CALOOSAHATCHEE RIVER MFL RESEARCH AND MONITORING PLAN

SEPTEMBER 26, 2019

The following provides a summary of current and proposed monitoring and research efforts that evaluate the recommended Minimum Flow and Minimum Water Level (MFL) criteria for the Caloosahatchee River and provide additional information for future re-evaluations. Recommendations are proposed to supplement current monitoring efforts in the estuary. The projects listed herein are designed to collectively evaluate ecological responses to freshwater inflow along the oligohaline and mesohaline zones of the Caloosahatchee River Estuary (CRE) beginning downstream of the S-79 water control structure. Additionally, these future monitoring efforts are meant to document ecological responses of indicators before and after operation of the C-43 Reservoir to determine the benefits of additional future freshwater inflows from the reservoir. The proposed and current ecological monitoring and research projects reflect the South Florida Water Management District's (SFWMD's) MFL evaluation priorities. Funding of these in the amount of $237,000 per year (**Table 1**), is contingent upon approval of the annual budget by the Governing Board.

Table 1. Time frames from FY20-FY27 and cost per year (in thousands of dollars) for proposed and current estuarine ecological* monitoring and research projects in the CRE.

Project	Time Frame							
	Baseline Period					Reservoir Operational Period		
Fiscal Year	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27
New Monitoring/Research								
Clam (*Rangia cuneata*) Monitoring	$60K	$60K	$60K	$60K	$60K	$60K	$60K	$60K
Zooplankton and Ichthyoplankton Monitoring	$150K	$150K	$150K	$150K	$150K	$150K	$150K	$150K
Current Monitoring/Research								
Estuary Water Quality Responses to Managed Flows	$27K	$27K	$27K	$27K	$27K	$27K	$25K	$27K
Submerged Aquatic Vegetation Monitoring (CERP RECOVER funded)	$80K	$80K	$80K	$80K	$80K	$80K	$80K	$80K
Oyster Monitoring (CERP RECOVER funded)	$70K	$70K	$70K	$70K	$70K	$70K	$70K	$70K
Tape Grass (*Vallisneria americana*) & Clam (*Rangia cuneata*) Salinity Stress Response Study (2-year study)	$35K	$35K						
TOTAL	$422K	$422K	$387K	$387K	$387K	$387K	$387K	$387K

*Budget reflects estuary ecological monitoring efforts.

ESTUARY ECOLOGICAL MONITORING

PROPOSED MONITORING

I. Zooplankton Monitoring Studies

Sampling for two studies can be collected simultaneously to evaluate vital components of planktonic community responses to flow in the CRE: 1) zooplankton community assemblage and distribution, and 2) ichthyoplankton (larval fishes and fish eggs) population distribution. Sampling methods will be similar to those from Component Studies 4 and 5 (SFWMD 2018), with a minimum of three sampling locations in both the oligohaline and mesohaline zones of the estuary.

A. Zooplankton Community Assemblage and Distribution

The center of abundance for many planktonic organisms in the CRE has been shown to move downstream as river flows increase and upstream as they decrease. During low-flow periods, some organisms will become concentrated in the narrow region of the estuary more than 30 km upstream of Shell Point. At even lower flows, organisms' upstream progress may be obstructed, and they can be impinged on the S-79 structure approximately 43 km upstream of Shell Point (Peebles and Greenwood 2009). The crowding of organisms in a relatively confined space, termed habitat compression (Crowder 1986, Copp 1992, Eby and Crowder 2002), may result in increased predation and competition for limited food resources. In addition, some organisms may be forced to use habitat that is physiologically suboptimal, which may result in lower growth and survival. It is recommended to monitor zooplankton in the upper region of the CRE, in areas at risk of impingement and habitat compression during periods of reduced flow. Additionally, monitoring the zooplankton community assemblage along the salinity gradient of the estuary is important to assess shifts in community composition in response to flow conditions.

B. Ichthyoplankton Population Distribution

Ichthyoplankton communities are key components of food webs in the CRE. The oligohaline and mesohaline zones are key areas in many ichthyofaunal life history stages (Able 2005, Sutherland et al. 2012). Previous studies and data analyses found that abundance of ichthyoplankton was greatest when the 30-day inflows at S-79 averaged between 151 and 600 cubic feet per second (SFWMD 2018). Data for the previous analyses were collected between 1986 and 1989; to assess current ichthyoplankton abundance and community structure this additional monitoring study is needed. These monitoring data will help refine the understanding of these indicators' responses to flows before and after C-43 Reservoir operations and will assist in future MFL re-evaluations.

Frequency: Monthly during dry season, sampling events during the wet season may vary temporally.

Duration: Annually, ongoing project re-evaluation every 5 years

Cost: $150,000/year, to be contracted

II. Clam (*Rangia cuneata*) Monitoring in the Oligohaline and Mesohaline Region of the CRE

This monitoring is consistent with recommendations contained in the 2017 peer-review report (SFWMD 2018) to measure an additional benthic indicator sensitive to salinity changes in the upper estuary when assessing the duration component of the MFL criteria. The peer-review panel questioned whether recovery of tape grass would occur in the future. *Rangia cuneata* was suggested as a potential candidate for the upper region of the CRE, which routinely experiences lower salinities and provides habitat for brackish to freshwater organisms (LaSalle and de la Cruz 1985, Wakida-Kusunoki and MacKenzie 2004, Wong et al. 2010). The current distribution of *Rangia* in the CRE is not well understood. Random samples were collected during the 2018 dry season in the oligohaline and mesohaline sections of the CRE to establish whether the organisms were present to collect for experiments and several individuals were observed. It is proposed that an annual monitoring program be designed to overlap with the estuary- wide SAV sampling. The monitoring would occur along the same hexagonal grid overlaid along the four segments of the estuary used for the SAV sampling points. Establishing a population baseline prior to project implementation is critical to monitor results of reservoir performance.

Frequency: Twice per year

Duration: Ongoing, with re-evaluation after 5 years

Cost: $60,000 to be contracted

CURRENT MONITORING AND RESEARCH

I. Monitoring Estuary Water Quality Responses to Managed Flows

The goal of this monitoring program is to determine how best to 1) deliver water to maximize benefits of low-level releases and minimize damage from high-level releases, 2) avoid unintended consequences (e.g., hypoxia or anoxia, algal blooms), and 3) provide high-resolution data of the water quality gradients from the oligohaline to polyhaline zones of the CRE (**Figure 1**). The existing, but currently unfunded program, Surveying Estuarine Response to Freshwater Inflows (SERFIS), uses a flow-through approach to capture system-wide responses (Madden and Day 1992, Lane et al. 2007, Buzzelli et al. 2014). SERFIS monitors and maps spatially contiguous water quality parameters, including salinity, turbidity, color (fluorescing dissolved organic matter), chlorophyll *a* concentration, dissolved oxygen, phycocyanin fluorescence (the pigment in freshwater blue-green algae), and plankton biomass >60 µm in surface waters of the CRE. Water quality grab samples also are collected at nine fixed locations along the estuary for nutrient analyses. SERFIS was implemented in 2011 and is recommended to continue in the future. Vertical profile data from the water column will be collected at times of low-flow conditions to supplement the data in Component Study 3 (SFWMD 2018).

Frequency: Bimonthly

Duration: Began 2011 annually; ongoing project re-evaluated every 5 years

Cost: $27,000/year for laboratory analytical services; additional labor is internal SFWMD staff

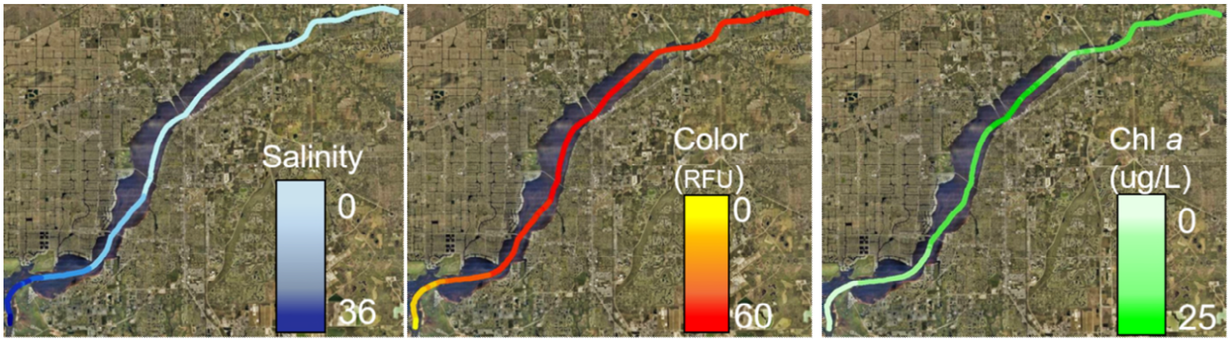

Figure 1. Maps from a Surveying Estuarine Response to Freshwater Inflows (SERFIS) water quality monitoring event in the CRE. A) Salinity; B) Color (fluorescing dissolved organic matter, Relative Fluorescent Units); and C) Chlorophyll *a* (micrograms per liter).

II. Submerged Aquatic Vegetation Monitoring

Annual estuary-wide monitoring (**Figure 2**) of submerged aquatic vegetation (SAV) abundance is conducted early in the wet season (~June) and early in the dry season (~December). This monitoring is part of the Comprehensive Everglades Restoration Plan (CERP) Restoration Coordination and Verification (RECOVER) Program and began in 2018. Additionally, permanent transects are established at upper, middle, and lower estuary sites (**Figure 3**) and are sampled more frequently (**Table 2**). This monitoring program covers the habitat area of oligohaline, mesohaline, and stenohaline species (e.g., *Vallisneria americana*, *Ruppia maritima*, *Halodule wrightii*, *Thalassia testudinum*). Biomass and shoot density data are collected at the transect sites, which can provide additional information for the *Vallisneria americana* response model. Water quality parameters, including salinity, temperature, dissolved oxygen concentration, and photosynthetically active radiation and light attenuation, are collected during seagrass surveys and permanent transect monitoring events.

Frequency: See **Table 2**

Duration: Annually; ongoing project re-evaluated every 5 years

Cost: $80,000/year; work done internally by SFWMD staff

Table 2. Parameters measured and frequency of SAV and oyster monitoring in the CRE.

	Current Benthic Habitat Monitoring											
	January	February	March	April	May	June	July	August	September	October	November	December
SAV Monitoring Parameter												
Permanent Transects*												
Cover and Abundance			X	X	X	X	X	X	X	X	X	
Shoot Counts			X	X	X	X	X	X	X	X	X	
Canopy Height			X	X	X	X	X	X	X	X	X	
Biomass					X		X		X			
Estuary-wide Surveys												
Cover and Abundance						X						X
Canopy Height						X						X
Oyster Monitoring Parameter												
Density Counts			**X**			**X**			**X**			**X**
Reproduction	X	X	X	X	X	X	X	X	X	X	X	X
Disease	X	X	X	X	X	X	X	X	X	X	X	X
Spat Recruitment	X	X	X	X	X	X	X	X	X	X	X	X
Growth and Survival	X	X	X	X	X	X	X	X	X	X	X	X
Water Quality	X	X	X	X	X	X	X	X	X	X	X	X

* Transects at CRE 2 and 8 are monitored monthly; CRE 5 is monitored bimonthly from March to November.

Figure 2. Example of estuary wide SAV monitoring points, randomly assigned every sampling event, in the CRE.

III. Oyster Monitoring

Oyster monitoring efforts are conducted in the CRE as part of the CERP RECOVER Program. Parameters collected include reproduction and recruitment, juvenile oyster growth and survival, presence and intensity of the oyster disease *Perkinsus marinus* (dermo), and live/dead density counts of adult oysters. **Table 2** provides details for each parameter and frequency of monitoring at each location. Monthly water quality parameters (dissolved oxygen, specific conductance, salinity, pH, and temperature) are sampled in conjunction with the field sampling at each study site. Future oyster monitoring will continue at the four different locations in the lower CRE near the mouth of the estuary (**Figure 3**).

Frequency: See **Table 2**

Duration: Annually; ongoing project re-evaluated every 5 years

Cost: $70,000/year; work contracted to the Florida Fish and Wildlife Conservation Commission

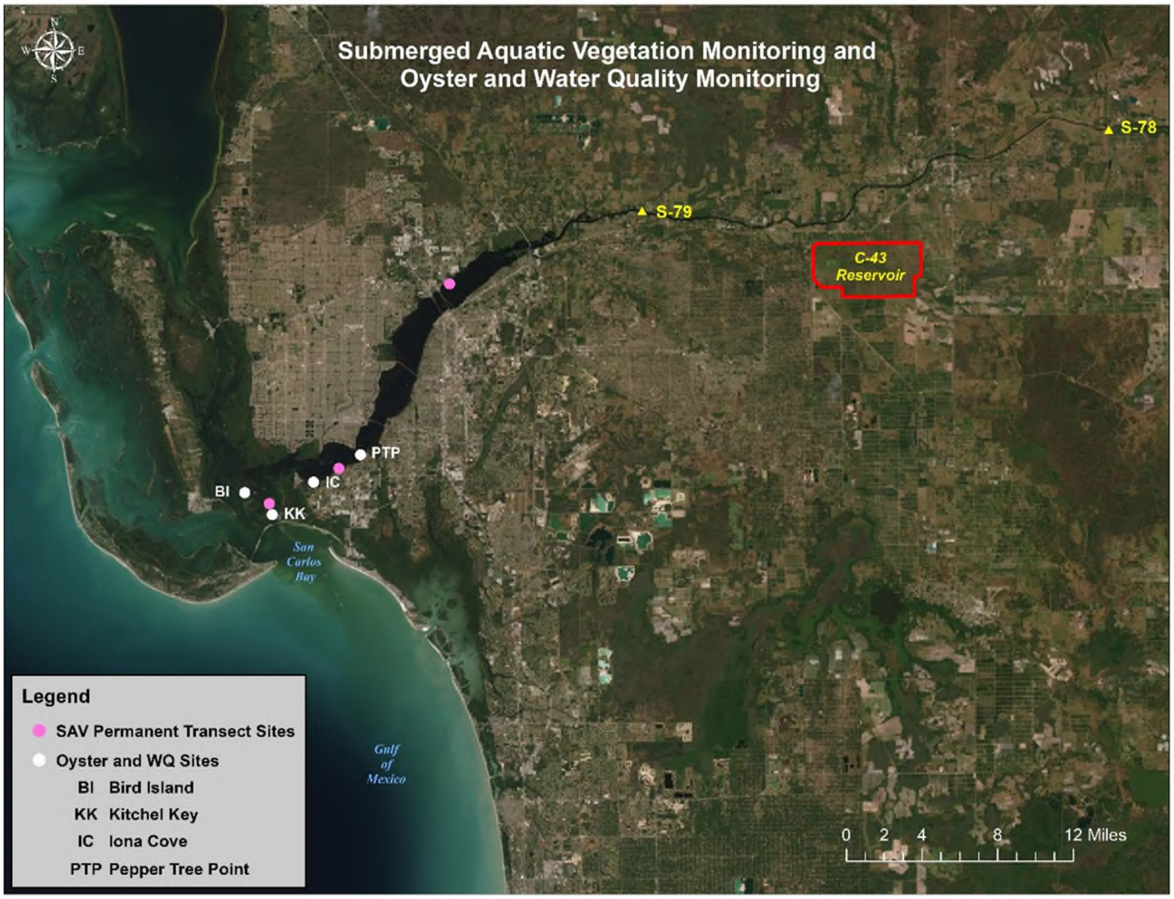

Figure 3. SAV permanent transect monitoring sites (pink circles) and oyster monitoring stations (white circles) in the CRE.

IV. Tape Grass (*Vallisneria americana*) and Clam (*Rangia cuneata*) Physiological Responses to Salinity: A Stress-Response Biomarker Study

The goal of this study is to enhance the understanding of salinity-induced stress responses of tape grass (*Vallisneria americana*) and the clam *Rangia cuneata*, which have been identified as ecological indicators in the CRE. The objectives are to measure physiological response indicators under various salinity treatments (0 to 20) using several biomarkers. Biomarkers such as oxidative stress enzymes can track stress responses over short time scales before a physical response is observed. Responses will be examined during two seasonal periods to compare wet season (June) and dry season (January) responses to assess temperature effects. Results from this study can be used to establish biomarkers for use in future monitoring efforts to indicate salinity stress responses and provide additional information on these organisms' salinity tolerances.

Frequency: Twice per year, winter (dry season) and summer (wet season)

Duration: 2 years

Cost: $35,000/year

FLOW AND WATER QUALITY MONITORING

I. Continuous Freshwater Inflow Monitoring

Continuous daily inflow volume (freshwater discharge volumes in cubic feet per second) into the CRE have been measured at the S-79 structure since 1966. The S-79 structure is the MFL compliance monitoring site and the primary control point where freshwater inflows enter the CRE from the upstream C-43 watershed (**Figure 4**). The mean monthly flows at S-79 would continue to be monitored daily to prevent MFL flow exceedances, when possible, until the recovery strategy is completed.

II. Continuous Salinity Monitoring

Continuous salinity monitoring will remain at the same locations in the upper, middle, and lower portions of the CRE, as shown in **Figure 4**. The salinity recorders measure specific conductance and water temperature, from which salinity is calculated (UNESCO 1981).

III. Monthly Water Quality Monitoring

Water quality will continue to be monitored monthly at stations along the estuary. Data collected include Secchi depth, chlorophyll *a* concentration, pH, dissolved oxygen concentration, specific conductance, temperature, and photosynthetic active radiation (**Figure 5**).

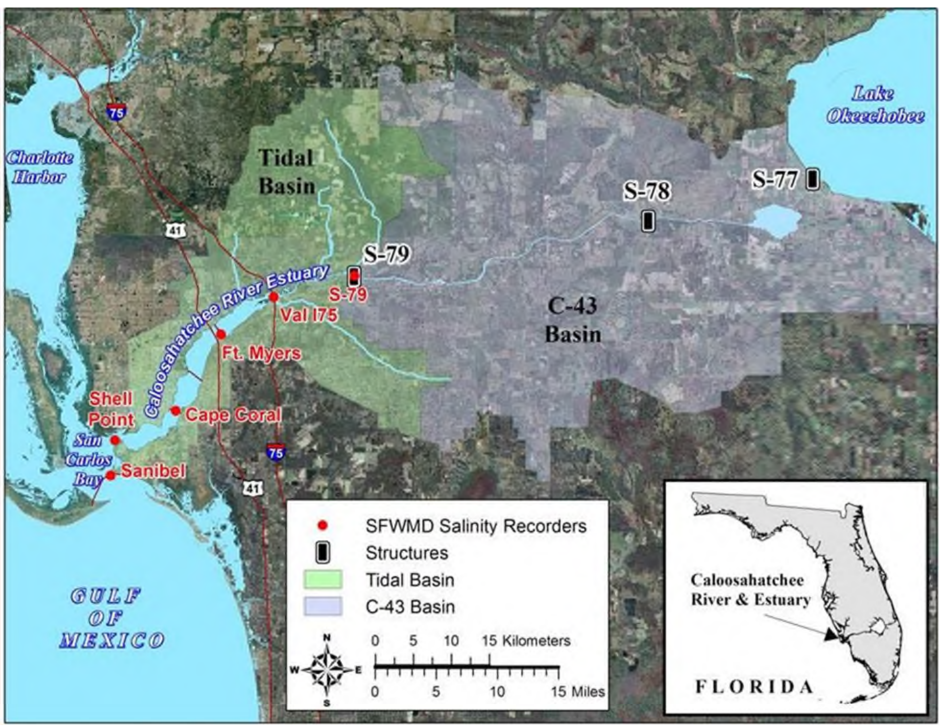

Figure 4. Location of continuous salinity recorders (shown in red) in the CRE and the continuous recorder located at the S-79 structure to measure flows.

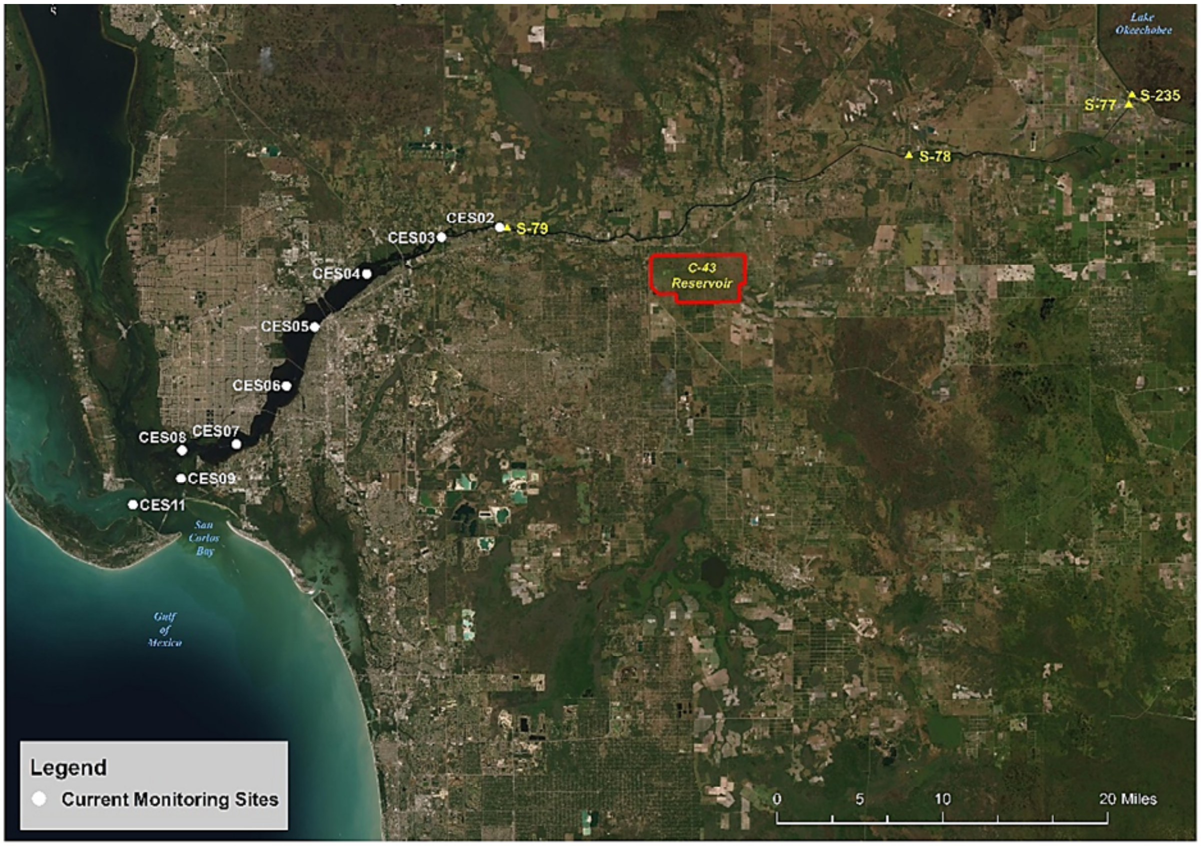

Figure 5. Location of monthly water quality monitoring sites (white circles) in the CRE.

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