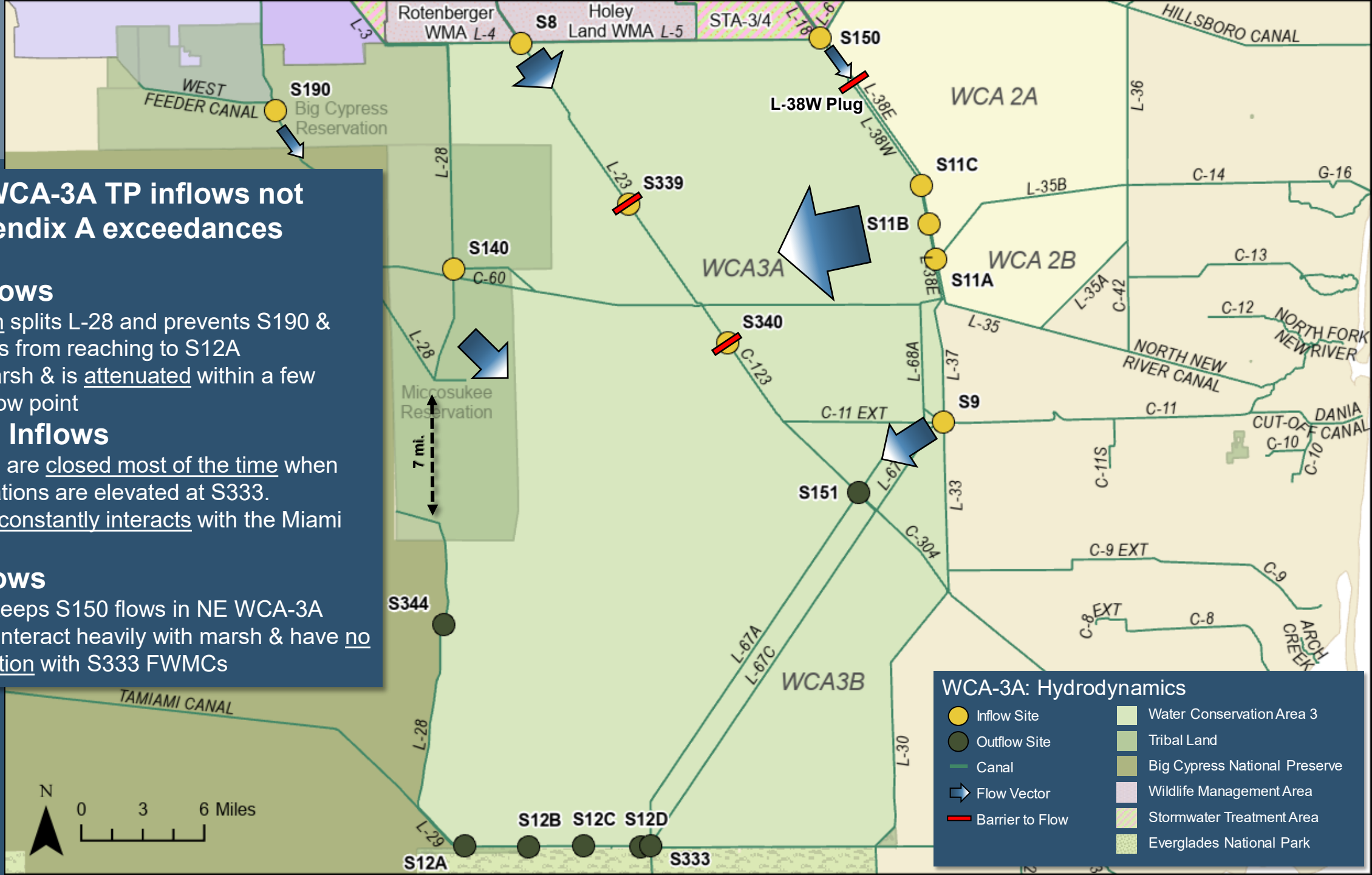
S9 Complex
 Negative Kendall τ indicates S333 TP FWMCs are lower when S9 cumulative loads are greater



No positive correlation between S9 cumulative TP loads and S333 TP FWMC concentrations could be established, regardless of any lag time



19



Summary: WCA-3A TP inflows not driving Appendix A exceedances

Western Inflows

- Mullet Slough splits L-28 and prevents S190 & S140 outflows from reaching to S12A
- TP enters marsh & is attenuated within a few miles of outflow point

Miami Canal Inflows

- S339 & S340 are closed most of the time when TP concentrations are elevated at S333.
- Marsh water constantly interacts with the Miami Canal.

Eastern Inflows

- L-38W plug keeps S150 flows in NE WCA-3A
- S9 TP loads interact heavily with marsh & have no direct correlation with S333 FWMCs

WCA-3A: Hydrodynamics

Inflow Site	Water Conservation Area 3
Outflow Site	Tribal Land
Canal	Big Cypress National Preserve
Flow Vector	Wildlife Management Area
Barrier to Flow	Stormwater Treatment Area
	Everglades National Park



20

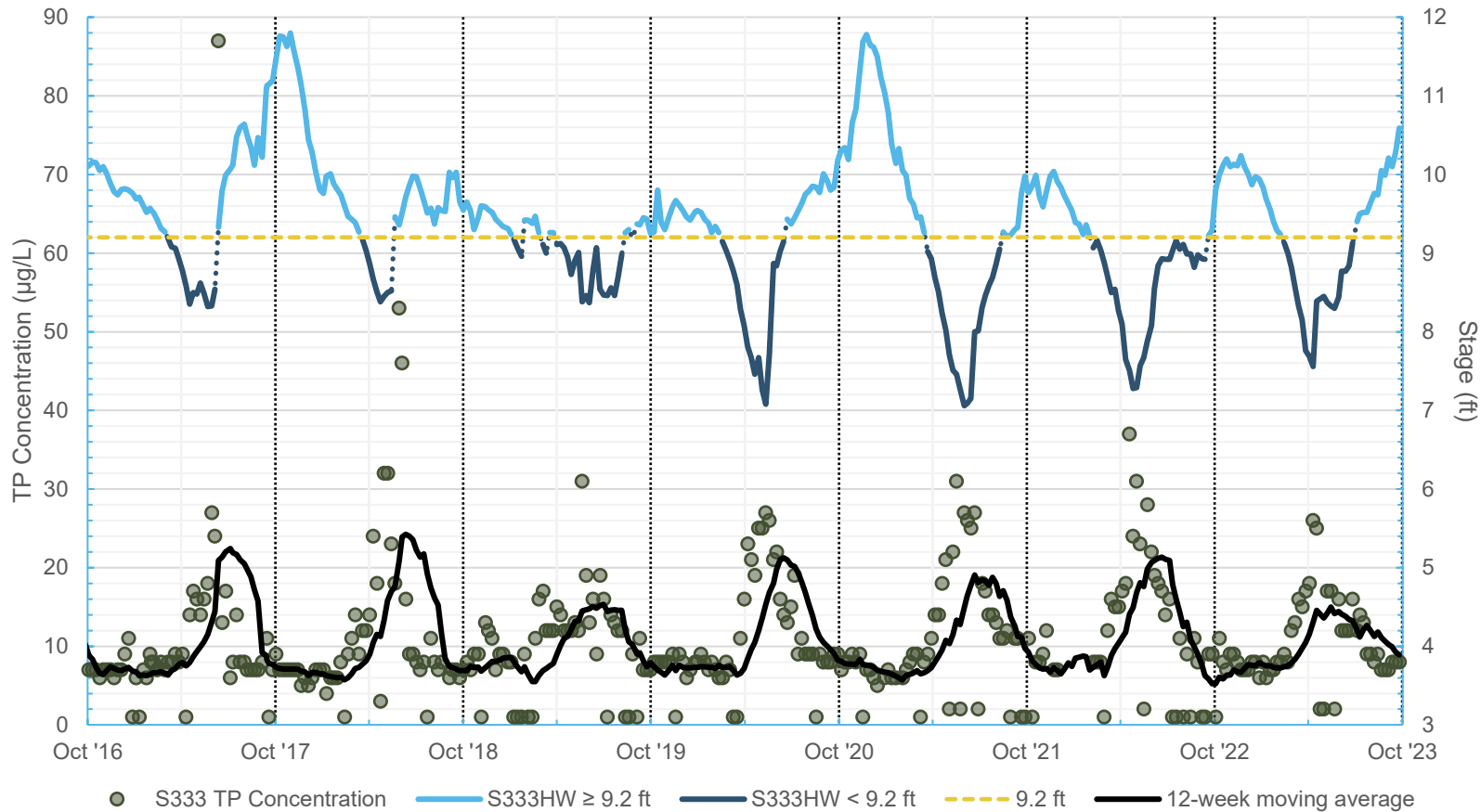
Local Drivers

Dec. 2023 TOC



21

High S333 TP Concentration Correlates to Low S333HW Stage



S333 TP Concentration-Stage Correlation (WY2007-2023)

Stage	Kendall's τ	p-value	Sen's slope ($\mu\text{g/L/ft}$)
≥ 9.2 ft	-0.21	< 0.001	-1.3
< 9.2 ft	-0.36	< 0.001	-7.6

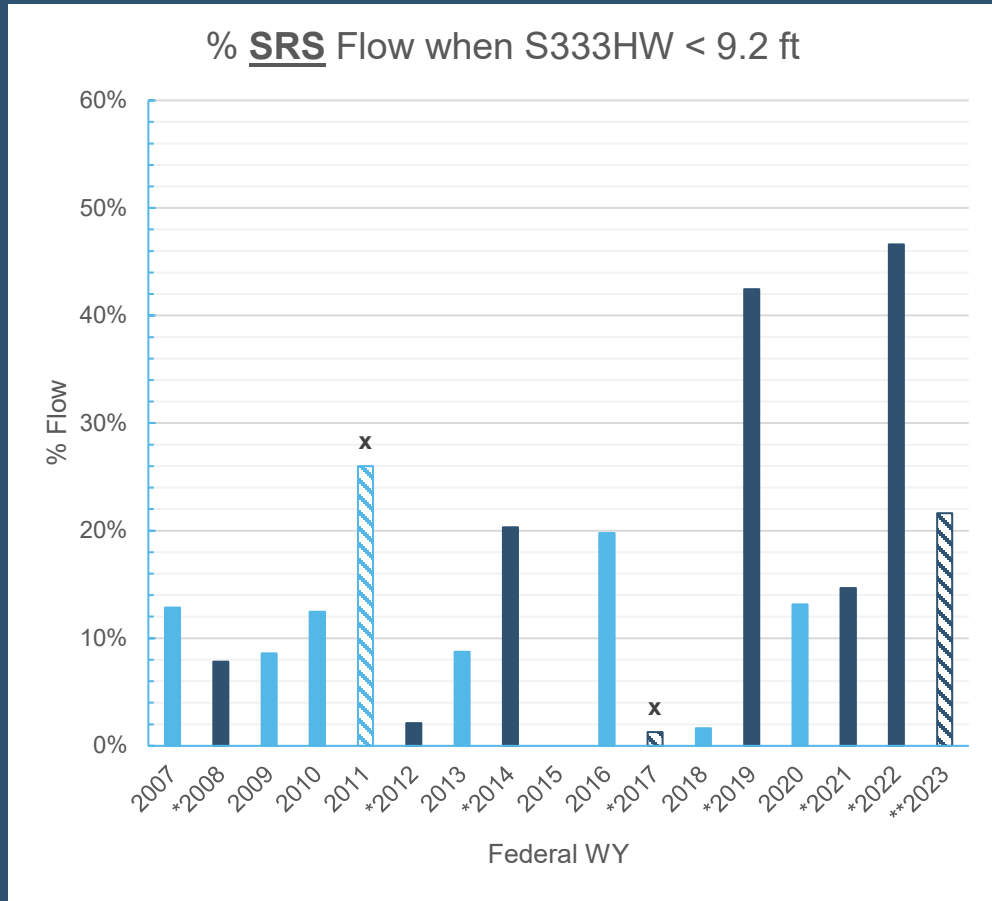
- Above 9.2 ft, TP concentration increases by 1.3 $\mu\text{g/L}$ for each foot of recession.
- Below 9.2 ft, TP concentration increases by 7.6 $\mu\text{g/L}$ for each foot of recession.

The rate of TP concentration increase compounds six-fold under 9.2 ft

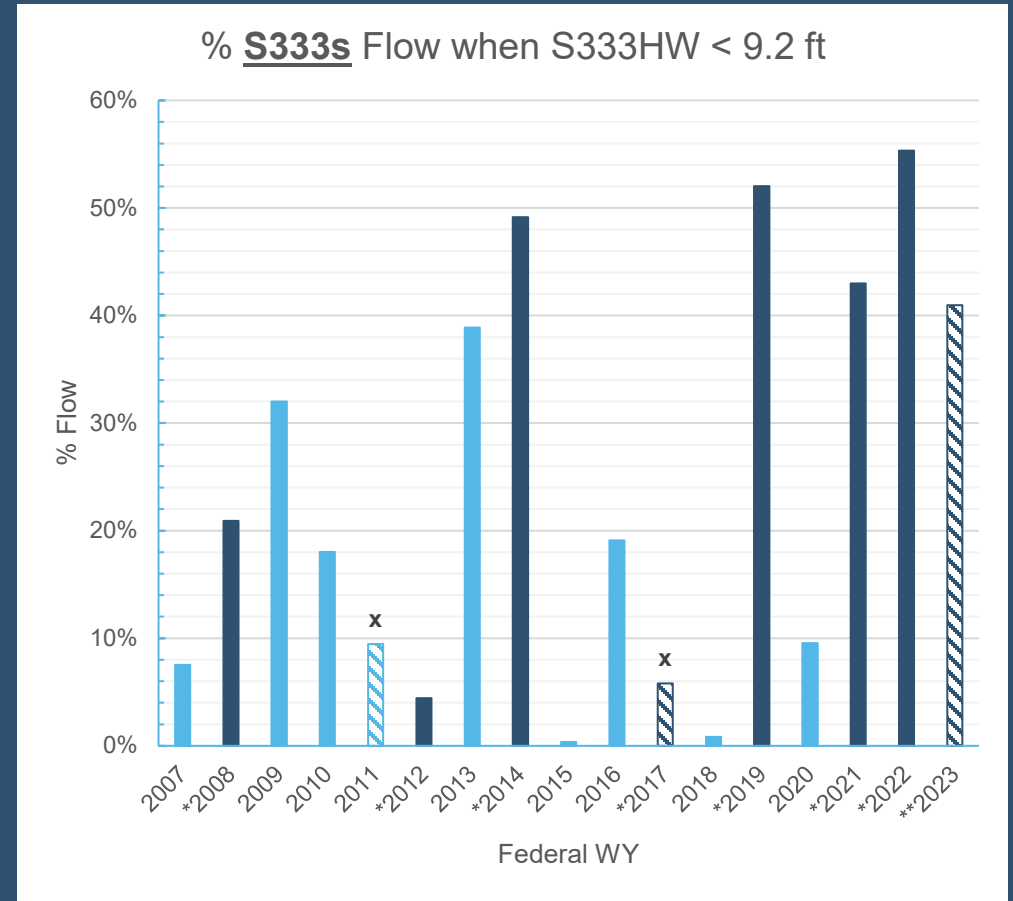
Note: Weekly TP grab data taken from SFWMD SRS TP spreadsheet (Updated 9/30/2023); WY2023 data is provisional; Kendall's tau and Sen's slope calculated in R.



Exceedance Years Appear to Have Higher Proportion of Flows when S333HW < 9.2 ft.



* Exceedance year; ** Provisional data; x – Exceptional circumstances (2011 – S333 flows routed around SRS; 2017 – drought year)



Note: S333s = S333 + S333N – S334



23

Conclusions

Dec. 2023 TOC



Water Quality Analysis – Conclusions

History of Recent Exceedances

- LTL has trended down, SRS FWMC has no trend
- Frequency & magnitude of exceedances have significantly increased
- More water is being delivered, especially during dry conditions

Hydrodynamics of WCA-3A

- Marsh data shows S190, S140, S150, & S11A-C TP loads do not reach SRS outflows
- Miami Canal water entering L-67A has been highly influenced by marsh interaction
- S9 TP loads can't be correlated with S333 TP FWMCs – marsh interaction along L-67A affects TP concentrations

Local Drivers

- TP concentrations rise at an increasing rate when S333HW stage recedes at a constant rate
- Higher annual proportions of low-stage SRS deliveries are strongly associated with exceedance years



Future Influences on WCA-3A Hydrodynamics

Central Everglades Planning Project (CEPP)

- **CEPP North**
 - Removal of L-4 & Miami canal sections will promote hydration in NW WCA-3A
- **CEPP South**
 - Blue Shanty Levee will be constructed in WCA-3B to create a new flow-way from the L-67A into NE SRS
 - L-67C, L-67 Ext., & L-29 will be partially or wholly backfilled to remove barriers to flow

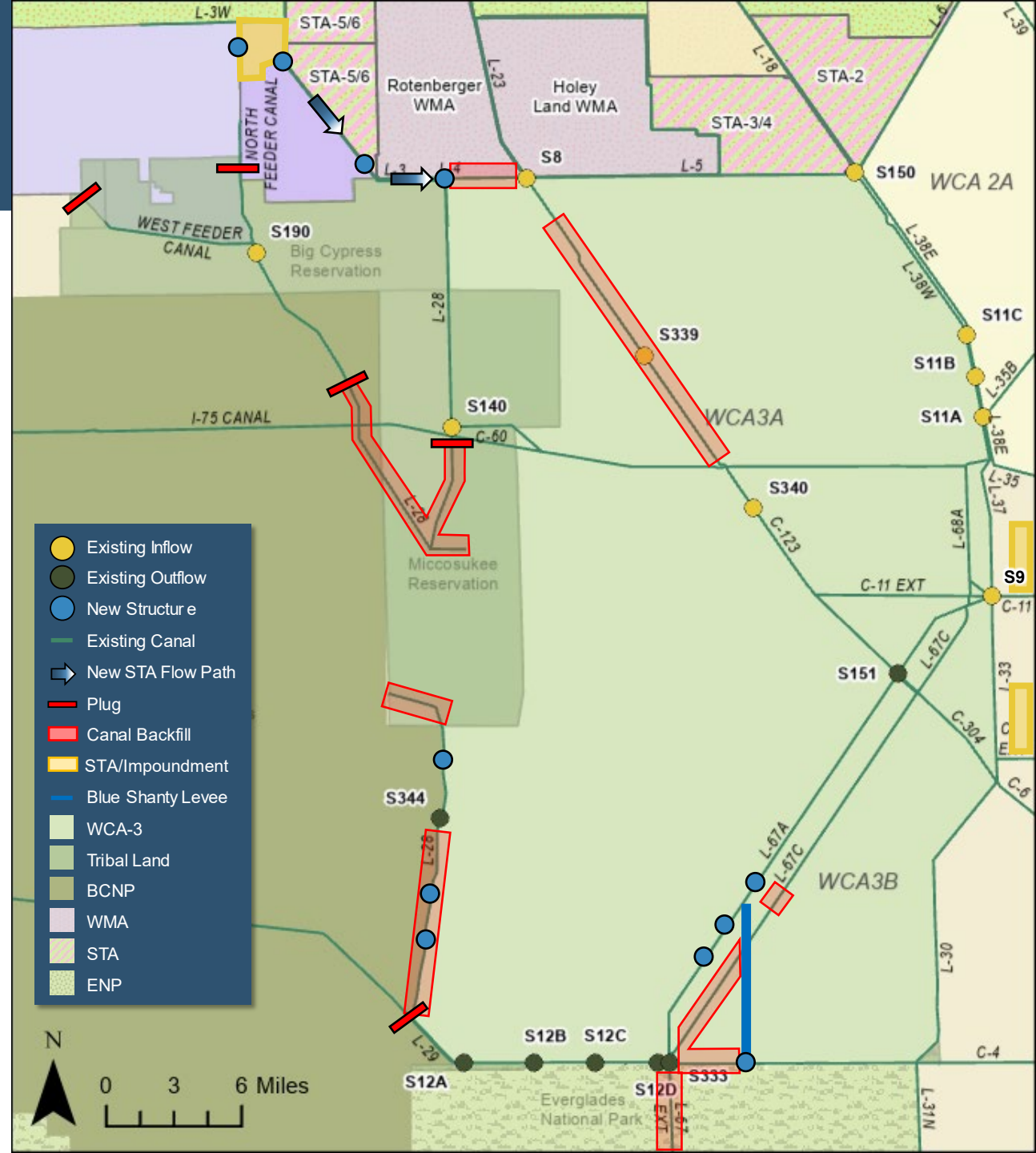
Western Everglades Planning Project (WERP)

Note: Scheduled for WRDA 2024 authorization

- **L-28 Canal Backfill/Levee Degrade**
 - Removal & plugging of L-28N, L-28 Int., L-28 Tieback, & L-28S canal sections will separate S190 from WCA-3A & restore hydrology
- **North Feeder STA**
 - New water treatment in feeder canal basin will improve Western WCA-3A inflow WQ from L-3 canal

Broward County Water Preserve Areas (BCWPA)

- Impoundments to capture untreated runoff from the C-11 and C-9 basins instead of discharging directly into WCA 3A







Terminology

SRS: Shark River Slough

WCA: Water Conservation Area

LTL: Long-Term Limit for Total Phosphorus

FWMC, FWM: Flow-Weighted Mean [Concentration]

TPC, TP: Total Phosphorus [Concentration]

µg/L: Micrograms per liter – equivalent to parts per billion (ppb)

S333HW: S333 Headwater Stage Elevation

FWY: Federal Water Year (Oct 1 – Sep 30)

COP: Combined Operations Plan

Low-Stage: S333HW < 9.2 ft