



Northern Everglades
River Watershed Research & Water
Quality Monitoring Program
St. Lucie River Watershed

April 2008



IRL Water Quality Targets

Biological Science

WATER QUALITY TARGET DEVELOPMENT IN THE
SOUTHERN INDIAN RIVER LAGOON

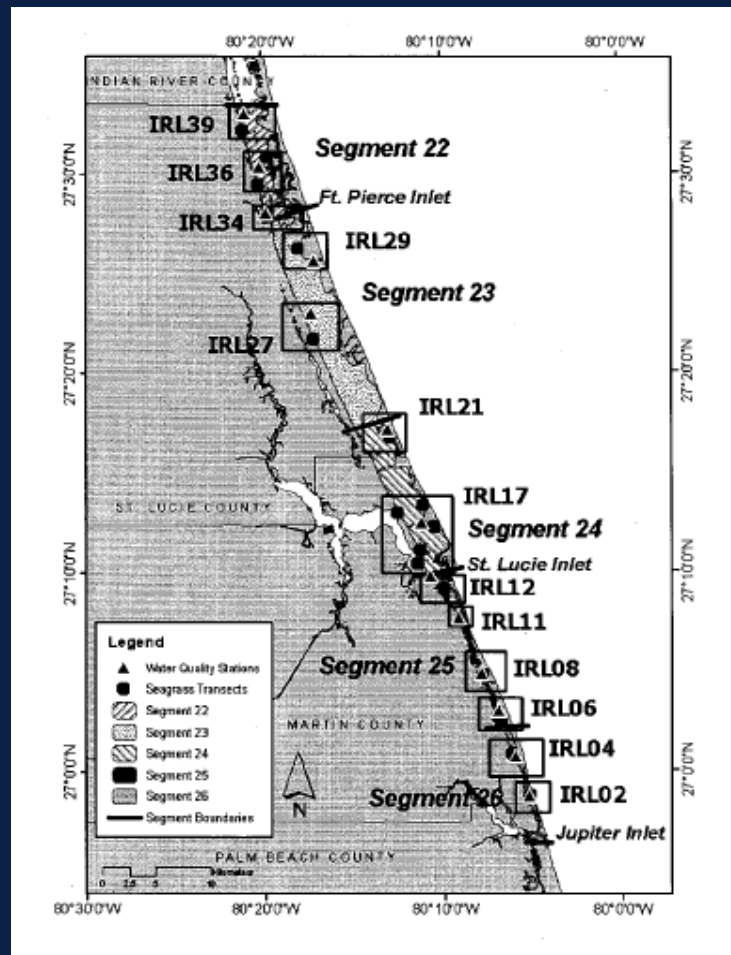
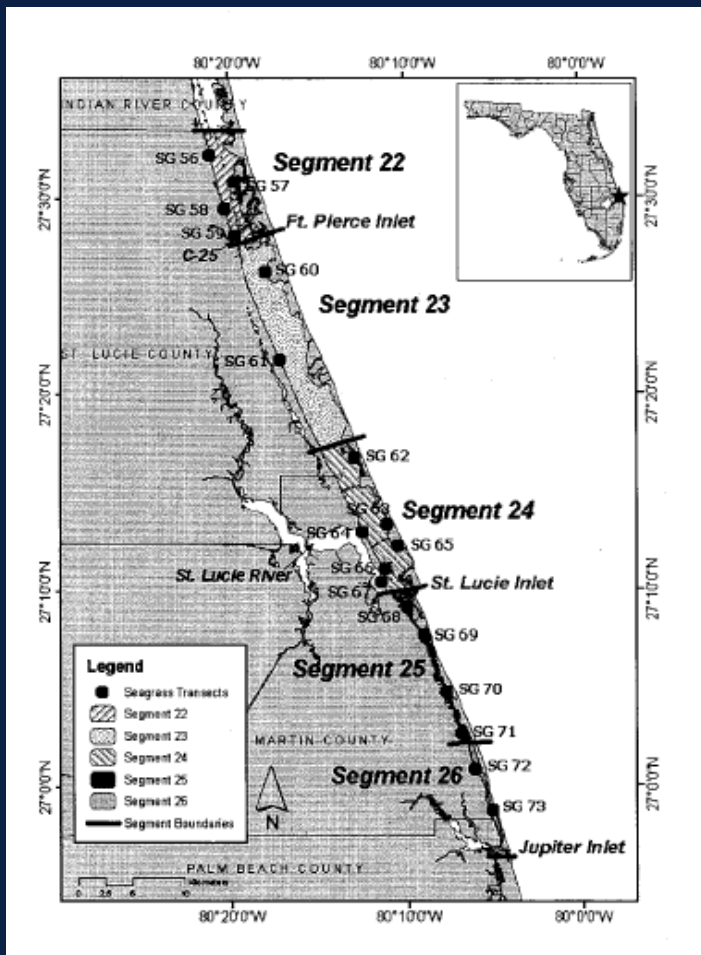
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- **Published 2007 in *Florida Scientist***
- **Targets based on water quality associated with “good” Seagrass beds**
- **“Good” seagrass beds were those with a deep edge of bed depth >1.3 m.**
- **Period or Record: 1994 – 1999**
- **TN Target= 0.7 mg/l, TP target= 53 µg/l**



Seagrass Transects and Water Quality Stations





Structure of Data

IRL Segment	Seagrass Transect	Water Quality Station
26	SG73	IRL02
	SG72	IRL04
25	SG71	IRL06
	SG70	IRL08, IRL08B
	SG69	IRL11, IRL11B
	SG68	IRL12, IRL12B
24	SG67	IRL17
	SG66	IRL17
	SG65	IRL17
	SG64	IRL17
	SG63	IRL17
	SG62	IRL21
23	SG61	IRL27
	SG60	IRL29
22	SG59	IRL34, IRL34B
	SG58	IRL36
	SG57	IRL36
	SG56	IRL39

- **5 Segments in the IRL South**
- **18 Seagrass Transects**
- **12 Water Quality Stations**
- **Several Transects Sometimes Associated with one Water Quality Station**



IRL Water Quality Targets

- **Significant relationship between the light extinction coefficient and edge of bed depth**
- **Link between nutrients and edge of bed depth not strong**

Crean et al. --- Water Quality Targets

Table 1. Correlations between water quality parameters and seagrass edge of bed depth (Spearman's Rank Correlation; * significant relationships).

Parameter	n	rs	95% CI	2-tailed p statistic
Color (PCU) *	102	-0.30	-0.47 to -0.12	0.0019
Volatile Suspended Solids (mg/l)	102	-0.01	-0.20 to 0.19	0.9463
Turbidity (NTU) *	102	-0.33	-0.50 to -0.15	0.0006
Total Suspended Solids (mg/l)	102	-0.03	-0.22 to 0.17	0.7663
Total Phosphorus (mg/l)	69	-0.08	-0.31 to 0.16	0.5364
Orthophosphate (mg/l)	69	-0.07	-0.30 to 0.17	0.5732
Total Kjeldahl Nitrogen (mg/l)	79	0.04	-0.18 to 0.26	0.7295
Total Nitrogen (mg/l)	84	0.09	-0.13 to 0.30	0.4063
Nitrate + Nitrite (mg/l)	102	-0.11	-0.30 to 0.08	0.2538
Nitrite (mg/l)	84	0.12	-0.10 to 0.33	0.2695
Chlorophyll <i>a</i> (mg/m ³)	97	-0.16	-0.35 to 0.04	0.1251
Secchi Disk (m)	75	0.21	-0.02 to 0.42	0.0680
Salinity (ppt) *	93	0.30	0.10 to 0.47	0.0038
Dissolved Oxygen (mg/l)	94	0.15	-0.05 to 0.35	0.1393
pH units *	93	0.23	0.03 to 0.42	0.0255
K_{par} *	78	-0.32	-0.50 to -0.10	0.0046



IRL Water Quality Targets

- **Potential Use of IRL Targets**
 - **Targets re-evaluated to explore link with nutrients using POR of 1994 - 2007**



Correlations with Deep edge of Bed Depth (1994-2007)

- **Kpar and Deep Edge of Bed Depth have positive signs**
- **Nutrients: Significant correlations with Total Phosphorus but not Nitrogen.**
- **AS color, turbidity and chlorophyll a increase deep edge of bed becomes shallower**

Parameter	rs	p-value	n
Kpar	-0.426	< 0.001	128
Color	-0.329	< 0.001	223
Turbidity	-0.393	< 0.001	223
Chlorophyll a	-0.167	< 0.014	218
Total Nitrogen	-0.059	0.397	205
Total Phosphorus	-0.308	< 0.001	190



Correlations with Light Extinction Coefficient (1994-2007)

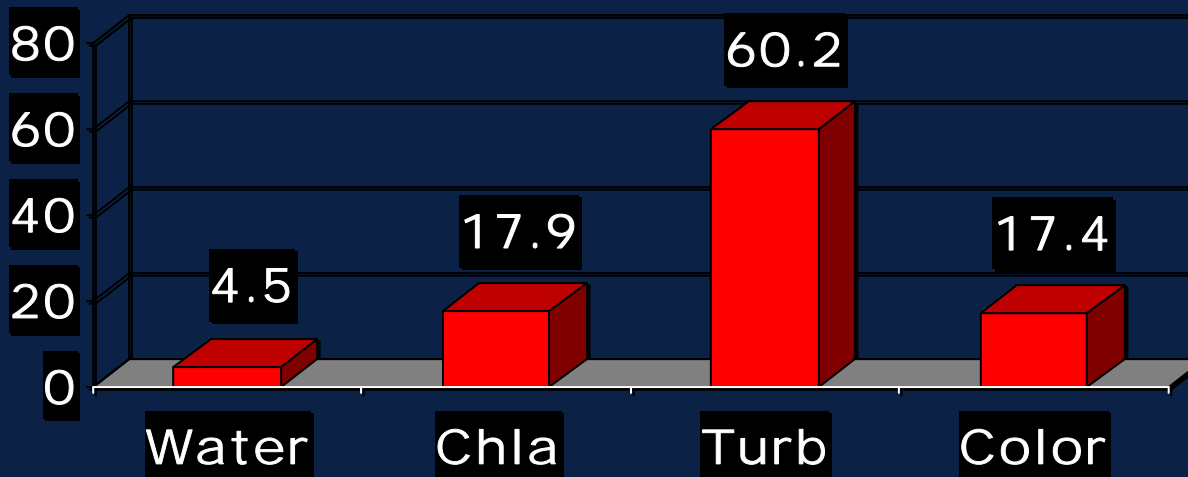
- **Kpar:** As chlorophyll a, color and turbidity increase Kpar increases.
- **Nutrients:** As nutrient concentrations increase Kpar increases.

Parameter	rs	p-value	n
Color	0.475	< 0.001	271
Turbidity	0.534	< 0.001	269
Chlorophyll a	0.347	< 0.001	268
Total Nitrogen	0.164	<0.008	263
Total Phosphorus	0.443	< 0.001	260



Optical Model: Light Attenuation (all segments)

% Contribution to Predicted Kpar

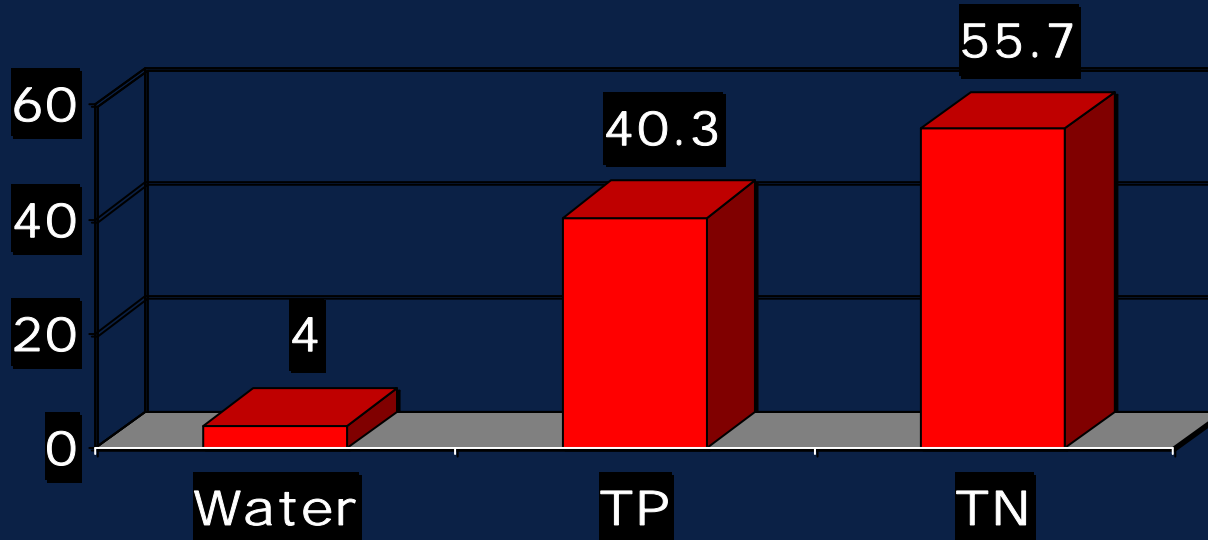


$$\text{KPAR} = 0.037 \cdot \text{Chla ug/l} + 0.011 \cdot \text{Color pcu} + 0.155 \cdot \text{Turb ntu} + 0.0384$$
$$R^2 = 0.734 \quad p < 0.0001$$



Optical Model: Light Attenuation

% Contribution to Predicted Kpar



$$\text{KPAR} = 7.07 \cdot \text{TP mg/l} + 1.51 \cdot \text{TN mg/l} + 0.0384$$

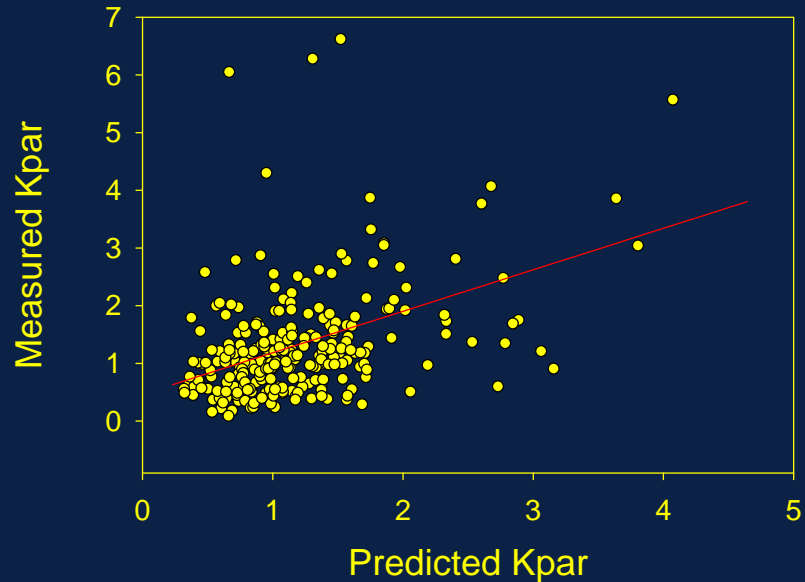
$$R^2 = 0.704 \quad p < 0.0001$$



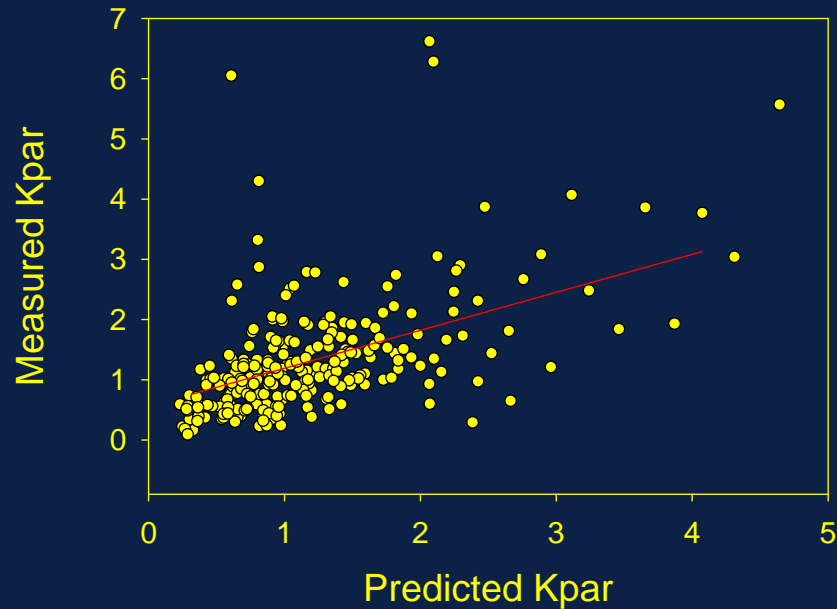
Modeled Kpar



Light Extinction: Color, Turbidity, CHLa



Light Extinction: Total N and P





Correlations between Nutrients and Chlorophyll a

	Segments	N	Spearman's r	p
Chla vs TN	22,23,24,25,26	263	0.33	<0.01
Chla vs TP	22,23,24,25,26	260	0.49	<0.01
TP vs TN	22,23,24,25,26	260	0.45	<0.01
Chla vs TN	24,25	123	0.35	<0.01
Chla vs TP	24,25	121	0.34	<0.01
TP vs TN	24,25	121	0.52	<0.01



Water Quality Targets Revisited- (1994 - 2007)

- wet season water quality associated with transects having an average EOB depth of ≥ 1.3 m.**

Parameter	Median	75 th Percentile
Kpar	-0.90	-0.5
Chlorophyll a ug/l	4.0	6.3
Turbidity NTU	3.2	5.2
Color PCU	9.0	20
TN mg/l	0.68	0.92
TP ug/l	49	82
Secchi Disk m	1.1	1.4



Water Quality Targets Revisited- Segments 24-25 (1994-2007)

- **N=20 dates when edge of bed \geq 1.3 m**

Parameter	Median	75 th Percentile
Kpar	-0.74	-0.43
Chlorophyll a ug/l	4.4	7.7
Turbidity NTU	3.9	4.5
Color PCU	9.0	16
TN mg/l	0.66	0.84
TP ug/l	55	67
Secchi Disk m	1.3	\geq 1.4



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April 2008



Estuarine Protection Plan Goals

- **Pollutant load reductions based upon adopted total maximum daily loads**
- **Salinity envelopes and freshwater inflow targets based on existing research and documentation**
- **Reduce the frequency and duration of undesirable salinity ranges while meeting other water –related needs in the region.**



Adaptive Management

- Every 3 years, the District and cooperating agencies will conduct an evaluation of any pollutant load reduction goals, as well as any other specific objectives and goals as stated in the River Watershed Protection Plans.



Research and Water Quality Monitoring Plan Objectives

- **Build upon the South Florida Water Management District's existing research program.**
- **Shall be sufficient to carry out, comply with or assess the plans, programs and other responsibilities (implementation, evaluation and prioritization) created by the legislation.**
- **Provide for an assessment of the water volumes and timing from Lake Okeechobee and the watersheds and their relative contributions to the timing and volume of water delivered to each estuary.**

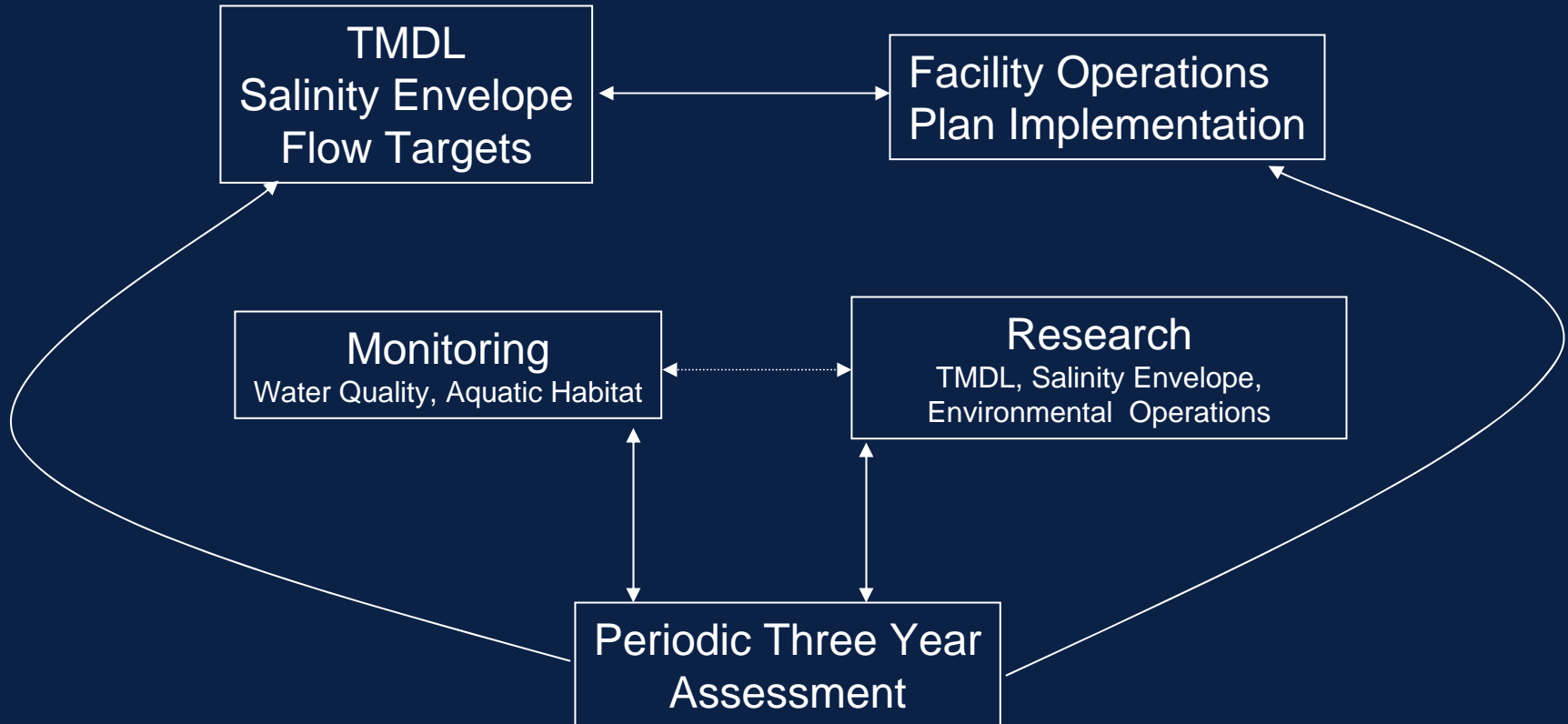


Research Program

- **The research program must provide technical information regarding inflow targets and salinity envelopes for both estuaries based on existing information. To allow for revision of these goals, future plans should identify projects that fill informational gaps identified during target and envelope development.**
- **To facilitate creation of predictive and/or numeric modeling tools in order to fulfill the requirement to assess plans and programs and to predict and evaluate progress towards overall protection program objectives. These tools can be used to evaluate and quantify the nutrient load reduction achieved by construction projects and/or operational modifications and progress towards restoration of natural hydrology and targeted water quality .**
- **The research program should also provide the empirical data and conceptual understanding of the St. Lucie River and Caloosahatchee River Watersheds and estuarine receiving waters to support and improve predictive models and identify new water quality management measures.**



Monitoring, Research and Adaptive Management





Areas of Research

- **TMDL**
 - **Nutrient Loading, Cycling**
 - **Biological Resources and Habitat**
 - **Seagrass , Oysters, Low Salinity Zone**
 - **Modeling**
- **Salinity Envelope**
 - **Biological Resources and Habitat**
 - **Seagrass , Oysters, Low Salinity Zone**
 - **Modeling**
- **Environmental Operations**
 - **Optimal Operating Rules for Environment**



**Northern Everglades
River Watershed Research & Water Quality
Monitoring Program
St. Lucie River Watershed**

April 22, 2008

UPDATES

- Research and Monitoring Plan
- Chapters 1 through 3 - Draft chapters are out to Technical editor
- Chapter 4 - Watershed and Estuarine Monitoring Program
 - Description of Existing Monitoring: Flow, Water Quality, Salinity and Aquatic Habitat- drafted
 - Assessment of Monitoring: Is it adequate to meet goals? – on-going
- Chapter 5 – Research for Adaptive Management
 - Underway



UPDATES – AD Hoc WQ

- Ad Hoc WQ Meeting on April 18, 2008
- Reviewed Group A Parameters for WQM, SE and SLT stations
 - New parameters: DTKN, BOD5
 - Frequency: Monthly
 - Optimize SLT in future
- Reviewed Group B Parameters
 - Fecal Coliform
 - Enterococcus
 - Existing monitoring by St. Lucie County & Health Dept.



UPDATES – Ad Hoc WQ

Group A Priority Parameters for WQ Monitoring - Monthly

- TN (cal), NH₄, NO₂/ NO₃, TKN, DON (cal), **DTKN**
- TP, OPO₄= SRP
- DO, **BOD5/TOC**
- Chl-a
- TSS
- Turbidity
- Color
- Total hardness
- Copper
- Arsenic

Blue: all WQM stations and SLT stations

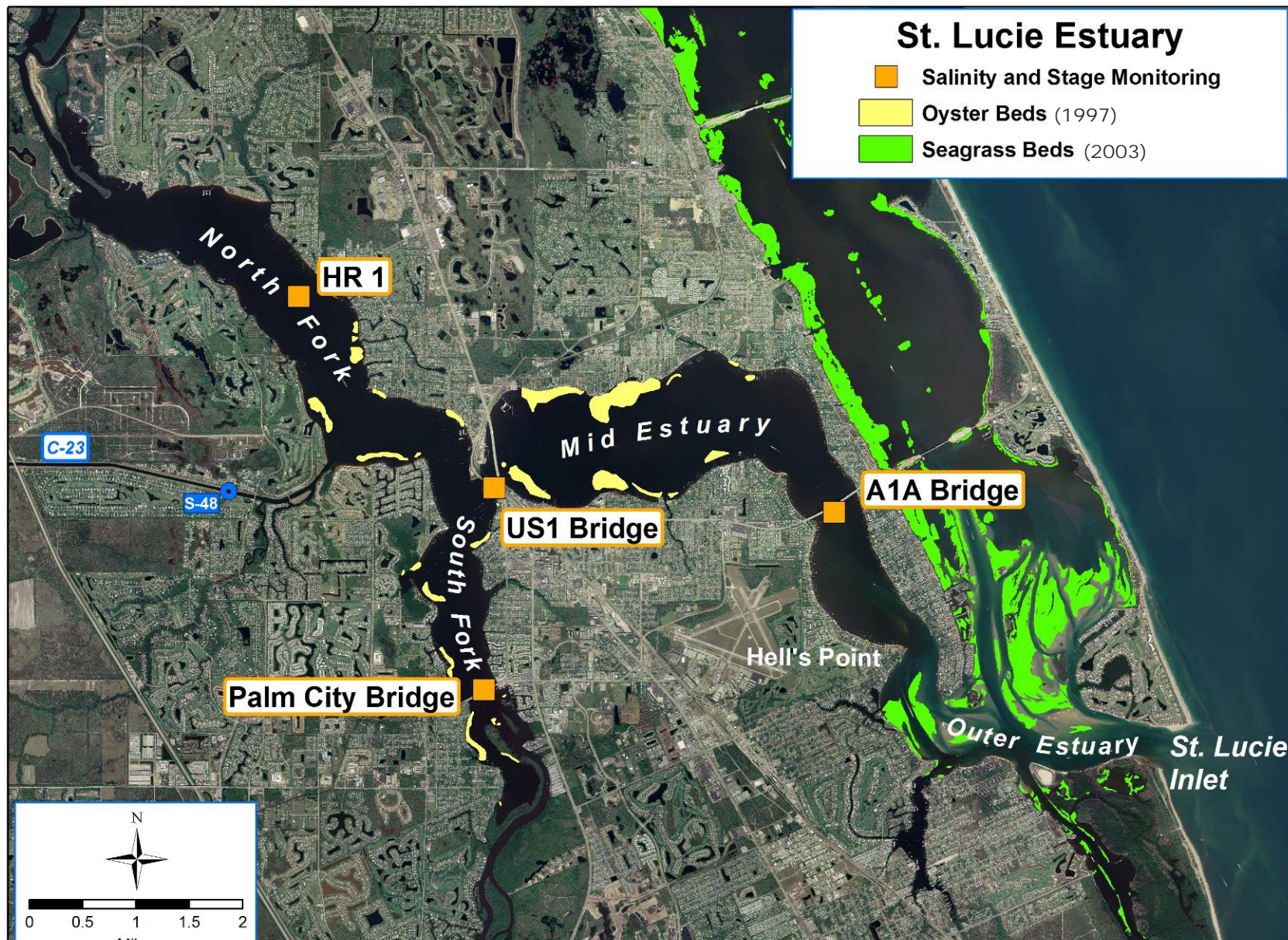
Green: additional parameters



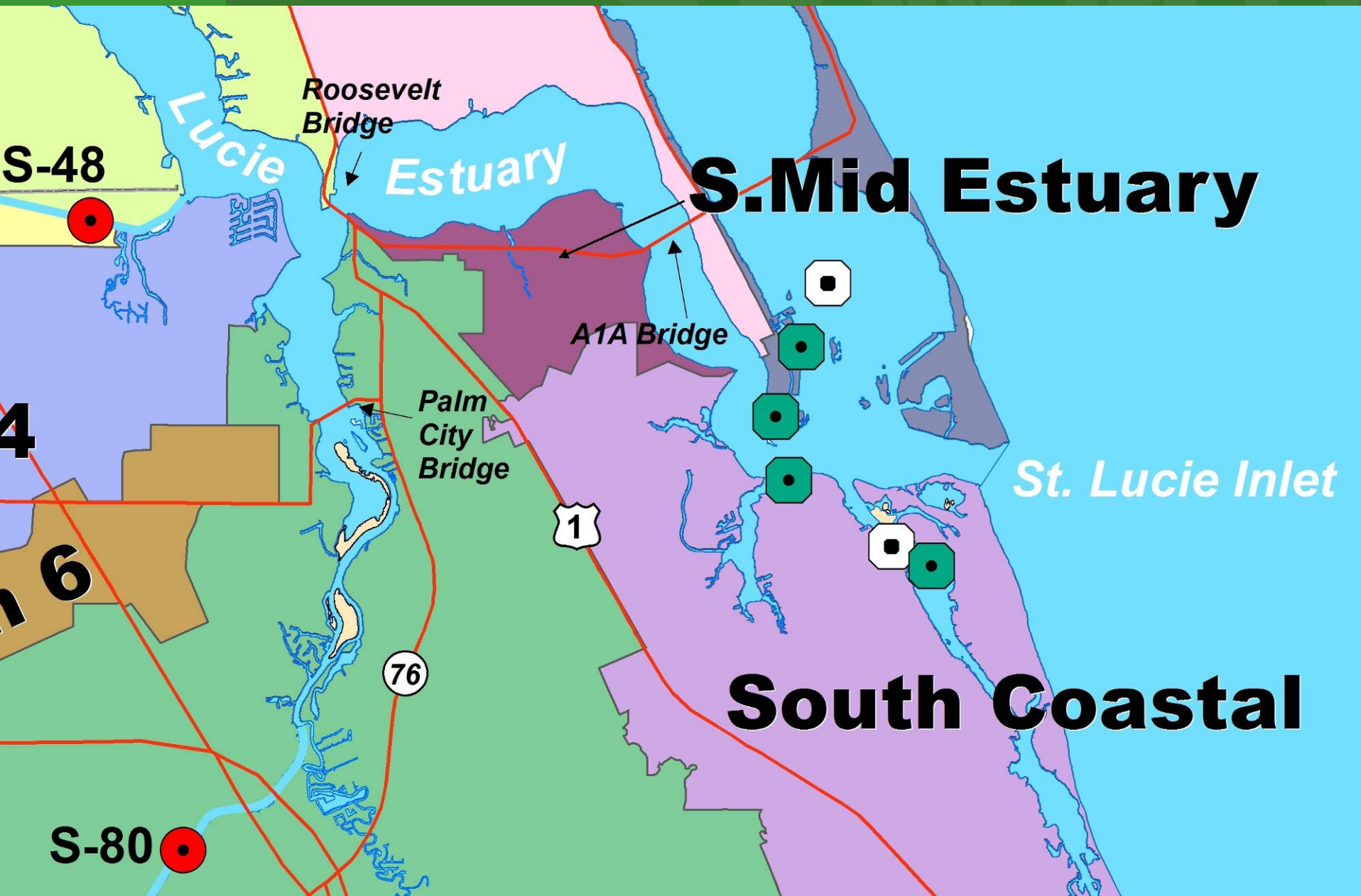
Aquatic Habitat Monitoring

Project Title	Objectives	Location	Stations	Frequency	Parameters	Period
Seagrass/SAV monitoring-SLE/IRL	Determine the impact of freshwater inflow on SAV in the IRL/SLE	IRL near St. Lucie Inlet	2 (1 north and 1 south of the inlet: Note-was 4 Sta.)	Monthly	Species % cover, height, shoot count, biomass, drift algae cover, epiphyte cover depth, temp, salinity, D.O., secchi	2002-present
Seagrass/SAV - Transects	Establish long-term baseline for SAV in the IRL	IRL	2 + Variable	2 times per year	Species % cover, height, shoot count, drift algae cover, epiphyte cover, <i>Halophila johnsonii</i> mapping	1994-present
Seagrass/SAV Aerial Survey	Establish long-term baseline for SAV in the IRL	IRL	Area Wide	Once every 2-3 years	Coverage	1986-present
SLE Oyster Distribution	Establish baseline condition of oysters in SLE	SLE	9	Monthly (Life/death counts-semi annual)	AdultLive/death counts, spat recruitment, reproduction and disease index, juvenile growth	2004-present
Benthic Surveys	Establish baseline benthic condition in SLE and IRL	SLE/IRL	10	Quarterly	Species ID and enumeration, sediment type, temp, D.O., pH, salinity	2004-present

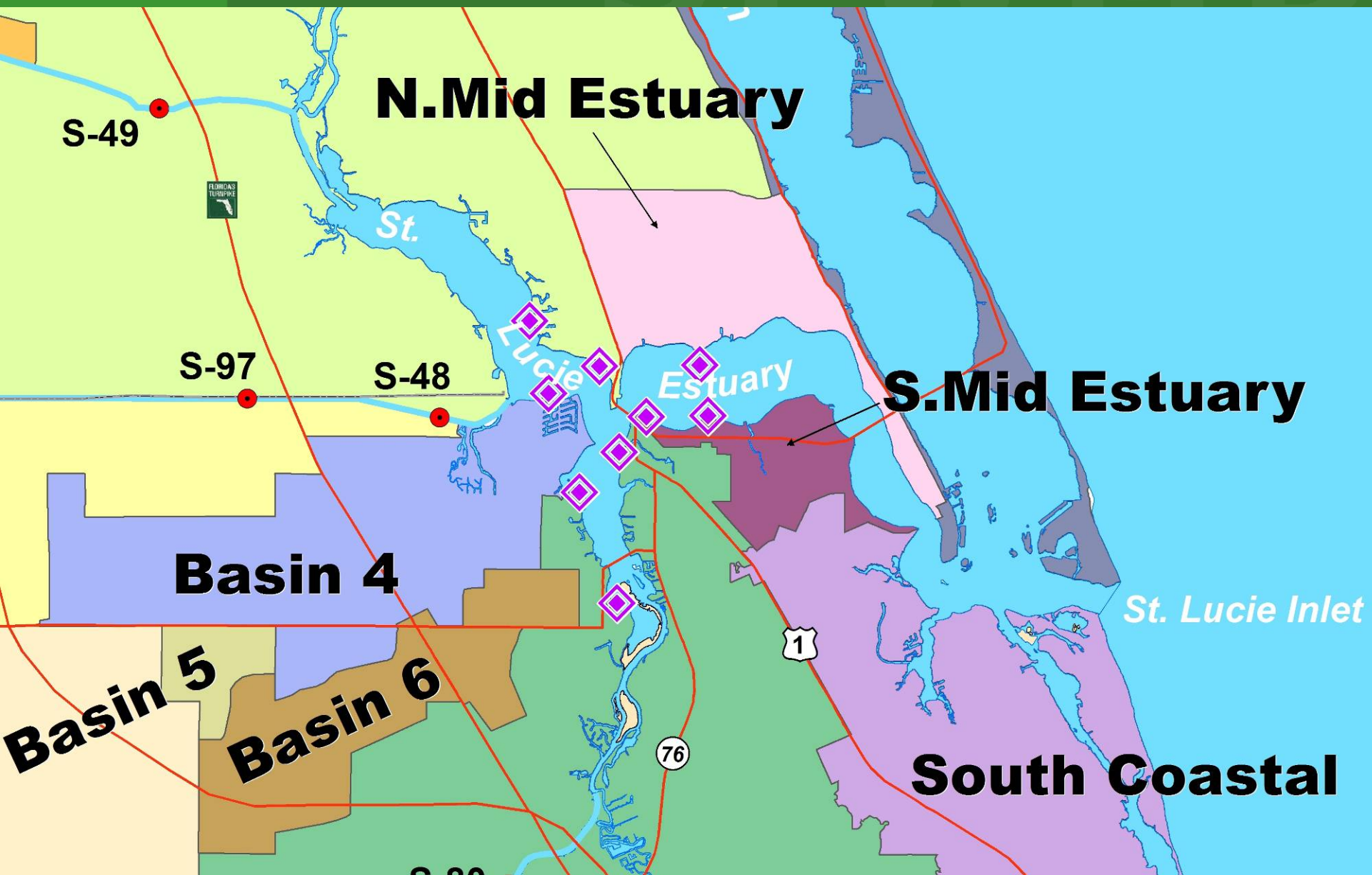
Seagrass and Oyster Resources



St. Lucie Seagrass Stations



St. Lucie Oyster Stations



Chapter 5: Research for Adaptive Management

- Compile Research Inventory
 - Water Quantity Related Research (Flow, Salinity, Aquatic Habitat)
 - Water Quality Related Research
 - Operations



St. Lucie Existing Research Inventory

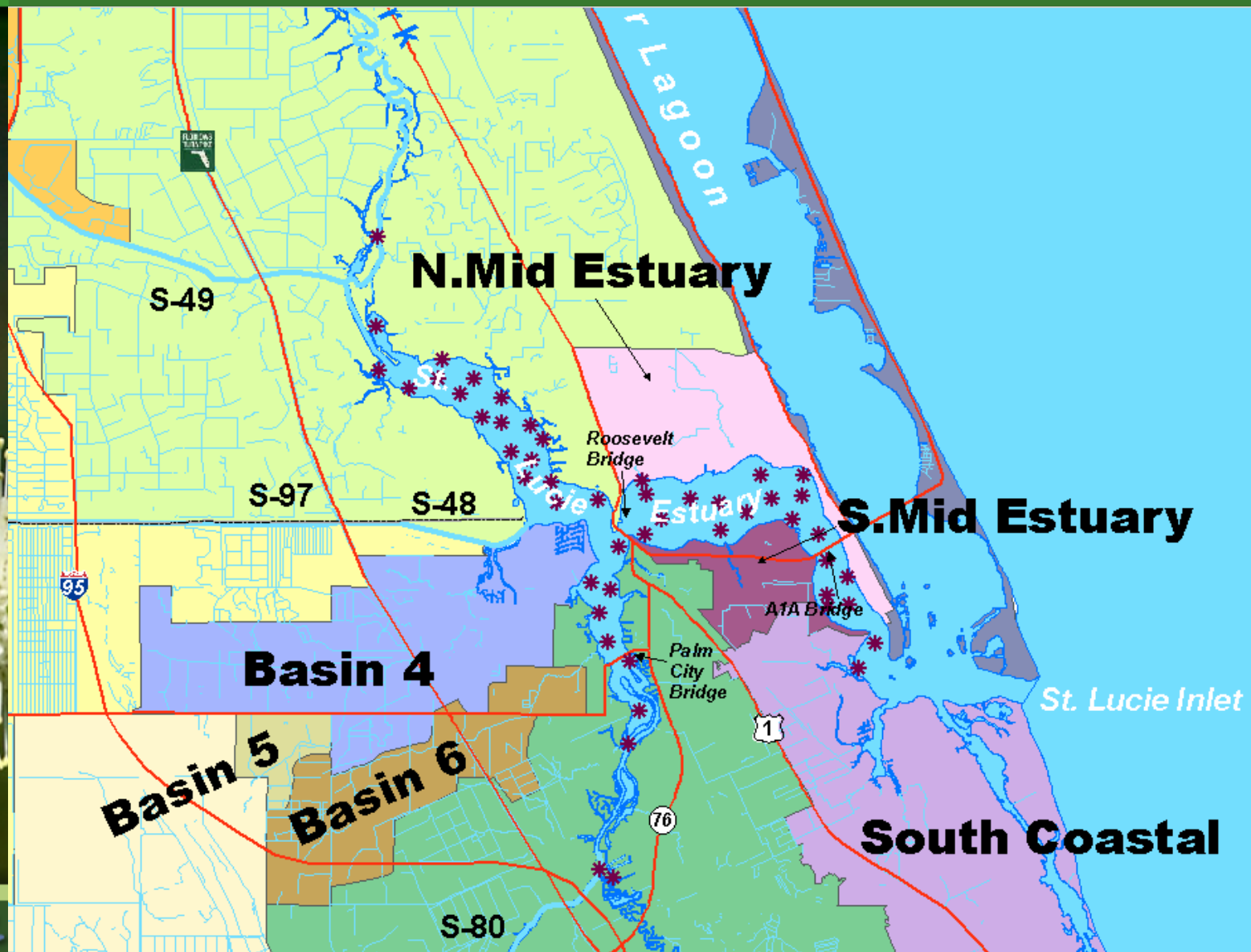
Project Title	Objectives	Location	Stations	Frequency	Parameters	Period
SLE Fish Monitoring	Establish fish baseline condition in SLE	SLE	3 fixed sta. and 1+ fish transient stations	Continuous	Acoustic sp. ID and enumeration of selected species.	2006-present
Limiting Nutrient-Phytoplankton in SLE	To determine limiting nutrient in SLE	SLE	5 (at SE Stations 11, 2, 3, 8, and HR1)	<u>Weekly</u> (WQ/Pyhto) <u>Monthly</u> (Bioassay)	WQ-(see SE description); Phytoplankton ID, enumeration cell volume; Bioassay for nutrient limitation and growth	2006-present
Nutrient Benthic Flux Work in St. Lucie Estuary	To determine sediment nutrient flux and Sediment O2 demand	SLE	54	Dry Season 2008	Nutrients, SOD	2008
Estuary Turbidity Maximum (ETM)	ID and locate ETM zone in the North and South Forks	SLE	Variable	Spring 2008	Salinity, Density, Turbidity, Suspended Sediments	2008
Zooplankton and Larval Fish	To determine the relationship of early life history of fish with the oligohaline environment	SLE/IRL	4 (Hells Gate, HR1, Kelstadt & to Prima Vista Bridges)	Every 2 weeks for 4 months	Larval and eggs-species ID and enumeration using light traps, pumps, and plankton tows	2006-2007

FY 08 Existing Research Contracts

Project Title	Objective	Timeline
St. Lucie Estuary Turbidity Maximum (ETM) Study Update	<ul style="list-style-type: none"> ▪ Identify and locate ETM zone in the North and South Forks ▪ Study ETM characteristics including salinity/density structure, turbidity structure, suspended sediment distribution ▪ Study ETM tidal and seasonal variations 	<ul style="list-style-type: none"> ▪ Field Work Completed ▪ Draft Final Report Due End of April
Nutrients in the St. Lucie Estuary (SLE)	<ul style="list-style-type: none"> ▪ To determine the temporal variability of nutrients (N, P, and silica) that limit phytoplankton growth and the changes in species composition related to nutrient availability in the SLE. 	<ul style="list-style-type: none"> ▪ Field Work Completed ▪ Draft Report Due May
Nutrient Benthic Flux Work in the St. Lucie Estuary	<ul style="list-style-type: none"> ▪ To determine sediment nutrient flux and sediment oxygen demand to support the St. Lucie River Watershed Research and Water Quality Monitoring Plan. 	<ul style="list-style-type: none"> ▪ Draft Final Report Received



Nutrient Benthic Flux Sites



Potential Research Topics

- Flow and Nutrient Budget and TMDLs
 - Event Mean Concentrations – stormwater sampling
 - Benthic nutrient flux
 - Atmospheric deposition (N and P)
 - Nitrogen fixation
 - Groundwater input – quantity and quality
 - WQ and TDMLs
 - Algal community composition
 - Relationships between BOD, TOC and DOC
 - Sediment Oxygen Demand: Research monitoring for unimpaired streams compared to those measured for verified impaired streams (for DO)
 - CDOM
 - Suspended sediment dynamics, Sediment map
 - Flow/Salinity Envelope and VECs (SAV, Oyster, Low Salinity Zone)
 - Environmental Operation



Existing Model Inventory

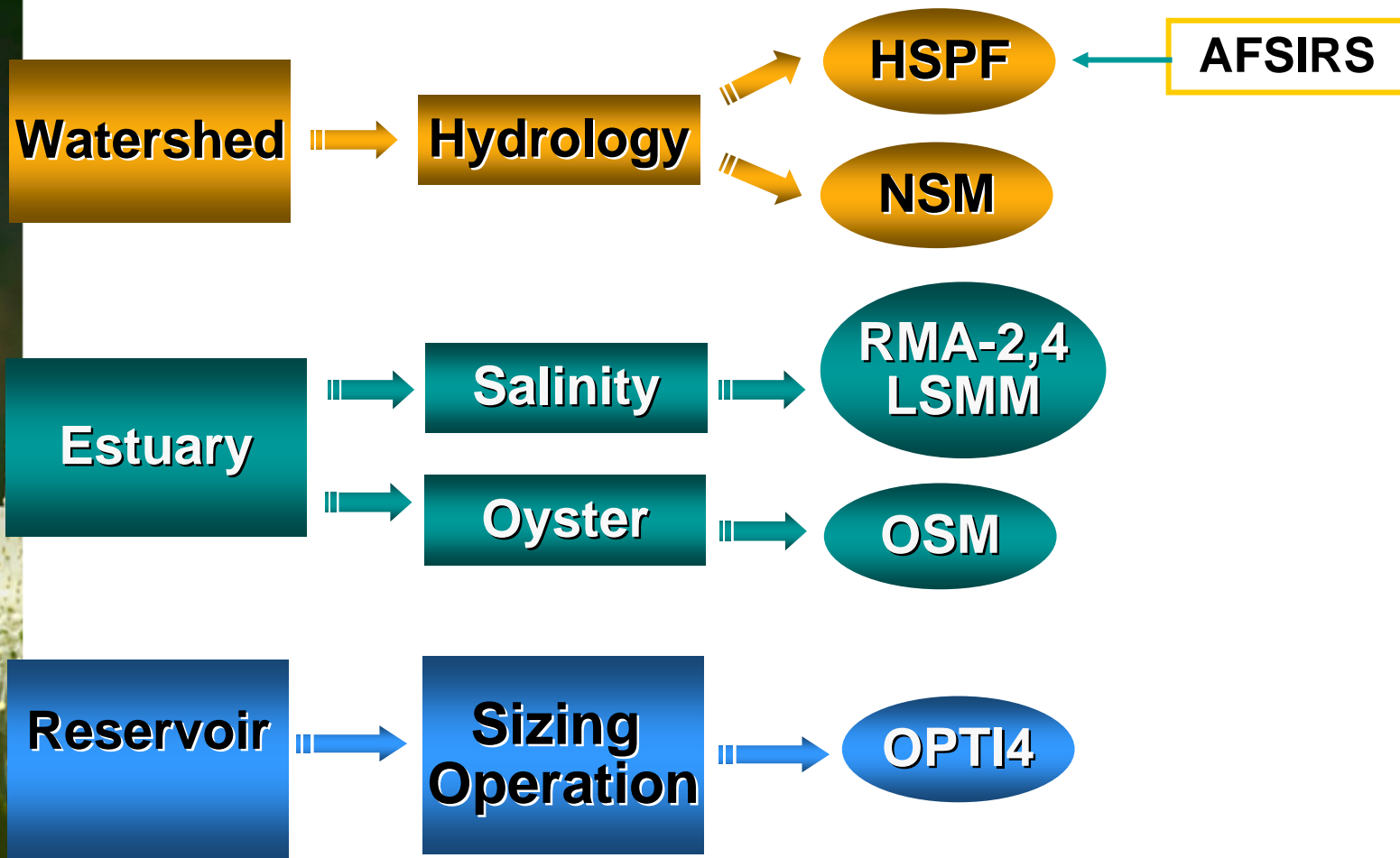
Model Category	Model	Model Domain	Main Outputs	District Contact	Past Applications (Year and Project)	Model Calibration/ Application Period
Watershed model	WaSh	St. Lucie River Watershed	Flow, stage, water quality	Fawen Zhen/Yongshan Wan	CERP, IRL PIR, C-44	1965-2005
Estuarine hydrodynamics model	RMA	SLE/IRL	Water level, flow velocity, salinity	Gordon Hu	1998 – 2000: SLE/IRL CERP PIR	1997-2000 and partly 2002
Estuarine hydrodynamic model and regression	LSMM	SLE/IRL	Salinity and water demand for salinity management	Gordon Hu	1998 – 2000: SLE/IRL CERP PIR 1999 – present: System Operations such as Lake O releases	1965-2005
Estuarine Hydrodynamic model	CH3D	St. Lucie Estuary	Water level, salinity, velocity	Detong Sun	TMC Adaptive management	Multiple-year simulation (1997-2005)
Estuarine Water quality model	Standalone WQ model	St. Lucie Estuary	nutrient, Chl a, DO, TSS	Detong Sun		Multiple-year simulation (1999-2003)
Optimization model for system planning and operation	OPTI	St. Lucie watershed and estuary	Reservoir and STA design parameters such as storage volume	Yongshan Wan	IRL PIR (CERP)	1965-1995
Oyster Stress Model: regression equation based	OSM	St. Lucie Estuary	Oyster stress level	Dan Haunert	IRL-S PIR	1965-1995

Existing Model Inventory

- NERSM
- RESOPS



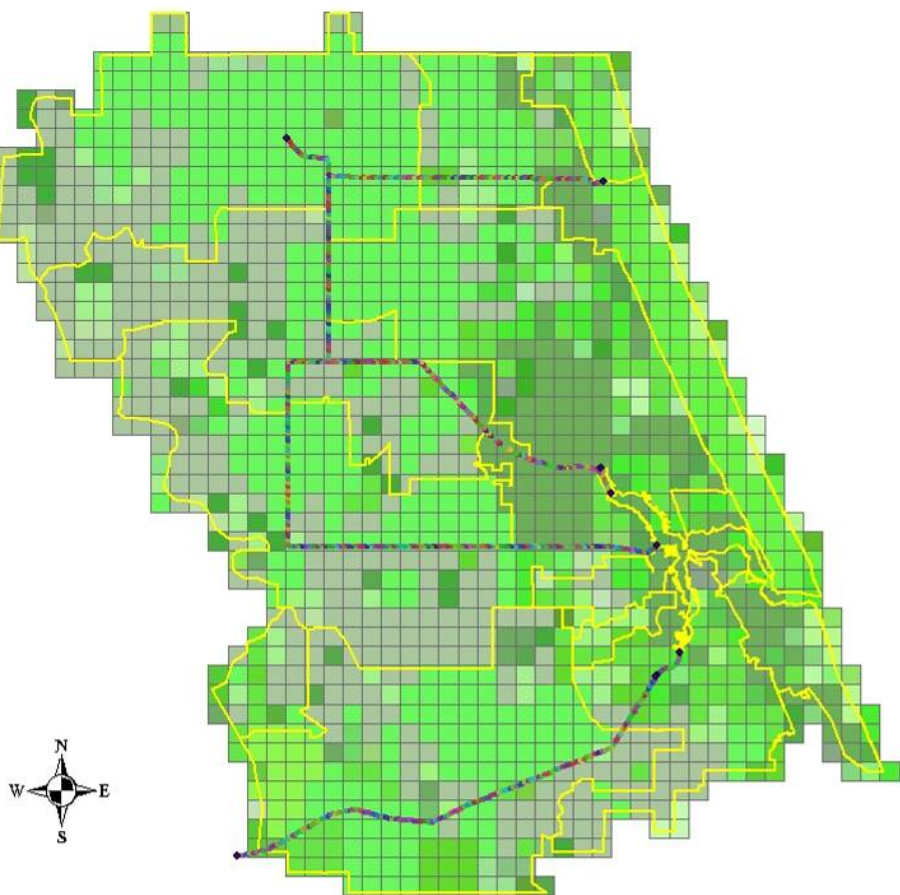
Modeling Tools used in IRL-PIR



31-y simulation from 1965 to 1995

Watershed: From HSPF to WaSh

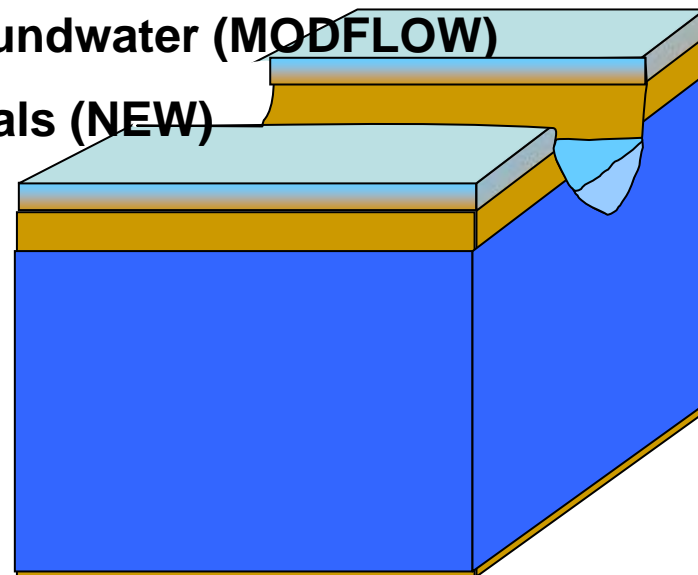
SLE WaSh Model Grids and Canal Segments



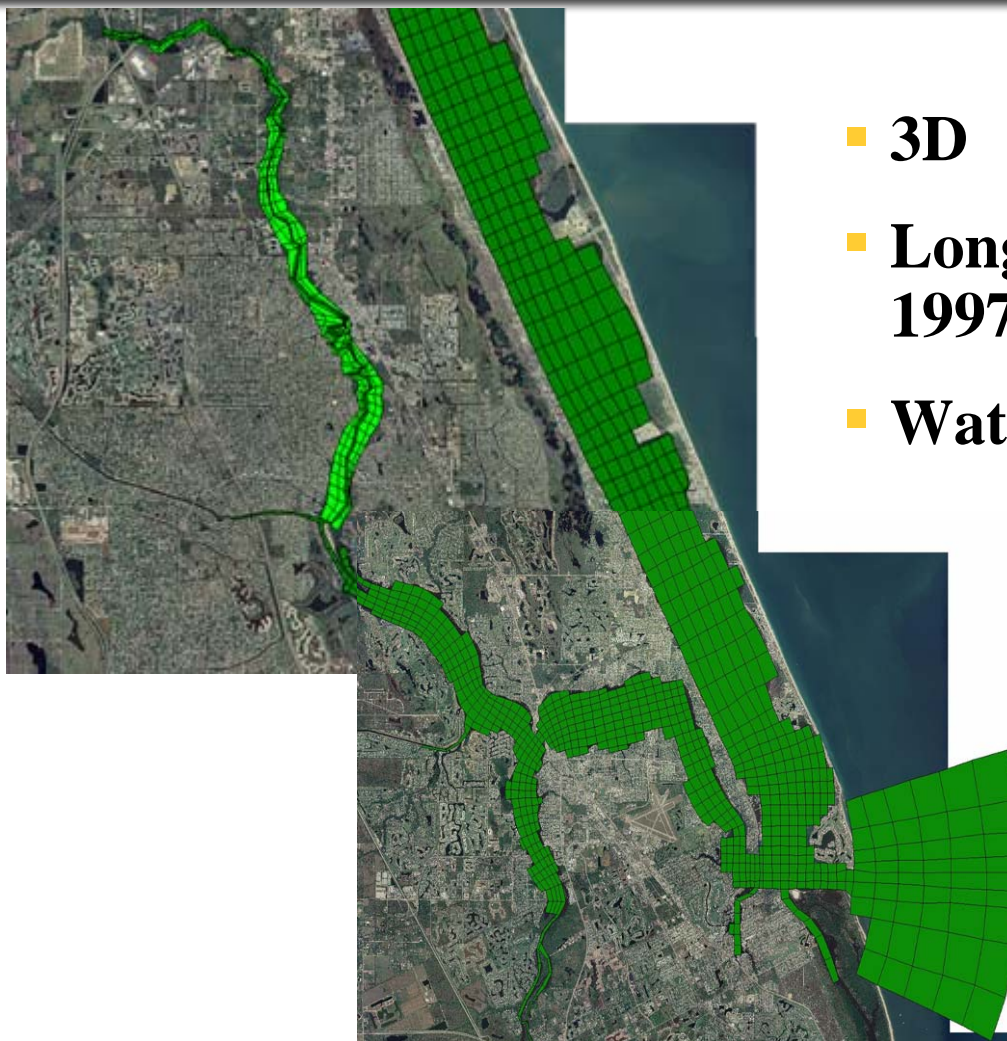
Surface Hydrology (HSPF)

Groundwater (MODFLOW)

Canals (NEW)

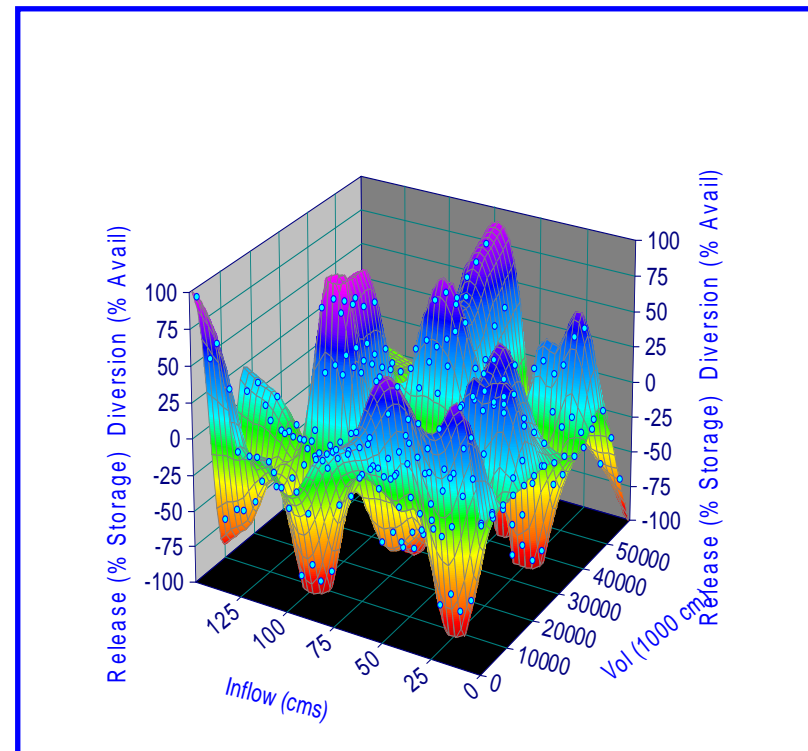
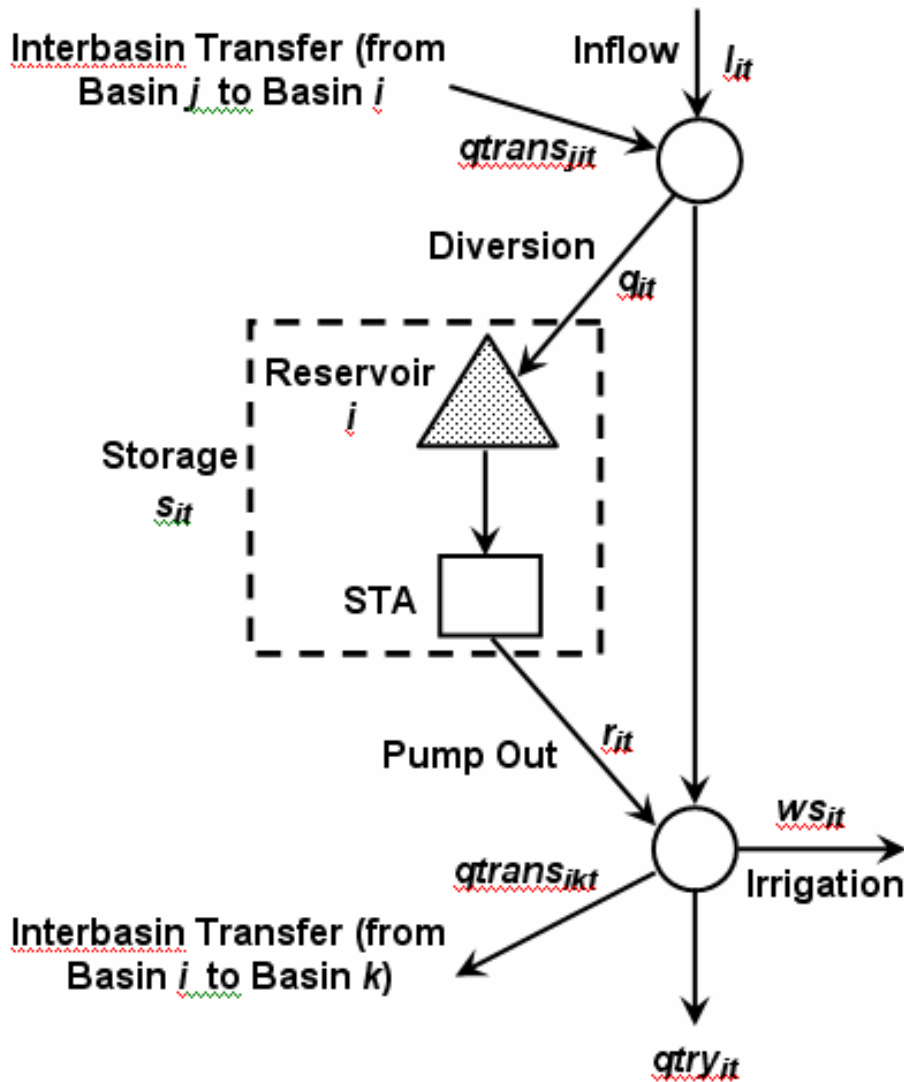


CH3D Model – Salinity and Water Quality

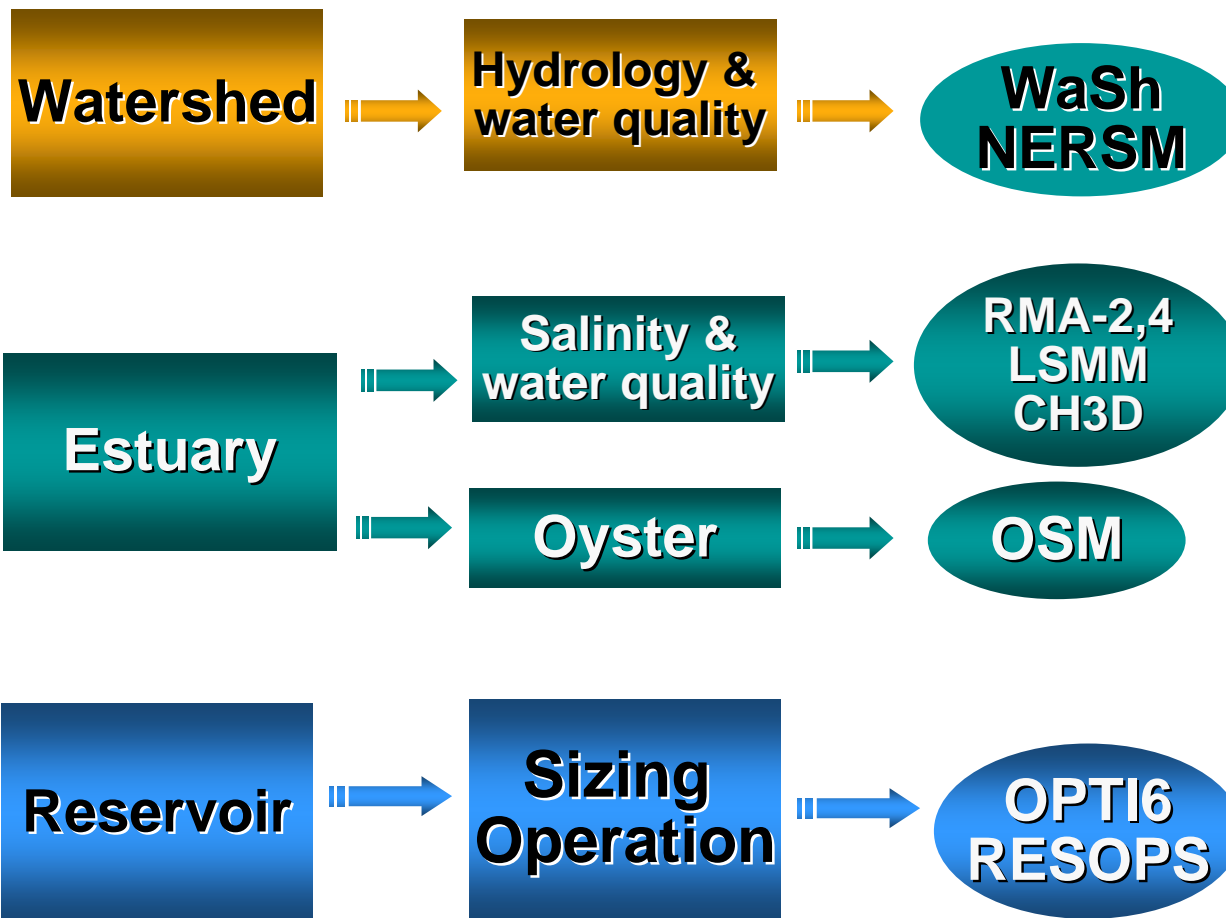


- 3D
- Long-term calibration: 1997-2006
- Water quality

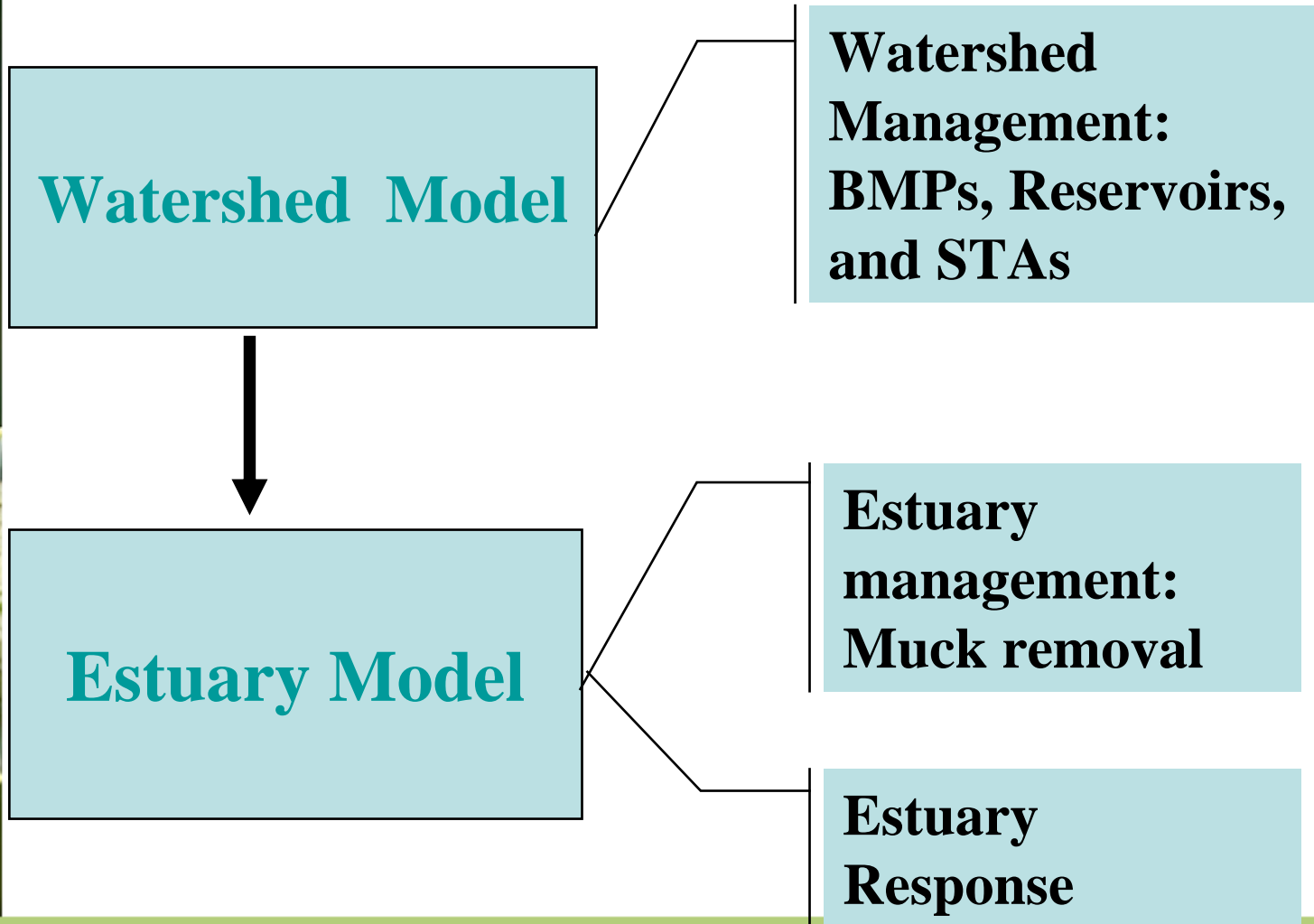
OPTI Update: Off-line Reservoir and Fuzzy Rule



Modeling Tools: Existing Models



Integrated Modeling Approach



Next Steps



- Future work

