Final Report

Deliverable 6.2

Western Basins Water Resources Evaluation Phase I

Prepared for

South Florida Water Management District

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Prepared by

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Executive Summary

Background

J- Tech, a joint venture between Jacob Engineering Group, Inc. and Tetra Tech, Inc. with support from A.D.A. Engineering, Inc. was contracted by the South Florida Water Management District (District) to complete the Western Basins Water Resources Evaluation Phase I (WBWREPI) Project. This Project provides the foundation for a broader evaluation of potential hydrologic and water quality improvements for the entire Western Basins Area including potential future Comprehensive Everglades Restoration Plan (CERP) features or projects.

One of the goals of the Project was to identify potential improvements to meet the numeric phosphorus criterion for the Everglades outlined in Rule 62-302.540 of the Florida Administrative Code. The purpose of this rule is to implement the requirements of the Everglades Forever Act of 1994. As part of the Everglades Forever Act, the Florida Department of Environmental Protection requires that the District monitor the progress of Non-Everglades Construction Project (non-ECP) basins that discharge directly to the Everglades Protection Area (**Figure ES-1**) to measure compliance towards water quality standards.

The focus of the WBWREPI work is characterizing and potentially improving hydrology and water quality (total phosphorous [TP] concentrations and/or loads) in the upstream flows to the Feeder Canal Basin, which is a non-ECP basin, consistent with the intent of the projects identified in the Central and Southern Florida (C&SF) Restudy and in parallel with the Everglades Forever Act. The project deliverable consists of a comprehensive basin watershed management plan that meets the U.S. Environmental Protection Agency's (USEPA) nine-point criteria for an effective nonpoint source (NPS) management program and watershed plan.

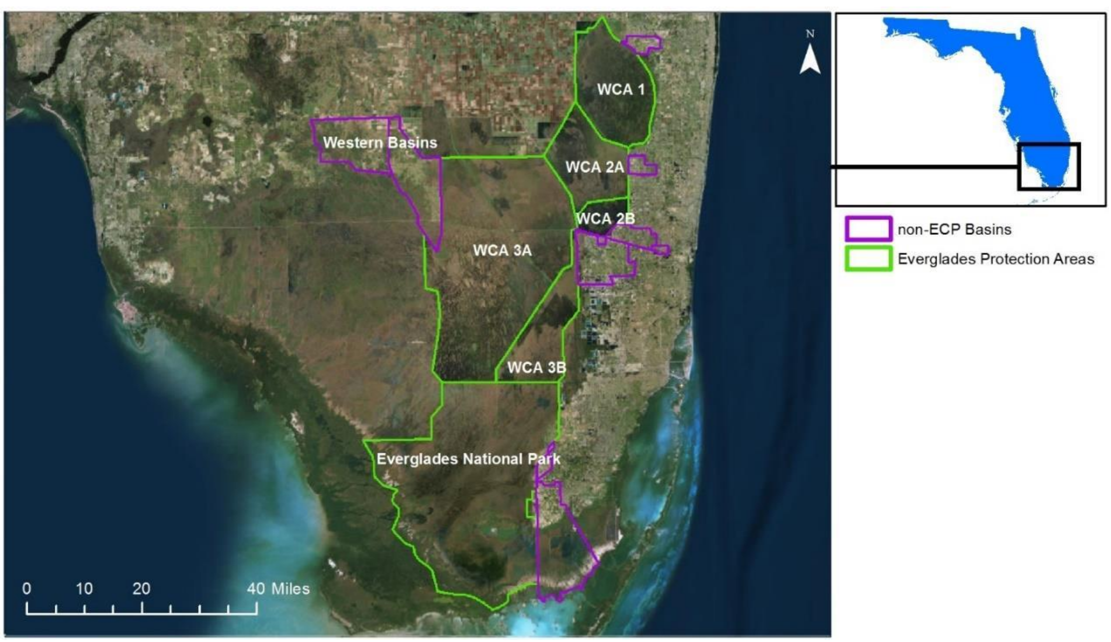

Figure ES-1: Everglades Protection Areas and Western Basins

General Description of the Study Area

For the purpose of this evaluation, the Western Basins region has been defined as the area within the Feeder Canal drainage basin and the C-139 Annex drainage basin. The L-8 interceptor drainage basin, also part of the Western Basins, is not included in the evaluation. The study region is located west of the Water Conservation Area 3A, south of the C-139 basin, and north of the Big Cypress National Preserve. The Feeder Canal drainage basin and the C-139 Annex drainage basin together encompass a region of approximately 86,776 acres. The southern portion of the Feeder Canal basin is inhabited by the Seminole Tribe of Florida and portions of the L-28 interceptor basin (south of the C-139 Annex) are occupied by the Miccosukee Reservation. As water flows from these drainage basins into tribal lands, close coordination with the Seminole Tribe of Florida and the Miccosukee Tribe about the proposed water quality resource evaluation occurred throughout the work effort.

The Western Basins have been split into a “Northern Reach,” which focuses on land and waterbodies that drain to the District water control structures FEEDER_WEIR (aka West Weir), PC-17A, and USSO, and a “Southern Reach,” which includes lands south of the Northern Reach and drain to the C&SF/ U.S. Army Corps of Engineers (USACE) water control structures S-190 and S-140. The initial phase of the Northern Reach, which is the focus of this project, is to lay the foundation for a broader analysis in a future Phase II that will include both the Northern Reach and the Southern Reach. The purpose of this Phase I is to update and expand the evaluation of water quality management measures within the Western Basins Northern Reach, which includes the Northern Feeder Canal and the C-139 Annex drainage basins.

Overview of Evaluated Water Quality Improvement Measures

Several water quality improvement measures for the Northern Reach were identified for evaluation. The measures include diversions from the basin, new detention facilities, and operational changes to existing structures. Factors that were considered in developing the measures included locations of higher TP concentrations, nutrient removal effectiveness, historical flow conditions, maintenance/operation, and site logistics. Implementation cost, land ownership, regulatory requirements, and specific targets for water quality were not considered. For each measure, the water quality benefit was quantified using spreadsheet methodologies and simple assumptions based on measured data and published relationships between land use and nutrient concentrations, a conceptual implementation cost was estimated, and regulatory considerations were outlined.

The alternatives evaluated were:

1. Diverting discharges from the North Feeder Canal sub-basin to the C-139 Annex
2. Replacing PC-17A, the outlet structure in the North Feeder Canal sub-basin, with a remotely operated structure
3. Degrading southern bank of Wingate Mill Canal in the southern boundary of the West Feeder Canal sub-basin
4. Diversion of water from South Boundary Canal in the North Feeder Canal sub-basin to the south
5. Utilization of the C-139 Annex Flow Equalization Basin (FEB) for North Feeder Canal sub-basin flows
6. Sub-regional detention storage and treatment facilities (floating aquatic vegetation tilling and FEB)

The table below summarizes the results of the evaluation conducted over a three-year period.

Table ES-1: Summary of Alternatives Evaluation Results

No.	Estimated Average Annual Flow Changes Downstream after Project (acre-ft)	Estimated Average Annual Load Changes Downstream after Project (mt)	Estimated Average Annual TP Downstream (mg/L)		Initial Cost of Measure Implementation
			Before	*After*	
1	+4,011	-0.1	0.160	0.108	$9,779,250
2	N/A	N/A	N/A	N/A	$4,049,500
3	-13,001	-0.9	0.058	0.058	$416,000
4	-4,901	-1.1	0.160	0.143	$5,487,300
5	-1,921	-0.4	0.160	0.156	$9,750,000
6	-563	-0.5	0.160	0.127	$13,221,000

The water quality benefit of measure number 2 could not be evaluated due to data limitations. However, a review of gate opening data illustrates the potential benefits of a remotely controlled structure that could moderate discharges through incremental openings. No operational costs were considered for these projects. However, it is expected that the alternatives with pump stations will have higher operational costs (Measure numbers 1, 4, 5 and 6).

In terms of the estimated water quality improvement per initial implementation cost, measure number 3 is the most beneficial because of the relatively large flow reduction and its relatively low cost. However, this measure would only change the outflow from the West Feeder Canal sub-basin, which has substantially lower average concentrations than the outflow from the North Feeder Canal sub-basin. Out of the measures that would impact the outflow from the North Feeder Canal sub-basin, measure number 4 is the most beneficial in terms of load reduction per cost. However, data and/or hydraulic modeling to determine the water quality improvement in measure number 2 should be gathered to quantify the benefits of this measure since it would involve less regulatory challenges than the other measures.

Finally, an analysis of which measures can be combined was performed, resulting in 4 alterative combinations. Measures 2 and 3 are independent of all other measures and may help enhance the benefit of any other measure; whereas the other measures depend on whether specific measures are implemented due to overlapping contributing areas.

1.0 Planning

1.1 Scope of Watershed Planning Effort

The Western Basins Water Resources Evaluation Phase I (WBWREPI) project provides the foundation for a broader evaluation of potential hydrologic and water quality improvements for the entire Western Basins Area including potential future Comprehensive Everglades Restoration Plan (CERP) features or projects. The initial improvements were identified in Section 9.1.6 of the Central and Southern Florida (C&SF) Project Comprehensive Review Study (Restudy) which describes several projects whose purpose is to:

"Reestablish sheetflow from the West Feeder Canal across the Big Cypress Reservation and into the Big Cypress National Preserve, maintain flood protection on Seminole Tribal lands, and ensure that inflows to the North and West Feeder Canals meet applicable water quality standards. Consistency with the Seminole Tribe's Conceptual Water Conservation System master plan will be maintained."

The purpose of this watershed planning effort is to update and expand the evaluation of water quality management measures within the Western Basins "Northern Reach" which includes the Feeder Canal and the C-139 Annex basins minus Tribal lands, as shown in **Figure 1**. The specific focus of the WBWREPI effort is concentrated on characterizing and improving hydrology and water quality (total phosphorous [TP] concentrations and/or loads) in the upstream flows entering the Northern Reach.

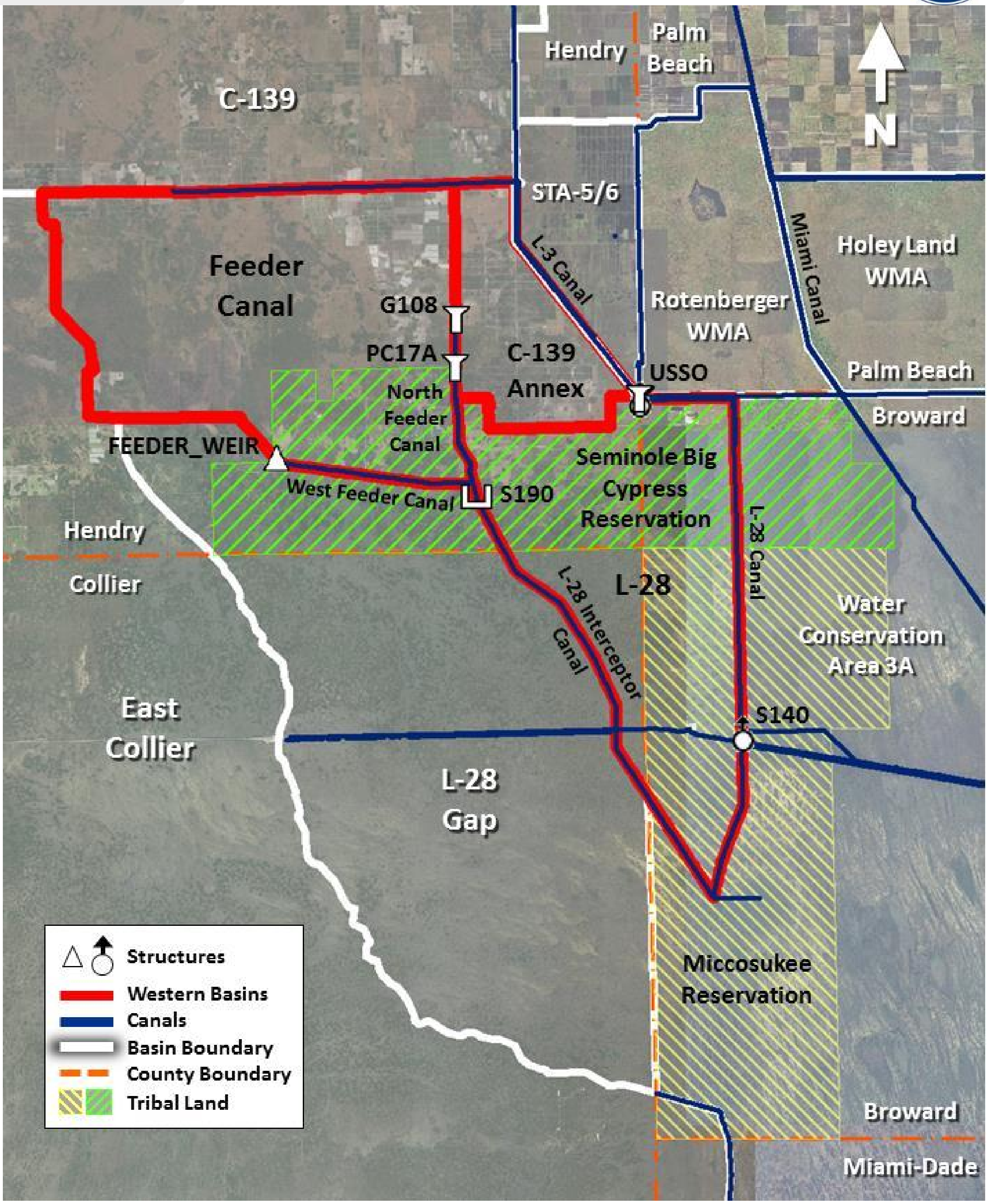

Figure 1: Western Basins Project Area

1.2 Stakeholder Coordination

As part of this project, significant coordination occurred to review potential water quality improvement measures. The coordination included two stakeholder meetings with landowners and interested parties in the Western Basins, as well as three meetings with District Staff to review the input and discuss specifics with respect to implementation of each potential water quality measure.

On October 7, 2015, the South Florida Water Management District (District) held a stakeholder meeting at the Natural Resources Conservation Service (NRCS)/University of Florida Institute of Food and Agricultural Sciences (IFAS) Extension Building Auditorium in LaBelle. The primary intent of this meeting was to introduce the WBWREPI scope of work to landowners and interested parties in the Western Basins. The District explained that the general project objective is to investigate opportunities for improving water quality, and that no targets were being developed for this improvement. In keeping with this objective, this report identifies potential water quality improvement measures in the region without quantifying expected TP reductions.

A second stakeholder meeting was held on January 28, 2016 at the District's Clewiston Field Station. This meeting included a progress report on the data collection and analysis completed to date, as well as a discussion of each of the eight potential water quality improvement measures identified for consideration. During the meeting, the stakeholders discussed each measure and provided feedback on viability and implementation. The District documented all comments received from the stakeholders.

There were three coordination meetings held with District staff to discuss the specifics of the potential water quality improvement projects. At the first meeting on March 8, 2016, the discussion provided agreement that there would be six measures evaluated, and that each measure evaluation would tabulate effects of treatment from water management facilities that were located outside the limits of the North and West Feeder Canal Sub-basins and accessed through a diversion of flows. Also agreed upon at the meeting was that DMSTA would not be used to evaluate the treatment effectiveness of detention facilities due to the short evaluation period and the likelihood of dry-out at the facilities.

At the second meeting on March 31, 2016, the discussion provided more detail on the potential measures and implementation. Specific information gathered during site visits on March 18th and 23rd was discussed including concerns with discharges from locations not currently documented, such as along the western boundary of the West Feeder Canal Sub-basin. During one of the site visits, a panther preserve south of the West Feeder Canal Sub-basin was identified as a potential location for storing water diverted from the Wingate Mill Canal. At the third meeting on April 19, 2016, each measure was discussed in detail and the proposed configuration for each location was agreed upon.

1.3 Watershed Management Plan Focus

The Feeder Canal and L-28 Basin basins are non-Everglades Construction Project (non-ECP) basins (i.e., basins that discharge directly into the Everglades Protection Area [EPA] without going through a stormwater treatment area [STA]). The District is required by the Florida Department of Environmental Protection (FDEP) to monitor and report on the progress to meet water quality standards in these basins, including its sub-basins.

The North Feeder Canal and West Feeder Canal sub-basins discharge through the PC-17A and WWEIR structures, respectively, and ultimately through the S-190 structure. The C-139 Annex sub-basin discharges through the USSO structure, and ultimately through the S-140 structure. The S-190 and S-140 structures discharge directly into Water Conservation Area 3A (WCA-3A). The S-190 and S-140 structures have contributed on average 9.0 and 6.7 metric tons of TP annually, respectively, to WCA-3A since 2006. **Figure 2** shows the annual TP flow weighted mean concentrations (FWMC) measured at S-190 and S-140 for the period of 2006 - 2015. The TP FWMC in water year (WY) 2015 for the PC-17A, WWEIR, and USSO structures were 228, 47, and 139 µg/L, respectively (**Figure 3**).

Considering the measured TP concentrations, the purpose of this effort is to update and expand the evaluation of water quality management measures within the Northern Reach to support the development of a Comprehensive Basin Watershed Management Plan.

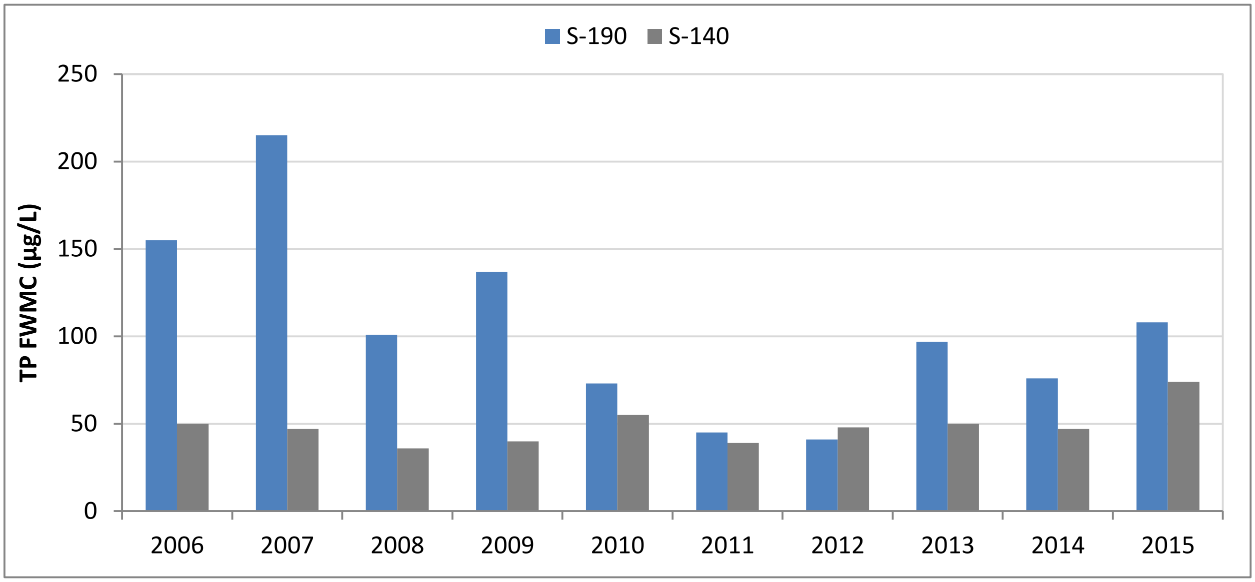

Figure 2: Annual TP FWMC for S-190 and S-140 (source: DBHYDRO)

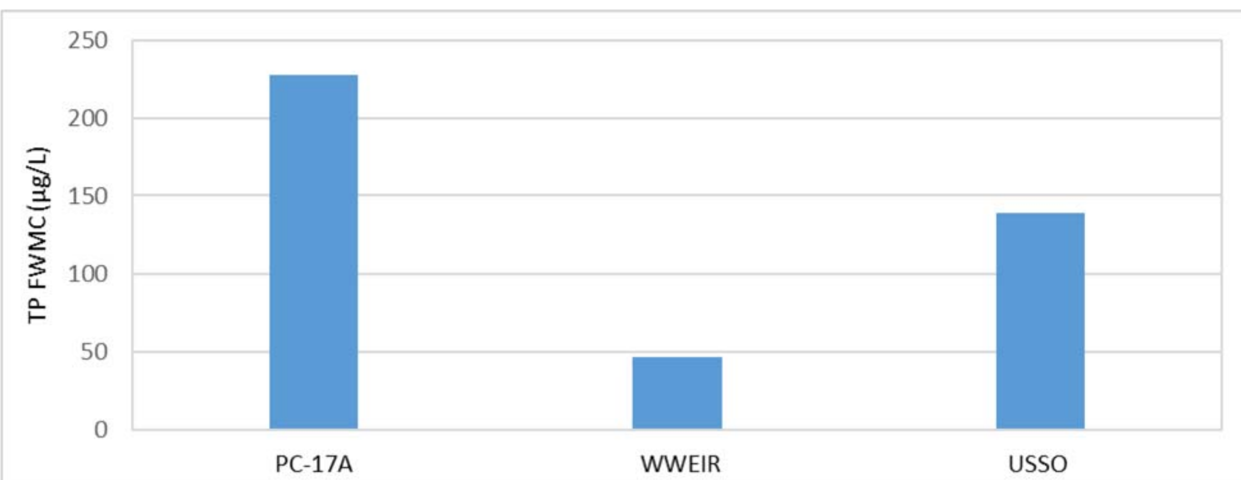

Figure 3. 2015 TP FWMC for Northern Reach Outlet Structures (source: DBHYDRO)

1.4 Indicators to Measure the Effectiveness of the Plan

The primary concern within the Western Basins is water quality; therefore, one of the key indicators to evaluate the effectiveness of a management measure is the projected TP concentration in discharges as compared to the existing condition. As data are limited in either spatial extent or period of record, the existing and projected TP concentration are often calculated based on combining the available measurements with known land uses and management practices. The second indicator evaluated is the projected volume of runoff discharge as compared to the existing condition. The seasonal timing of any changes in runoff volume are a critical consideration because the availability of runoff for consumptive uses is a concern. A third indicator evaluated is implementation cost. Some management measures require more capital investment than others and these differences affect the feasibility of implementation. The final indicator evaluated is the regulatory feasibility of implementation. The following regulatory considerations are relevant when assessing the viability of each management measure:

a. The C-139 Basin (north of the Northern Reach) is subject to a statutory requirement, Section 373.4592 (3)(f)5, Florida Statutes, that governs existing landowners and is restrictive on new surface inflows.
b. The Seminole Tribe has a legal agreement that targets a TP concentration of 50 parts per billion (ppb) for discharges from PC-17A to limit the impacts of heightened nutrient levels.
c. Stakeholders downstream of the Northern Reach have consumptive use demands that require delivery of surface flows.
d. The C-139 Annex Flow Equalization Basin (FEB) is intended to discharge to the STA-5/STA-6 facility; therefore, all flows diverted to the FEB will not be easily available for consumptive use by existing stakeholders downstream of the Northern Reach.
e. Low lying pasture lands to the south of the C-139 Annex are affected by seepage from water stored within the C-139 Annex. This outcome would negatively affect flood protection for an existing landowner such that mitigation of impacts may be required.
f. The only state-owned land within the region is the C-139 Annex and any construction or diversion proposed outside of state-ownership would require significant coordination.
g. Implementation of any measure should not negatively affect flood protection for any existing landowners.

1.5 Level of Accuracy of Data Collection

There are only two locations where hydraulic and water quality measurements are made on a continuous basis: PC-17A and WFEED. These measurement locations are at the outlets of the North Feeder and West Feeder Canal sub-basins, respectively. Continuous measurements have been recorded at PC-17A since 1999 and WFEED since 1996. In this regard, there is 17-20 years of good temporal data with minimal spatial extent because the outlet of each sub-basin does not provide detail about what is happening at a finer scale upstream. There have also been grab samples taken upstream of the outlets in each basin; however, those are at discrete times and are not sufficient to establish patterns over time. Therefore, the available data does not provide accurate information to predict the effects of upstream management measures because the forecasted runoff volumes and TP concentrations are based on blending the temporal patterns of the continuous measurement at the outlets with the spatial patterns of the discrete grab samples upstream.

2.0 Description of the Watershed

2.1 History of the Watershed

Spatial data of historical flow patterns is a useful tool in developing recommendations and concepts for water quality improvement projects. Observing and restoring historic flow paths increases the likelihood of success for any project. There are three spatial datasets that can be used to estimate historic flow paths: topography, aerial photography, and soils.

Light Detecting and Ranging (LiDAR) data for the West and North Feeder Canal sub-basins obtained in 2015 were combined with data obtained in 2013 for the C-139 Annex to create highly accurate 2 foot x 2 foot cell raster dataset for the Northern Reach. Tools in ArcGIS™ were used to create flow paths based on the LiDAR raster surface. However, because of constructed linear improvements such as roads, canals, ditches and levees, the tools cannot be used without a significant effort to erase those features. Even if the major features are removed, there have been other non-linear changes such as leveling of agricultural fields, which could skew the software results.

Unlike topography, soils information is more temporally reliable and includes information that may indicate historical hydrologic conditions. According to the Soil Survey Geographic (SSURGO) Database available through the NRCS, the soils in the Northern Reach are described as 84% sand, 8% fine sand, 5% fine sandy loam, 2% muck, and 1% not applicable or water. Although the soils are sandy in composition, they are almost exclusively Hydrogroup D soils, 77% of which are poorly drained and 23% of which are very poorly drained. The drainage condition of the soils is largely related to high water tables as evidenced by the fact that the soils in the study area are 68% hydric and 32% non-hydric. Hydric soils are soils that have been historically inundated on a seasonal basis and could indicate the presence of flow-ways.

Aerial photography, can be highly useful in estimating historic flow paths. The oldest available basin wide aerial photography in the region was taken by the U.S. military in 1940. The photograph composites were obtained from the University of Florida and rectified to match the District preferred spatial reference (State Plane Feet, NAD 83). This photography captured the region before any major improvements were made including the West and North Feeder Canals, L-28 Interceptor Canal, paved roads, and agricultural activity. The quality of the photography is fair, but suitable to discern wetland sloughs. There were no natural rivers or streams in the region.

All three of the above datasets were used to delineate estimated historical flow paths through the region. The results for each dataset are shown in **Figure 4**, **Figure 5**, and **Figure 6**. As the figures demonstrate, excess runoff was historically collected by wetland slough systems that meandered in a generally southeast direction. Some areas, such as the North Feeder Canal sub-basin, could flow in multiple directions varying from north/south to west/east. It also appears that runoff may have historically flowed from the West Feeder Canal sub-basin into the West and North Feeder Canal sub-basins and then back again, which is something that may still be occurring.

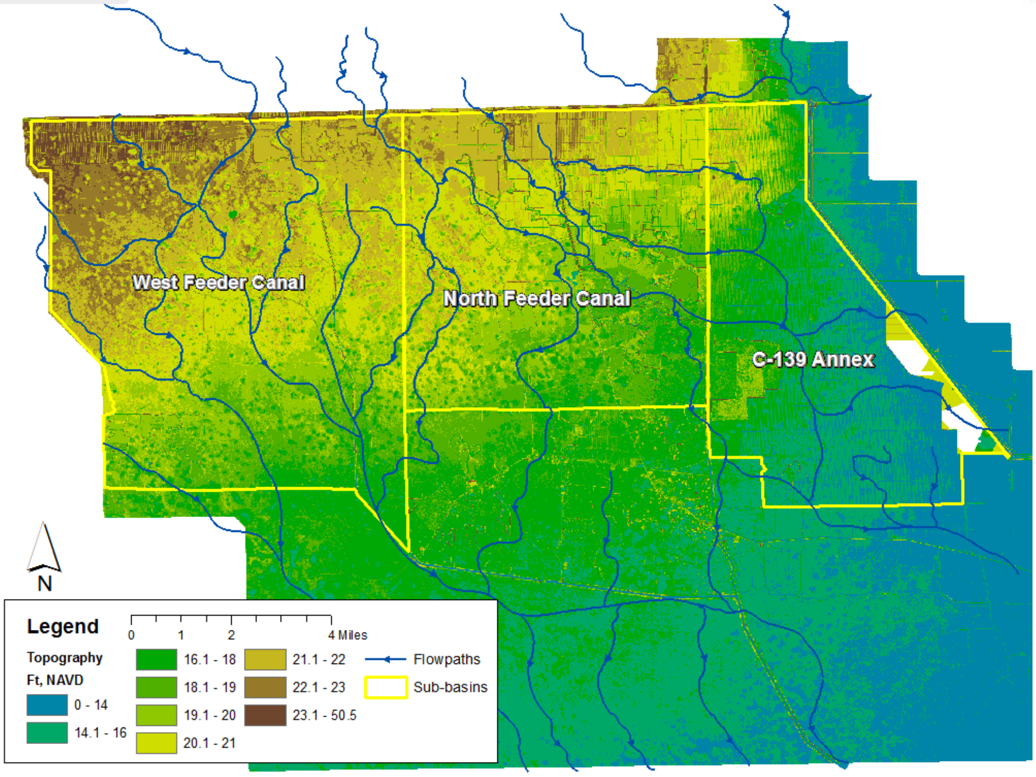

Figure 4: Historical Flow Paths on LiDAR Topography

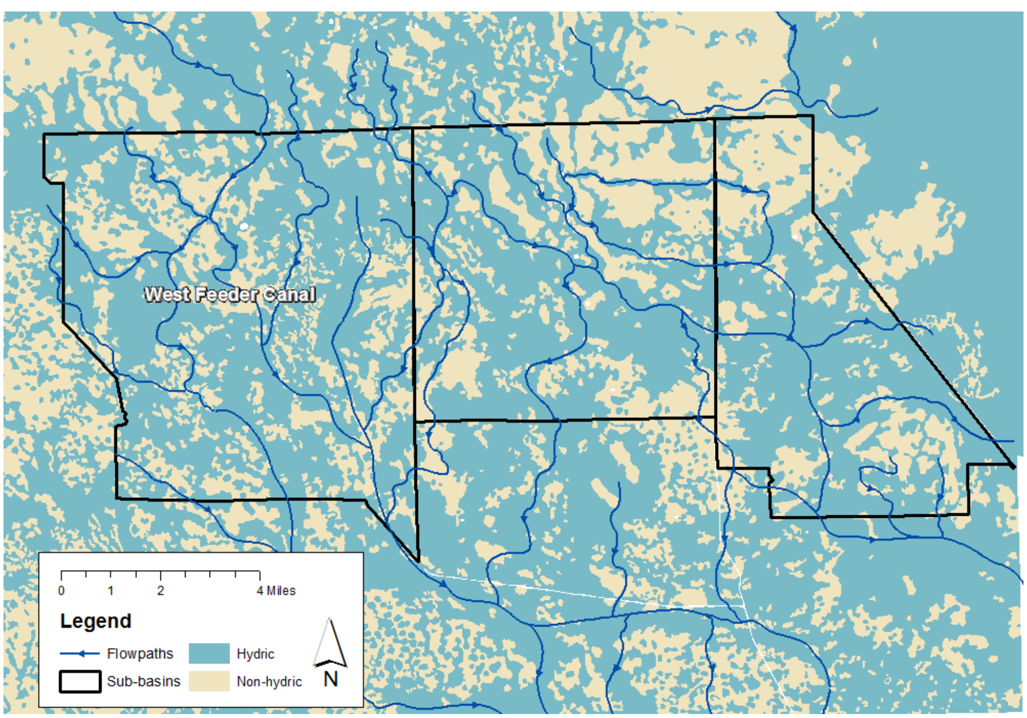

Figure 5: Historical Flow Paths on Soil Hydrology

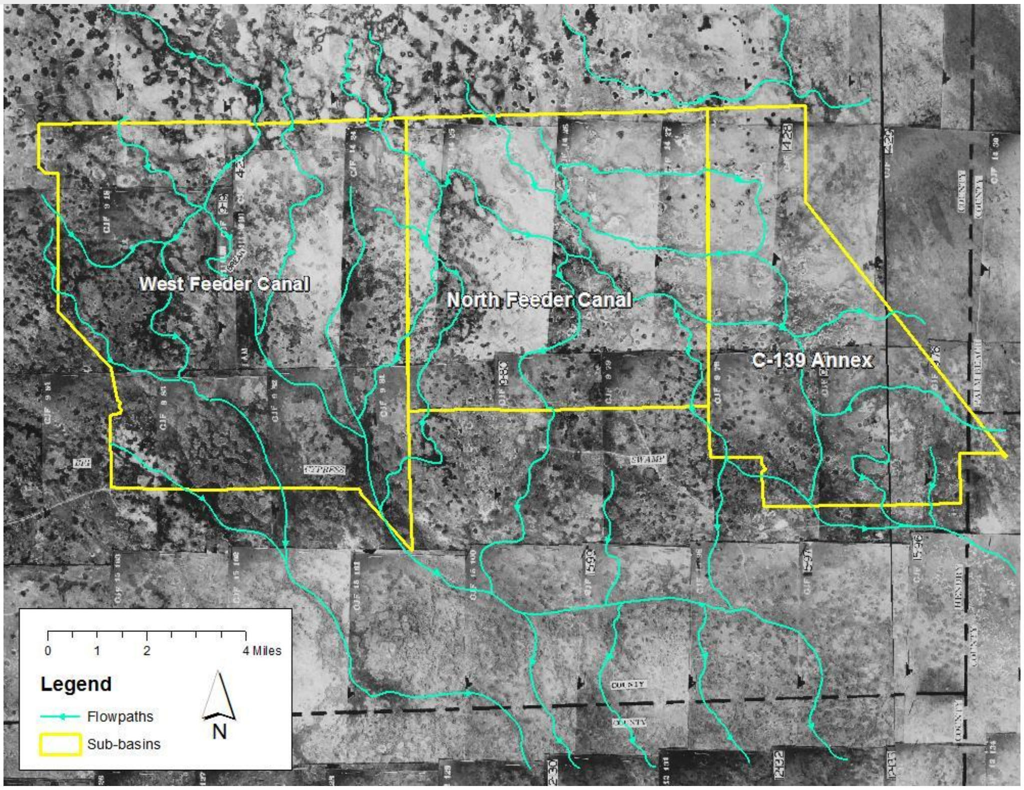

Figure 6: Historical Flow Paths on 1940 Aerial Photography

2.2 Geographic Extents

The Western Basins is located in southeastern Hendry County with portions in western Palm Beach County and northern Collier County. The Northern Reach is made up of the North Feeder and West Feeder Canal sub-basins, as well as the C-139 Annex, which are entirely contained within southeastern Hendry County. **Figure 1** illustrates the location of the 23,158-acre North Feeder Canal Sub-basin, 31,865-acre West Feeder Canal Sub-basin, and 17,993-acre C-139 Annex.

2.3 Climate

2.3.1 Rainfall

Figure 7 shows the active and inactive rainfall monitoring stations in the near the project area. **Figure 8** shows the total annual rainfall measured in three stations near the study area during the period of 1998 through 2014. The annual average rainfall is approximately 50 inches. On average, more than 30 inches of rainfall occur during the months of June to September and the driest months are November to February.

Radar-based rainfall (Next-Generation Radar [NEXRAD]) data were obtained from the District (http://www.sfwmd.gov/nexrad2) for the study area at an hourly frequency. These data are generated on a 2km x 2km spatial grid. **Figure 9** shows the spatial variation of rainfall during a large rainfall event on June 15, 2011. The figure shows a range of 0.18 to 1.64 inches of rainfall during the wettest hour of the rainfall event.

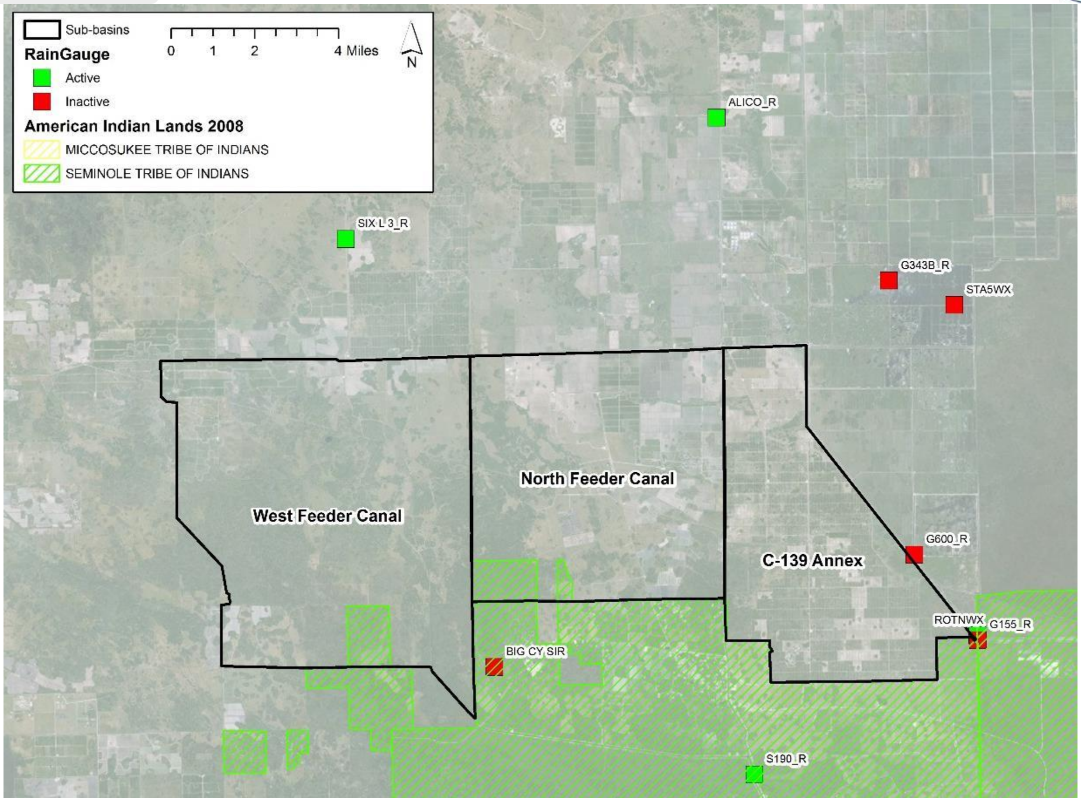

Figure 7: Rainfall Monitoring Stations

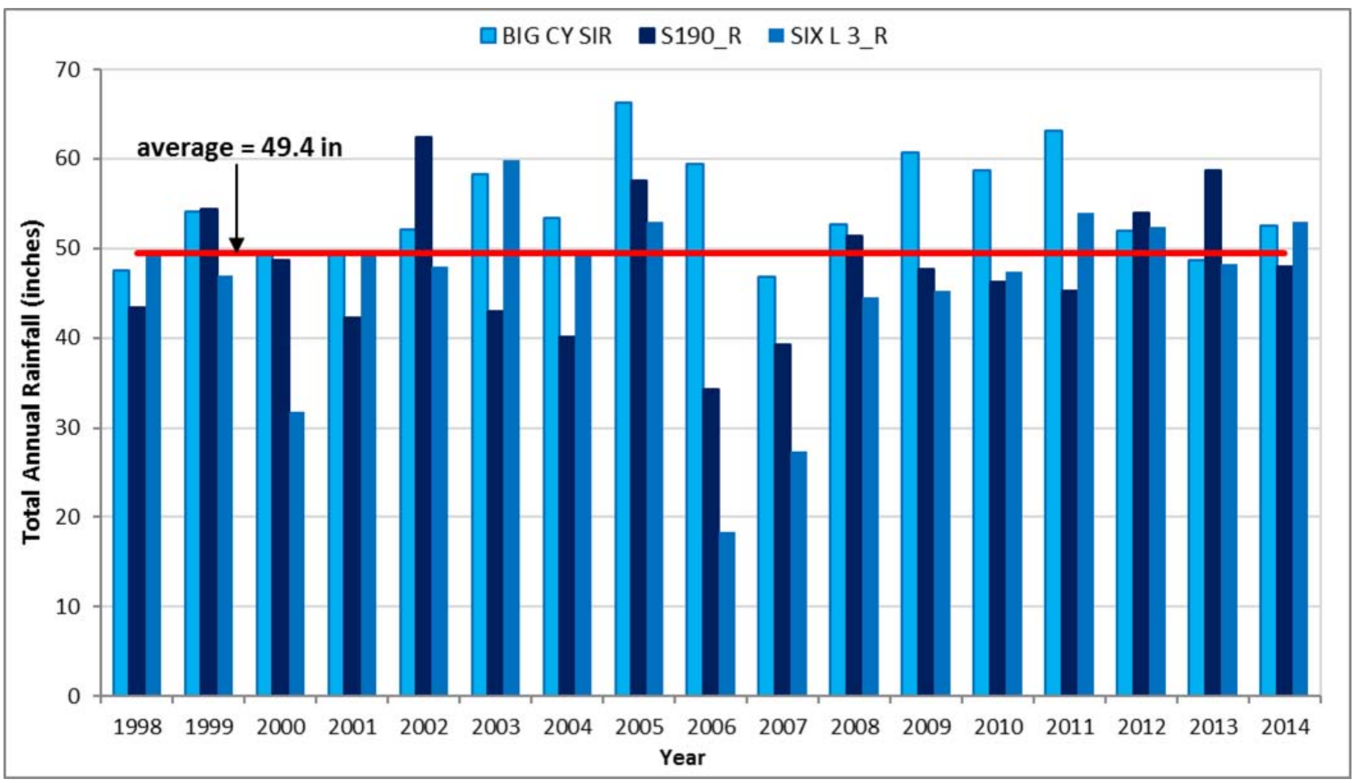

Figure 8: Annual Rainfall Measured at the BIG CY SIR, S190_R, and SIX L3_R Stations

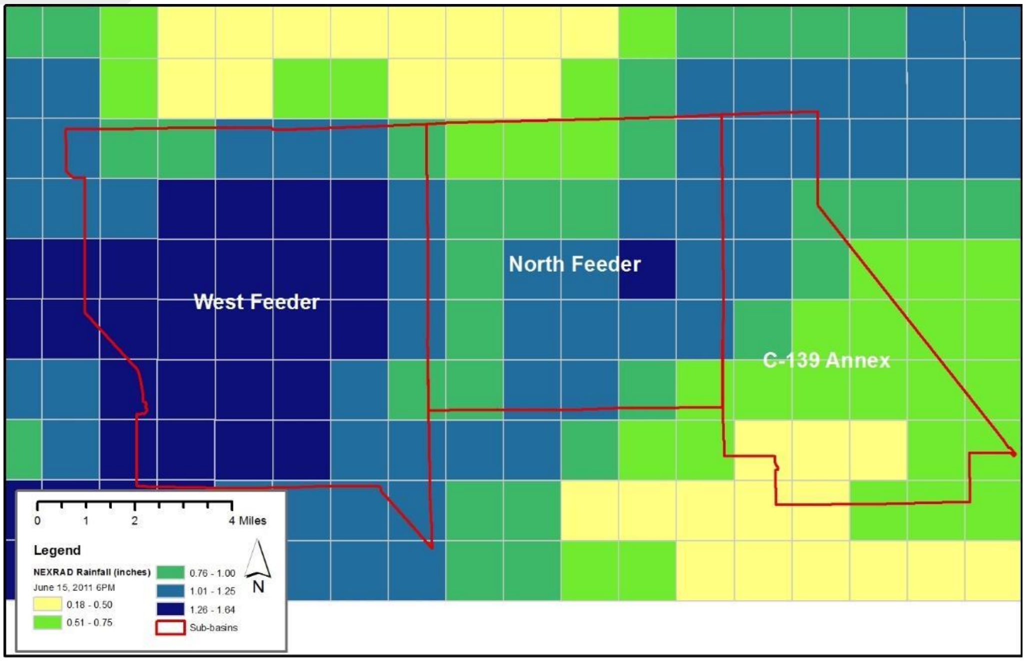

Figure 9: Spatial Distribution of Radar Rainfall Data on June 15, 2011

2.3.2 Air Temperature

Table 1 shows the average monthly mean, maximum, and minimum air temperatures measured in the BIG CY SIR station from October 1992 to April 2014. The average temperatures during June to September are near 80°F and in the mid-60s during the winter months.

Table 1: Average Monthly Air Temperatures (°F)

Month	Mean	Maximum	Minimum
January	62.3	76.0	50.7
February	64.8	78.6	52.7
March	67.4	81.1	54.8
April	71.4	85.1	58.7
May	75.5	88.9	63.9
June	78.3	90.9	69.8
July	79.3	92.1	71.3
August	79.8	92.1	72.3
September	79.0	90.3	72.0
October	75.0	86.8	66.3
November	68.7	81.3	58.9
December	64.4	77.3	53.9

2.3.3 Evapotranspiration

Figure 10 shows the total monthly potential evapotranspiration (PET) values at the BIG CY SIR and ROTNWX stations obtained from DBHYDRO for 1998 through 2013. PET time series data for the DBHYDRO stations are generated from the weather stations using the Simple Method (Abtew et al., 2002; Pathak, 2006). The largest PET monthly total values are measured during the months of April and May (approximately 5.4 inches/month), followed by June to August (approximately 4.5 inches/month), and the lowest values occur during November to January (approximately 3 inches/month). The annual average is approximately 48 inches.

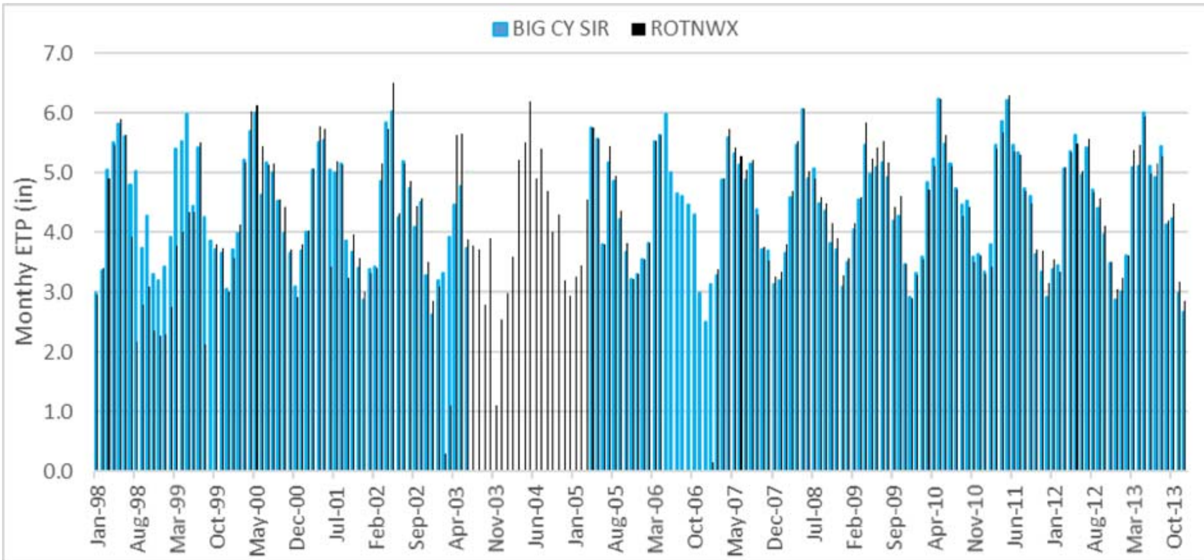

Figure 10: Total Monthly PET at the BIG CY SIR and ROTNWX Stations

Spatially distributed reference evapotranspiration (RET) data from satellite measurements were obtained from the District (http://www.sfwmd.gov/nexrad2). The data are generated using the Penman-Monteith equation using solar radiation measurements from the Geostationary Operational Environmental Satellite (GOES) system (Pathak, 2008). The data are spatially distributed in the same 2km x2 km NEXRAD rainfall grid. **Figure 11** shows a comparison between the satellite data and the BIG CY SIR weather station data from June 2011 through April 2014. The maximum and average absolute differences in the monthly totals are 0.8 and 0.2 inches, respectively.

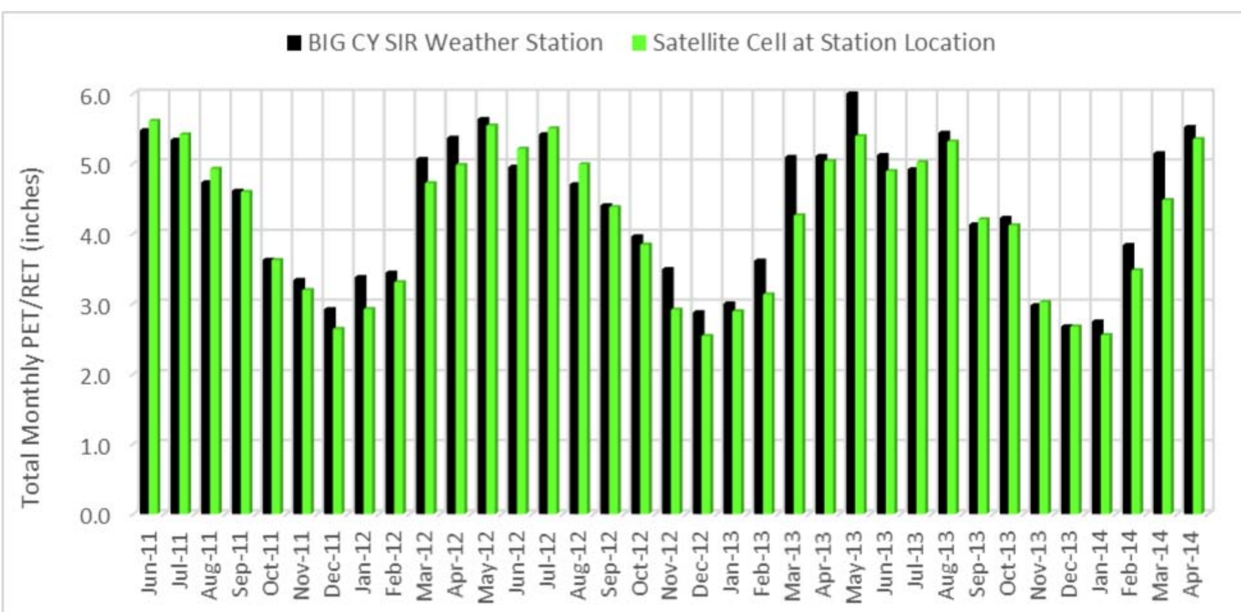

Figure 11: Comparison of RET from Satellite vs. PET from the BIG CY SIR Weather Station

2.4 Topography

In the summer of 2015, the District's subcontractor (WGI/Pickett & Associates) acquired LiDAR data for the Northern Reach study area with the exception of the C-139 Annex sub-basin. These data were collected with the intention of producing a Digital Elevation Model (DEM) in the North American Vertical Datum of 1988 (NAVD88) with an absolute horizontal accuracy of 1-foot or better at 95% the confidence interval and with an absolute vertical accuracy of 0.4' or better root mean square error (RMSE), which correlates to 0.6 feet at 95% confidence interval. The data were gathered using an Optech Orion M300 LiDAR sensor and CS-10000 digital camera (80MP). Sensor parameters were as follows:

- Flying height 2,500 feet above ground level
- Air speed 100 knots
- Camera focal length 70.3mm
- Field of view 40° (±20°)
- System PRF 300 kHz
- Scan frequency 50 Hz
- Side lap 40%
- Power high
- Roll compensator on
- Mean point density 10.82 pts/m2 on a single pass

The raw data were calibrated with ground survey points and refined such that the final overall density of the LiDAR point cloud within the project boundary is 1.768 points per square foot (19.031 points per square meter), having an estimated ground sample distance of 0.752 feet (0.241 meters). The point cloud was classified into ground, non-ground, and water features. Hydrologic break lines were also created at water boundaries for ponds, ditches and creeks.

The Fundamental Vertical Accuracy (Category 1) for the data was found to be 0.268 feet at the 95% confidence interval. The Consolidated Vertical Accuracy (CVA) and the Vegetated Vertical Accuracy (VVA) at the 95% confidence interval was found to be 0.475 feet and 0.577 feet, respectively. These results were better than the target accuracy for the topographic data collection effort and, as such, are more than sufficient for use in the WBWREPI effort.

LiDAR results for the West and North Feeder Canal Sub-basins were combined with previous LiDAR datasets including LiDAR of the C-139 Annex Sub-basin, which was produced in 2013 by GMR Aerial Surveys, Inc. (dba Photo Science). The combined information was used to generate a DEM with 2-foot spacing (**Figure 12**). The report submitted with the data indicates that there is a 95% percent confidence level for both vertical and horizontal accuracies. In the report it was noted that the data for Ponds 5-N and 5-S were removed and that conventional survey techniques should be used in those areas. This is presumably due to the submerged nature of the ponds. Upon review of the remainder of the data, it appears that Pond 3 may not reflect bare earth elevations, perhaps because it was also submerged or because the vegetation could not be penetrated.

The LiDAR data are a useful tool in understanding the drainage patterns and features that are not documented, such as berms and ditches within unpermitted areas. The resolution of the LiDAR data is high enough to make it possible to extract topographic features that resulted from anthropogenic activities associated with farming. The data can also be useful in locating low points in roadways where flow can pass. ESRI™ Spatial Analyst focal and surface functions will be used in subsequent tasks to extract this information.

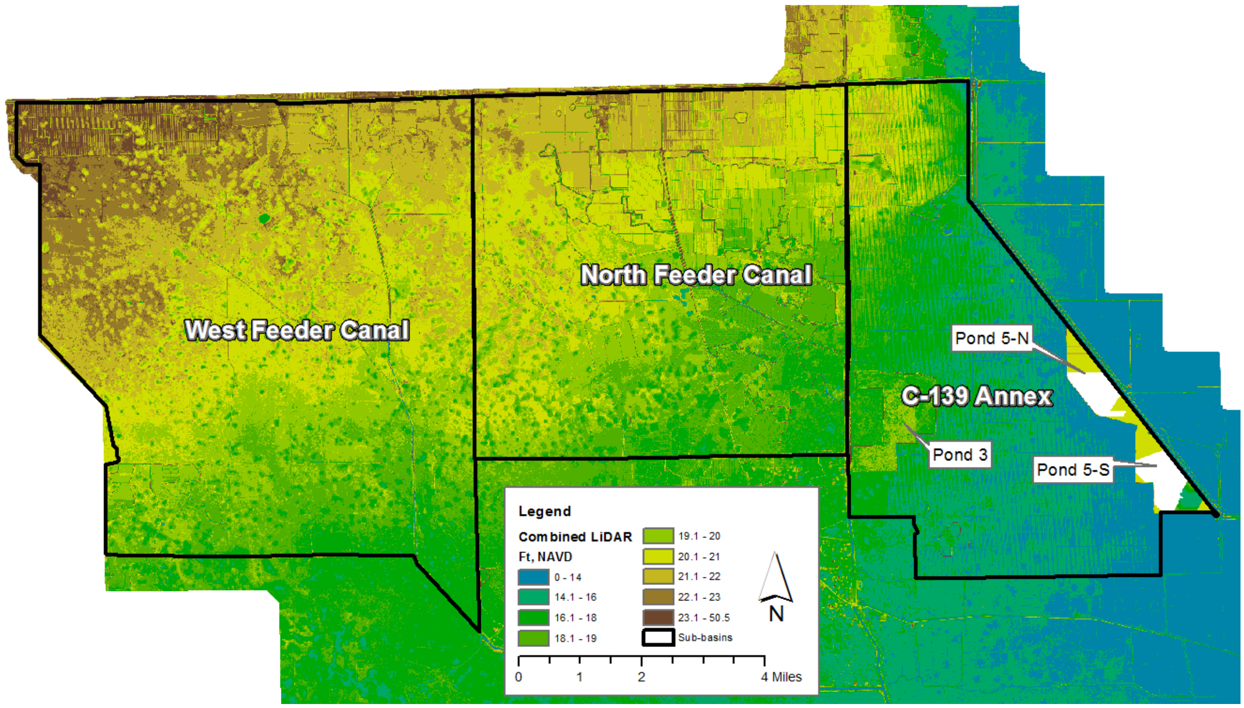

Figure 12: Northern Reach LiDAR Topography

2.5 Soil Types

A soils map was generated based on the NRCS SSURGO map unit database for the model area (available at http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/survey/). There are 40 soil types (NRCS map units) in the Northern Reach. **Figure 13** shows the soils spatial distribution in the model area lumped into general soil types (sand, fine sand, muck, etc.). For each type, the soil input parameters (water content at saturation [Θ_S], field capacity [Θ_{FC}], wilting point [Θ_{WP}], and the saturated hydraulic conductivity [K_S]) has been extracted from the NRCS database. The database contains several soil horizons for each map unit, and each horizon has a “low,” “high,” and “representative” value for each parameter. The map unit symbols, names, average of the representative values for all soil horizons within a map unit are shown in **Table 2**.

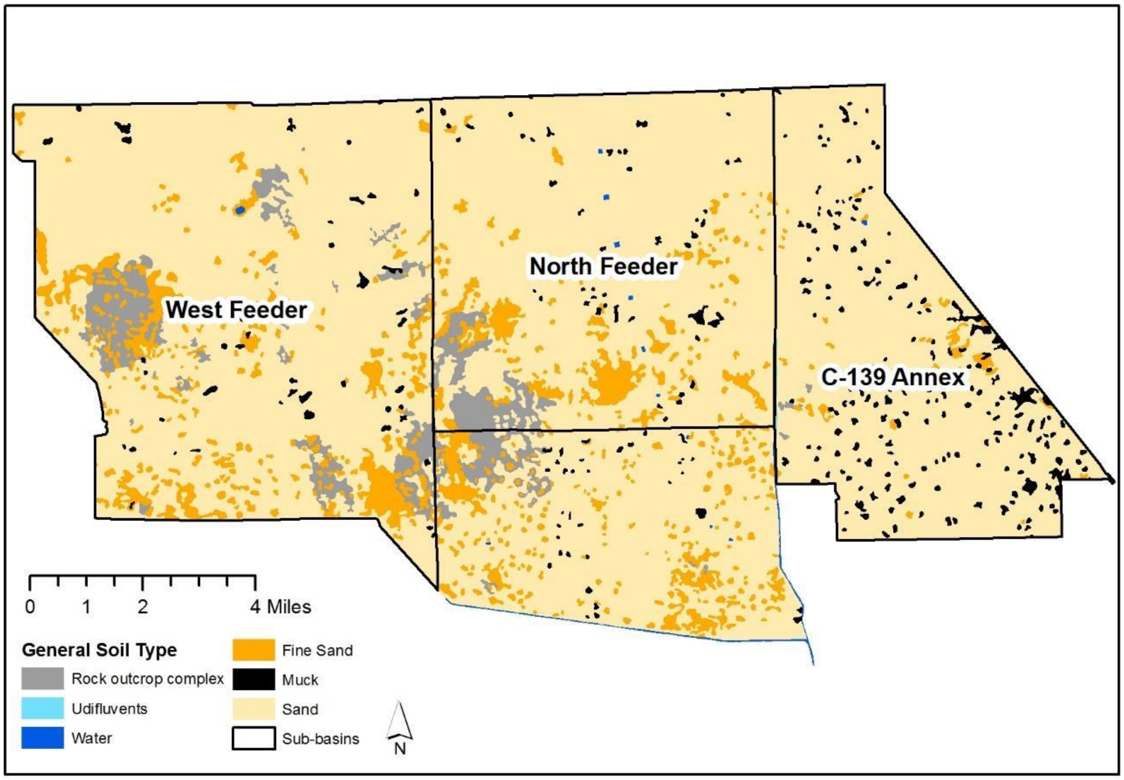

Figure 13: General Soils Map (NRCS SSURGO map units lumped into general categories)

Table 2: Average Values of Various Soil Parameters in the NRCS Database Map Unit (MU) Soil Horizons

MU	Map Unit Name	K_S[1]	Θ_S[2]	Θ_{FC}[2]	Θ_{WP}[2]
1	Boca sand	16	13	10	4
2	Pineda sand, limestone substratum	18	12	10	4
4	Oldsmar sand, 0 to 2 percent slopes	20	13	11	5
6	Wabasso sand, 0 to 2 percent slopes	20	13	11	5
7	Immokalee sand, 0 to 2 percent slopes	22	14	11	4
8	Malabar sand	19	12	9	4
9	Riviera fine sand, 0 to 2 percent slopes	18	13	11	5
10	Pineda fine sand, 0 to 2 percent slopes	20	12	9	4
13	Gentry fine sand, depressional	13	21	18	9
14	Wabasso sand, limestone substratum	17	17	15	7
15	Myakka sand, 0 to 2 percent slopes	21	13	10	4
17	Basinger sand, 0 to 2 percent slopes	23	12	9	4
19	Gator muck	17	48	45	22
20	Okeelanta muck	21	30	28	13
21	Holopaw sand	18	13	10	4
23	Hallandale sand	21	11	9	3
24	Pomello fine sand, 0 to 5 percent slopes	27	10	7	2
26	Holopaw sand, limestone substratum	20	12	9	4
27	Riviera sand, limestone substratum	16	17	14	7
28	Boca sand, depressional	21	17	15	7

MU	Map Unit Name	K_S[1]	Θ_S[2]	Θ_{FC}[2]	Θ_{WP}[2]
29	Oldsmar sand, limestone substratum	19	11	9	4
32	Riviera sand, depressional	17	13	11	5
33	Holopaw sand, depressional	19	12	9	4
34	Chobee fine sandy loam, limestone substratum, depressional	16	25	22	11
37	Tuscawilla fine sand	19	12	10	4
39	Udifluvents	15	13	11	5
42	Riviera sand, limestone substratum, depressional	17	16	13	6
44	Jupiter fine sand	14	14	12	5
45	Pahokee muck, drained, 0 to 1 percent slopes	22	54	45	25
50	Delray sand, depressional	18	22	19	9
51	Malabar fine sand, high, 0 to 2 percent slopes	24	12	10	4
57	Chobee fine sandy loam, depressional, 0 to 1 percent slopes	17	25	22	11
63	Jupiter-Ochopee-Rock outcrop complex	19	13	10	4
64	Hallandale sand, depressional	19	17	15	7
65	Plantation muck	24	24	22	10
66	Margate sand	23	22	19	9
67	Lauderhill muck	23	45	42	20
68	Dania muck	26	41	38	18
69	Denaud-Gator mucks	17	18	16	8
70	Denaud muck	16	19	16	8

[1] K_S – saturated hydraulic conductivity (ft/day)

[2] Θ_S, Θ_{FC}, Θ_{WP} – moisture content at saturation, field capacity, and wilting point, respectively (%)

2.6 Geology and Aquifer Characteristics

The upper hydrogeology of the region (depths generally above 200 feet) is defined in terms of three aquifers layers (the water table aquifer, Lower Tamiami aquifer, and Sandstone aquifer) and two confining units (the Tamiami and Upper Hawthorn). Groundwater abstractions for agricultural use are mostly from the Lower Tamiami aquifer. The presence of the Sandstone aquifer is only significant in the western portions of the subject area; however, there is a fairly large area in the north-central portion of the model area where the Upper Hawthorn confining unit between the Lower Tamiami aquifer and the Sandstone aquifer is not present. Elevations for each hydrogeologic unit are available in a report titled Hydrogeologic Unit Mapping Update for the Lower West Coast Water Supply Planning Area (Geddes et al., 2015). **Figure 14, Figure 15**, and **Figure 16** show the thickness of the water table aquifer, Tamiami confining unit, and Lower Tamiami aquifer, respectively.

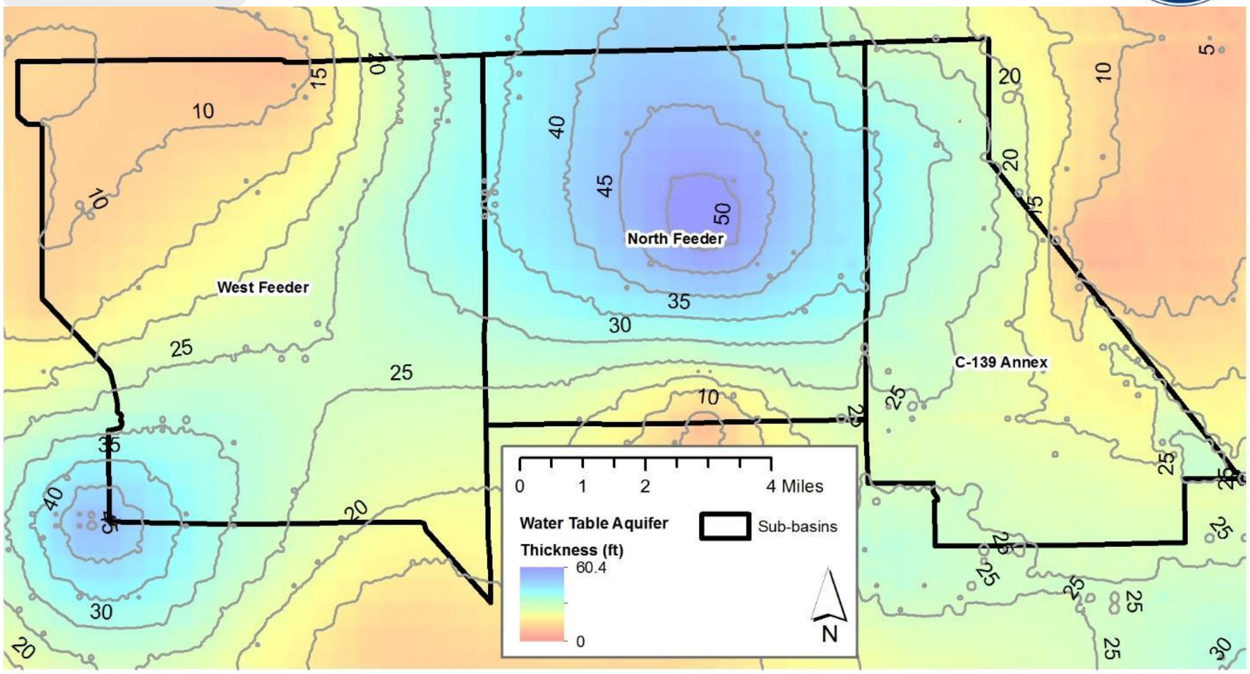

Figure 14: Thickness of the Water Table Aquifer

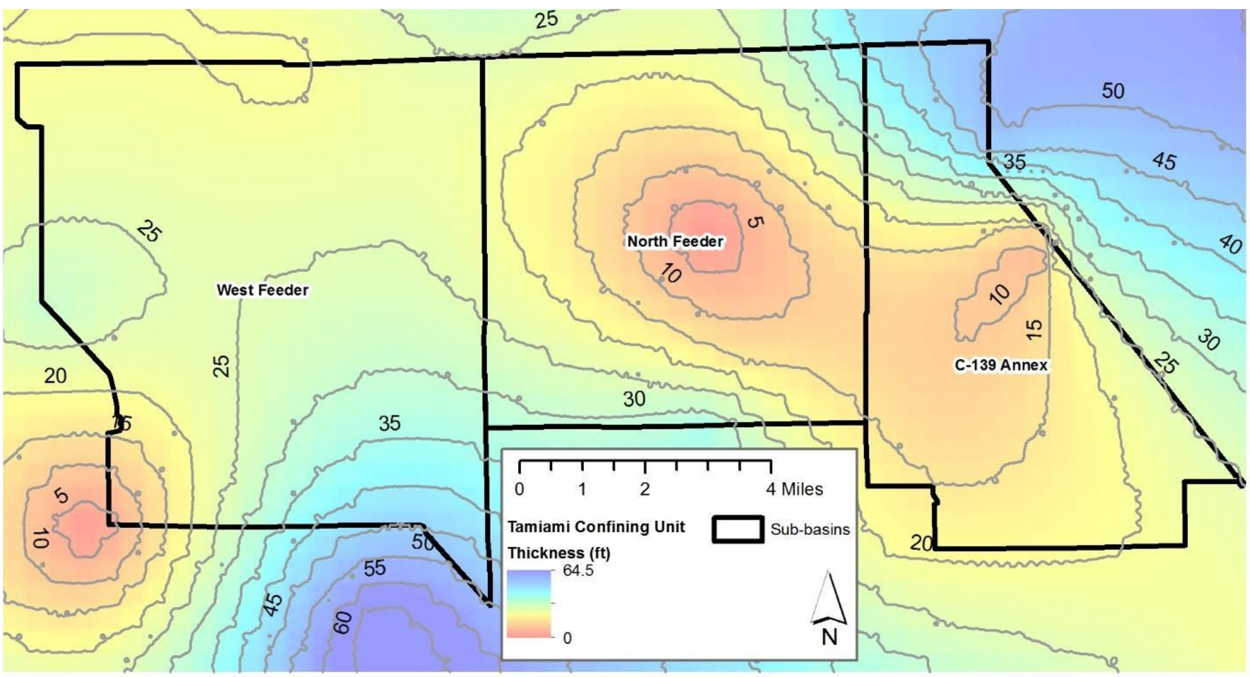

Figure 15: Thickness of the Tamiami Confining Unit

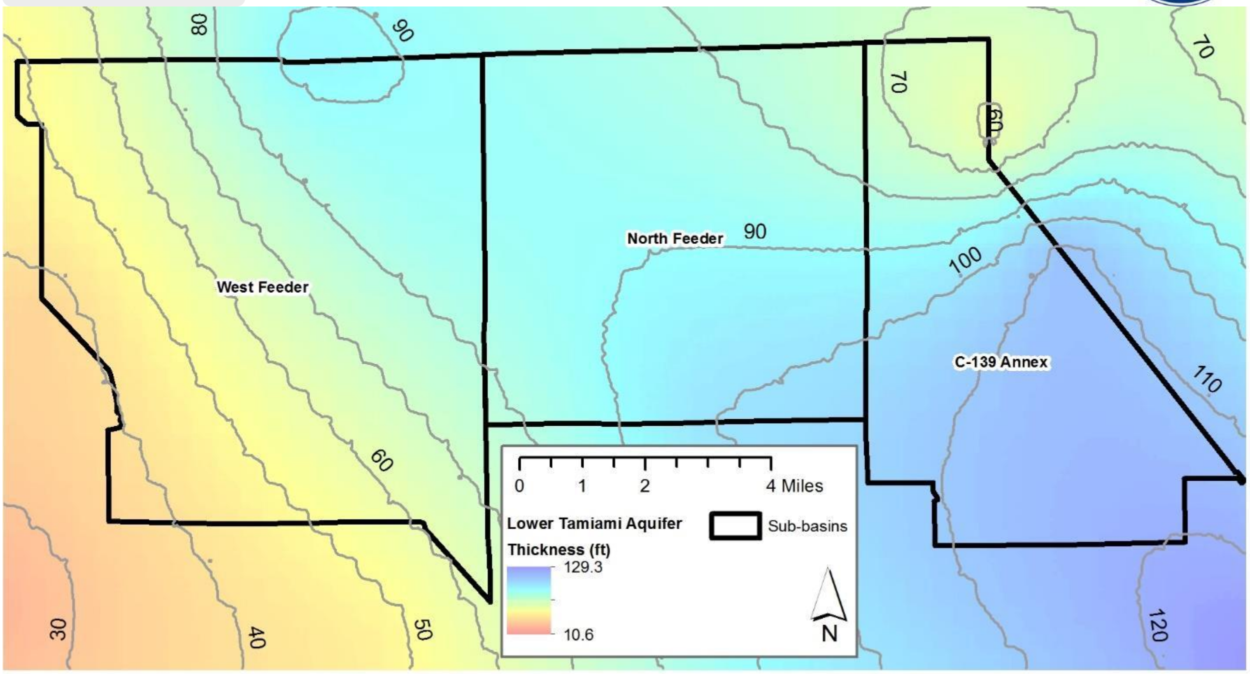

Figure 16: Thickness of the Lower Tamiami Aquifer

Measurements of aquifer parameters (hydraulic conductivities and storage coefficients) are not widely available. Spatially distributed transmissivities for each of the hydrogeologic layers were obtained from the SFWMD LWC MODFLOW model and converted to horizontal and vertical hydraulic conductivities (**Table 3**).

Table 3: Range of Hydraulic Conductivities from the LWC MODFLOW Model

Conductivity (ft/d)	Minimum	Maximum	Average
Water Table Aquifer Horizontal	0.1	150	10
Water Table Aquifer Vertical	0.1	10	1
Tamiami Confining Unit Horizontal	0.02	2.5	0.05
Tamiami Confining Unit Vertical	0.005	0.5	0.01
Lower Tamiami Aquifer Horizontal	100	5,000	800
Lower Tamiami Aquifer Vertical	10	500	80

2.7 Hydrology

The Northern Reach is divided into three sub-basins: West Feeder Canal, North Feeder Canal, and C-139 Annex. Each of the sub-basins generally flow in the same direction, north to south/southeast, and discharge through a single structure. Internally, each sub-basin includes sub-areas that have been established based on natural drainage divides, permitted water management systems and other anthropogenic features, such as roads and berms along property lines. The sub-areas for the West and North Feeder Canal sub-basins were delineated in a 2002 study performed by the District (SFWMD, 2002), but may be refined as a result of the new LiDAR topography. It should be noted that it is possible that flows are exchanged between the West and North Feeder Canal sub-basins depending on the distribution of rainfall in the area. The sub-areas for the C-139 Annex sub-basin were based on permitted drainage area delineations. The sub-basins and their sub-areas are shown in **Figure 17** and are described in more detail below.

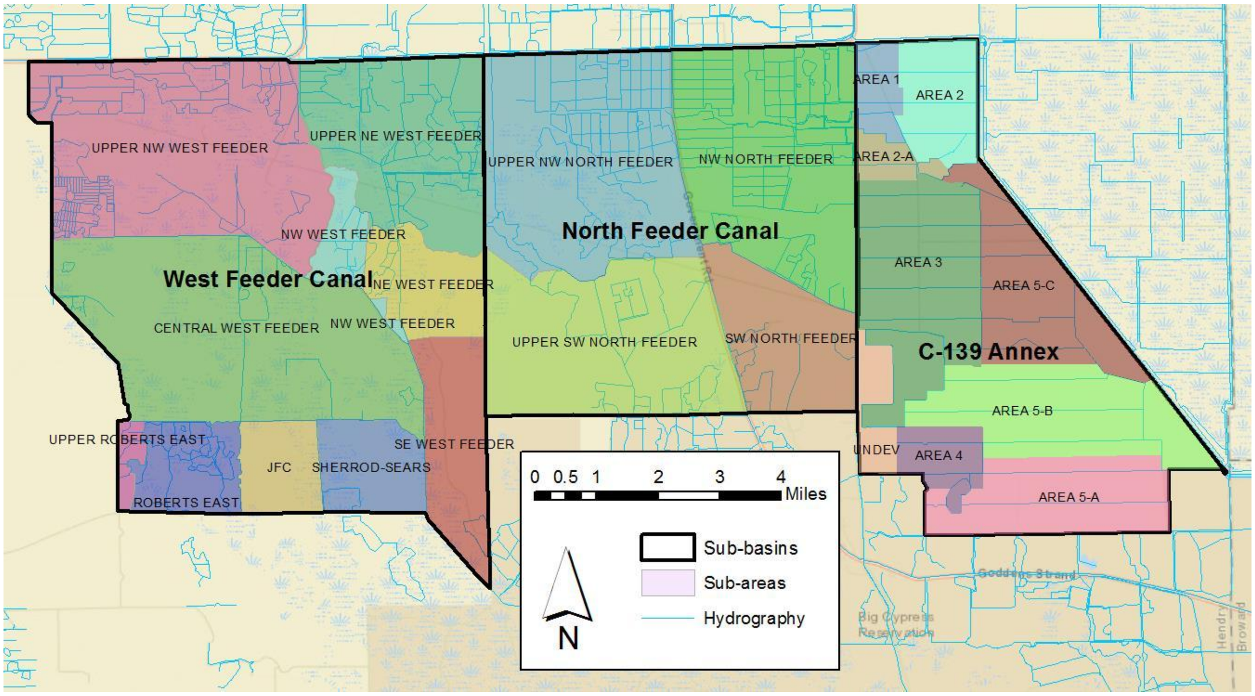

Figure 17: Northern Reach Sub-basins and Sub-areas

2.7.1 West Feeder Canal

The West Feeder Canal Sub-basin includes 32,200 acres of mixed agricultural land uses such as pasture, citrus, and row crops. There are several permitted farms in the sub-basin that include water management systems with reservoirs and control structures. These farms are located in one of two locations: the northern extent just south of the Deer Fence Canal (outside the Northern Reach), or the southernmost extent north of the Wingate Mill Canal (inside the Northern Reach). The northern farms, which include Crows Nest Grove, are associated with the Upper NW and NE West Feeder sub-basins. Discharges from the northern farms are routed south through natural sloughs. The natural slough systems in the West Feeder Canal Sub-basin include Tony Strand and Boggy Slough (see **Figure 18**).

An interesting geologic feature in the Upper NW West Feeder sub-area is an 880-foot diameter lake known as Rocky Lake which was formed by a sink hole and is approximately 50 feet deep based on U.S. Geologic Survey (USGS) soundings. Based on the LiDAR, the lake does not have a large catchment area associated with it. The LiDAR detected a surface water elevation of 17.5 feet, NAVD.

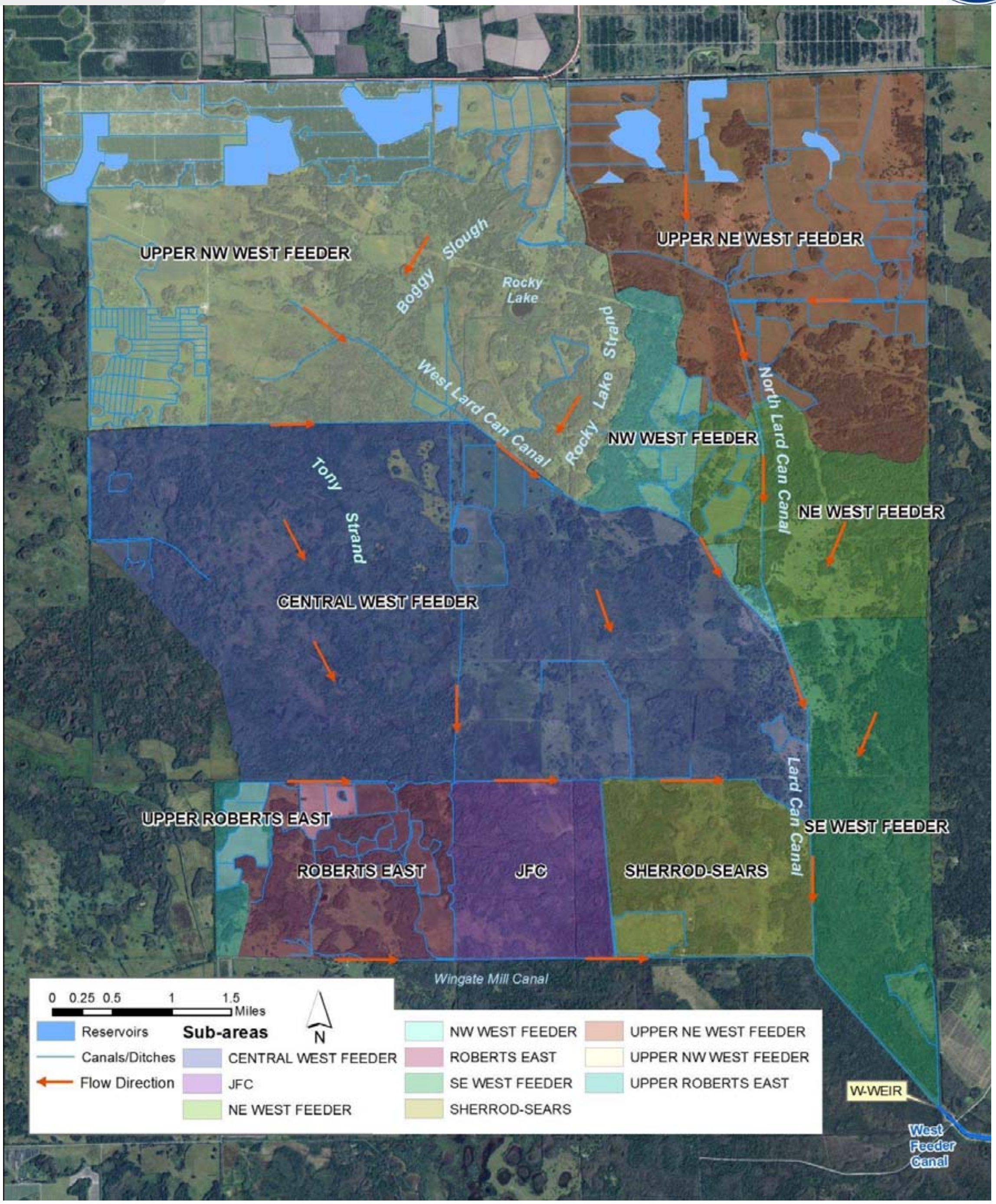

Figure 18: Drainage Patterns in the West Feeder Canal Sub-basin

The majority of the natural systems in the West Feeder Canal Sub-basin discharge to the Lard Can Canal. The Lard Can Canal traverses through the sub-basin flowing from north to south through an area previously referred to as Lard Can Slough. The canal is split into northern and western reaches in the northern portion of the sub-basin. The Immokalee Ranch and the Cow Bone Slough cattle operation are located in the vicinity of the canal within the Central West Feeder sub-basin. The Lard Can Canal is privately owned and maintained and has at least six separate owners based on the location upstream.

The southern portion of the sub-basin is drained by Wingate Mill Canal which flows from west to east and discharges into Lard Can Canal. As shown in **Figure 18**, the southern area is defined by the JFC, Roberts East, and Sherrod-Sears sub-areas. Wingate Mill Canal collects drainage from farms located on the northern side of the canal such as Giddens Ranch, which has 1,600 acres of pasture in the JFC sub-area. The Wingate Mill Canal is privately owned and maintained and has fourteen separate owners based on the location upstream.

The Lard Can Canal continues in a southeast direction and discharges to the West Feeder Canal, which is privately owned and maintained by the Miccosukee Tribe up to the WWEIR structure (**Figure 19**), which consists of a 136-foot long steel sheetpile weir with a crest elevation of 16.9 feet, NGVD (15.5 feet, NAVD). This structure is also referred to as the West Weir, Feeder Weir, and L-28 Weir.

Figure 19: WWEIR Structure (Looking North and Upstream)

2.7.2 North Feeder Canal

The majority of the North Feeder Canal Sub-basin is often referred to as McDaniel Ranch due to the past ownership of the land. The original ranch has been subdivided and sold or leased to other entities, but the active farming areas such as Garcia Farms and Property NW are still covered by Permit 26-00623-P. As is seen in **Figure 20**, the 22,977-acre sub-basin can generally be described as being less developed west of County Road 833 and as having active agriculture in the eastern portions, although there is some agriculture occurring in the northwestern portion of the sub-basin.

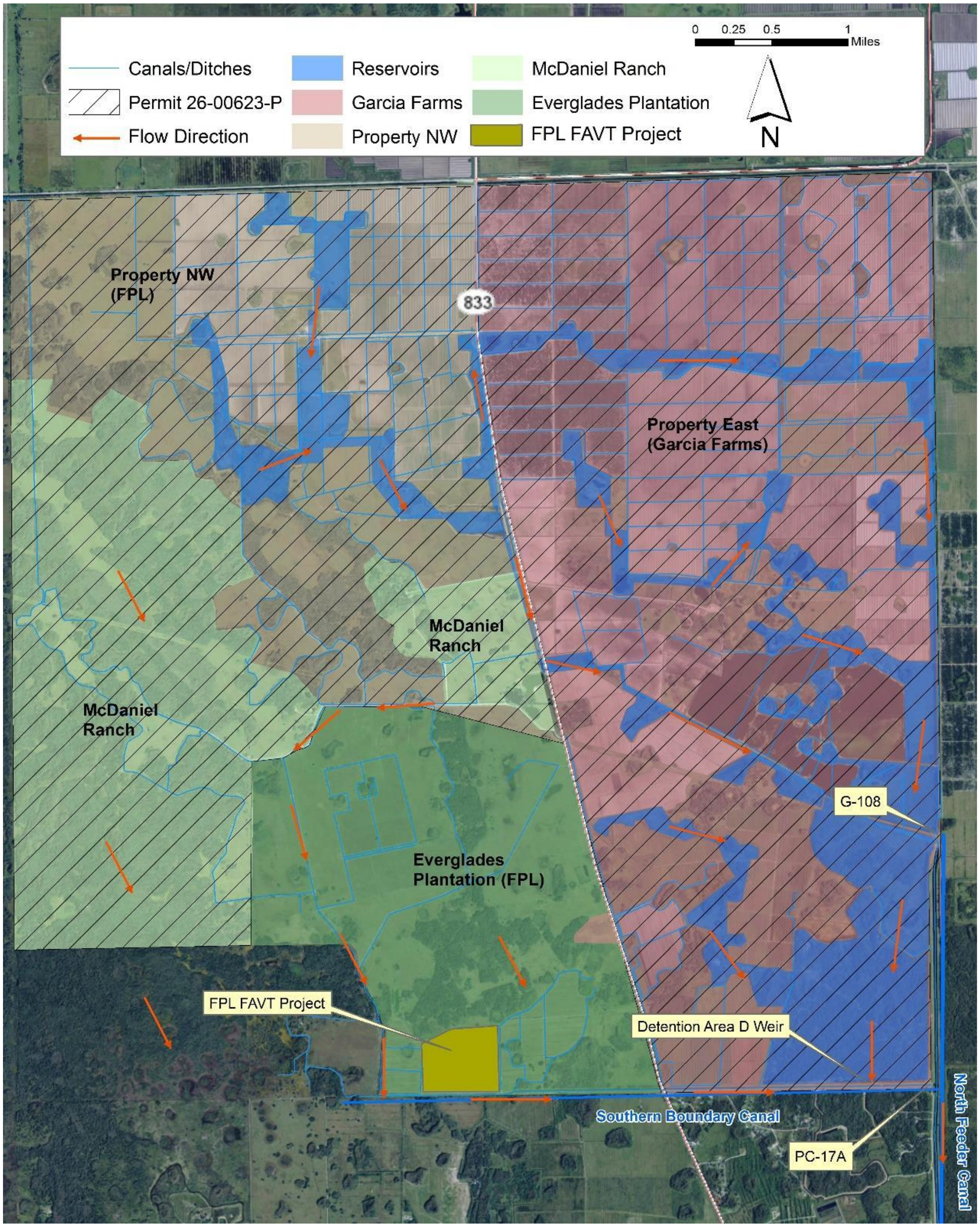

Figure 20: North Feeder Canal Sub-basin Parcels and Existing Water Management

Flow is from north to south and is collected by a canal known as Southern Boundary Canal, which is privately owned and maintained. The developed portions drain through a series of cascading reservoirs that discharge from Detention Area D through an outfall structure owned by Garcia Farms (Detention Area D Weir, a.k.a. W-D Structure) to the Southern Boundary Canal. The Detention Area D Weir consists of two twin 72-inch risers with 60-inch diameter corrugated metal pipe (CMP) culverts. The risers are normally set at elevation 19.0 feet, NGVD (17.6 feet, NAVD). This structure replaced another structure in 2011 that was restricted by a 48" CMP culvert.

The Southern Boundary Canal also accepts sheetflow from natural areas to the west, as well as some potential inter-basin runoff from the northeastern headwaters of Lard Can Canal. The Southern Boundary Canal flows west to east and discharges into the North Feeder Canal through Structure PC-17A. This structure, as shown in Error! Reference source not found., includes four gates that discharge to two 81-foot long, 72-inch diameter culverts. The original design of this structure by USACE was based on an assumed runoff of 135 cfs for a 10-year design storm for a 4.5 square-mile drainage area (USACE, 1963). Each gate is operated by installing or removing plates that are 44 inches wide by 36 inches high and fit into half of a vertical riser. The normal operation of the structure is to be set at 16.6 feet, NAVD in the dry season and at 13.6 feet, NAVD in the wet season. However, this may vary based on requests from the landowners.

Figure 21: PC-17A Control Structure

In 1996, the surface water permit was modified to reflect a landowner agreement between McDaniel Ranch and the Seminole Tribe of Florida to work cooperatively to reduce the amount of phosphorus produced by human activities on McDaniel Ranch. McDaniel Ranch and the Tribe agreed to set a target concentration (50 ppb) to gauge the effectiveness of various water management activities and best management practices (BMPs) (see Section 4.0).

In January 1999, McDaniel Ranch was issued permit #26-00623-P covering a total area of 21,596.80 acres, which superseded permit # 26-00239-S issued in May 1996 covering an area of 6,499 acres. The 1999 permit included provisions for pumping discharges from farm fields and native areas to pre-treatment detention ponds which would provide attenuation, treatment, and polishing of the water prior to discharging from the site, in response to the requirement of the 1996 Landowner Agreement between the Tribe and McDaniel Ranch. In July 2006, McDaniel Ranch was issued a modification to permit #26-00623-P, which did not include the areas sold to the Everglades Plantation (approximately 3,100 acres) and did not include pre-treatment ponds for areas within the ranch that were native lands or were used for cow pasture. McDaniel Ranch substantially completed construction of the surface water management systems by May 2007. Between 2007 and 2011, McDaniel Ranch applied for several modifications to the permit to expand row crop areas and relocate or change control structures. In 2013, most of the areas east of CR-833 were sold to Garcia Farms and the northwest portion of the property was sold to Florida Power & Light (FPL). McDaniel Ranch still owns some of the native and pasture areas. Although the ownership of portions of McDaniel Ranch has changed since 1999, the compliance target identified in the 1996 Landowner Agreement remains in place.

Another structure, G-108 as shown in **Figure 20**, was located at the headwaters of the North Feeder Canal. The structure had two 72-inch risers with plates that act as gates. The gates were either in the open or closed position allowing water to flow over the top of the plates, if closed, or over the top of the sill, if open. As part of the 2006 permit modification issued to McDaniel Ranch, most of the discharges from the surface water management system were to be routed to Structure W-D which discharges to the Southern Boundary Canal that then discharges into the North Feeder Canal by way of PC-17A. To that end, a new structure (W-D1AB) was installed upstream of G-108. Structure W-D1AB has an overflow elevation of 22.6 feet, NAVD and is expected to pass less than 20 cfs during a 25-yr, 3 day storm. Thus, the G-108 structure was no longer needed and was removed in April 2010. No discharge has occurred through the new structure W-D1AB since it was installed in May 2007.

In August of 2015, a water use permit (26-01205-W) was issued to FPL for a 140-acre nutrient removal project using a Floating Aquatic Vegetation Tilling (FAVT) system with an annual allocation of 5,829.05 million gallons. The project will be located in the southern portion of FPL's property (see **Figure 20**) and will consist of wetland cells which will be utilized to remove nutrients from the surface water in order to improve water quality and establish a viable submerged aquatic vegetation community. A 20 cfs inflow pump will pump water from an onsite pasture ditch. Two inflow pumps (20 cfs and 40 cfs) will also pump water from Southern Boundary Canal into the project. The water will be circulated through the treatment system and discharged back to the Southern Boundary Canal. The project was issued an agricultural exemption permit (26-00002-K, application #150302-16) in April of 2015 and construction is anticipated to occur in 2016.

2.7.3 C-139 Annex

C-139 Annex was formally owned and operated by U.S. Sugar Corporation (see Appendix A for permit history) and purchased by the District with the intent of building a FEB and for site restoration (SFWMD, 2012). Most of the sub-basin is still operated as a citrus grove where drainage is collected by a system of ditches and canals and cascaded through reservoirs via pump stations and gravity structures that ultimately discharge through the USSO structure.

The C-139 Annex Restoration Project will restore the citrus grove into approximately 14,500 acres to an upland/wetland mosaic. Current conditions consist of approximately 6,500 acres of groves, 2,000 acres of District-controlled acreage, and 6,000 acres of abandoned or non-farmed land. Current flows from the C-139 Annex outflow structure (USSO) are expected to be reduced and the TP concentrations are expected to improve (i.e. decrease) as compared to historical values.

The northern 2,800 acres of the 17,900-acre C-139 Annex is planned for a future FEB. As described in the Restoration Strategies Regional Water Quality Plan (2012), the FEB will utilize a 1,000 cfs pump station to move water from the Deer Fence Canal into a roughly 2,400-ac treatment zone and a 400-acre "deep zone" before being discharged for treatment by the STA-5, Compartment C, STA 6 complex. The discharges could be directed to the treatment facilities through either the L-3 Canal just south of G-406 or through the Deer Fence Canal and the G-508 pump station.

The remainder of the watershed will be restored in two phases as shown on **Figure 22**. Phase 1 restoration design is underway and will be followed by site clearing, levelling, backfilling canals, degrading levees to restore sheetflow and micro topography earthwork to restore interconnections between wetlands. Phase 2 is planned to start in 2018.

The G-139 station, located at the north end of Pond 5-S, was completed in 2006, but was never operated and the pumps have been removed. The 1994 Everglades Construction Project planned for the C-139 Annex flows to be redirected away from the L-28 Canal through the USSO structure and into STA 6 by 2006. Structure G-139 was completed in 2006 towards that end, but the structure was never operated and the pumps have since been removed. The 2012 Restoration Strategies changed the original diversion plans such that flows from the restored portion of the C-139 Annex would continue to discharge to the L-28 borrow canal by way of a new structure that would replace the USSO and would be located upstream of USSO.

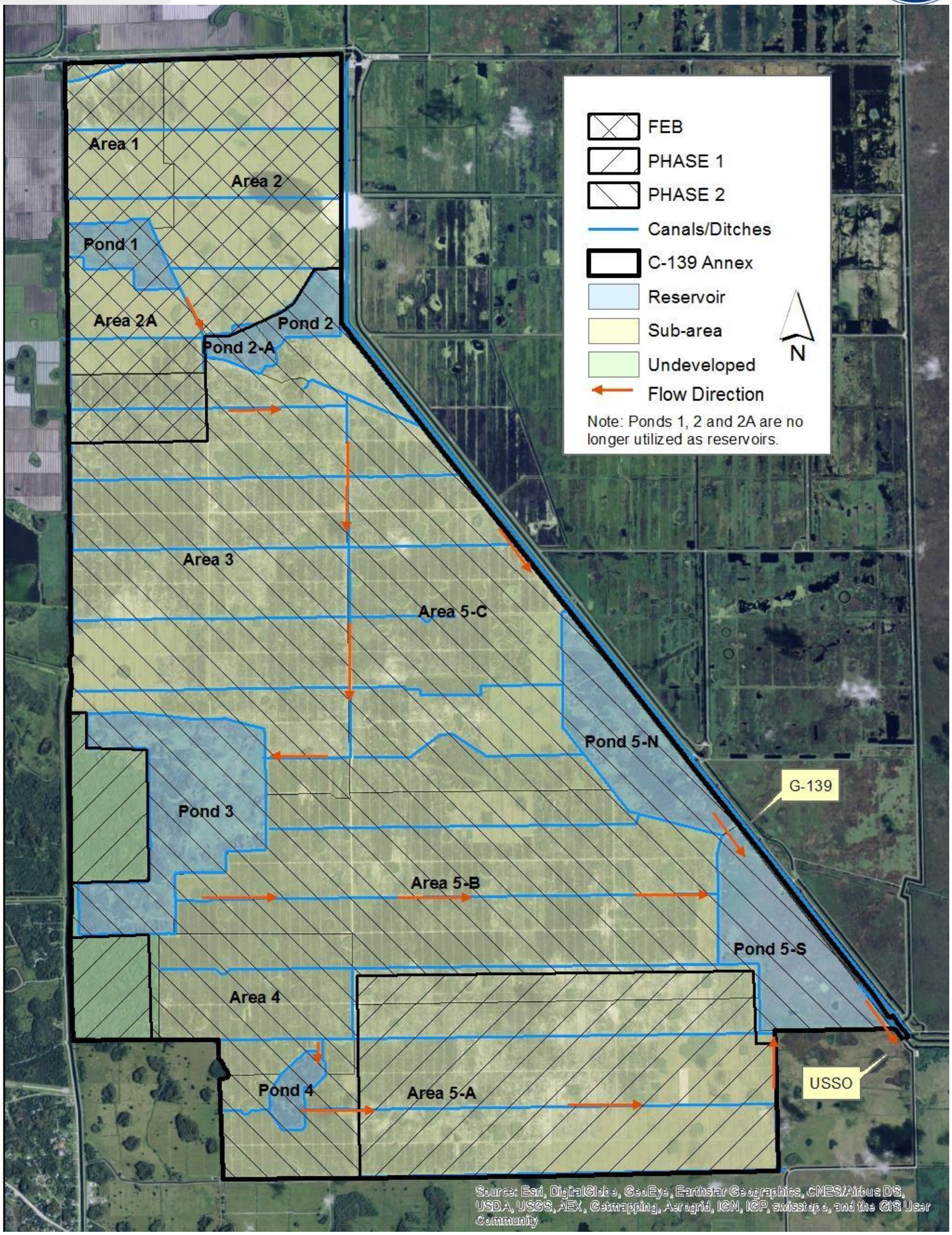

Figure 22: C-139 Annex Sub-basin Restoration Phasing and Existing Water Management

2.8 Habitats

There are numerous types of wetland habitats in the Western Basins Northern Reach, such as cypress swamps, wet prairies, and freshwater marshes. The Feeder Canal Basin is located just south of the Dinner Island Ranch Wildlife Management Area. This area is a habitat for the Florida panther, Florida black bear, white-tailed deer, and wetland bird species such as sandhill cranes, wood storks, heron, egret, ibis, and roseate spoonbill (http://myfwc.com/viewing/recreation/wmas/lead/dinner-island/wildlife/).

2.9 Population of Communities within the Basin

The Feeder Canal Basin is sparsely populated and primarily agricultural. The only urbanized area within the basin exists in the territory of the Seminole Tribe of Florida in the southeast portion of the Feeder Canal Basin. According to the *2010 Census Block Groups in Florida* geospatial dataset from the Florida Geographic Data Library (FGDL), the region is described as having a population density of 0.007 people per acre.

2.10 Land Use

The Western Basins Northern Reach region is primarily classified as agricultural (69.5%) and wetland (27%), with the minor classifications consisting of upland forest (2.6%) and rangeland (1%). The land use characterization of the Western Basins Northern Reach is described in **Table 4** below. **Figure 23** illustrates the land use in the Western Basins Northern Reach.

Table 4: Summary of Western Basins Northern Reach Land Use Distribution

LUCODE	Land Use Description	Land Area (acres)	Percentage of Northern Reach Area
Urban and Built-up		*9.8*	*0.01%*
1180	Residential, rural - one unit on 2 or more acres	9.8	0.01%
Agriculture		*50,668.5*	*69.52%*
2110	Improved Pastures	18,341.4	25.17%
2120	Unimproved Pastures	2,644.9	3.63%
2130	Woodland Pastures	5,534.4	7.59%
2140	Row Crops	8,784.5	12.05%
2210	Citrus Groves	1,4770.2	20.27%
2610	Fallow Cropland	593.2	0.81%
Rangeland		*757.7*	*1.04%*
3100	Herbaceous (Dry Prairie)	272.8	0.37%
3200	Shrub and Brushland	315.9	0.43%
3210	Palmetto Prairies	3.7	0.01%
3300	Mixed Upland Nonforested	165.3	0.23%
Upland Forest		*1,865.2*	*2.56%*
4110	Pine Flatwoods	374.6	0.51%
4200	Upland Hardwood Forests	1,082.0	1.48%
4240	Melaleuca	1.5	0.00%
4271	Oak - Cabbage Palm Forests	267.6	0.37%
4280	Cabbage Palm	23.2	0.03%
4340	Upland Mixed - Coniferous / Hardwood	116.2	0.16%

LUCODE	Land Use Description	Land Area (acres)	Percentage of Northern Reach Area
Water		*119.9*	*0.16%*
5120	Channelized Waterway	61.7	0.08%
5200	Lakes	25.6	0.04%
5300	Reservoirs	32.6	0.04%
Wetlands		*19,241.1*	*26.40%*
6170	Mixed Wetland Hardwoods	2,561.3	3.51%
6172	Mixed Shrubs	2571.8	3.53%
6180	Cabbage Palms	386.1	0.53%
6191	Wet Melaleuca	18.9	0.03%
6210	Cypress	3,022.0	4.15%
6215	Cypress- Domes/Heads	1,116.3	1.53%
6216	Cypress - Mixed Hardwoods	4,407.2	6.05%
6240	Cypress - Pine - Cabbage Palm	89.6	0.12%
6250	Hydric Pine Flatwoods	235.3	0.32%
6260	Pine Savannah	78.6	0.11%
6300	Wetland Forested Mixed	83.3	0.11%
6410	Freshwater Marshes	3,486.1	4.78%
6430	Wet Prairies	1,046.5	1.44%
6440	Emergent Aquatic Vegetation	138.1	0.19%
Barren Land		*130.1*	*0.18%*
7470	Dikes and Levees	130.1	0.18%
Transportation, Communication and Utilities		*86.5*	*0.12%*
8115	Grass Airports	17.3	0.02%
8200	Communications	5.6	0.01%
8320	Electrical Power Transmission Lines	63.6	0.09%

*From the “Statewide Land Use Land Cover 2004-2013” spatial data file which is based on imagery and created by Florida’s water management districts.

**Codes are derived from the Florida Land Use, Cover and Forms Classification System (FLUCCS)

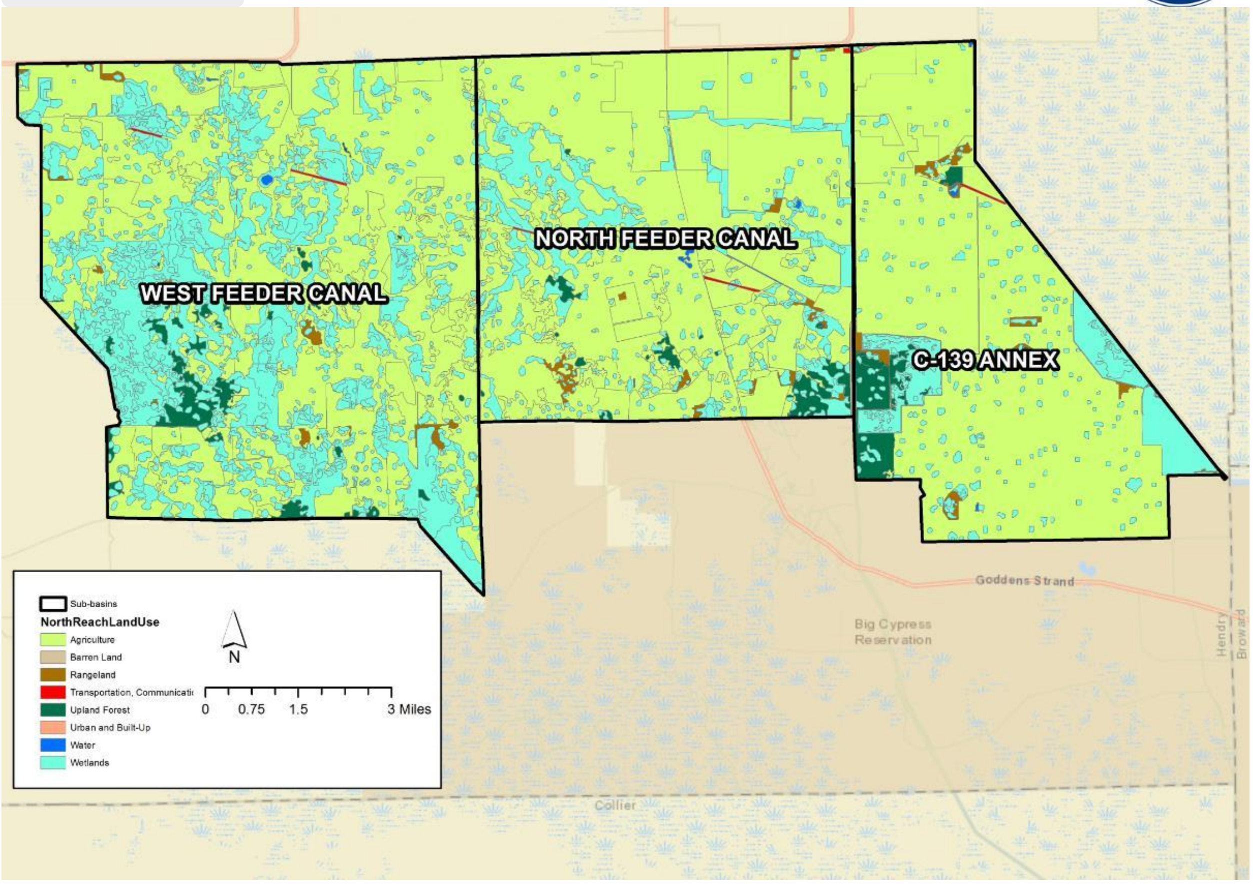

Figure 23: Land Use

2.11 Economic Activities

The main economic activity in the area is agriculture. Section 2.10(Land Use) discusses the proportion and types of crops in the study area.

2.12 Water Usage

The West Feeder Canal Basin has 662 acres of above ground impoundments (AGIs) in the northern portion of the basin, and the North Feeder Canal Basin has 2,728 acres of AGIs in the north and east portions of the basin. AGIs are not a separate land use category in the land use map; they are classified according to the type of vegetation, which consists mostly of forested wetlands and pastures. However, operationally, they function as reservoirs with outlet control structures that receive excess water from the agricultural fields.

There are 15 water use permits in the region with reported water use: five are in the West Feeder Canal Basin, two are in the North Feeder Canal Basin, and seven are immediately outside (north and west) of the basin. It is assumed that these permits are the active agricultural fields, whereas agricultural fields with no reported pumping data during the study period are assumed inactive. According to these permits, water for irrigation is mostly pumped from the Lower Tamiami aquifer.

Groundwater pumping data is available in the District permit database. The agricultural fields that are within the water use permit boundaries (based on the District water use permit shapefile) with reported pumping data greater than zero for the simulation period were considered active irrigated fields. **Table 5** shows the total monthly volumes of water use reported by the farms within or immediately surrounding the Feeder Canal Basin

Table 5. Total Reported Water Use for Permit Numbers 26-xxxxx-W (Million Gallons per Month)

Mo-Yr	West Feeder					North Feeder		C-139 Annex
	00630	00116	00533	00639	00539	01135	01136	00094
Jun-11	120	32	0	0	0			972
Jul-11	4	0	0	0	0			18
Aug-11	13	0	0	0	0			62
Sep-11	22	0	0	1	1			465
Oct-11	48	0	0	7	1			375
Nov-11	112	0	6	9	3			544
Dec-11	91	0	9	9	3			476
Jan-12	88	0	29	29	9			386
Feb-12	93	0	25	17	5			533
Mar-12	108	0	25	0	0			632
Apr-12	139	1	0	0	0	0	54	780
May-12	107	0	0	0	0	7	80	271
Jun-12	99	0	0	0	0	0	17	300
Jul-12	87	0	0	0	0	0	29	452
Aug-12	94	1	0	0	0	0	10	173
Sep-12	75	0	0	0	0	21	22	140
Oct-12	32	0	0	0	0	39	42	138
Nov-12	107	0	0	0	0	432	576	371
Dec-12	90	0	0	0	0	574	439	233
Jan-13	84	0	0	0	0	294	553	172
Feb-13	85	0	0	0	0	168	436	466
Mar-13	71	0	0	0	0	74	393	381
Apr-13	65	0	0	0	0	0	240	513
May-13	62	0	0	0	0	0	206	497
Jun-13	24	0	0	0	0	0	15	63
Jul-13	1	0	0	0	0	0	212	15
Aug-13	11	0	0	4	0	44	233	150
Sep-13	9	0		4	0	73	6	14
Oct-13	39	0			0	812	301	182
Nov-13	80	0			0	660	411	602
Dec-13	86	0			0	759	476	454
Jan-14	99	0			0	928	722	401
Feb-14	45	0			0	227	484	159
Mar-14	62	0			0	173	394	293
Apr-14	37	0			0	79	487	393
May-14	98	0			0	0	154	654

The table above shows that there are several months of missing data in some of the permits. Notably, the water use permits 26-01135-W and 26-01136-W, corresponding to the farms in the North Feeder Canal Basin, show missing data during the period prior to April 2012. Based the Environmental Resource Permit (ERP) documents and on the groundwater measurements in the area (at the HES-28 station), it is likely that this large area was farmed during the period of missing pumping data.

2.13 Tribal lands

The Seminole and Miccosukee Tribes have tribal lands within and immediately surrounding the Feeder Canal Basin. The Big Cypress Seminole Reservation falls within the Feeder Canal Basin boundary. **Figure 1** at the beginning of this report shows the extents of those tribal lands in relation to the Western Basins study area.

3.0 Water Quality/Impairments

In order to characterize the water quality in the region and to determine management measures suited to the region, water quality data were collected. Phosphorus plays an integral role in the health of the ecosystems downstream of the basin; therefore, particular attention was paid to the availability of TP, total dissolved phosphorus (TDP), and total particulate phosphorus (TPP) data.

3.1 Compile Existing Watershed Data and Create an Inventory

Due to the fact that much of the Feeder Canal Basin land, including its canals are privately owned, there are only two locations that are currently actively monitoring surface water quality. There was one groundwater well approximately 500 feet east of West Weir that measured water chemistry briefly between the period of June 1985 and February 1987, but there are no active water quality monitoring wells to characterize the chemistry of the groundwater within the basin.

The two surface water quality monitoring locations are at the headwaters of the West Weir and PC-17A. The West Weir monitoring station is located approximately 250 feet upstream of the weir and has been collecting data since 1997. The PC-17A monitoring station is located immediately upstream of the PC-17A structure in the South Boundary Canal and has been collecting data since 1996. There are seven other inactive monitoring locations in the Western Basins Northern Reach with surface water quality monitoring data available. Data for PC-17A, WWEIR, and the monitoring points upstream of WWEIR are available in the District's DBHYDRO database. Data for the upstream points in the North Feeder Canal sub-basin were provided by the District in a spreadsheet. The surface water quality monitoring points are described in greater detail in **Table 6. Figure 24** shows the locations of the water quality monitoring sites.

Table 6: Summary of Available Water Quality Data

Site	Parameters Measured	Auto (A) / Grab (G) Samples	TP Measurement Period	
			Start	End
WWEIR	AMMONIA-N, DISSOLVED OXYGEN, KJELDAHL NITROGEN (TOTAL), NITRATE+NITRITE-N, PH (FIELD), PHOSPHATE (DISSOLVED AS P), PHOSPHATE (ORTHO AS P), PHOSPHATE (TOTAL AS P), SP CONDUCTIVITY (FIELD), TEMP	G/A	1997	2015
LC02.9TW01	DISSOLVED OXYGEN, KJELDAHL NITROGEN (TOTAL), NITRATE+NITRITE-N, PH (FIELD), PHOSPHATE (DISSOLVED AS P), PHOSPHATE (ORTHO AS P), PHOSPHATE (TOTAL AS P), SP CONDUCTIVITY (FIELD), TEMP	G	1996	2011

Site	Parameters Measured	Auto (A) / Grab (G) Samples	TP Measurement Period	
			Start	End
LC03.0TN01	DISSOLVED OXYGEN, PH (FIELD), PHOSPHATE (DISSOLVED AS P), PHOSPHATE (ORTHO AS P), PHOSPHATE (TOTAL AS P), SP CONDUCTIVITY (FIELD), TEMP	G	1996	2011
LC01.7TN	DISSOLVED OXYGEN, PH (FIELD), PHOSPHATE (DISSOLVED AS P), PHOSPHATE (ORTHO AS P), PHOSPHATE (TOTAL AS P), SP CONDUCTIVITY (FIELD), TEMP	G	2005	2009
LC03.0TN	DISSOLVED OXYGEN, PH (FIELD), PHOSPHATE (DISSOLVED AS P), PHOSPHATE (ORTHO AS P), PHOSPHATE (TOTAL AS P), SP CONDUCTIVITY (FIELD), TEMP	G	1996	2009
LC02.9TW	DISSOLVED OXYGEN, PH (FIELD), PHOSPHATE (DISSOLVED AS P), PHOSPHATE (ORTHO AS P), PHOSPHATE (TOTAL AS P), SP CONDUCTIVITY (FIELD), TEMP	G	1996	2009
WC01.11TN	DISSOLVED OXYGEN, PH (FIELD), PHOSPHATE (DISSOLVED AS P), PHOSPHATE (ORTHO AS P), PHOSPHATE (TOTAL AS P), SP CONDUCTIVITY (FIELD), TEMP	G	2005	2009
G108	DISSSOLVED OXYGEN, PH (FIELD), PHOSPHATE (TOTAL AS P), SP CONDUCTIVITY (FIELD), TEMP	A/G	1998	2009
PC-17A	DISSOLVED OXYGEN, PH (FIELD), PHOSPHATE (DISSOLVED AS P), PHOSPHATE (ORTHO AS P), PHOSPHATE (TOTAL AS P), SP CONDUCTIVITY (FIELD)	A/G	1996	2015
S3 (P-11)	TOTAL PHOSPHOROUS	G	2005	2014
S9N (SBP-6)	TOTAL PHOSPHOROUS	G	2005	2014
S9S (SBP-9)	TOTAL PHOSPHOROUS	G	2005	2014
S10 (P-14)	TOTAL PHOSPHOROUS	G	2005	2014
S11N (P-13, SBP-19)	TOTAL PHOSPHOROUS	G	2005	2014

Site	Parameters Measured	Auto (A) / Grab (G) Samples	TP Measurement Period	
			Start	End
S11S (P-23)	TOTAL PHOSPHOROUS	G	2005	2014
USSC HP (W-D1011)	TOTAL PHOSPHOROUS	G	2003	2008
JOHN'S HOUSE (OUTFALL FROM POND)	TOTAL PHOSPHOROUS	G	2004	2006
CUR (PT-D1)	TOTAL PHOSPHOROUS	G	2003	2014
CUR PUMP (NW PUMP)	TOTAL PHOSPHOROUS	G	2005	2007
S26 (P-50)	TOTAL PHOSPHOROUS	G	2005	2014
S25 (P-56)	TOTAL PHOSPHOROUS	G	2014	2014
IRUR (CR833 BRIDGE)	TOTAL PHOSPHOROUS	G	2003	2014
S9 PUMP	TOTAL PHOSPHOROUS	G	2005	2005
V-NOTCH (W-D4)	TOTAL PHOSPHOROUS	G	2003	2014
WEST HP (W-D12)	TOTAL PHOSPHOROUS	G	2003	2014
P-53 (JOHN'S HOUSE FIELD PUMP)	TOTAL PHOSPHOROUS	G	2006	2014
W-D9	TOTAL PHOSPHOROUS	G	2010	2014

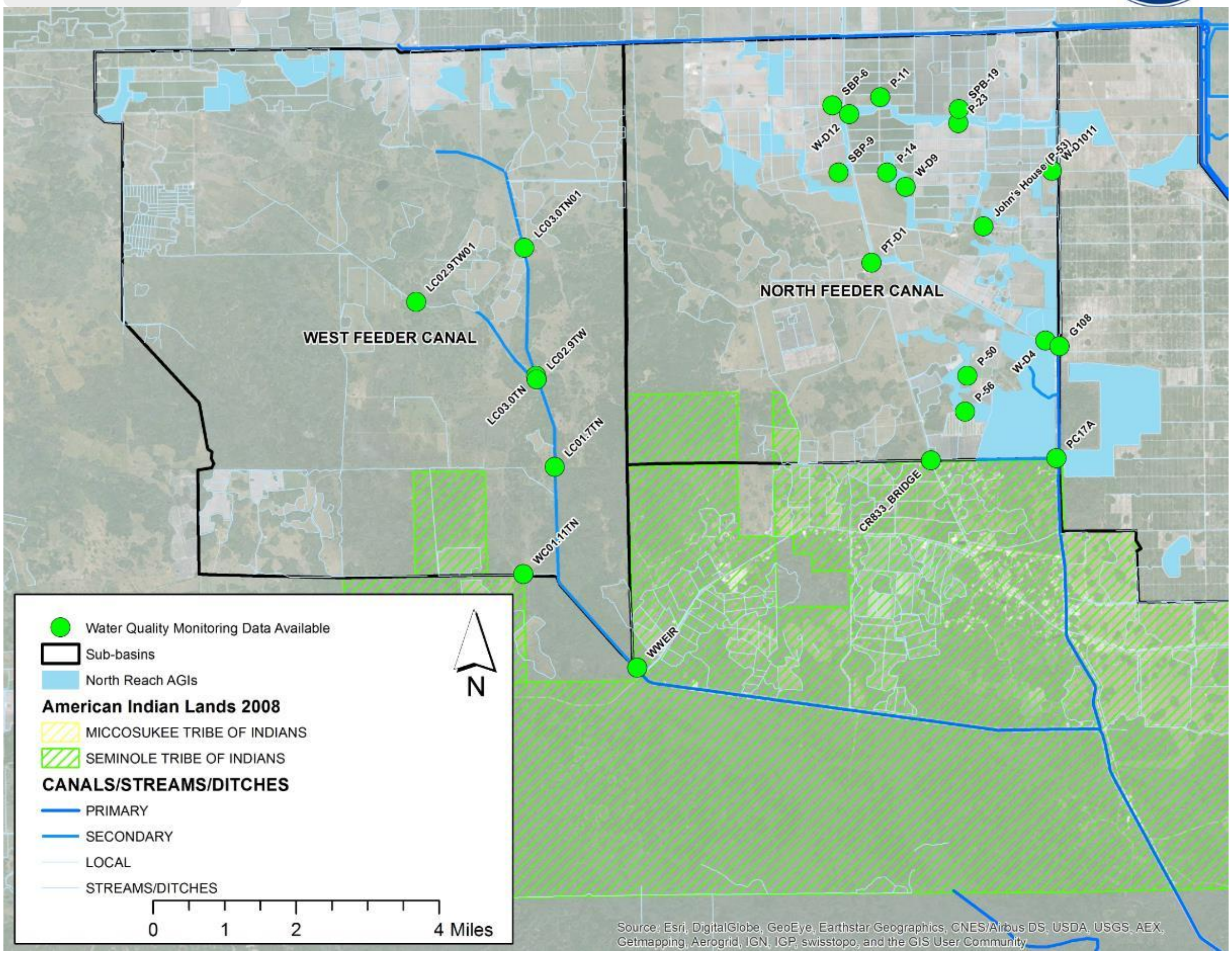

Figure 24: Locations of Surface Water Quality Monitoring Locations

3.2 Identify Data Gaps and Collect Additional Data

As described in the water quality data inventory, the only locations where surface water quality is actively being monitored is at the sub-basin outflow points, WWEIR and PC-17A. Consistent water quality monitoring locations upstream in the West Feeder Canal and North Feeder Canal Sub-basins would fill a data gap and better characterize the spatial and temporal characteristics of water chemistry in the region. Within the North Feeder Canal Sub-basin, additional monitoring of TP levels in the runoff at various locations over a longitudinal period could provide insight into the sources and sinks within a given farm. The selected locations for the sampling could allow for a more accurate determination of the treatment effectiveness of each AGI considering quantitative data would show the concentrations before, during and after being routed through the facility. Currently, the available data at WWEIR and PC-17A indicate that the greater amount of active agricultural land upstream of PC-17A contributes to much higher phosphorus measurements at PC-17A than those at WWEIR. More water quality monitoring upstream of PC-17A could significantly improve the viability of future investigations into the high levels of phosphorus in the region.

Figure 25 shows some proposed upstream water quality monitoring locations that would better delineate the sources of the pollutants found downstream. The points in the West Feeder Canal Sub-basin were placed at key locations where agricultural activity may impact the water chemistry. These locations are the outflows from farms with surface water permits, on the two branches of the Lard Can Canal, and upstream on the Wingate Mill Canal. The points in the North Feeder Canal Sub-basin were placed along the cascading system of AGIs and network of farm fields. This can better indicate which crops during which time of year at which location contribute to the water chemistry composition found at PC-17A. The points on the South Boundary Canal will clarify whether the highly developed agricultural activity in the north and east portions of the Sub-basin or the undeveloped pastureland in the southwest portions of the Sub-basin contribute to the water quality measurements at PC-17A.

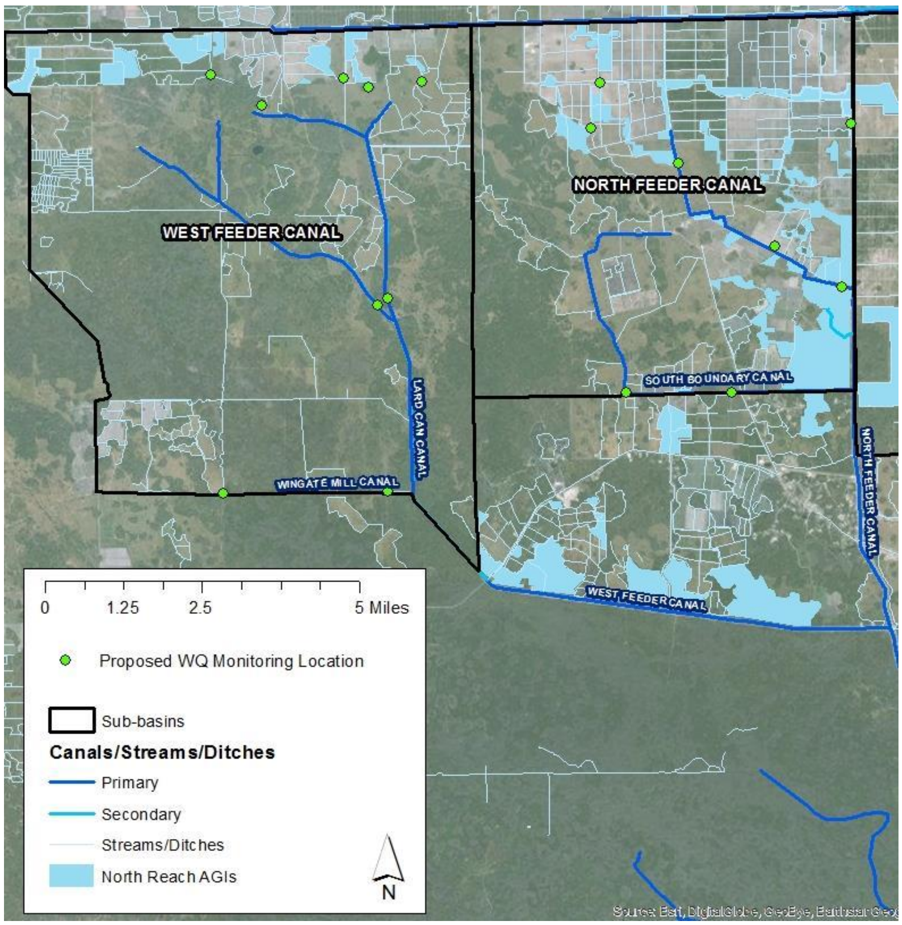

Figure 25: Potential Water Quality Monitoring Locations

Groundwater quality data is not being monitored within the basin. The closest groundwater quality monitoring well to the Feeder Canal Basin is located approximately 10 miles west of the basin's western boundary.

3.3 Surface Water Quality

3.3.1 303(d) Listed Waterbodies within Basin

There are no 303(d) listed waterbodies within the Feeder Canal Basin. The Water Conservation Area (WCA) 3A, which is part of the Everglades Protection Area and is the receiving waterbody for the Feeder Canal Basin discharge, is listed for mercury. Mercury impairments throughout the state are being address through the statewide mercury total maximum daily load (TMDL). There is no TMDL for phosphorus in the Everglades, instead the regulatory criteria for phosphorus is established in Rule 62-302.540 of the Florida

Administrative Code. The rule implements the requirements of the Everglades Forever Act, which established the phosphorus numeric criterion for the Everglades.

Table 7. Error! Reference source not found. shows the measured loads at the S-190 and S-140, which discharge into WCA-3A.

Table 7. Measured Loads at the S-190 and S-140 Structures (metric tons)

Water Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
S-190	10.69	27.20	17.77	2.99	14.06	7.79	2.24	2.53	3.02	6.61
S-140	7.22	12.51	5.12	4.05	6.65	9.21	3.77	5.06	4.48	6.24

Source: SFWMD, 2015

3.3.2 Additional Supporting Data

The primary nutrient of concern for water quality in this region is phosphorus. TP reflects all the species of phosphorus within the water column. Water quality sampling protocols typically differentiate various types of phosphorus; however, for the purposes of developing an overview of the existing water quality conditions, the first consideration of this effort is the TP concentration. To develop recommendations for additional water quality treatment, it is imperative to know where the problems exist based on measured TP. This helps to identify the sources of high nutrients and where to concentrate efforts to resolve them. After the initial evaluation of TP, a further investigation into the different species of P provides a more nuanced perspective on the potential effectiveness of proposed water quality improvement projects.

Table 8 describes the period of record and number of observations for TP measurements used in the following water quality analysis. The locations of the measurements are shown in **Figure 28**. The autosampler locations (WWEIR and PC-17A) also included grab sample data, which were added to the site datasets. It should be noted that a quality control review was performed prior to using the data. Some values were removed from the analysis if they showed abnormally high concentrations accompanied with notes indicating equipment or wildlife issues. For example, the highest phosphorus concentration at USSO was measured at over 5,000 ppm, but was accompanied with a note that a dead frog was found in the equipment. Average and maximum phosphorus concentrations were calculated at each location from the data sets outlined in **Table 8**.

Table 8: Period of Record and Number of Observations for Average and Maximum TP (μg/L)

SITE	END DATE	START DATE	NO. OF OBSERVATIONS	AVG.	MAX
G108	11/2009	06/1996	298	197	727
USSO	10/2015	10/1995	3576	83	260
LC01.7TN	10/2009	09/2005	114	63	316
LC02.9TW	10/2009	12/1996	87	66	293
LC02.9TW01	10/2011	12/1996	163	45	289
LC03.0TN	10/2009	08/1996	140	87	481
LC03.0TN01	10/2011	07/1996	184	119	619
PC-17A	06/2015	06/1996	1002	83	421
WC01.11TN	10/2009	09/2005	115	26	84
WFEED	10/2015	10/1997	1557	45	175
P-11	09/2014	05/2005	33	294	937

SITE	END DATE	START DATE	NO. OF OBSERVATIONS	AVG.	MAX
SBP-6	07/2014	05/2005	12	221	486
W-D12	08/2014	06/2003	30	232	741
P-23	07/2013	05/2005	6	926	1756
W-D1011	09/2006	06/2003	15	235	720
P-14	10/2014	05/2005	36	250	851
SBP-9	08/2014	05/2005	10	210	423
John's House (P-53)	10/2014	09/2006	38	165	734
SPB-19	07/2013	05/2005	11	469	1861
P-50	09/2014	05/2005	11	201	394
W-D4	10/2014	06/2003	72	78	392
PT-D1	08/2014	06/2003	49	201	407
CR833_BRIDGE	10/2014	06/2003	74	139	410
W-D9	10/2014	07/2010	27	313	777

Figure 26 and **Figure 27** show lower phosphorous levels at WWeir (average = 0.04 mg/L) than at PC-17A (average = 0.09 mg/L). This is to be expected as the West Feeder Basin has a higher portion of undeveloped wetland areas (39%) than the North Feeder Canal (18%).

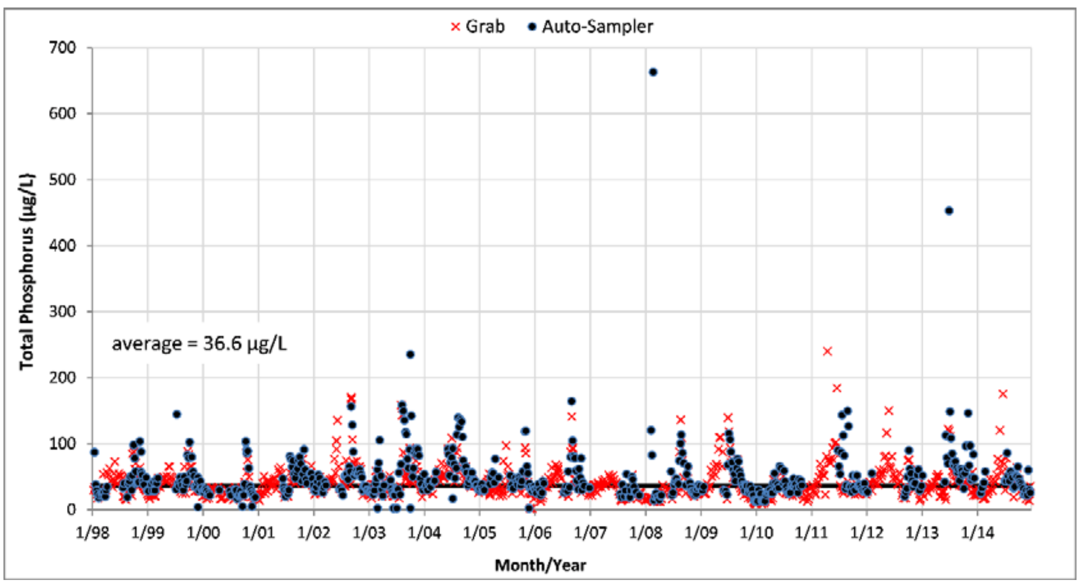

Figure 26: TP Measured at WWeir

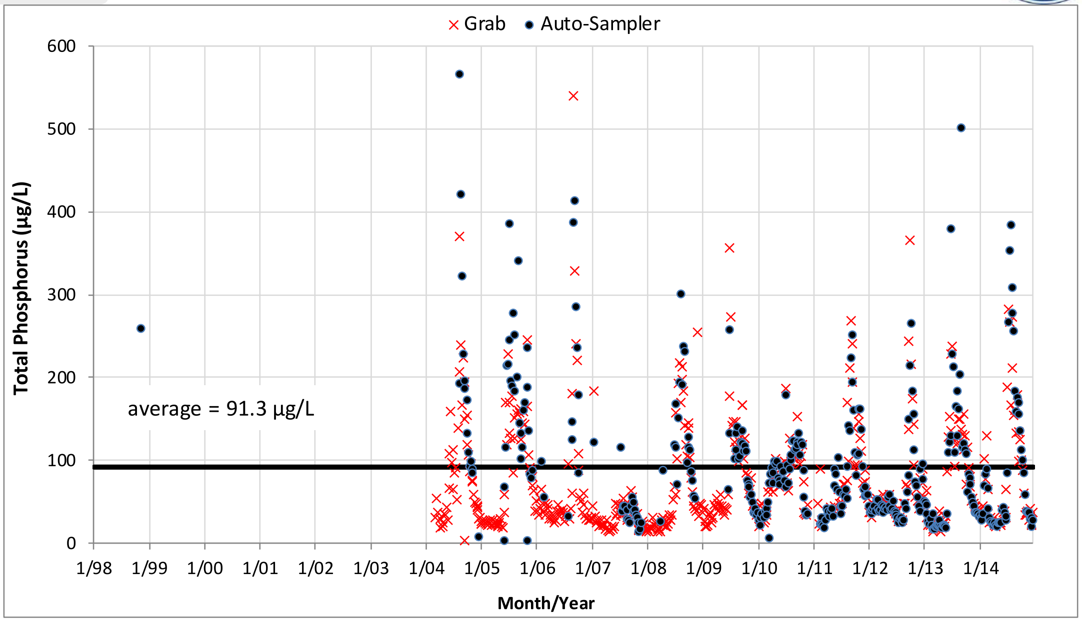

Figure 27: TP Measured at PC-17A

Figure 28 and **Figure 29** show the magnitude of the average and maximum concentrations, respectively, at each sample location with the use of graduated symbols in order to spatially display the magnitude of phosphorous levels within the region.

The figures show that the highest concentrations occurred in the North Feeder Canal Sub-basin, specifically, the northern half of Garcia Farms. Measurements for the North Feeder Canal Sub-basin are conducted as part of the 1996 landowner agreement between McDaniel Ranch and the Seminole Tribe of Florida. The measurements at SPB-19 and P-23 in the northwest farms showed maximum concentrations as high as 1,861 and 1,756 µg/L, respectively (**Figure 29**). Concentrations are also elevated in the southern half. Since flow is from north to south, issues at PC-17A are likely due to higher concentrations in the north, which are attenuating as they reach the Southern Boundary Canal. The data also indicate that upstream sampling sites in the West Feeder Canal Sub-basin recorded significantly lower TP levels than those sites in the North Feeder Canal Sub-basin. As previously stated, these lower phosphorus levels measured in the West Feeder Canal Sub-basin are to be expected because it has a higher portion of undeveloped wetland areas.

There are significantly less data at the grab sample locations than at sites that include auto samplers, which should be considered when comparing the results. The timing of the grab samples in relation to storm events can significantly affect the results. Typically, higher values are reported immediately following rain events that are strong enough to generate runoff. This can sometimes skew results when there are fewer samples taken at a given site.

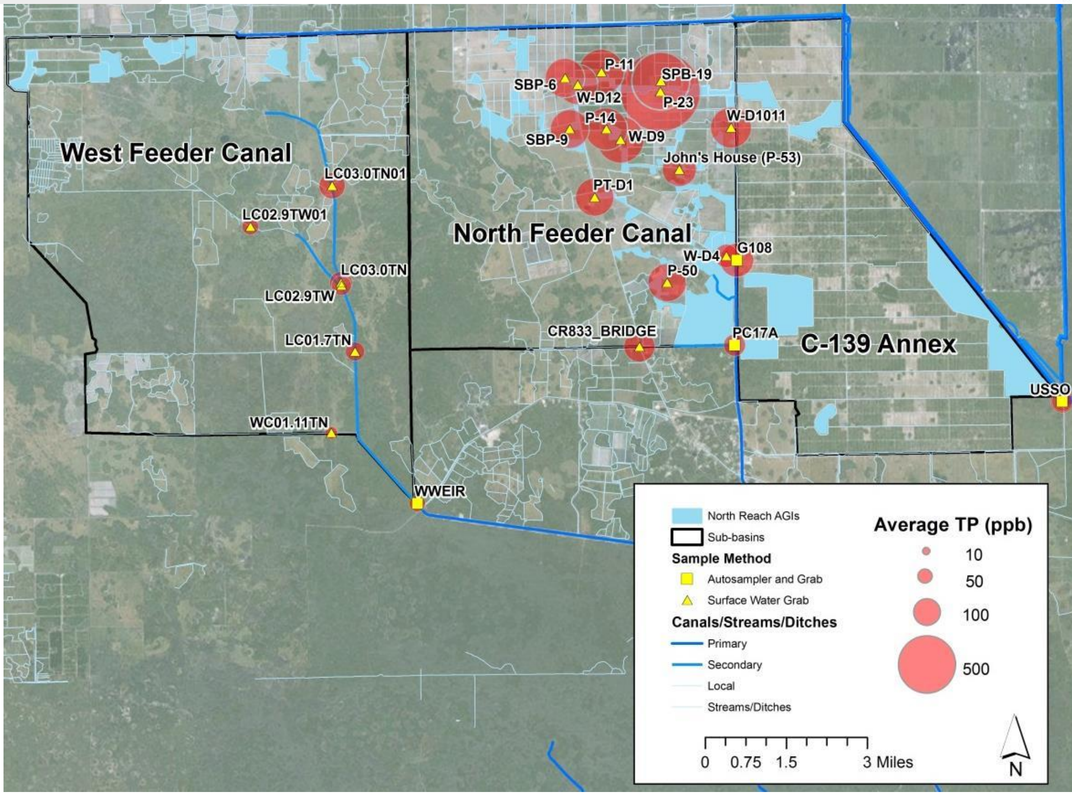

Figure 28: Average TP Concentrations

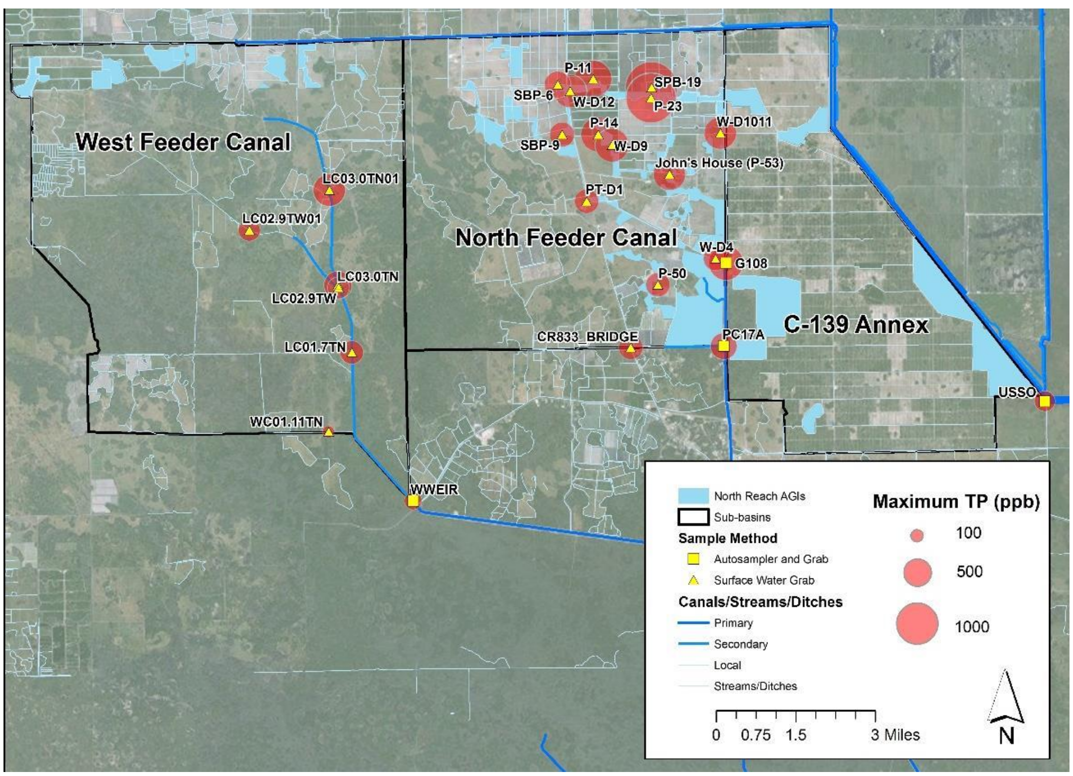

Figure 29: Maximum TP Concentrations

Due to the higher levels of phosphorus within the North Feeder Canal Sub-basin, as well as legal agreements monitoring discharges at PC-17A, a closer look was taken at the monitoring within the sub-basin. The water quality samples in the North Feeder Sub-basin were collected at locations within active agricultural fields and AGIs. **Figure 30** breaks down the measurements taken within the North Feeder Canal Sub-basin into samples that were taken in the pond and samples that were taken from field inflows. **Figure 30** illustrates that the samples collected within AGIs have a lower TP concentration than samples from active agricultural fields upstream.

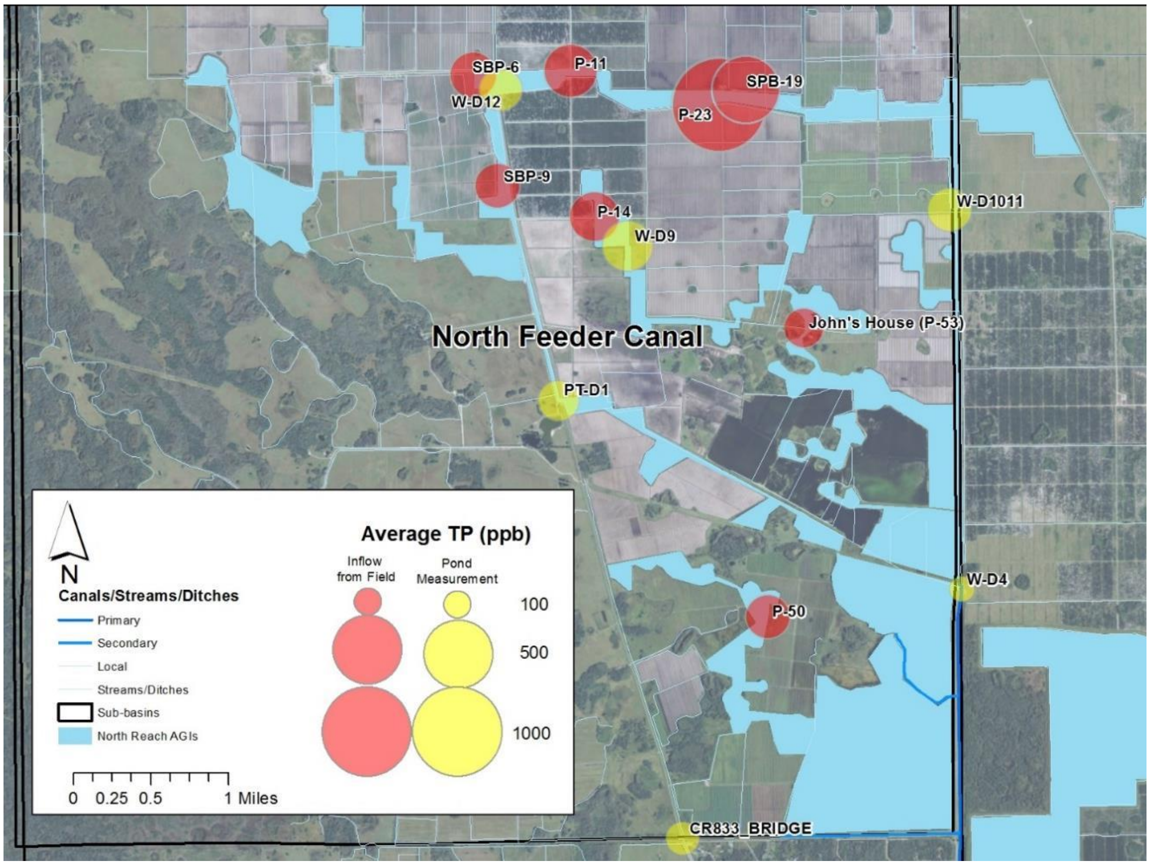

Figure 30: Comparison of Field and AGI Measurements in North Feeder Canal Sub-basin

After a review of the TP within the region, an investigation into the type of P within the runoff is warranted. Within the water column of the regional canals and farm ditches, there are two types of phosphorus that are of concern: dissolved and particulate. Some water quality improvement projects that may be proposed do not address all of the phosphorus in the water column. For instance, sediment traps or settling basins can be effective at removing particulate phosphorus from the water column, but do not address the dissolved component of TP. **Figure 31** illustrates the average particulate and average dissolved phosphorus at each monitoring location. **Table 9** lists the period of record and number of observations for the dissolved and particulate phosphorus measurements. It should be noted that the water quality samples taken upstream of PC-17A did not measure the specific form of phosphorus; therefore, characterizing the speciation of phosphorus upstream of PC-17A is not possible with available data.

Table 9: Period of Record and Number of Observations for Dissolved and Particulate Phosphorus

SITE	END DATE	START DATE	NO. OF OBSERVATIONS
USSO	10/2015	12/1995	455
LC01.7TN	10/2009	09/2005	110
LC02.9TW	10/2009	09/2005	72
LC02.9TW01	10/2011	09/2005	124
LC03.0TN	10/2009	09/2005	106
LC03.0TN01	10/2011	09/2005	145
PC-17A	09/2011	10/2008	60
WC01.11TN	10/2009	09/2005	112
WFEED	09/2011	10/2008	69

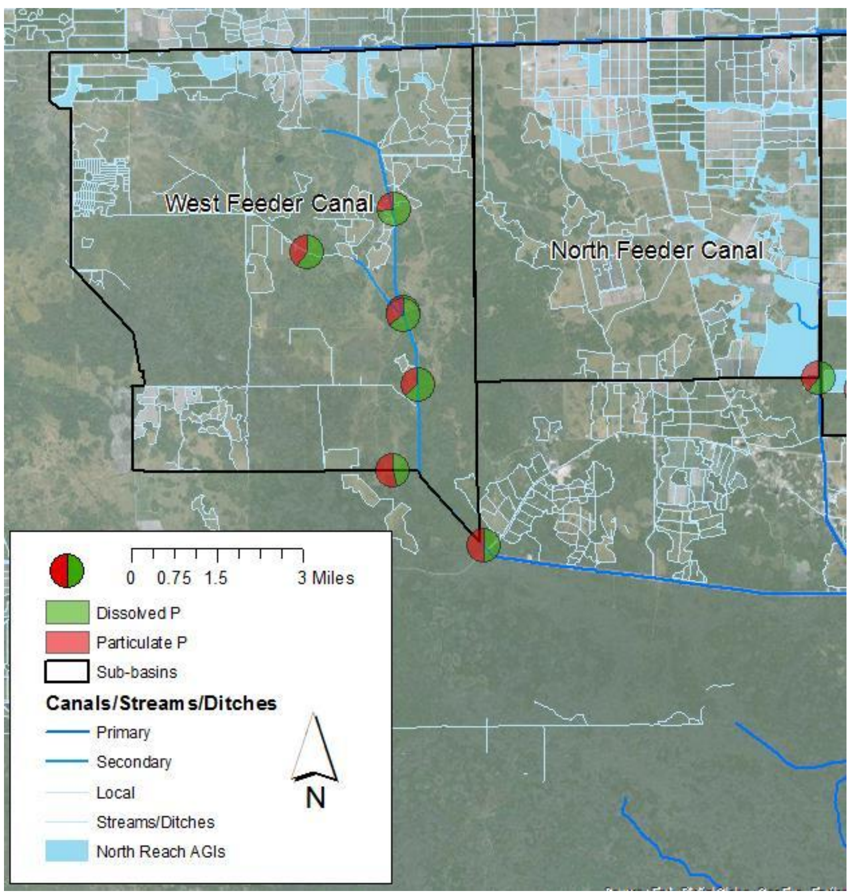

Figure 31: Ratio of Dissolved and Particulate Phosphorus at Selected Sampling Locations

Lard Can Canal in the West Feeder Canal Sub-basin includes a fairly consistent higher ratio of soluble (dissolved) phosphorus compared to particulate phosphorus which could suggest that settling of phosphorus could be occurring in the upstream systems. Particulate phosphorus at WWEIR structure, however, is relatively high and is likely due to similarly higher particulate phosphorus from Wingate Mill

Canal. It should also be noted that average TP values (**Figure 31**) are relatively low at those two locations suggesting that the percentage of particulate phosphorus in those locations is higher because the amount of soluble phosphorus is reducing.

Since the upstream grab samples within the North Feeder Canal sub-basin only analyzed TP, the only breakdown of phosphorus for this sub-basin occurs at the PC-17A structure. The phosphorus speciation results at PC-17A show that a substantial portion of phosphorus remains in particulate form. This structure receives flows from a surface water management system serving approximately 13,000 acres that includes a series of cascading AGIs to treat and attenuate runoff generated in citrus groves and vegetable farms. The PC-17A structure also serves another approximately 10,000 acres of pastures and natural area drained by gravity and where no treatment or attenuation to runoff flows is provided. It is not clear if both, or just one of these areas, is contributing disproportionate amounts of particulate phosphorus.

Overall, when reviewing the results at WWEIR and PC-17A, there are significant portions of both forms of phosphorus, which could potentially be addressed upstream with, for example, sediment trapping techniques for particulate phosphorus and additional vegetation uptake for soluble phosphorus.

3.4 Groundwater Quality

FDEP's watershed monitoring program provides a limited spatial and temporal perspective on the TP concentrations in the Lower Tamiami Aquifer. For the 13 monitoring sites nearest to the study area, there has been only one measurement taken at each location since 2000. The average TP concentration measured is 0.05 mg/L (ADA Engineering and URS, 2011).

3.5 Groundwater/Surface Water Interaction and Effects of Impairment on Groundwater Resources

In the adjacent C-139 Basin, there has been evidence of the groundwater conditions affecting the surface water conditions, specifically with respect to water levels in the regional canals (ADA Engineering, 2006). However, further information on groundwater quality in and around the Western Basins is both scarce and dated. A study of the potential for groundwater effects on TP levels within internal farm canals could be performed by an individual land owner or by an agency, such as USGS.

3.5.1 Regional Studies

A study in the eastern border of Everglades National Park compares well data and canal data (Muñoz-Carpena et al., 2005). The analyses performed indicated general patterns between well water and nearby north-south canals, C-111 and L-31W. Some chemical concentrations correlated very closely while others displayed an inverse correlation throughout. For phosphorus, a direct correlation indicated that phosphorus is leaching into groundwater from the surface, especially after fertilizer application during the growing season. Spikes in groundwater phosphorus concentration also corresponded to heavy rainfall events likely due to the increase of speed and amount of phosphorus leaching through heavily fertilized top soil. Since excess phosphorus presents a threat to the quality of current Everglades habitats, further groundwater monitoring and mitigation of phosphorus leaching would aid in the symbiotic thriving of species native to the Everglades.

4.0 Source of Water Quality Issues/Impairments

4.1 Nonpoint Sources

The land use within the Feeder Canal Basin is more than 50% agricultural. The other major land classification within the basin is wetlands, which comprises approximately 30% of the basin. Since the land use is mostly agricultural, the sources of water quality issues and impairments can be characterized as nonpoint. **Figure 32** shows the land uses and several key boundaries within the basin.

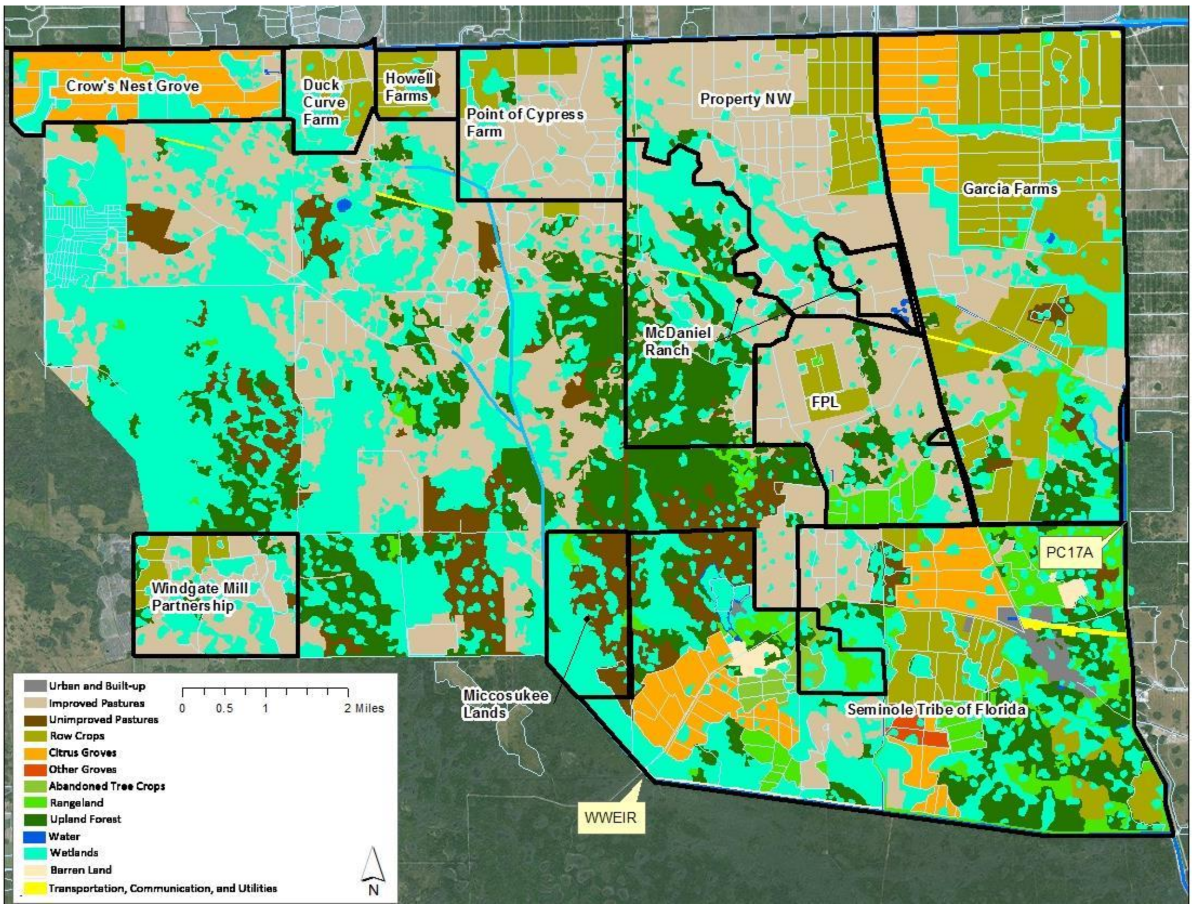

Figure 32: Land Use and Farms within the Feeder Canal Basin

4.1.1 Upstream of PC-17A

The areas with water quality concern are primarily in the North Feeder Canal Sub-basin where active agricultural areas seem to be contributing to higher-than-desirable phosphorous levels measured at PC-17A. Garcia Farms comprises the eastern portion of the North Feeder Canal Sub-basin. It is an actively farmed area with row crops as the primary type of agricultural production. The 2013 permit update for Garcia Farms indicated that potatoes, melons, small vegetables, and citrus were being produced within Garcia Farms. Property NW and the FPL property both have row crop and pasture land. The agricultural land within McDaniel Ranch is pastureland. Due to the fact that there is little monitoring upstream of PC-17A, the role that each upstream party plays in the water chemistry at PC-17A is unable to be delineated.

4.1.2 Upstream of WWEIR

The West Feeder Canal Sub-basin phosphorous levels measured at WWEIR are much lower than those measured at PC-17A. In the north portion of the West Feeder Canal Sub-basin, there are actively farmed citrus and row crop lands in Crow's Nest Grove, Duck Curve Farm, Howell Farms, and Point of Cypress Farm. There is also active row crop land in the southwest corner at the Wingate Mill partnership land. The remainder of the agricultural land within the West Feeder Canal Sub-basin is pastureland. Due to the fact that there is little monitoring upstream of WWEIR, the role that each upstream party plays in the water chemistry at WWEIR is unable to be delineated.

5.0 Management Measures and Activities

5.1 Current Management Measures and Activities

BMPs are land management and agricultural techniques that are implemented to improve water quality in discharges. The Florida Department of Agricultural and Consumer Services (FDACS) maintains documentation in the form of Notice of Intent (NOI) forms that provide details on the BMPs being implemented on agricultural lands to improve water quality in offsite discharges. FDACS-adopted BMPs include water quality improvement and water conservation practices to manage nutrients and irrigation and to protect water resources. After filing an NOI with FDACS, landowners are expected to implement applicable BMPs within 18 months. Landowners with a filed NOI are also expected to keep records of BMP implementation for at least five years. FDACS has a BMP Implementation Assurance Program that helps determine how BMPs are implemented and any difficulties in using the practices.

5.1.1 BMPs North of West Weir (WWEIR)

Table 10 lists the farms where BMPs have been registered as described in the NOI paperwork maintained by FDACS. **Figure 33** illustrates the farm areas corresponding to NOIs submitted in the region.

Table 10: NOIs Supplied by FDACS for Areas Upstream of West Weir

NOI NUMBER	SITE NAME	COMMODITY
4831	Crow's Nest Grove	Row/Field Crop
5617	Crow's Nest	Citrus
12606	Sherrods Ranch South	Cow/Calf
13087	Immokalee Ranch	Cow/Calf
13114	Lipman - Hendry - Potato Farm	Row/Field Crop

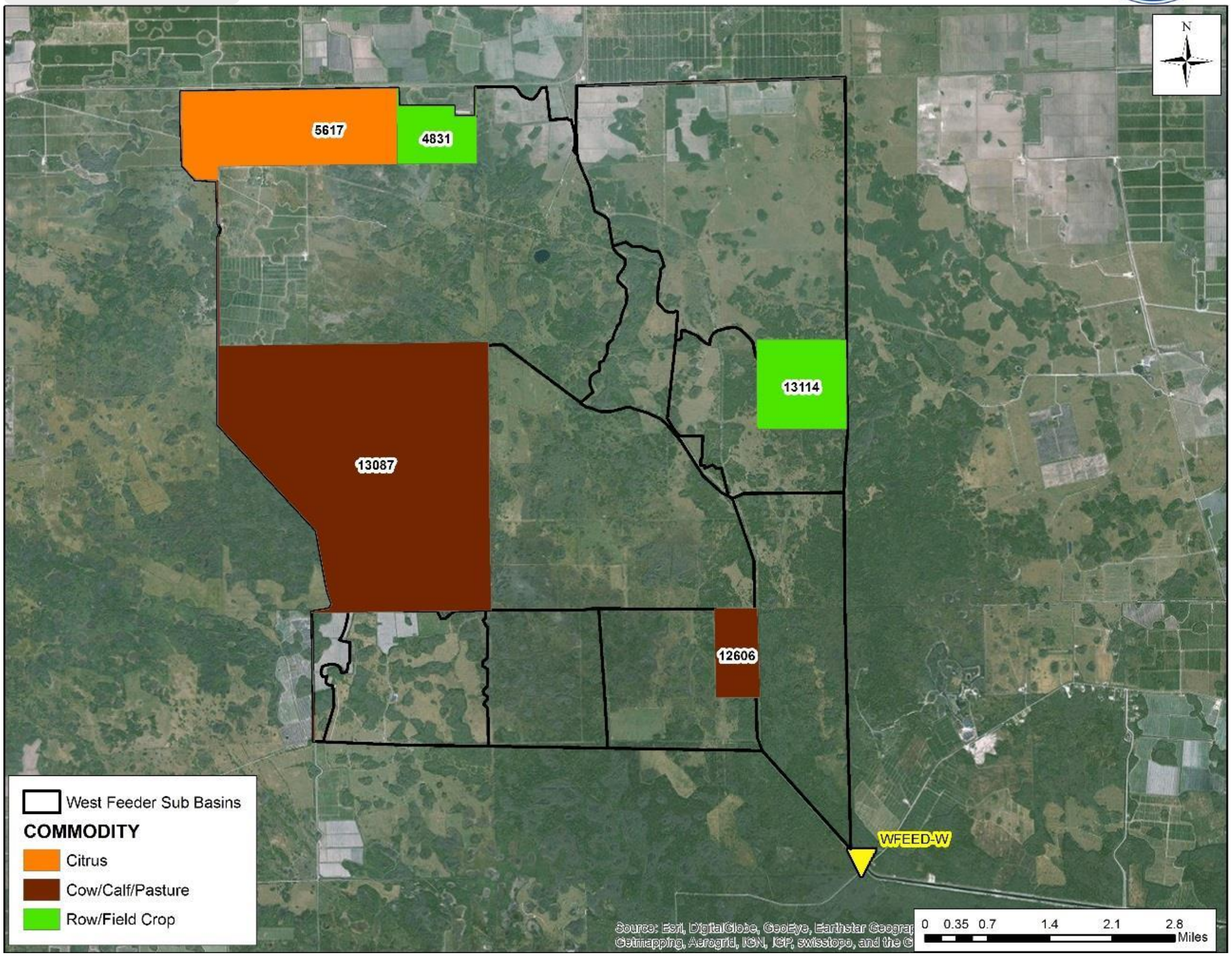

Figure 33: Locations of Currently Active NOIs Upstream of West Weir

5.1.1.1 Citrus BMPs in West Feeder

The citrus BMPs in the FDACS manual focus primarily on water quality improvement efforts, but also include water quantity conservation practices. The one farm upstream of West Weir that has an active NOI for the implementation of citrus operation BMPs in the region is Crow's Nest Grove (NOI number 5617). NOI number 5617 was marked as received by the FDACS Office of Agricultural Water Policy (OAWP) on August 23, 2012. The BMPs registered as implemented on Crow's Nest Grove are listed in **Table 11**.

Table 11: FDACS Citrus BMP Checklist for Crow's Nest Grove

Best Management Practice	NOI # 5617
Acreage	1,703
Water Resource Management	
Water table management	N
Irrigation	Y
Drainage	Y
Managing salinity	N
Mobile irrigation lab	Y
Irrigation system maintenance/evaluation	Y
Moderate discharge rate	Y
Water furrow maintenance	Y
Monitor soil moisture	N
Drainage management plan	N
Drainage rate and volume	Y
Discharge structures	Y
Detention, tailwater recovery, and surface water use	Y
Erosion Control and Sediment Management	
Riser and board water control structures	N
Sediment settling basins in all ditches	N
Ditch construction	Y
Stabilize bare soils	Y
Ditch bank contours & vegetation maintenance	Y
Protect ditch banks	N
Vegetative stabilization	Y
Aquatic plant management	Y
Ditch maintenance, cleaning & dredging	Y
Herbicide applications	Y
Middles management (herbicide)	Y
Grove development and renovation	Y
Settling basins (sumps)	N
Water furrow drain pipes	Y
Water furrow maintenance	Y
Construction activities and temporary erosion control measures	Y
Pest Management	
Integrated pest management (IPM)	Y
Label is the law	Y
Product selection	Y
Minimize spray drift	Y

Best Management Practice	NOI # 5617
Application timing	Y
Precision application of CP products	Y
Maintenance and calibration	Y
Record keeping	Y
Protect water sources during mixing	Y
Spill management	Y
Permanent mix-load sites	NA
Portable mix-load sites	Y
Utilize nurse tanks for random field mixing	Y
Excess mixture	Y
Container management	Y
Equipment sanitation & wash water handling	N
Storage	Y
Excess formulation	Y
Purchase and transport	Y
Product use training	Y
Nutrient Management	
Education	Y
Nutrient management	Y
Waste utilization	N
Utilize tissue and soil analyses	Y
Use appropriate application equipment	Y
Equipment calibration and maintenance	Y
Apply materials to target sites	Y
Avoid high-risk applications	Y
Fertilizer storage	Y
Spilled fertilizers	Y
Use caution when loading near ditches, canals and wells	Y
Alternate loading operation sites	Y
Use backflow prevention devices	Y
Split applications throughout season	Y
Erosion control and sediment management	Y
Irrigation management	Y
Incorporate organic materials	N
Well protection	NA
Use appropriate sources and formulations	Y
Salinity	Y
Conservation buffers and setbacks	N

5.1.1.2 Cow/Calf BMPs in West Feeder

The BMPs for cow/calf operations are primarily intended to protect water quality, but water conservation benefits are also possible. The two cow/calf operations in the region with active FDACS NOIs are Sherrod's Ranch South (NOI number 12606) and Immokalee Ranch (NOI number 13087). NOI number 12606 was signed by the owner on October 4, 2013. NOI number 13087 was signed by the ranch manager on December 10, 2013. **Table 12** lists the BMPs implemented for these two cow/calf operations.

Table 12: FDACS Cow/Calf Operations BMP Checklist for Sherrod's Ranch South and Immokalee Ranch

Best Management Practice		NOI #	
		13087	12606
	Acreage	4809	316
1.0 Nutrient Management			
1.1	Level I Fertilizer Management		
1	Use Mehlich-1 soil test results or equivalent to determine P application rate	Y	Y
2	Determine supplemental fertilizer needs using appendix 5 worksheet	NA	Y
3	Use IFAS publication SL-129 to determine fertilization rates	Y	Y
4	Time fertilizer applications for maximum nutrient uptake	Y	Y
5	Prevent spreading fertilizer material within 50' of streams, sinkholes, or wetlands	Y	Y
1.2	Level I - Residuals or Biosolids Application		
1	Follow FDEP/FDOH regulations for residuals/septage application	NA	NA
2	Request the Calcium Carbonate Equivalency and nutrient analysis of treated biosolids	NA	NA
3	Obtain copy of FDEP "Agricultural Use Plan"	NA	NA
1.3	Level I - Animal Nutrition and Feedstock		
1	Manage supplemental feed to avoid high nutrient loads	Y	Y
2	Locate confined feeding areas away from sensitive features	Y	Y
3	Locate mineral and supplemental feed 100' from sensitive features	Y	Y
1.4	Level I - Animal Waste Management		
1	Manage livestock distribution to reduce waste accumulation	Y	Y
2	Use concentrated on-site manure sources for fertilizer	Y	Y

2.0 Alternative Cattle Water Sources			
2.1	Level I - Water Needs Inventory		
1	Inventory existing water sources and compare to livestock demand	Y	Y
2	Review water management district records on regional well water quality data	Y	Y
2.2	Level I - Upland Pond Construction Criteria - Existing		

1	Construct ponds less than 2 acres and locate at least 50' from wetlands, or further based on water management district requirements	Y	Y
2	Construct cattle access areas with minimum 3:1 slope	Y	Y
2.3	Level I - Other Watering Sources		
1	Locate troughs/shade to keep cattle from streams or watercourses	Y	Y
2	Construct troughs/tanks with stable base	Y	Y
3	Extend pipe at least 100' from waterbody	Y	Y
3.0 Prescribed Grazing			
3.1	Level I - Prescribed grazing guidelines		
1	Manage forages/pastures for plant vigor, erosion and maintain soil moisture	Y	Y
2	Use rotational grazing or other measures for regrowth	Y	Y
3	Manage wetlands through flash grazing or exclusion	NA	NA
3.2	Level II - Comprehensive Prescribed Grazing		
1	Develop grazing schedules based on NRCS Code 528	NA	Y
2	Incorporate cross-fencing in larger pastures	Y	Y
4.0 Sediment and Erosion Control Measures			
4.1	Level I - General Erosion and Sediment Control Measures		
1	Minimize vegetation clearing during construction	Y	Y
2	Clear land during dry season	Y	Y
3	Vegetate road banks and disturbed areas within 14 days of construction	Y	NA
4	Use rock crossings for low flow streams	NA	NA
5	Manage livestock to prevent erosive trails	Y	Y
4.2	Level I - Silt Fences		
1	Use silt screens (less than 3 months) for sheet flow	NA	NA
4.3	Level II - Check Dams		
1	Install check dams perpendicular to flow	NA	NA
4.4	Level II - Sediment Traps		
1	Install sediment traps within conveyance system or near cowpens	NA	NA
2	Retrofit associated sediment trap structures with flashboard risers	NA	NA
4.5	Level III - Grade Stabilization Structures		
1	Clear construction area of debris	NA	NA
2	Vegetate disturbed areas within 14 days of construction	NA	NA
3	Fence around structure to exclude livestock	NA	NA
4	Install structures during dry season	NA	NA
5	Follow criteria for fill placement and spreading per this BMP	NA	NA
6	Prevent damage from overtopping the structure, and divert excess flows	NA	NA
7	Follow earth embankment side slope specifications per this BMP	NA	NA
8	Obtain technical assistance as needed	NA	NA
5.0 Water Resources Management			
5.1	Level I - Water Supply		
1	Know quantity/quality of irrigation source	NA	NA

2	Determine water requirements for forage grasses	NA	NA
5.2	Level I - Ditch Construction and Maintenance		
1	Follow appropriate grades and plans during ditch excavation	Y	NA
2	Use appropriate setbacks to avoid hydraulic drawdown impacts to wetlands	Y	NA
3	Use structural control measures in areas with high water velocity	Y	NA
4	Control broadleafs to maintain permanent vegetative cover	Y	NA
5	Remove unconsolidated sediments from ditches	Y	NA
5.3	Level I - Installation of Water Control Structures		
1	If economically feasible, install water control structures to rehydrate wetlands that have offsite flows	NA	NA
2	Maintain boards in all structures to reduce discharge volume	NA	NA
5.4	Level I - Grassed Waterways		
1	Install grassed waterways per USDA-NRCS specifications	NA	NA
6.0 Conservation Buffers			
6.1	Level I - Field Borders		
1	Install and maintain field borders at perimeter on new improved pastures	Y	Y
2	Time planting borders for plant survival and consider using native species	Y	NA
6.2	Level I - Filter Strips		
1	Install filter strip to treat runoff from concentrated livestock areas	NA	NA
2	Follow filter strip construction criteria in this BMP	NA	NA
6.3	Level I - Riparian Buffers		
1	Install and maintain riparian buffer if > 1% slope, and follow NRCS criteria	NA	NA
7.0 Fence Installation			
7.1	Level I - General Fence Installation		
1	Minimize soil and vegetative disturbances while clearing land	Y	Y
2	Select materials based on purpose and site conditions	Y	Y
3	Adjust stocking rates or subdivide larger pastures	Y	Y
4	Stabilize streambanks and provide alternative water sources in improved pastures, or install exclusion fencing	NA	NA
5	Provide riparian buffer in native or semi-improved pastures that runoff to perennial streams	NA	NA
7.2	Level I - Fence Installation in Wetlands		
1	Minimize use of mechanical equipment, and limit clearing to 12' on either side of fence	Y	Y
2	Perform work during the dry season	Y	Y
7.3	Level II - Livestock Use Exclusion		
1	In area regulated by water management district, install exclusion fencing 300' from discharge point	NA	NA
2	In area not regulated by water management district, install exclusion fencing 500' from discharge point	NA	NA

3	Install exclusion fencing adjacent to perennial streams where significant erosion occurs	NA	NA
	8.0 High Intensity Areas		
8.1	Level I - High-Intensity Area Management		
1	Locate new cowpens 200' from sensitive features; use berm	Y	Y
2	Direct runoff from high-intensity areas away from sensitive features	Y	Y
8.2	Level II - Design Retrofits		
1	Use aggregate materials to prevent erosion	NA	NA
2	Treat discharges occurring into sensitive features	NA	NA
	9.0 Animal Mortality		
9.1	Level I - Sanitation and Disease Control Measures		
1	Transport carcasses in a sanitary manner	Y	NA
2	Clean equipment that comes into contact with carcasses	Y	NA
3	Report dangerous diseases to the state veterinarian (refer to list in this BMP)	Y	Y
9.2	Level I - Disposal		
1	Move carcasses to upland areas	Y	Y
2	Locate burial sites at least 200' from sensitive feature and 50 ' from adjacent property	Y	NA
9.3	Level I - Rendering and Incineration		
1	Use a licensed rendering/incinerating facility	NA	NA
	10.0 Wellhead Protection for Drinking Water Wells		
10.1	Level I - Well Planning and Protection		
1	Construct new wells upgradient from likely pollutant sources	Y	Y
2	Research well permit requirements	Y	Y
3	Cap or valve free-flowing wells	Y	NA
4	Keep livestock 75' from potable wells	Y	Y
10.2	Level I - Well Construction and Operation		
1	Use a Florida-licensed water well contractor	Y	Y
2	Follow pad and casing specifications in the BMP	Y	Y
3	Retrofit existing wells with concrete collar and fence	ENF	Y
4	Use backflow prevention devices at the wellhead	Y	Y
	11.0 Wetland and Springs Protection		
11.1	Level I - Wetland Protection and Impact Avoidance		
1	Identify wetland or hydric soil types using soil survey	Y	Y
2	Eliminate or reduce adverse impacts to wetlands	Y	Y
	11.0 Wetland and Springs Protection (cont)		
3	Maintain a 25' vegetative buffer from wetlands, or follow buffers prescribed in WMD permit	Y	Y
4	Obtain a USDA-NRCS wetland determination prior to conducting activities in a wetland	Y	Y
11.2	Level I - Water Quality Treatment and Field Discharges		

1	Use pretreatment practices to protect wetlands	Y	Y
2	Rotate livestock through wetlands at accelerated pace	NA	NA
3	Use spreader swales or other means to encourage sheetflow	Y	Y
11.3	Level I - Special Criteria for First and Second Magnitude Springs		
1	Maintain a 100' vegetative buffer around spring features	NA	NA
2	Use split applications of fertilizers on pasture areas that discharge to springs	NA	NA
	12.0 Prescribed Burning		
12.1	Level I - Burn Preparation		
1	Develop and implement a burn prescription plan, or use a Certified Prescribed Burn Manager	Y	Y
2	Obtain burn permit from DOF and heed burning bans	Y	Y
3	Use burning in conjunction with roller copping in areas with an abundance of palmettos	Y	Y
4	Burn only when weather conditions are favorable	Y	Y
12.2	Level I - Construction of Firelines		
1	Carefully select fireline locations and avoid constructing them in wetlands	Y	Y
2	Use alternatives to plowed firelines	OTHER	Y
3	Construct firelines with the contour to minimize soil erosion	Y	Y
12.3	Level I - Fire Safety and Control		
1	Have adequate fire equipment and control burn temperature	Y	Y
2	Ensure fire is completely out before leaving the site	Y	Y
	13.0 Integrated Pest Management and Pharmaceuticals		
13.1	Level I - General IPM Practices		
1	Store pesticides in roofed structure with lockable door, at least 100' from surface water	Y	NA
2	Use appropriate mix/load sites and measures, per this BMP	Y	NA
3	Practice IPM and use all pesticides in accordance with label	Y	NA
4	Rinse, recycle, or dispose or empty pesticide containers following all applicable regulations	Y	NA
13.2	Level I - Pharmaceutical Use and Disposal		
1	Use FDA-approved products, and mix only the amount needed	Y	Y
2	Follow label and dosing instructions	Y	Y
3	Dispose of spent needles and unused pharmaceutical products responsibly	Y	Y

5.1.1.3 Row/Field Crop BMPs in West Feeder

There are two areas specified within the BMP enrollment shapefile provided by FDACS with row/field crop BMP implementation. The Lipman – Hendry Potato Farm (NOI number 13114) documentation indicates that that the area shown on the shapefile provided by FDACS does not seem to correspond to the area that the NOI encompasses. Therefore, the BMPs described in NOI number 13114 are not being practiced within the West Feeder Canal sub-basin. The other location that was included in the FDACS documentation was Crow's Nest Groves. However, Crow's Nest Grove (NOI number 4831) indicates in the

NOI that the land use in the Feeder Canal is citrus, and that the BMP implemented is an approved and operational surface water reservoir. One potential cause for this discrepancy could be row/field crop operations from the ownership of Crow's Nest Grove that are occurring at locations outside of the West Feeder Canal sub-basin. Based on this review of the two specified areas, there appears to be no FDACS NOI documentation for any active row/field crop operations within the West Feeder Canal sub-basin.

5.1.1.4 West Feeder Canal Sub-basin BMP Survey

The purpose of the 2005 West Feeder Sub-basin BMP survey was to identify which BMPs were being implemented at the time by landowners in the West Feeder Canal Sub-basin to aid in the management of the C-139 and Western Basins Grant Program that was created in 2002.

In 2005, the West Feeder Canal Sub-basin survey was distributed to farms within the sub-basin. The farms that returned the BMP survey were Wingate Mill Partnership, Point-of Cypress Partnership, and Crescent H Ranch (James P Howell). **Table 13** summarizes the BMPs specified as implemented from each of the farms surveyed. **Figure 34** shows the farm boundaries corresponding to these surveys. Fry Basin indicated on the map is not within the West Feeder Basin, and therefore is not included in **Table 13**.

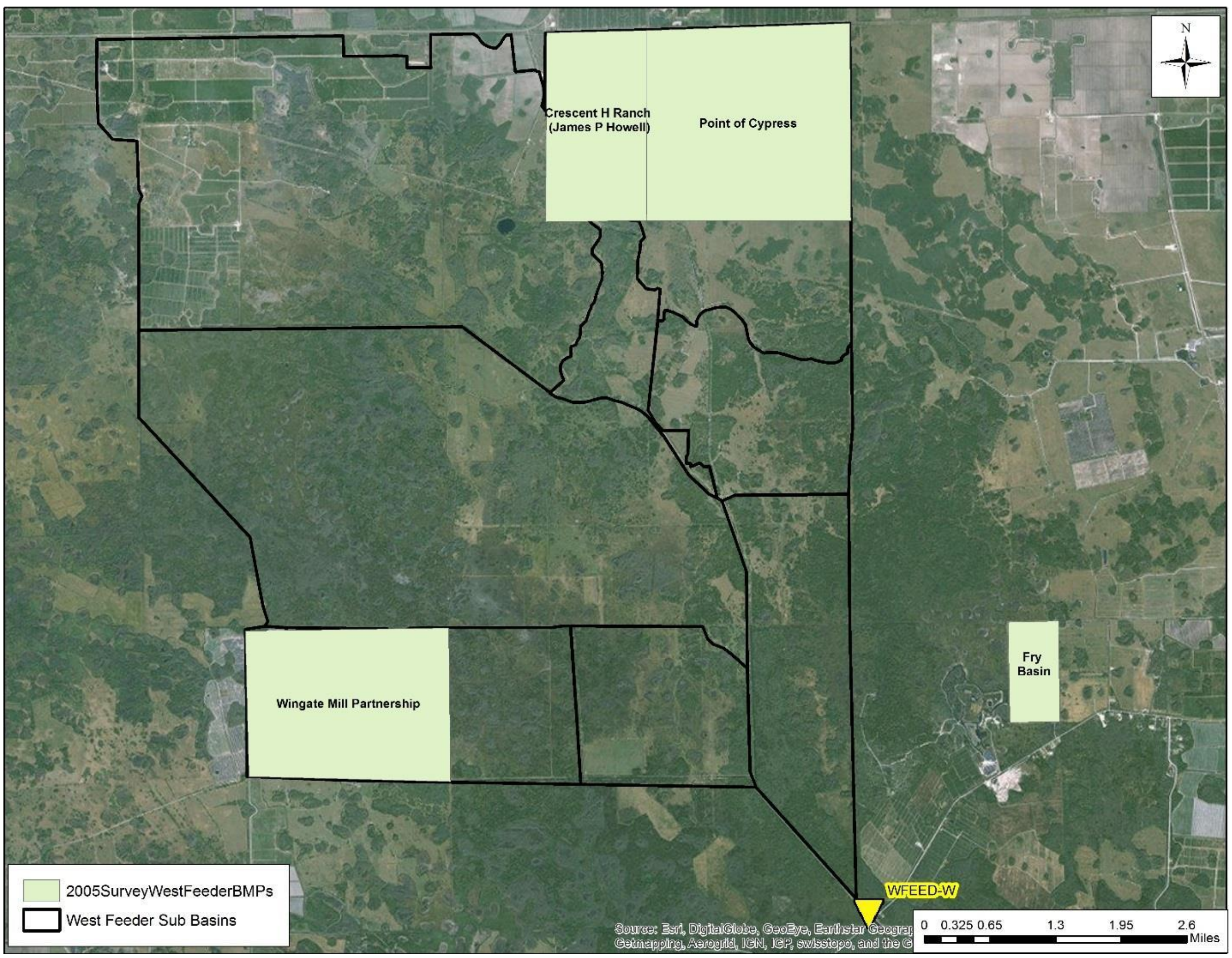

Figure 34: Farms with Responses to the 2005 West Feeder Canal Sub-basin Survey

Table 13: 2005 West Feeder Canal Sub-basin BMP Survey Summary

Best Management Practice	Wingate Mill Partnership		Point of Cypress Partnership		Crescent H Ranch (James P Howell)	
	Y/N/NA	Description	Y/N/NA	Description	Y/N/NA	Description
Heavy Use Area Stabilization	Y					
Filter Strip	Y		Y		Y	
Grassed Waterway	Y		Y		Y	
Cattle Watering Facilities	Y		Y	Ponds	Y	Ponds
Canal Fencing						
Ditch Cleaning	Y		Y		Y	Maintaining ditches for proper flow - cleaning every other year
Water Control Structures (with headers)	Y		Y		Y	3--2 section 3, 1 section 10
Sediment Basins - Water Treatment Areas	Y		Y		Y	
Waterway, Ditch, or Canal Bank Stabilization	Y		Y		Y	Planted grass on dikes
Reservoir or Retention Area	Y		Y		Y	Diked area of about 150 acres
Improved Internal Infrastructure Controls			Y		Y	Structures installed w/ plates and headers
Nutrient Management	Y					
Pasture Renovation	Y		Y		Y	Replant, chop, mowing
Prescribed Grazing	Y		Y		Y	
Land Use Conversion						
Crop Residue Management	Y				Y	Improve soil tilth, and provide wildlife food and cover

Best Management Practice (cont)	Wingate Mill Partnership (cont)		Point of Cypress Partnership (cont)		Crescent H Ranch (James P Howell) (cont)	
	Y/N/NA	Description	Y/N/NA	Description	Y/N/NA	Description
Nutrient Control Practice	Y	Calibrated soil test, banding fertilizer for vegetable production instead of broadcasting it, prevention of fertilizer spills and direct spreading of fertilizer into drainage ditches.	Y	Calibrated soil test, banding fertilizer for vegetable production instead of broadcasting it, prevention of fertilizer spills and direct spreading of fertilizer into drainage ditches.	Y	Prevention of fertilizer spills and the direct spreading of fertilizer into drainage ditches
Water Management Practices	Y	Retention of drainage on-farm.	Y	Retention of drainage on-farm.	Y	Retention of drainage on-farm
Particulate Matter and Sediment Control	Y	Changing the cropping pattern of vegetables, sugar cane, fallow flooding, etc. on a farm so that the optimum use of the above BMPs can be accomplished	Y	Changing the cropping pattern of vegetables, sugar cane, fallow flooding, etc. on a farm so that the optimum use of the above BMPs can be accomplished		
Pasture Management	Y	Reduced phosphorous in cattle feed, carefully located watering and feeding sites, management plans for grazing rotation and temporary holding areas	Y	Reduced phosphorous in cattle feed, carefully located watering and feeding sites, management plans for grazing rotation and temporary holding areas	Y	Reduced phosphorous in cattle feed, carefully located watering and feeding sites, management plans for grazing rotation and temporary holding areas
Others	Y	Mechanically removed Brazilian Pepper and exotics				

5.1.2 BMPs North of PC-17A

The BMPs implemented for the area upstream of PC-17A is not documented through the FDACS NOI records, but is instead archived within legal agreements and BMP verification reports that are on file in the Districts records. The following sub-sections describe the recorded information and summarize the selected BMPs being implemented.

5.1.2.1 Landowner Agreement between McDaniel Ranch and Seminole Tribe of Florida (1996)

The 1996 landowner agreement between McDaniel Ranch and the Seminole tribe of Florida stated that in order to start meeting a water quality goal of 50 ppb TP, within six months of the executed agreement, a BMP plan for existing and future uses should be developed. The agreement also stated that within one year of the agreement the BMPs for existing uses should be initiated, and that within two years of the agreement, all BMPs for existing uses should be in place. In Exhibit B of the landowner agreement, 47 BMPs were specified, which are listed in **Table 14**.

Table 14: Recommended BMPs from 1996 Landowner Agreement Exhibit B

Source Control		Transport (cont)		Treatment (cont)	
1	Biological control of pests (IPM)	17	Fencing	33	Detention pond
2	Correct application of pesticides	18	Grade stabilizing structure	34	Field border
3	Correct pesticide container disposal	19	Pastures and hay land management	35	Flood water reduction structures
4	Cultural control of pests	20	Planned grazing systems	36	Grassed waterway or outlet
5	Resistant crop varieties	21	Prescribed burning	37	Irrigation reservoir
6	Irrigation water conveyance	22	Proper grazing use	38	Land absorption area
7	Irrigation water management	23	Range seeding	39	Livestock exclusion
8	Mulching	24	Shade areas	40	Regulated runoff impoundments
9	Slow release fertilizer	25	Streambed protection	41	Vegetative filter strip
10	Soil testing	26	Strip-cropping	42	Waste management system
11	Timing/placement of fertilizer	27	Tree planting	43	Waste treatment lagoon
Transport		28	Water table management	44	Waste utilization
12	Artificial barriers	29	Water feeder location	45	Water tolerant crops
13	Conservation cropping system	**Treatment**		**Maintenance**	
14	Critical area planting	30	Aquatic Filter pond	46	Canal maintenance
15	Crop residue use	31	Brush management	47	Nutrient management
16	Deferred grazing	32	Debris basin		

5.1.2.2 Historical Tracking for 1998

The document "McDaniel Ranch BMPs Historical Tracking 1997-1998" (Exhibit 9A-FC_002) describes the initial implementation of the 1996 landowner agreement BMPs as of February 1998. **Table 15** summaries the BMP implementation indication from this 1998 document.

Table 15: BMPs Indicated as Implemented in February 1998

BMP	Implementation Year Specified
Biological Control of Pests (IPM)	1997
Correct Application of Pesticides	1997
Cultural Control of Pests	1998
Resistant Crop Varieties	1996
Irrigation Water Conveyance	1987
Irrigation Water Management	1992
Slow Release Fertilizers	1998
Soil Testing and Planting Analysis	1992
Conservation Cropping System	1996
Critical Area Planting	1990
Field Border	1980
Vegetative Filter Strip	1997
Canal Maintenance	1996
Grade Stabilizing Structure	1987
Irrigation Reservoir	1997
Flood Water Reduction Structures	1997
Detention Pond	1987
Artificial Barriers	1960
Pastures and Hayland Management	1980
Range Seeding	1980
Shade Areas	1920
Water Table Management	1980

According to the “Summary Report of Annual McDaniel Ranch Site Reconnaissance and Water Quality Improvement Information” from 2001, precision farming and slowing the velocities of surface water discharges at the project outfalls were implemented in 2000.

5.1.2.3 BMP Documentation Update (2005)

Based on a letter dated May 6, 2005 from Lockhart Ag Technologies to the District, the land uses for the McDaniel Ranch Region and their corresponding BMPs are listed in **Table 16**.

Table 16: 2005 BMP Implementation Verification

Sugar Cane (McDaniel Ranch)	Pastures (McDaniel Ranch)
Crop Rotation/Cover Cropping	Deferred grazing
Correct application of pesticides	Fencing
Integrated pest management	Floodwater reduction structures
Pesticide container disposal practices	Livestock exclusion
Pesticide spill prevention practices	Pasture management
Correct application of fertilizers	Planned grazing systems
Soil testing and analysis	Prescribed burning
Customized fertilizer recommendations	Shade areas
Slow release fertilizer use	Water/feeder locations
Controlled boundary application for P fertilizers	**Citrus (McDaniel Ranch)**
Field borders	Biological control of pests (IPM)
Floodwater reduction structures	Correct application of pesticides
Regulated runoff impoundment	Customized fertilizer recommendations
Resistant crop varieties	Soil testing and analysis
Stripcropping	Field borders
Vegetables (Leased Lands)	Floodwater reduction structures
Crop Rotation/Cover Cropping	Regulated runoff impoundment
Correct application of pesticides	Resistant crop varieties
Integrated pest management	Cedar trees used for windbreaks
pesticide container disposal practices	**Other Ranch lands**
pesticide spill prevention practices	Aquatic filter pond
correct application of fertilizers	Artificial barriers
soil testing and analysis	Canal maintenance
Customized fertilizer recommendations	Debris basin
Controlled boundary application for P fertilizers	Detention pond
Field borders	Grade stabilization structures
Floodwater reduction structures	Streambank protection
Regulated runoff impoundment	Vegetative filter strips
Resistant crop varieties	

5.1.2.4 BMP Verification (2007)

A 2007 BMP Implementation Report by TAC Environmental Water Resources Consulting, Inc. verified the implementation of BMPs relevant to the 1996 Landowner Agreement. The landowners and lessees with agricultural operations in the area under the 1996 agreement that were certified in this report for BMP Implementation were McDaniel Ranch, Thomas Produce, Pero Family Farms LLC, South Florida Tomato Growers--Harllee (SFTG), and B.F. Stanford Farms. The report contained a table that described whether or not certain BMPs were applicable to the farms in the region as well as certification of BMP implementation forms completed by the landowner or lessee. **Table 17** summarizes the BMP implementation verification forms that were completed by the landowners/lessees on McDaniel Ranch.

Table 17: 2007 BMP Implementation Verification for each Agricultural Field on McDaniel Ranch

Best Management Practice	Citrus		Pasture Native Residence				Row Crop										
Field Name	M-1	M-2	M-E1	M-E2	M-E3	M-W	T-1	T-2	T-3	T-4	P-1	P-2	P-3	P-4	P-5	SFTG-1	BF-1
Source Control																	
Integrated pest management program	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V		V
Correct application of pesticides	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V		V
Herbicide/Pesticide Container Disposal	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V		V
Irrigation Water Management	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
Mulching							V	V	V	V	V	V	V	V	V	V	V
Slow Release Fertilizer	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
Soil Testing and Plant Analysis							V	V	V	V	V	V	V	V	V	V	V
Timing and Placement of Fertilizer (Fertilizer application control)	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
Nutrient Spill Prevention	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
No P imported via direct land application	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
Internal farm water management	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
SFWMD SWMS Permit	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
Transport																	
Fencing			V	V	V	V											
Pasture and Hayland Management			V	V	V	V											
Proper Grazing Use			V	V	V	V											
Shade Areas (away from drainage)			V	V	V	V											

Best Management Practice	Citrus		Pasture Native Residence				Row Crop										
Field Name	M-1	M-2	M-E1	M-E2	M-E3	M-W	T-1	T-2	T-3	T-4	P-1	P-2	P-3	P-4	P-5	SFTG-1	BF-1
Transport (cont)																	
Wind Breaks between blocks	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
Leveled fields							V	V	V	V	V	V	V	V	V	V	V
Restricted placement of feed and water to reduce "hot spots" near drainage ditches, canals and discharge locations			V	V	V	V											
Reduced P in feed minimum of 20% below accepted standard requirements			V	V	V	V											
Maintenance																	
Canal Maintenance (Canal and Ditch Cleaning)	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
Maintain vegetation on canal and ditch banks	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
Sediment sump upstream of outflow pump (cleaned regularly)	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
Sediment sump upstream of internal culverts or culvert bottoms above ditch bottoms	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
Control aquatic weeds upstream of outflow pumps	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V

*V=Verified BMP Implementation

5.1.2.5 BMP Verification Update (2009)

The purpose of the 2009 site visits and report were to verify the implementation of the BMPs required by the 1996 Landowner Agreement. The 2009 report found that McDaniel Ranch had implemented the BMPs required. The sites verified were the Thomas Produce leased lands, B.F. Standford Farms (a.k.a. Mark's Produce) leased lands, Pero Farms leased lands, 6L's Farms leased lands, and farms still maintained by McDaniel Ranch. **Table 18** describes the BMPs verified by the 2009 site visits and report. **Figure 35** shows the locations of the fields where BMPs were implemented.

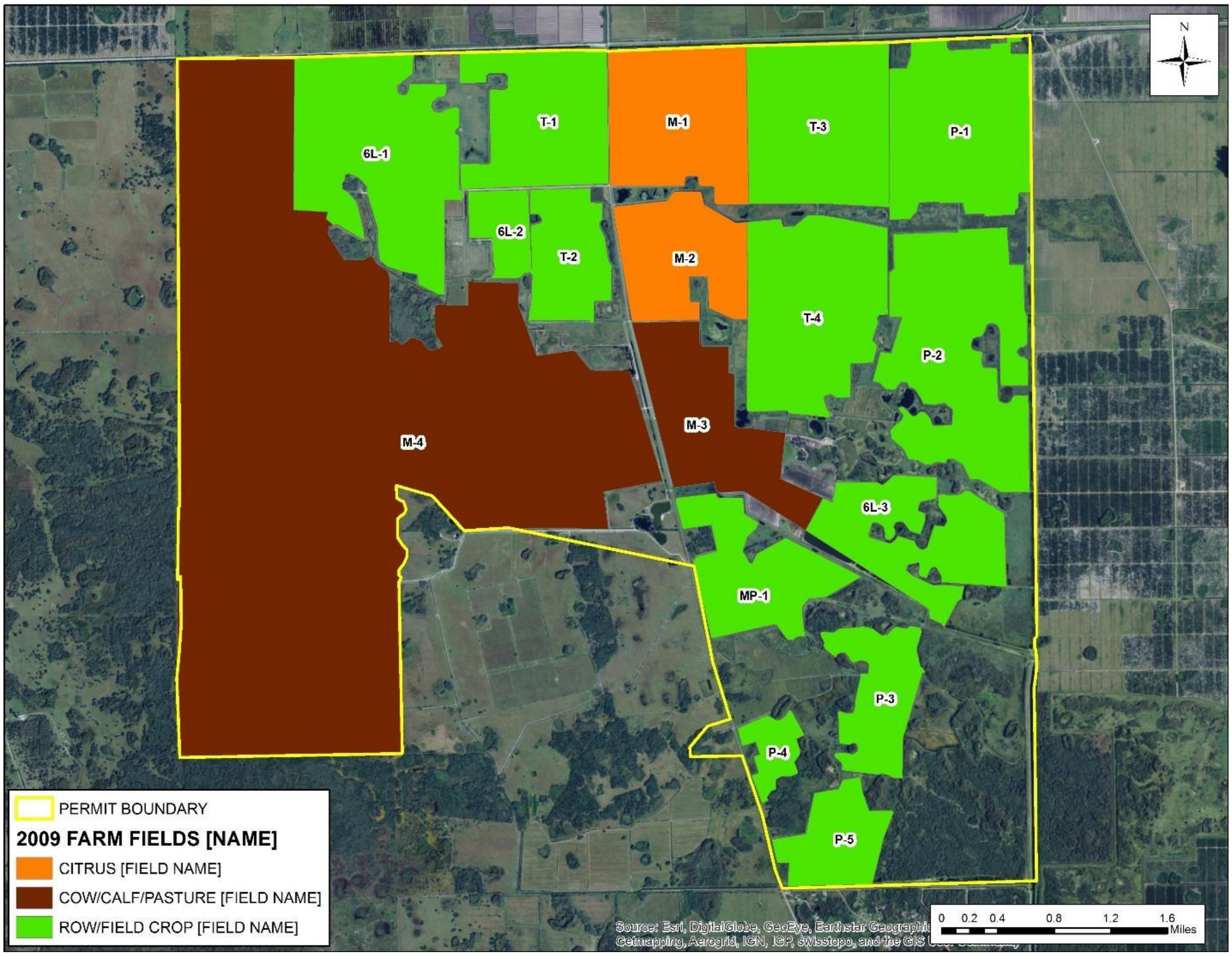

Figure 35: 2009 Fields on McDaniel Ranch with BMP Implementation

Table 18: 2009 BMP Implementation Verification for each Agricultural Field on McDaniel Ranch

Best Management Practice	Citrus		Pasture		Row Crop												
Field Name	M-1	M-2	M-3	M-4	T-1	T-2	T-3	T-4	P-1	P-2	P-3	P-4	P-5	MP-1	6L-1	6L-2	6L-3
Acreage	525	625	552	5,739	551	303	729	776	729	949	311	105	260	423	900	140	525
Pasture Management																	
Low Cattle Density			V	V													
Cattle Feeder			V	V													
Canal/Ditch Cleaning and Maintenance	V	V	V	V													
Maintain Vegetation to Stabilize Field and Lateral Ditch and Main Canal Banks	V	V	V	V													
BMP Training	V	V	V	V													
Fertilizer Spill Prevention																	
Training	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
Fertilizer/Pesticide Storage	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
Transport/Field Loading	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
Spill Clean-Up	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
Reporting Requirements	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
Container Disposal	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
Spill Records																	

Nutrient Control																	
Foliar spray	V	V															
Timing and placement of fertilizer	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
Soil Testing	V	V			V			V	V	V	V	V	V	V	V	V	V
Plant Tissue Analysis	V	V															
Other																	
Fields Left Fallow					V	V	V	V	V	V	V	V	V	V	V	V	V
Soil Erosion Control					V	V	V	V									
Field Borders and Strip Cropping Between Row Crops					V	V	V	V									
Field Border along Canal Ditches					V	V	V	V									
Canal or Ditch Cleaning					V	V	V	V	V	V	V	V	V		V	V	V
Cover Crops					V	V	V	V									
Wind breaks, field borders or strip cropping									V	V	V	V	V	V			
Plastic covering of rows									V	V	V	V	V	V			
Laser Leveling									V	V	V	V	V		V	V	V
Sumps for Maintenance									V	V	V	V	V				
Vegetation on Banks									V	V	V	V	V				
Plant burning to eliminate vines															V	V	V

*V=Verified BMP Implementation

5.1.2.6 BMP Verification Update (2014)

The 2014 BMP Verification Letters and reports, specified the verification for Everglades Plantation and Property NW, Garcia Farms, Garcia Farms - Lands Leased to Pero Farms, Garcia Farms - Lands Leased to Thomas Produce, and Garcia Farms - Lands Leased to Lipman Farms. All verification letters stated that the subject farms generally appeared to have implemented BMPs in accordance with the 1996 Landowner Agreement. The attachments to the letter recommend follow up activities for some of the BMPs that were verified onsite. **Table 19** describes the BMPs verified in the 2014 reports. **Figure 36** shows the delineation of the NW Property, Everglades Plantation, and Garcia Farms.

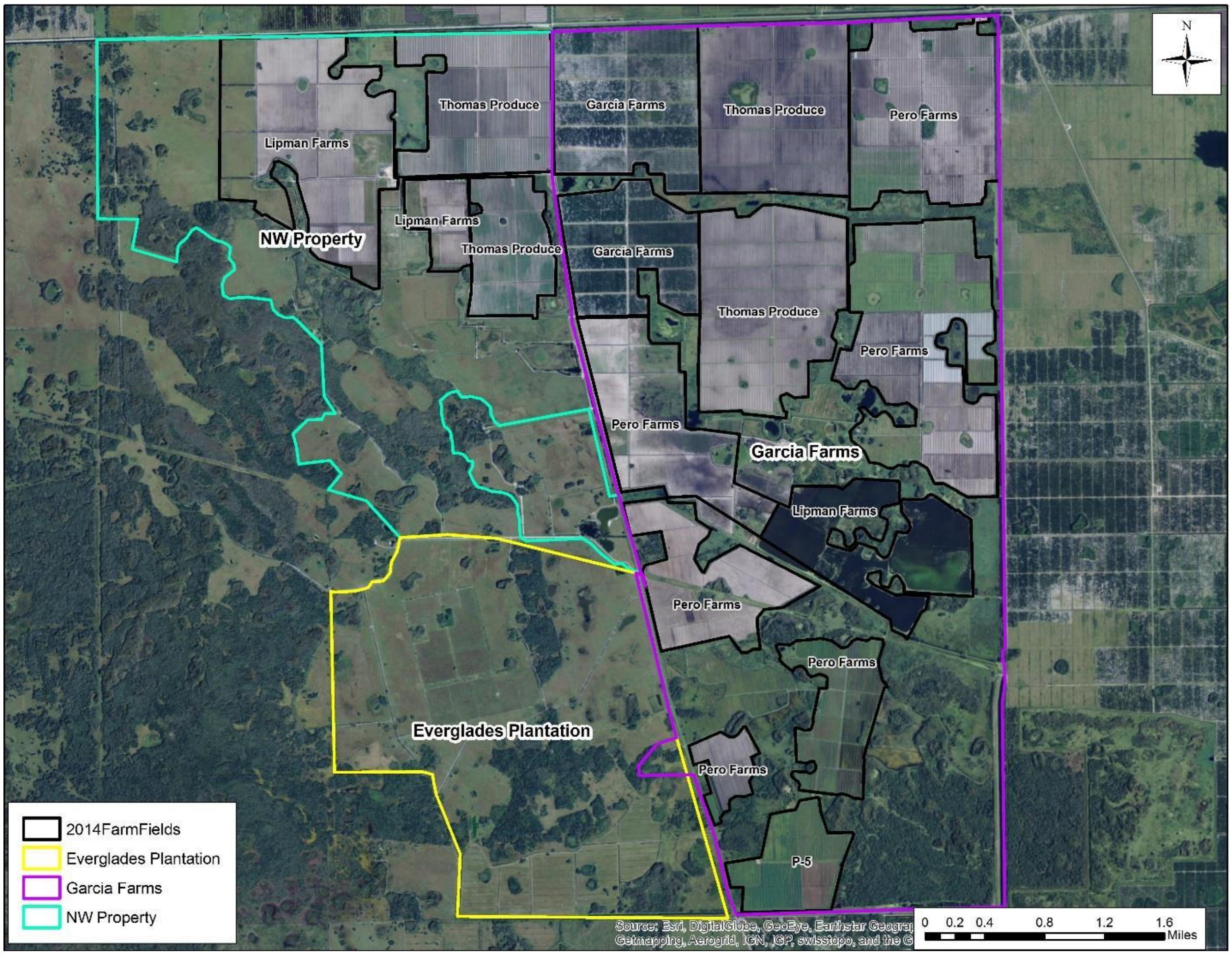

Figure 36: NW Property, Everglades Plantation, and Garcia Farms

Table 19: 2014 BMP Implementation Report Summary

	Thomas Produce	Pero Farms	Lipman Farms	Garcia Farms	NW Property and Everglades Plantation
Nutrient Control Practices					
Soil testing and Planting Analysis	V	V	V	V	V
Timing/placement of fertilizer	V	V	V	V	V
Mulching		V			
Nutrient maintenance	V	V	V	V	V
Particulate Matter and Sediment Controls					
Canal maintenance	V	V	V	V	V
Streambed protection	V	V	V	V	V
Debris basin	V	V	V	V	V
Field Leveling	V	V	V		
Grassed waterway or outlet				V	V
Water Management					
Regulated Runoff Impoundments	V	V	V	V	
Irrigation Water Management	V	V	V	V	
Water Table Management	V	V	V	V	
Flood water reduction structures					V
Pasture Management					
Livestock exclusion to prevent soil erosion					V
Planned grazing system					V
Proper grazing use					V
Fencing					V
Pastures and hay land management to protect soil					V
Shade areas					V
Water and feeder locations					V

*V=Verified BMP Implementation

5.1.2.7 FAVT

In August of 2015, a water use permit (26-01205-W) was issued to FPL for a 140-acre nutrient removal project using a FAVT system with an annual allocation of 5,829.05 million gallons. The project will be located in the southern portion of FPL's property (see **Figure 20**) and will consist of wetland cells, which will be utilized to remove nutrients from the surface water in order to improve water quality and establish a viable submerged aquatic vegetation community. A 20 cfs inflow pump will pump water from an onsite pasture ditch. Two inflow pumps (20 cfs and 40 cfs) will also pump water from Southern Boundary Canal into the project. The water will be circulated through the treatment system and discharged back to the Southern Boundary Canal. Construction of this project is anticipated to occur in 2016.

5.2 Management Measures and Activities Proposed for this Watershed Plan

There are six sub-regional (SR) water quality improvement measures that were identified for further evaluation. The measures include proposals to implement diversions from the basin, incorporation of new detention facilities, and operational changes of existing structures. Factors that were considered in developing the measures included locations of higher TP concentrations, nutrient removal effectiveness, historical flow conditions, maintenance/operation, and site logistics. Factors that were not considered in developing the projects included implementation cost, land ownership, regulatory requirements, and specific targets for water quality.

There are five management measures that are proposed within the North Feeder Canal Sub-basin, and one management measure proposed in the West Feeder Canal Sub-basin. All six measures are shown in **Figure 37** with a brief description included in **Table 20**.

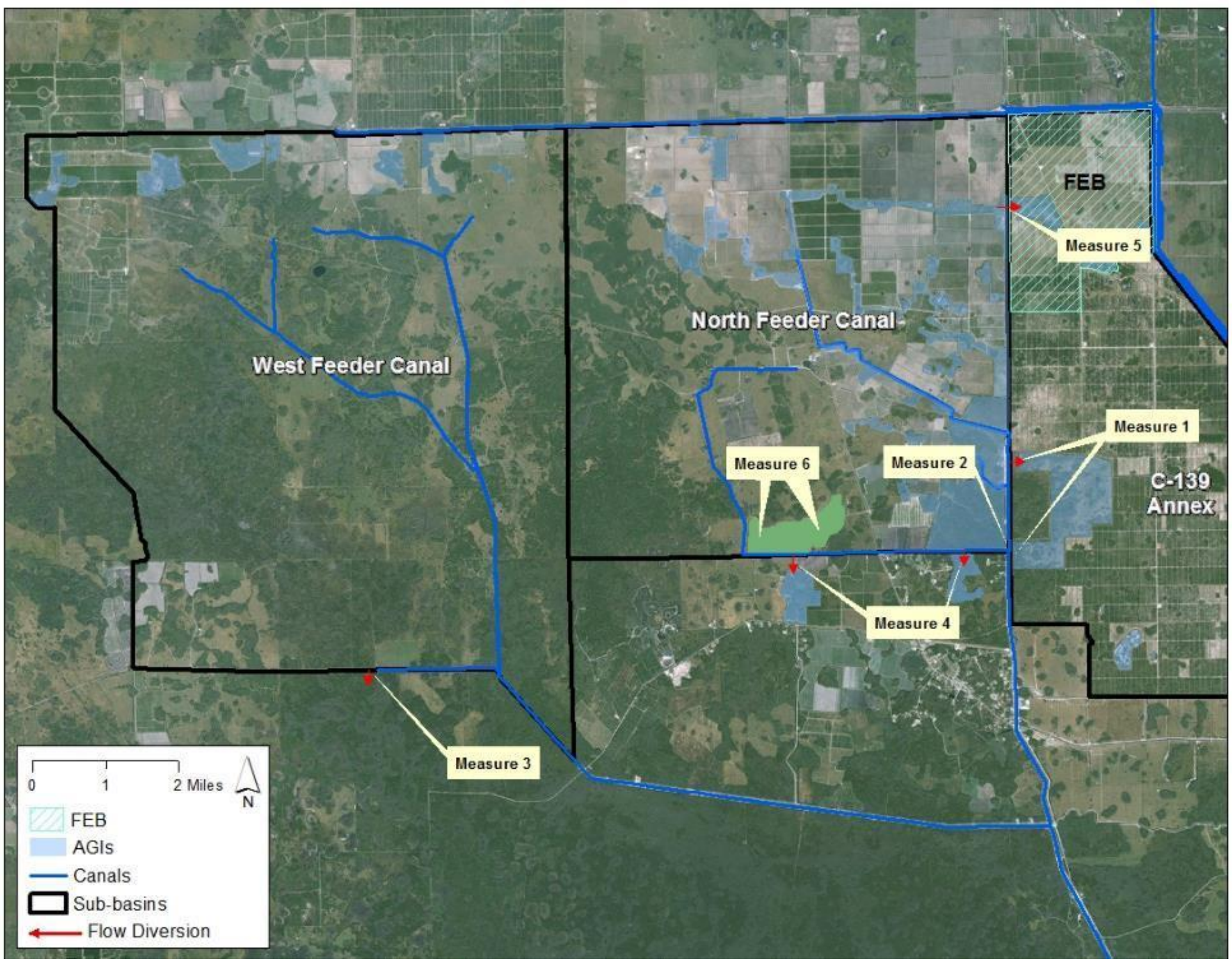

Figure 37: Potential SR Water Quality Improvement Measures in the Northern Reach

Table 20: Summary of Potential SR Water Quality Improvement Measures

Number	Proposed Project
SR-1	Diverting discharges from North Feeder Canal sub-basin to the C-139 Annex
SR-2	Replacing PC-17A with a remotely operated structure
SR-3	Degrading southern bank of Wingate Mill Canal
SR-4	Diversion of water from South Boundary Canal to the south
SR-5	Utilization of the C-139 Annex Flow Equalization Basin (FEB)
SR-6	Sub-regional detention storage and treatment facilities (FAVT and FEB)

5.3 Evaluation of Management Measures and Activities

5.3.1 Measure #1 – Diverting Discharges from North Feeder Canal Sub-basin to the C-139 Annex

Within the existing C-139 Annex facility there is an AGI, referred to as Pond 3, that is immediately east of the North Feeder Canal and is approximately one foot lower in comparison with the Garcia Farm's Detention Area D. Measure #1 proposes to use Pond 3 to receive diverted runoff. There are two primary benefits associated with this measure: (1) re-establishment of a historic flow-path from west to east in this location, and (2) anticipated water quality improvement from increasing the retention time of water as it is routed through Pond 3. In the interest of maintaining the volume of water for downstream users, all water proposed to be diverted into Pond 3 will be discharged back into the North Feeder Canal. **Figure 38** illustrates the proposed configuration.

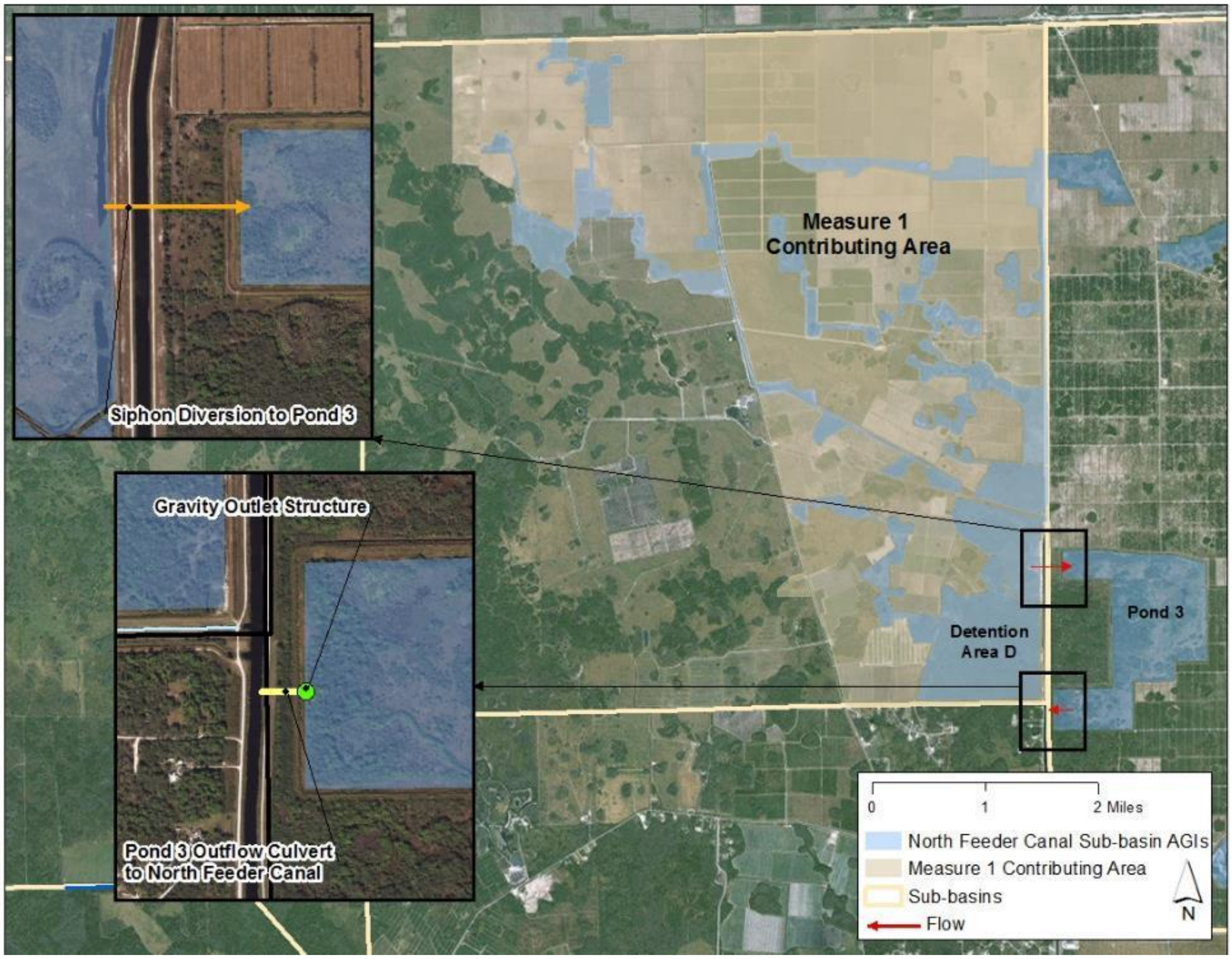

Figure 38: Contributing Area for the Proposed Measure #1 Diversion and the C-139 Annex

5.3.1.1 Measure #1 – Water Quality Benefit

It is assumed that water could be diverted to Pond 3 through infrastructure, such as additional canals and structures, or potentially a siphon structure or pump station from Detention Area D to Pond 3. In order to connect Detention Area D to Pond 3, an approximately 1,100 foot-long, 60-inch pipe would need to cross under the North Feeder Canal. For the North Feeder Canal sub-basin, the only site where flow and water quality data are available on a continuous basis is PC-17A. The contributing area for PC-17A includes two regions: (1) Garcia Farms (east of County Road [CR] 833), and (2) McDaniel Ranch/FPL (west of CR 833).

Measure #1 includes diverting the runoff through either the L-3 Canal through USSO to the east or back to the North Feeder Canal through a new structure. Based on discussions with District staff during the April 19, 2016 coordination meeting, the selected option for this evaluation is to discharge the water to the North Feeder Canal after being routed through Pond 3 for additional detention and treatment.

The proposed contributing area to be diverted in Measure #1 is the Garcia Farms portion of the North Feeder Canal (east of CR 833). In order to quantify the water quality benefit of Measure #1 as it affects PC-17A, the flow and concentration of the water being discharged must be evaluated. Since there are no measured data to calculate discharge at the Detention Area D outfall, and there is a sophisticated surface water management system in the area, a combination of the calibrated model results and a simple spreadsheet approach was used to evaluate the benefits.

The daily time series of flows into Pond 3 was generated using the modeled flows at the Detention Area D outfall and PC-17A from the calibrated 2016 MIKE 11 hydrologic and hydraulic model. For the period of June 2011 through May 2014, the modeled flow volume at the Detention Area D Outfall is 48% of the modeled flow volume at PC-17A. Therefore, a time series was created by assuming that the flow routed to Pond 3 is 48% of the measured flow at PC-17A. This fractional flow volume and the rainfall measured from the Big Cypress gage are the only inflows into Pond 3.

The assumed outflows from Pond 3 are the daily levee seepage, daily vertical seepage, daily estimated evapotranspiration (ET), and proposed discharge. Based on preliminary analyses, the discharge capacity did not need to be significant in order to maintain water levels below the depth threshold for minor impoundments (4 feet). In fact, using the estimated inflows and outflows, there are months at a time with no expected discharge from Pond 3. Considering that this outcome would have a negative effect on downstream consumptive users, the proposed discharge capacity was developed based on maximizing the water quality benefit only. The estimated ET was calculated based on the measurement taken at the nearest weather station (BIG CY SIR) and the total composite area of the AGIs south of the South Boundary Canal. The daily levee seepage was calculated using the perimeter of the AGI levees, beginning-of-day depth in the reservoir, and seepage rate of 1 cfs/ft head/mile levee. The seepage rate is an assumption based on comparable levees in the Everglades Agricultural Area. Notably, the soils in the Western Basins can have very different characteristics than soils in the Everglades Agricultural Area, so prior to detailed design of any proposed facilities, a geotechnical field investigation would be necessary to verify this assumption. The infiltration rate was assumed to be 0.0041 (cm/d)/cm based on the average of values determined for the STA-5 and STA-6 facilities. The daily discharge was calculated based on a residence time of four days, assumed from the size of Pond 3. Therefore, outflow was calculated by dividing the volume of water in the pond at the end of the previous day by the target residence time.

Based on each calculated water budget component, the inflows and outflows are added and subtracted, respectively, from the previous day's water volume to calculate the current water volume. Using the area of the pond and the estimated beginning of day water volume stored in the AGI, the estimated depth of water in the pond was calculated. **Figure 39** shows the magnitude of the daily outflows, the inflow volume from the Detention Area D, and the depth in the pond.

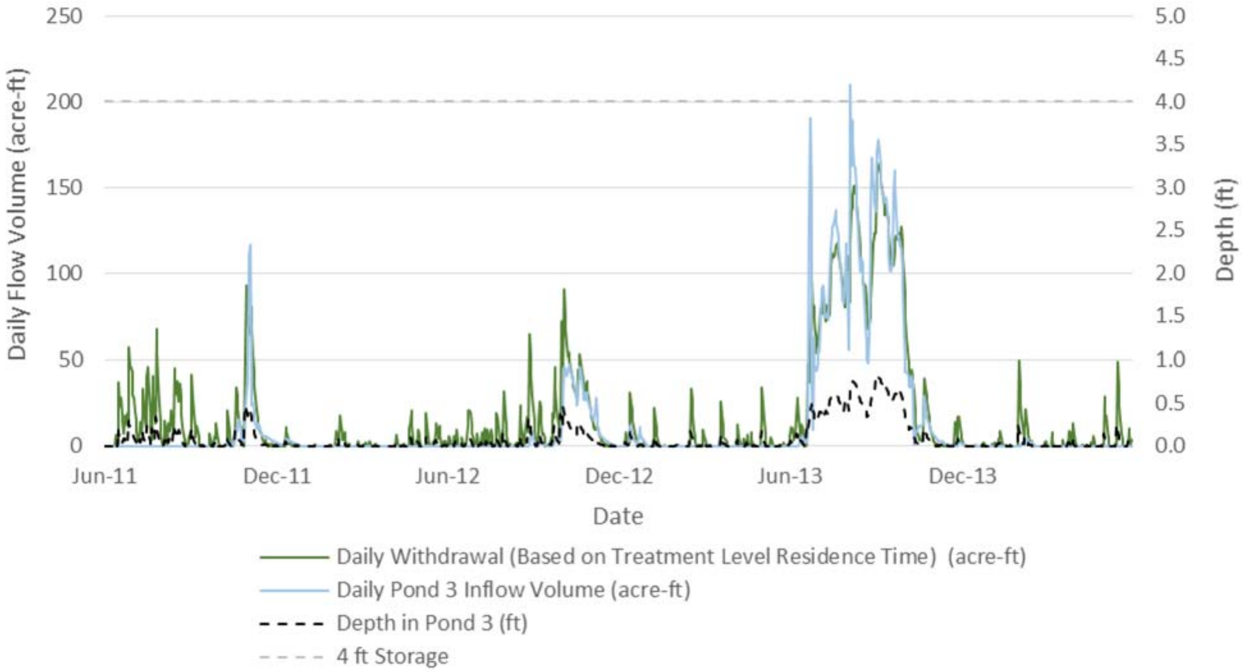

Figure 39: Inflows to, Outflows from, and Depth in Pond 3 with Implemented Diversion Measure #1

Assuming that all flows from Garcia Farms are discharged into Pond 3, the remaining flow at PC-17A would consist of only the flows from the contributing area upstream of the CR 833 culvert. **Figure 40**, **Figure 42**, and **Figure 44** predict how diverting Detention Area D completely away from PC-17A impacts the hydraulic loading of PC-17A. **Figure 41**, **Figure 43**, and **Figure 45** illustrate the difference between the existing and proposed condition to the North Feeder Canal and downstream users. These figures compare the existing PC-17A discharges with the combined proposed discharges of PC-17A and Pond 3. From a hydraulic loading perspective, the proposed improvements increase the flows to the North Feeder Canal and downstream users due to the addition of Pond 3 to the contributing area.

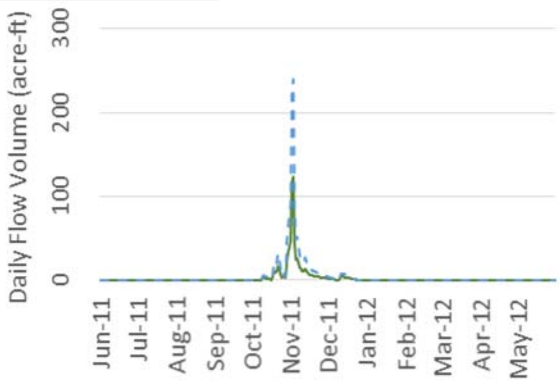

Figure 40: 2011/12 Existing (Dashed) and Predicted Flow Volumes at PC-17A

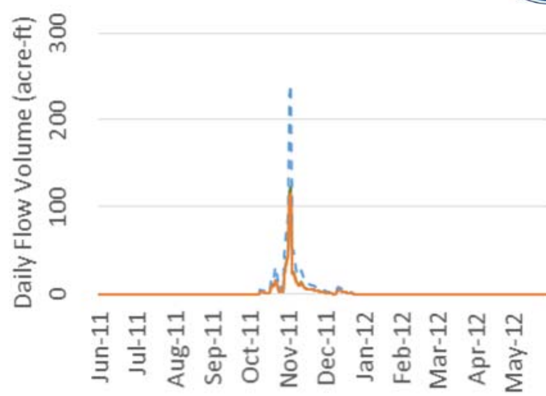

Figure 41: 2011/12 Existing (Dashed) Flow Volumes at PC-17A and Pond 3 inflows

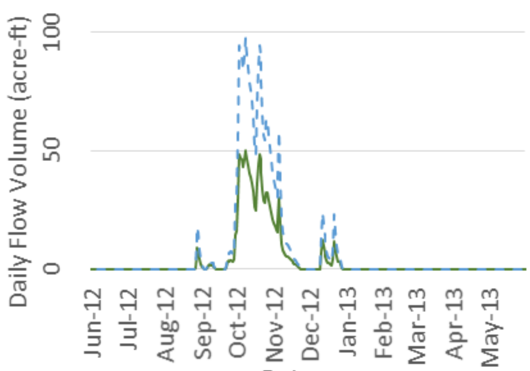

Figure 42: 2012/13 Existing (Dashed) and Predicted Flow Volumes at PC-17A

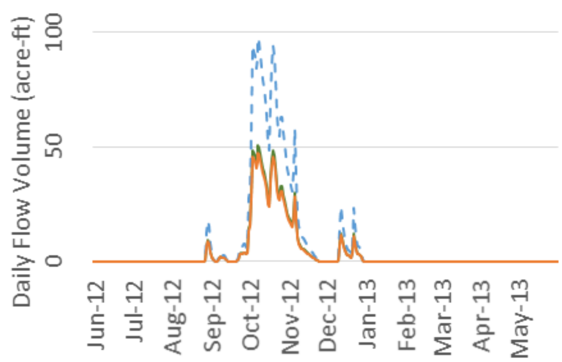

Figure 43: 2012/13 Existing (Dashed) Flow Volumes at PC-17A and Pond 3 inflows

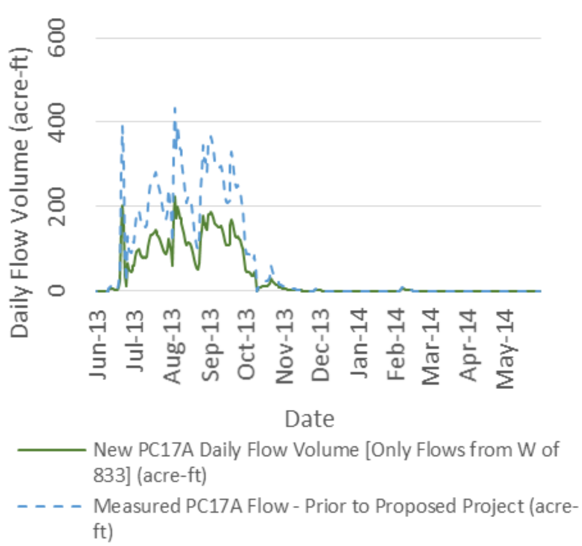

Figure 44: 2013/14 Existing and Predicted Flow Volumes at PC-17A

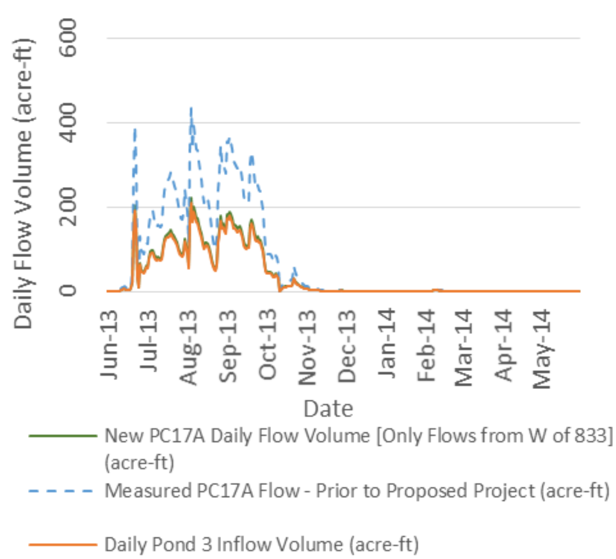

Figure 45: 2013/14 Existing Flow Volumes at PC-17A and Pond 3 inflows

In order to estimate the water quality impact of Measure #1, event mean concentrations (EMCs) published in scientific literature (Harper, 2011) in combination with measured values at PC-17A were used to predict the average TP concentration entering Pond 3, as well as a daily time series for estimated TP load at PC-

17A and entering Pond 3. In this case, EMCs used on their own to predict runoff concentrations from the North Feeder Canal sub-basin significantly overestimate the load at PC-17A because best management practices implemented in the sub-basin are not taken into account. Adjusted concentrations for runoff from each contributing area were found by determining a factor to reduce the EMC-predicted loads for each area. A reduction factor of 0.37 was calculated based on the sum of the loads from each contributing area within the North Feeder Canal sub-basin over the period from June 2011 to May 2014 compared to the total measured load through PC-17A over that same time period. This factor was then applied uniformly to the overall contributing area.

Table 21 shows the annual flow reduction by volume, annual load reduction by mass, average annual concentrations measured at PC-17A, and average annual concentrations predicted for PC-17A with the implementation of Measure #1. Because the annual flow reduction in 2012 exceeded the load reduction, the predicted TP concentration for 2012 with the implementation of Measure #1 is greater than the measured average annual TP concentration. These results reflect only the impact of diverting a significant portion of the contributing area of PC-17A to Pond 3. These values do not reflect the entire effect downstream in the North Feeder Canal as they do not incorporate the effect of attenuation in Pond 3.

Table 21: Predicted Annual Flows at PC-17A before and after Measure #1 Implementation and Resulting Average Annual TP Concentrations

Year	Annual Flow at PC-17A before Measure #1 (acre-ft)	Annual Flow at PC-17A after Measure #1 (acre-ft)	Average Annual Concentration before Measure #1 (mg/L)	Average Annual Concentration after Measure #1 (mg/L)
2011	1,563	805	0.12	0.07
2012	2,954	1,521	0.19	0.21
2013	25,433	13,098	0.17	0.16

In order to calculate the TP attenuation in Pond 3, a mass-balance calculation was applied to estimate the decay of TP due to the various processes that occur during treatment by detention. The mass balance for a well-mixed lake is represented by the following equation:

Accumulation = Loading – Outflow – Reaction – Settling (Chapra, 1997).

The equation above is mathematically described by the first order differential equation:

$$V\frac{dc}{dt} = W(t) - Qc - kVc - \nu A_s c$$

where, V = volume, c = concentration, W(t) = time-varying load ($Q_{in}\times C_{in}$), Q = flow, k = decay, v = settling velocity, and As = surface area of sediments.

Neglecting the settling term and dividing by the volume term, the equation above becomes:

$$\frac{dc}{dt} = \frac{W(t)}{V} - \lambda c$$

where, λ = Q/V + k.

The Euler approach is a numerical approximation for the differential equation above and has the following form:

$$c_{i+1} = c_i + \left[\frac{W(t)}{V} - \lambda c_i\right](t_{i+1} + t_i)$$

The influent TP concentration was estimated to be 0.170 mg/L by multiplying the previously discussed weighting factor by the calculated EMC for the Measure #1 contributing area. Both an unsteady-state mass balance (using the Euler approximation above) and a steady-state mass balance were used to calculate the removal of TP in Pond 3 at various decay rates. However, the steady state calculation does not take into account the previous day's concentration and may be less accurate. Therefore, the non-steady state approximation was used to determine the proposed attenuation.

Table 22 shows the removal efficiencies for a period of significant flow into the Pond 3 from June 15, 2013 to November 1, 2013 for various decay rates and residence times (RT) using the non-steady state mass balance approach. During times with no withdrawals from Pond 3, it is assumed that 100% of the phosphorus that enters Pond 3 is removed; therefore, a period with continuous non-negligible flows (June 15-November 1, 2013) was chosen to illustrate the potential TP treatment of Pond 3. Depending on processes within the AGIs, decay rates may vary; thus, a range of values from 0 to 0.4 day^{-1} are presented for RT of 4 days. Decay rates were assumed using Paudel et al., 2010.

Table 22: Non-Steady State Removal Efficiency (Chapra, 1997)

RT (days)	Decay rate (day^{-1}) (Paudel et al., 2010)	Avg. TP June 15 - November 1, 2013 (mg/L)	Percent Removal
4	0	0.142	16%
4	0.1	0.109	36%
4	0.2	0.088	48%
4	0.3	0.074	56%
4	0.4	0.064	62%

Based on this calculation, a range of removal efficiencies between 16% and 62% is possible. For the purpose of this analysis, an average decay rate of 0.2 day^{-1} was used such that an average concentration of 0.088 mg/L can be estimated for the discharge from Pond 3. This water will not flow through PC-17A; however, it will discharge to the same receiving waterbody and should be considered when evaluating the overall water quality benefit of this measure. **Table 23** shows the characteristics of the water discharged from Pond 3 and **Table 24** shows the net effects on volume, concentrations, and loads from this measure.

Table 23: Predicted Annual Pond 3 Inflow and Outflow Volumes and Concentrations

Year	Annual Pond 3 Inflow Volume (acre-ft)	Annual Pond 3 Outflow Volume (acre-ft)	Pond 3 Inflow Concentration (mg/L)	Pond 3 Outflow Concentration (mg/L)
2011	758	575	0.170	0.088
2012	1,433	575	0.170	0.088
2013	12,335	1,734	0.170	0.088

Table 24: Predicted Annual Reductions in the North Feeder Canal (NFC) Downstream of PC-17A and Resulting Average Annual TP Concentrations before and after Measure 1 Implementation

Year	Yearly Measured NFC Flow (PC-17A) Before Measure 1 (acre-ft)	Yearly NFC Flow Volume After Measure 1 (acre-ft)	Average Annual NFC Concentration before Measure 1 (mg/L)	Average Annual NFC Concentration after Measure 1 (mg/L)
2011	1,563	6,098	0.12	0.09
2012	2,594	6,815	0.19	0.12
2013	25,433	29,071	0.17	0.12

As illustrated in the quantitative results, the estimated effects of Measure #1 are an increase in flow to the North Feeder Canal and a reduction in TP concentration. Both of these effects could be benefits to downstream consumptive users, assuming there is no impact to existing flood protection. It should be noted that the reduction in TP concentration is not significant enough to reach the 50 ppb target of the Seminole Tribe agreement.

5.3.1.2 Measure #1 – Estimating the Conceptual Implementation Cost

The new infrastructure required to implement Measure #1 consists of a pump station and a control structure with related piping. Unfortunately, the LiDAR information in Pond 3 cannot be relied on to develop an accurate stage-storage relationship because the data were obtained while the reservoir had water in it. A conventional survey performed for the District in 2013 by Focal Geomatics included a cross-section through a portion of the reservoir, which indicated a typical elevation of approximately 17.0 feet-NAVD, but with wetlands and ditches as low as 13.5 feet.

Considering the potential that a gravity system may not provide adequate flood protection, a pump station is recommended to pump water from the Garcia Farms reservoirs to Pond 3. It is recommended that three pumps be used for a maximum flow of 140 cfs based on the 25-year design storm event permitted for Garcia Farms. The pump discharges should be combined into a single 1,100-foot long, 60-inch steel pipe extending under the North Feeder Canal and into Pond 3. The outfall structure should consist of a 72-inch wide flashboard riser and a 390-foot long, 60-inch diameter culvert. **Table 25** displays an estimated cost for the implementation of Measure #1.

Table 25: Estimated Implementation Cost for Measure #1

ITEM	UNIT	QUANTITY	PRICE	AMOUNT
Construction Costs				
140 cfs Inflow Pump Station	CFS	140	$50,000.00	$7,000,000.00
Inflow pipe (60-in)	LF	1,100	$250.00	$275,000.00
Discharge Structure (72-in Flashboard Riser)	EA	1	$150,000.00	$150,000.00
Discharge Pipe (60-in)	LF	390	$250.00	$97,500.00
			SUBTOTAL	**$7,522,500.00**
Mobilization, Engineering Design & Construction Administration				
Mobilization (10% of Construction Costs)	EA	1	$752,250.00	$752,250.00
Construction Management (7.5%)	LS	1	$564,187.50	$564,187.50
Engineering Planing and Design (10%)	LS	1	$752,250.00	$752,250.00
Program Management (2.5%)	LS	1	$188,062.50	$188,062.50
			TOTAL	**$9,779,250.00**

It should be noted that these facilities are based on estimated values and that a more detailed analysis, including design storm modeling and additional surveys, will be needed to determine the types and sizes of the facilities. If ground elevations in Pond 3 support gravity flow, then a siphon structure may be considered instead of a pump station.

5.3.1.3 Measure #1 – Regulatory Considerations

The following regulatory issues should be considered before implementing this measure:

h. As noted in the Restudy language, one objective for the project is to, "maintain flood protection on Seminole Tribal lands, and ensure that inflows to the North and West Feeder Canals meet applicable water quality standards. Consistency with the Seminole Tribe's Conceptual Water Conservation System master plan will be maintained."

i. The Seminole Tribe has a legal agreement that targets a TP concentration of 50 ppb for discharges from PC-17A to limit the impacts of heightened nutrient levels. The proposed diversion to Pond 3 may improve water quality but not enough to reach the 50 ppb target. Project implementation would not change the terms or the responsible parties of the existing legal agreement.

j. Stakeholders downstream of the Northern Reach have consumptive use demands that require delivery of surface flows; therefore, any decrease in discharges would be seen as a negative while increases in discharges would be positive, as long as no impacts to flood protection would occur.

k. All land within the C-139 Annex is currently being planned for restoration and Pond 3 is planned to be hydraulically connected to the adjacent lands with the installation of several open culvert connections through the levee. Therefore, the proposed diversions and associated infrastructure for Measure 1 must be coordinated with designers of the C-139 Annex FEB and restoration projects to ensure that the operation of the structures remains compatible with the planned future use.

l. Low lying pasture lands to the south of the C-139 Annex are affected by seepage from water stored within the C-139 Annex. Prior to implementation, the impact of the diversion should be considered with respect to impacts on seepage to the south.

m. Previously issued permits for projects within the C-139 Annex have identified 680 acres as a "Panther Mitigation Area." Proposed projects will need to ensure compatibility with the goals of the mitigation area.

5.3.2 Measure #2 – Replacing PC-17A

One of the current concerns with PC-17A is the operational parameters of the structure. The operation is based on a cooperative and mutually beneficial agreement between the District and the landowner. The existing structure consists of four, 44-inch wide flashboard risers connected to two, 72-inch diameter culverts. The normal operation of the structure is to maintain the wet season water level at 15.1 feet-NGVD and the dry season water level at 18.1 feet-NGVD. The structure, however, is currently intended to be operated as part of a two-year pilot program to maintain a wet season control elevation of 18.5 feet-NGVD and a dry season control elevation of 19.0 feet-NGVD. There have been several occasions when the control elevation of the gate is lowered to 9.9 feet-NGVD due to flooding concerns despite the intentions of the pilot program. In these situations, the discharge is larger than what was planned in order to provide the necessary reduction in stages upstream. One concern of these high flow periods is the scouring of the canal bottom and re-suspension of sedimentary TP that may not have been discharged under normal operations. In order to provide higher discharges without reducing the preferred control elevation, one option is to replace PC-17A with a top opening, remotely controlled, operable structure to provide the discharge necessary during flooding conditions while minimizing scour of the canal bottom and maintaining water tables at acceptable levels.

5.3.2.1 Measure #2 – Water Quality Benefit

Prior to design and implementation, Measure #2 would require evaluation with a hydrologic and hydraulic modeling tool. From a qualitative standpoint, top-opening structures could provide a water quality benefit due to the fact that when water is forced to flow over the top board, a low-current zone at the bottom of the canal is created and nutrients are deposited. Bottom opening structures sweep sediments and their nutrient loadings out with the discharge waters.

Technically, PC-17A is already a top-opening structure. However, when the gates are dropped from 15.1 feet-NGVD to 9.9 feet-NGVD, it can cause the canal stages to be substantially lower than necessary. Lower stages result in higher velocities, which can cause erosion and resuspension of TP sediments. **Figure 46** illustrates a comparison of gate opening data and measured TP concentrations. An analysis was performed to determine if any correlation could be made between plate levels and TP concentrations during similar rain events; however, no direct correlation could be made. Therefore, a quantitative estimate of water quality improvement for implementing Measure #2 could not be developed. However, a review of gate opening data illustrates the potential benefits of a remotely controlled structure that could moderate discharges through incremental openings.

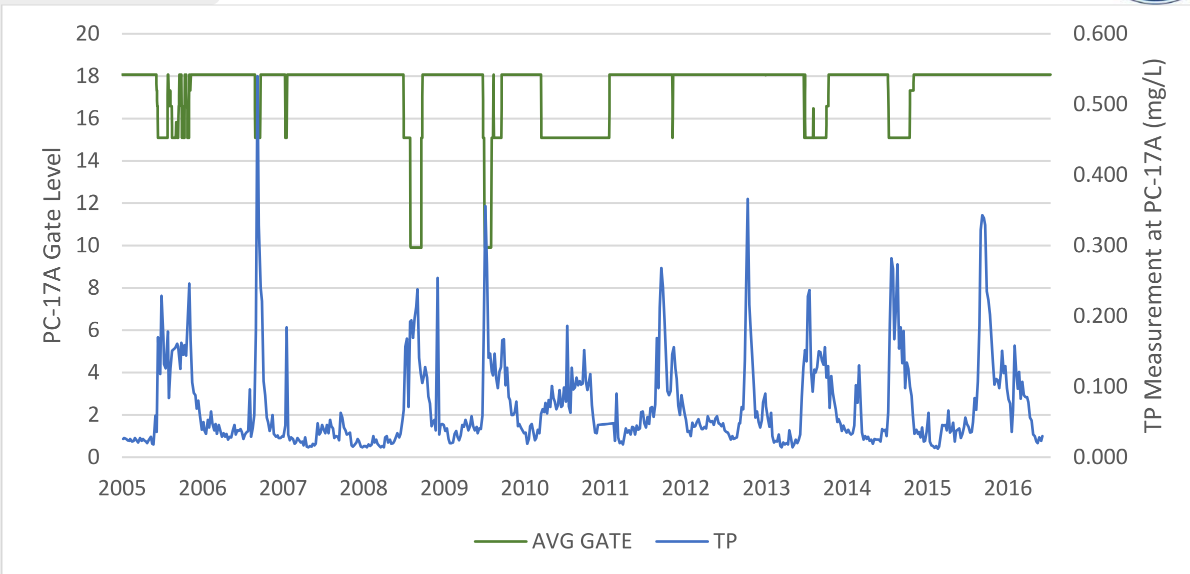

Figure 46: Measured Gate Opening and TP Concentration Data at PC-17A

5.3.2.2 Measure #2 – Estimating the Conceptual Implementation Cost

The costs for Measure #2 include removal/demolition of the existing PC-17A structure and construction of a new concrete structure with four top opening 44-inch wide gates. The new structure would be a remotely controlled, operable structure to provide the discharge necessary during flooding conditions while minimizing scour of the canal bottom and maintaining water tables at acceptable levels.

Table 26: Estimated Implementation Cost for Measure #2

ITEM	UNIT	QUANTITY	PRICE	AMOUNT
Construction Costs				
Remove Existing PC-17A	EA	1	$15,000.00	$15,000.00
Construct Replacement PC-17A (Underflow with Telemetry)	EA	1	$3,100,000.00	$3,100,000.00
			SUBTOTAL	**$3,115,000.00**
Mobilization, Engineering Design & Construction Administration				
Mobilization (10% of Construction Costs)	EA	1	$311,500.00	$311,500.00
Construction Management (7.5%)	LS	1	$233,625.00	$233,625.00
Engineering Planing and Design (10%)	LS	1	$311,500.00	$311,500.00
Program Management (2.5%)	LS	1	$77,875.00	$77,875.00
			TOTAL	**$4,049,500.00**

5.3.2.3 Measure #2 – Regulatory Considerations

The following regulatory issues should be considered before implementing this measure:

a. As noted in the Restudy language one objective for the project is to, "maintain flood protection on Seminole Tribal lands, and ensure that inflows to the North and West Feeder Canals meet applicable water quality standards. Consistency with the Seminole Tribe's Conceptual Water Conservation System master plan will be maintained."
b. The Seminole Tribe has a legal agreement that targets a TP concentration of 50 ppb for discharges from PC-17A to limit the impacts of heightened nutrient levels. The proposed

replacement of PC-17A is unlikely to improve water quality significantly enough to reach the target concentration.

c. Stakeholders downstream of the Northern Reach have consumptive use demands that require delivery of surface flows, so any changes to the operations of the new PC-17A must not negatively impact surface water deliveries.
d. Implementation of any measure should not negatively affect flood protection for any existing landowners; therefore, the operation of the new PC-17A must be constrained to provide the existing level of service for flood protection both upstream and downstream.

5.3.3 Measure #3 – Degrading Southern Bank of Wingate Mill Canal

The Wingate Mill Canal is an east-west canal constructed in the development and drainage of the Western Feeder Canal Sub-basin. The Wingate Mill Canal intercepts the historic north to south drainage pattern and diverts the water east over the West Weir and towards the L-28 Basin. The intent of the proposed Measure #3 is to re-establish the north-south flow pattern during high runoff periods. In order to accomplish this goal, the proposed implementation for Measure #3 consists of degrading the southern bank of the Wingate Mill Canal to create a series of weirs that will act as small spillways when peak stages occur as illustrated in **Figure 49**. During high flow periods, water will be diverted south to re-hydrate the historic wetlands. Notably, there is no publicly-owned land immediately downstream of the proposed diversion. Therefore, land to the south will need to be evaluated for a flow easement for hydrologic restoration.

5.3.3.1 Measure #3 – Water Quality Benefit

The daily flow and TP concentration calculation is based on reducing the measured peak flow and load at West Weir by a ratio of the contributing area for the proposed diversion to the area for the West Feeder Canal sub-basin. By doing this, the total volume discharged at West Weir will be reduced in proportion to the contributing area. However, due to the nature of the proposed measure, the reduction will only apply during high flow periods.

The data collected at West Weir are the only available data for analyzing the impact of proposed Measure #3 on flow and TP at West Weir. No upstream points on the Lard Can Canal or the Wingate Mill Canal measure the surface water parameters required to evaluate this measure. **Figure 47** shows the current flow and TP concentration measurements at West Weir for 1999 through 2015 as recorded in DBHYDRO. Noticeably, the peak flows prior to 2009 were larger in magnitude than after 2009, while the peak TP concentrations were higher in magnitude after 2010. In reviewing the hydraulic data there was no change to the flow estimation equation that would have had this affect and the stages upstream of WWEIR demonstrate the same pattern. **Figure 48** illustrates that there is minimal correlation between flow magnitude and TP concentration. It is more likely that the differences seen in **Figure 47** are a reflection of changes in land management practices. These flows and concentrations were used as the basis for analyzing the impact of a diversion weir upstream of West Weir on the Wingate Mill Canal.

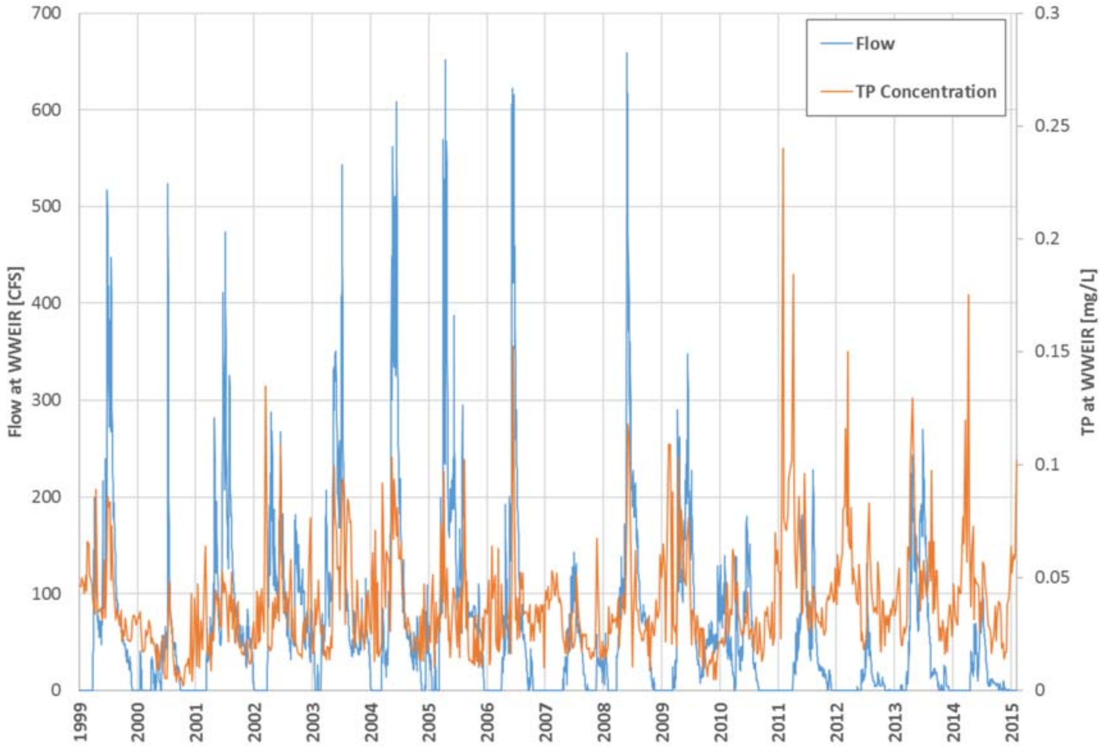

Figure 47: Current Average Daily Flow Rates and TP Concentrations at WWEIR

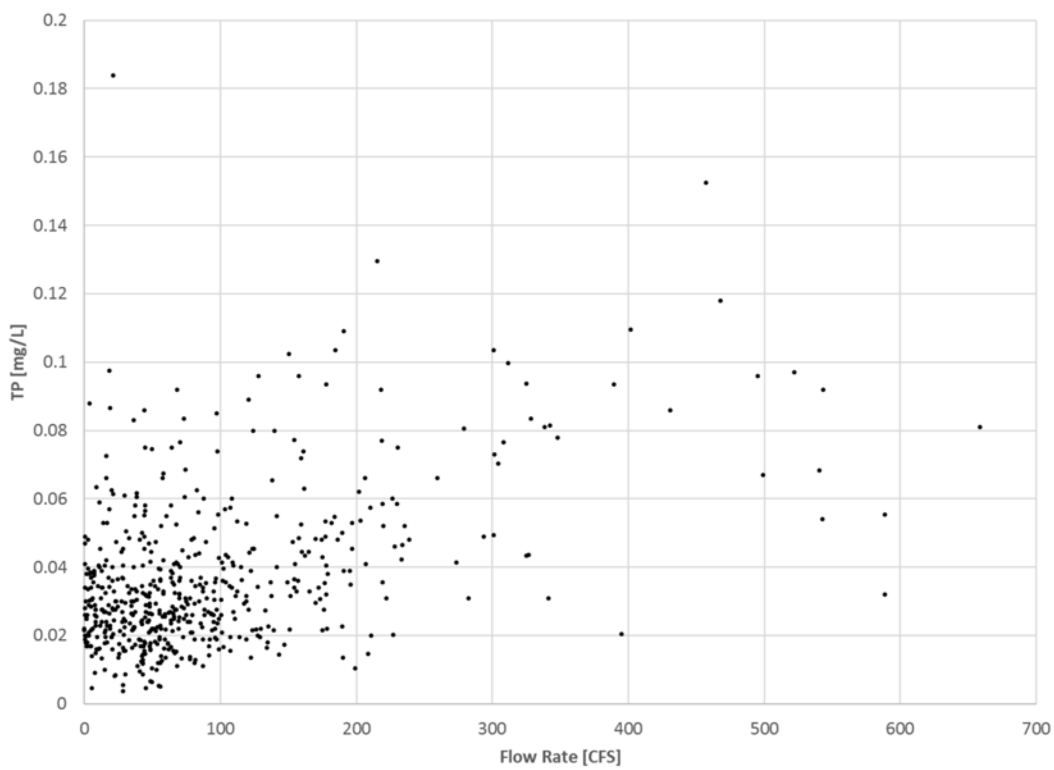

Figure 48: Comparison of Flow and Concentration at WWEIR

In order to calculate the stage at the project location, the head loss from the proposed project location to West Weir was estimated by using Manning's equation. Since the portions of the Lard Can Canal and Wingate Mill Canal upstream of the proposed project site have different sizes and flows, they contribute differently to the head losses. Therefore, the head losses from these two sections of canal were calculated separately. **Figure 49** illustrates the canal sections where head losses were estimated, with the Lard Can Canal identified as Section A and the Wingate Mill Canal as Section B. If the project is implemented, it is recommended that remote stage monitoring equipment be placed at the location of the diversion to estimate discharges.

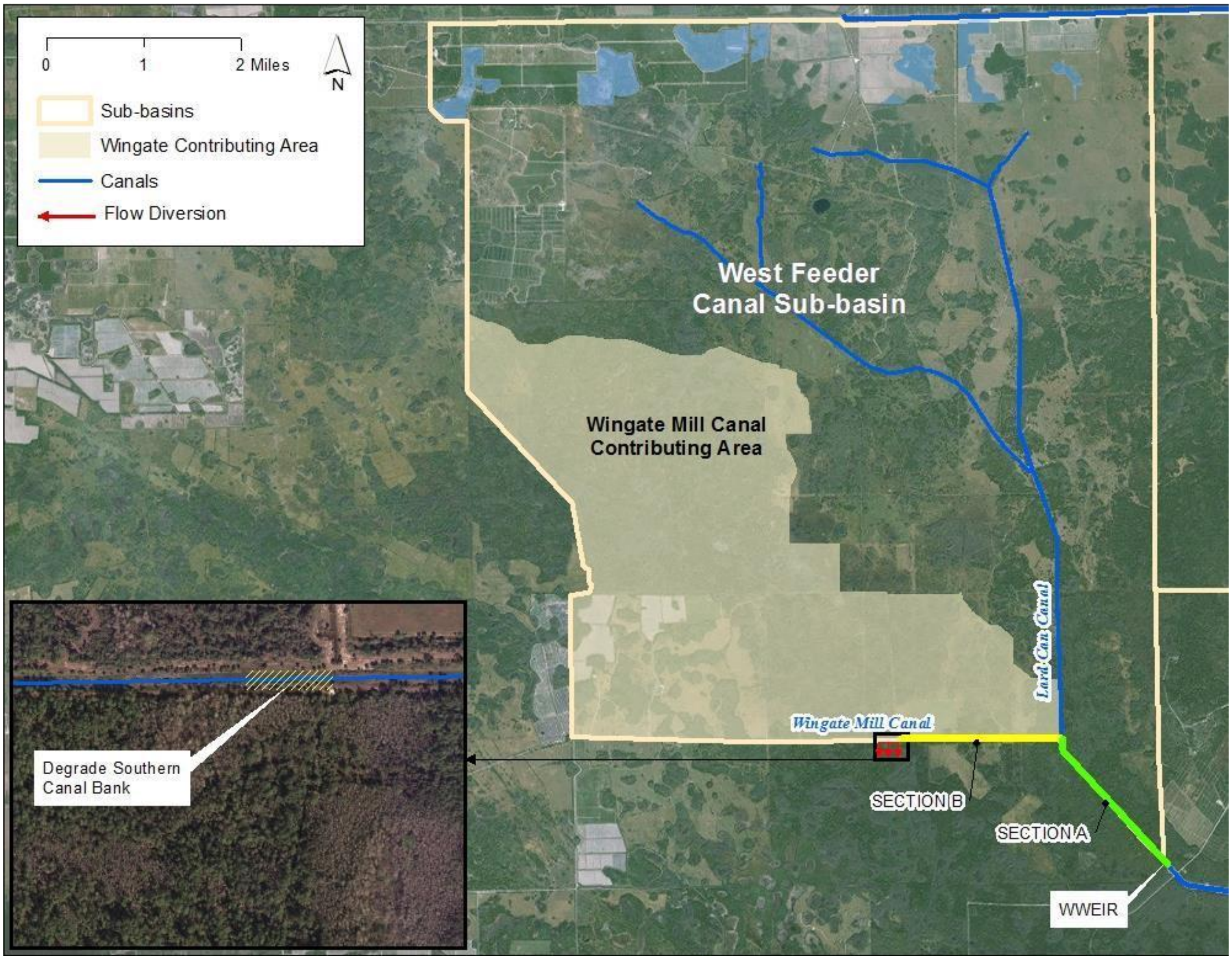

Figure 49: Measure #3 Contributing Area and Downstream Canal Sections

In calculating the head loss in the Lard Can Canal (Section A), the canal bottom was assumed to be at an elevation of 10.6 feet-NAVD. The bottom width was assumed to be 26 feet, the side slopes were assumed to be 3 to 1, and a Manning's n value of 0.03 was used. The length of Section A was measured on aerials to be approximately 9,117 feet. In calculating the head loss in the Wingate Canal (Section B), the canal bottom was assumed to be at an elevation of 11.6 feet-NAVD. The bottom width was assumed to be 5 feet, the side slopes were assumed to be 3 to 1, and a Manning's n value of 0.03 was used. The length of Section B was measured on aerials to be approximately 8,920 feet.

As shown in **Figure 49**, the Wingate Mill Canal contributing area makes up 28% of the West Feeder Canal sub-basin by land area. For the purpose of calculating the head loss upstream of West Weir and downstream of the proposed measure, the flow in the portion of the Wingate Mill canal downstream of the project (Section B) was assumed to be 28% of the flow measured at West Weir.

Using the estimated Section A cross-section and the measured stages and flows at West Weir, Manning's equation was used to calculate the head loss in Section A of the canal to determine the stages at the confluence of the Wingate Mill Canal (Section B) and the Lard Can Canal (Section A). Similarly, by using the estimated Section B cross-section, the estimated stage at the confluence of Sections A and B, and 28% of the measured flow at West Weir as inputs for Manning's equation, the head loss in Section B was calculated. The estimated head loss in Section B was then added to the calculated stage at the confluence of Sections A and B to determine the stage at the proposed project location. Using the estimated stages at the proposed project location, the discharge for a broad crested weir was calculated using the equation for submerged discharge over a broad crested weir.

Figure 50 shows the historically measured flows at West Weir compared to the estimated flows at West Weir with a 300-foot-wide broad crested weir approximately 3.4 miles upstream of West Weir with a crest elevation of 17.5 feet-NAVD. The proposed weir would divert water to the south from the Wingate Mill Canal. The weir flow calculations show the shaving of West Weir's peak flows greater than approximately 300 cfs. Notably, there are very few flows greater than 300 cfs after 2009. For reasons that are not documented in existing literature, the peak discharge rates at West Weir have decreased since 2009. The proposed measure would have a beneficial effect on the basin if the hydrologic response was characteristic of the period prior to 2009, but would have minimal effect on the basin if recent hydrologic responses remain typical.

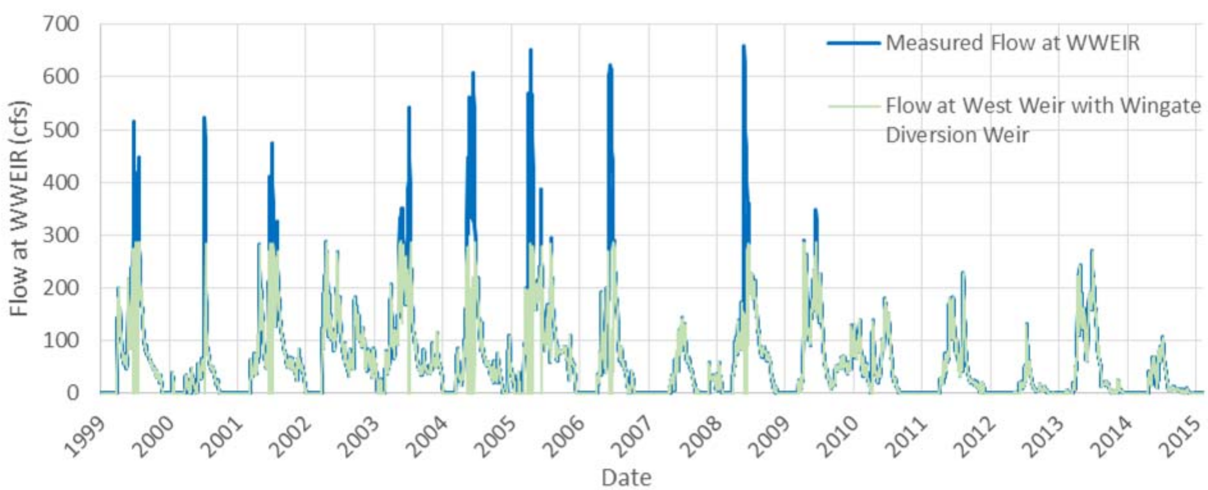

Figure 50: Estimated Flow at WWEIR after Proposed Weir vs. Current Flow at WWEIR

There are minimal water quality data upstream of WWEIR available. The only period where grab samples were collected simultaneously with measurements at WWEIR were from May 1997 to November 1997. During this period approximately 12 samples were collected at 8 upstream locations. For the majority of samples, the grab sample data reflects the measurements at WWEIR in both magnitude and pattern, as evidenced by comparing the average at WWEIR (0.033 mg/L) with the average for all grab samples (0.036

mg/L). In consideration of this comparison, for calculating the reduced load at West Weir from the weir diversion the TP concentration in the Wingate Mill Canal was assumed to be the same as the concentration upstream of West Weir. The reduction in TP load was calculated by multiplying the estimated daily volume of water diverted south through the proposed weir structure by the TP concentration at West Weir.

The estimated flow and TP load diverted at the proposed site is shown in **Figure 51** and **Figure 52**, respectively. Based on the stages estimated for the six years between 2009 and 2014, there is no diversion predicted.

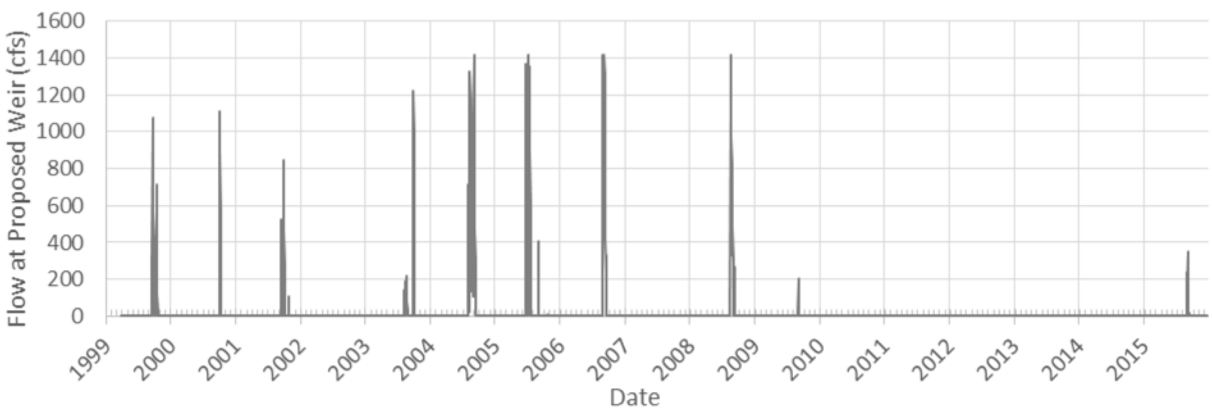

Figure 51: Estimated Diverted Flows through the Proposed Weir (Calendar Year)

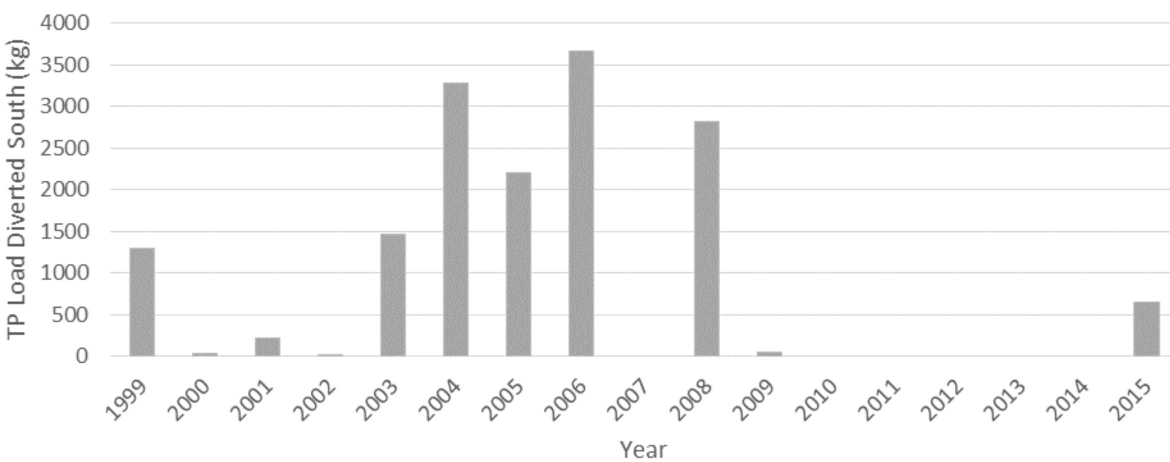

Figure 52: Estimated Diverted TP Loads through the Proposed Weir (Calendar Year)

Figure 53 shows the difference in TP loads through West Weir with the diversion of water from the Wingate Mill Canal. Since there is no predicted diversion for any of the stages between 2009 and 2014, there is no reduction in TP loading at West Weir for that time period.

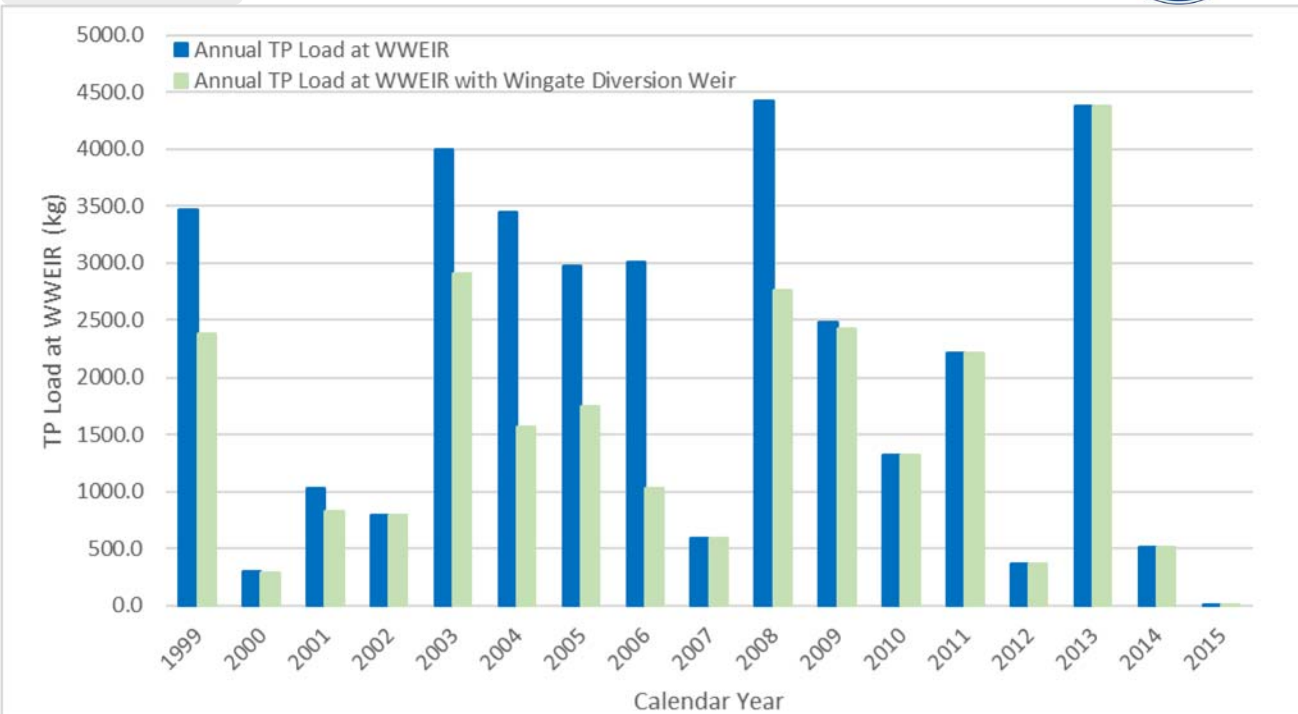

Figure 53: Current Load at WWEIR vs. Estimated Load at WWEIR with Wingate Diversion

Based on current assumptions, there is no treatment facility proposed south of the Wingate Mill Canal to receive the diverted flows. As such, the flow and load reductions at West Weir would result in increases in flow and load to the south. Wetlands and ET, however, will take up some of the nutrients and volume as the flow disperses through the region where it once discharged prior to the construction of the Wingate Mill Canal. The addition of water, however, may require the acquisition of a flow easement to the south.

5.3.3.2 Measure #3 – Estimating the Conceptual Implementation Cost

The only infrastructure improvement necessary to create the diversion is degrading three separate 100-foot wide sections of the southern embankment to the elevation of 17.5 feet-NAVD at a location approximately 3.4 miles upstream of West Weir. However, as currently conceptualized there is no receiving waterbody for the discharges at this diversion point. If a reservoir or distributed storage facility is planned, then there will be significant capital expenditure on the associated canals, embankments, and structures.

Table 27: Estimated Implementation Cost for Measure #3

ITEM	UNIT	QUANTITY	PRICE	AMOUNT
Construction Costs				
Excavation of Existing Levee Material	CY	667	$5.00	$3,333.33
Hauling and Disposal of Levee Material	CY	667	$25.00	$16,666.67
Fabriform for Soil Stabilization at Degraded Locations	SY	2,000	$150.00	$300,000.00
			SUBTOTAL	**$320,000.00**
Mobilization, Engineering Design & Construction Administration				
Mobilization (10% of Construction Costs)	EA	1	$32,000.00	$32,000.00
Construction Management (7.5%)	LS	1	$24,000.00	$24,000.00
Engineering Planing and Design (10%)	LS	1	$32,000.00	$32,000.00
Program Management (2.5%)	LS	1	$8,000.00	$8,000.00
			TOTAL	**$416,000.00**

5.3.3.3 Measure #3 – Regulatory Considerations

The following regulatory issues should be considered before implementing this measure:

a. As noted in the Restudy language one objective for the project is to, "maintain flood protection on Seminole Tribal lands, and ensure that inflows to the North and West Feeder Canals meet applicable water quality standards. Consistency with the Seminole Tribe's Conceptual Water Conservation System master plan will be maintained."
b. Stakeholders downstream of the Northern Reach have consumptive use demands that require delivery of surface flows, so any changes to the operations of West Weir must not negatively impact surface water deliveries. Considering that only high flows are diverted in Measure #3, it is unlikely that these diversions would be seen as a negative impact to downstream consumptive users.
c. Implementation of any measure should not negatively affect flood protection for any existing landowners; therefore, the impacts on flood protection to landowners south of Wingate Mill Canal must be mitigated or an easement must be obtained.
d. There is no publicly-owned land immediately downstream of the proposed diversion. Therefore, at a minimum for implementation land to the south of Wingate Mill Canal will need to be evaluated for a flow easement for hydrologic restoration.

5.3.4 Measure #4 – Diversion of Water from South Boundary Canal to the South

Unlike the approaches for Measures #1 and #3, the proposed diversion in Measure #4 is constrained by the receiving waterbody. The intent of Measure #4 is to divert runoff to a pair of existing privately-owned storage facilities south of the North Feeder Canal sub-basin. By diverting flows from the South Boundary Canal to two separate AGIs owned and operated by the Seminole Tribe (see **Figure 54**), Measure #4 is intended to utilize existing storage to attenuate high flows at PC-17A and provide water directly to existing agricultural operations. This diversion would provide an additional source for consumptive demands south of the canal, reduce discharges at PC-17A and leverage the treatment potential of an existing facility.

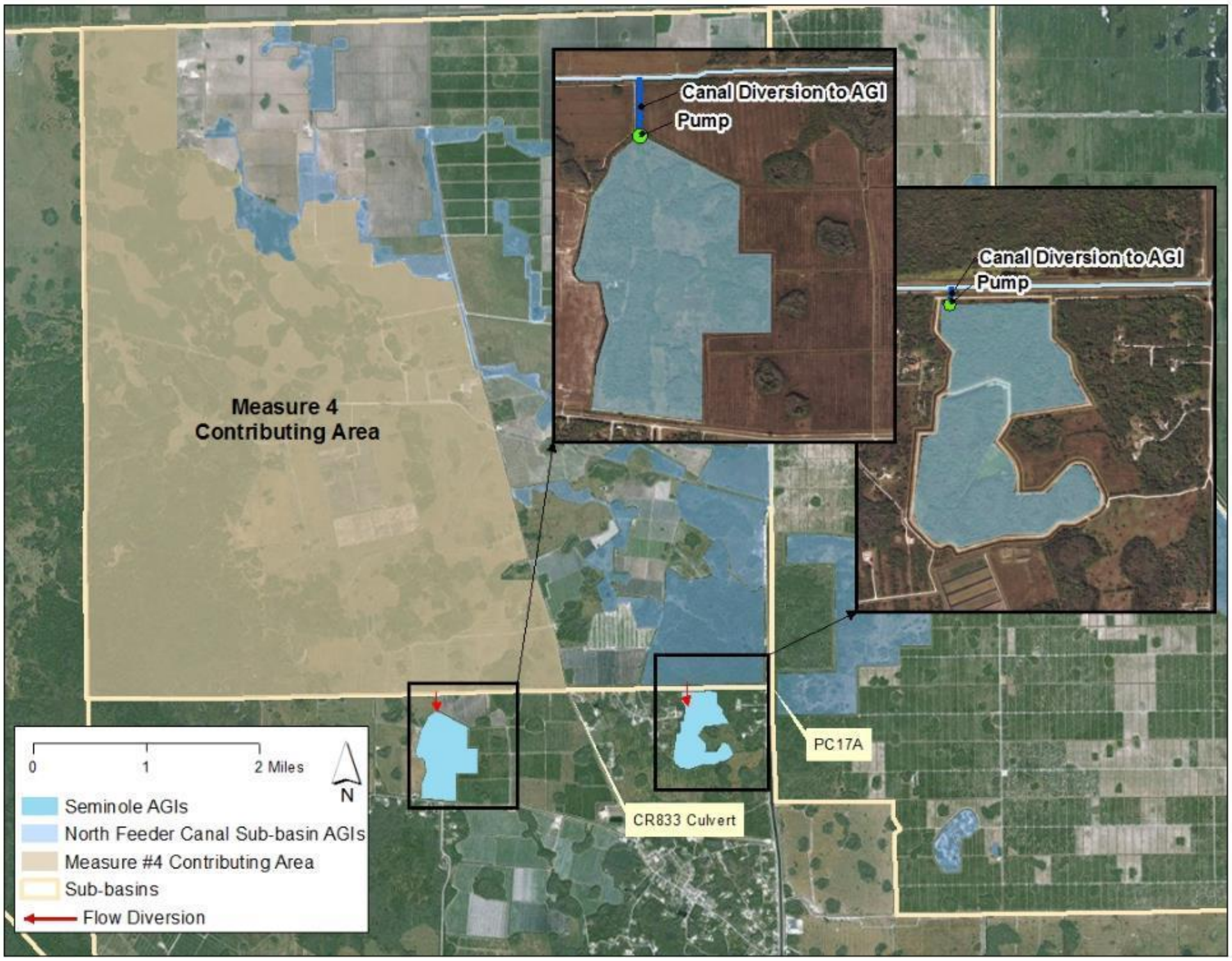

Figure 54: Measure #4 Diversion to Seminole AGIs

5.3.4.1 Measure #4 – Water Quality Benefit

In order to quantify the potential benefit at PC-17A, first the potential for available storage in the AGIs must be quantified. The area of the impoundments is approximately 329 acres and it was assumed that a maximum of four feet of storage is available within each AGI. For the purpose of this initial analysis, the Seminole AGIs were treated as a single AGI.

Since the contributing area for the proposed diversion is primarily the portion of the North Feeder Canal sub-basin that is west of CR 833 and there are no available flow measurements for this area, a method to determine the predicted flow hydrograph is necessary. First, a simplistic hydrologic spreadsheet was developed to convert known rainfall measurements into predicted runoff hydrographs at the South Boundary Canal using the Soil Conservation Service Curve Number Method. Upon examination of the results, this method gave overly conservative estimates of runoff for the Measure #4 contributing area. The curve number method estimates that the runoff from the western portion of the North Feeder Canal sub-basin contributes to 64% of the flows at PC-17A, while the findings of the 2016 hydrologic and hydraulic model predicts that 52% of PC-17A flows are from this land area.

Therefore, the approach used to generate the daily time series of flows into the AGIs was based on the findings of the 2016 hydrologic and hydraulic model developed under Task 4 of this work order. The calibrated MIKE11 model results file was used to extract the modeled flows in the South Boundary Canal at the CR 833 culvert and the modeled flows at PC-17A. A time series was created by assuming that the flow available to be routed to the AGIs is 52% of the measured flow at PC-17A.

The potential inflow time series for routing through the AGIs is 52% of the daily flows at PC-17A plus the rainfall directly into the AGIs measured at the Big Cypress rain gage. For this conceptual evaluation, the Big Cypress rain gage is sufficient to determine the potential benefits of the AGIs, if the project is determined to require detailed design more accurate rainfall data such as NEXRAD is recommended. Depending on the amount of water being stored in the AGIs by the Seminole Tribe and if the runoff from the land upstream of the CR 833 culvert is greater than the AGI capacity, the water may bypass the AGIs and return to the PC-17A flows.

The assumed outflows from the AGIs are the daily levee seepage, daily vertical seepage, daily estimated ET, and the daily estimated withdrawal for land application. The estimated ET was calculated based on the measurement taken at the BIG CY SIR weather station and the total composite area of the AGIs south of the South Boundary Canal. The daily levee seepage was calculated using the perimeter of the AGI levees, beginning-of-day depth in the reservoir, and seepage rate of 1 cfs/ft head/mile levee. The infiltration rate was assumed to be 0.0041 (cm/d)/cm based on the average of values determined for the STA-5 and STA-6 facilities. Unlike the other potential facilities, it is assumed that the water stored in these AGIs will be used directly for irrigation. Therefore, daily withdrawal was estimated by calculating the daily demand for the 708 acres of adjacent citrus crops based on the water use permit and land uses located south of the South Boundary Canal on the Seminole tribal lands.

Subtracting the daily outflows and adding the daily inflows to the water stored in the AGI gives an end of day AGI volume. Using the area of the AGIs and the estimated beginning of day water volume stored in the AGI, the estimated depth of water in the AGI was calculated. **Figure 55** shows the magnitude of the daily withdrawal for the irrigation demands, AGI inflow volume from the South Boundary Canal, bypass volume, and depth in the reservoir.

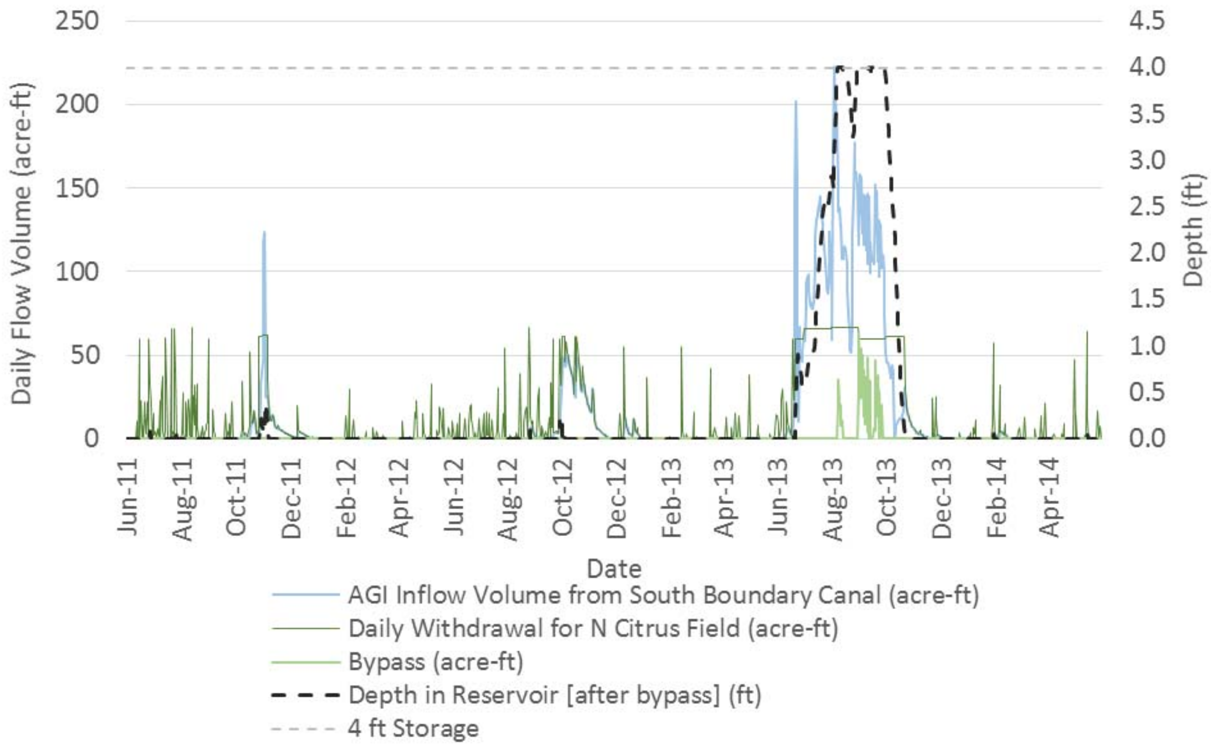

Figure 55: Inflows to, Outflows from, and Depth in Seminole AGIs for Proposed Diversion Measure #4

Currently the AGIs are being used by the Tribe. In order to determine if Measure #4 is a feasible option when the AGIs have joint-use, **Table 28** through **Table 35** were created to compare differing trigger elevations for diverting the South Boundary Canal inflows away from the AGIs when a certain depth in the AGIs is reached. Trigger elevations of 1, 2, 3, and 4 feet were evaluated to illustrate the varying levels of use the AGIs can provide for holding South Boundary Canal inflows.

Table 28, **Table 30**, **Table 32**, and **Table 34** show how a counting function was used to count the number of days between June 2011 and May 2014 that the volume in the AGIs was such that the depth in the AGIs, from only South Boundary Canal inflows, is greater than or equal to 1, 2, 3, and 4 feet with differing amounts of volume available. **Table 29**, **Table 31**, **Table 33**, and **Table 35** show the inflow volumes for WYs 2011-2013 when differing magnitudes of volume are available within the AGIs. Notably, in consideration of the irrigation demands of the nearby citrus crop, for both 2011 and 2012 the annual withdrawal from the AGIs exceeds the annual inflow. Only in the wettest of the three years (2013) is there more inflow than withdrawal and, accordingly, this is the only year where there is bypass. In addition, the nature of the inflows is such that the temporal usage is minimal. There are only sufficient flows to fill the first foot of the AGIs for one month per year on average based on the three years was evaluated.

Since the required AGI volume does not exceed one foot of depth for three of the four years, significant differences are not present in the inflows, outflows or bypass volumes except for 2013. The bypass depth used for analysis of water quality is 4 ft.

Table 28: AGI Depth Count for 4-foot Bypass Depth

Depth (ft)	Number of Days AGIs are Over Specified Depth
1	94
2	84
3	62
4	30

Table 29: Measure 4 Yearly Inflow, Withdrawal, and Bypass Volumes for 4-foot Bypass Depth (acre-feet)

Year	Total Yearly Inflow	Total Yearly Withdrawal	Total Yearly Bypass Volume
2011	805	2,225	0
2012	1,521	2,909	0
2013	11,925	9,012	720

Table 30: AGI Depth Count for 3-foot Bypass Depth

Depth (ft)	Number of Days AGIs are Over Specified Depth
1	92
2	80
3	43
4	0

Table 31: Measure 4 Yearly Inflow, Withdrawal, and Bypass Volumes for 3-foot Bypass Depth (acre-feet)

Year	Total Yearly Inflow	Total Yearly Withdrawal	Total Yearly Bypass Volume
2011	805	2,225	0
2012	1,521	2,909	0
2013	11,925	9,012	1,173

Table 32: AGI Depth Count for 2-foot Bypass Depth

Depth (ft)	Number of Days AGIs are Over Specified Depth
1	88
2	49
3	0
4	0

Table 33: Measure 4 Yearly Inflow, Withdrawal, and Bypass Volumes for 2-foot Bypass Depth (acre-feet)

Year	Total Yearly Inflow	Total Yearly Withdrawal	Total Yearly Bypass Volume
2011	805	2,225	0
2012	1,521	2,909	0
2013	11,396	8,845	1,700

Table 34: AGI Depth Count for 1-foot Bypass Depth

Depth (ft)	Number of Days AGIs are Over Specified Depth
1	62
2	0
3	0
4	0

Table 35: Measure 4 Yearly Inflow, Withdrawal, and Bypass Volumes for 1-foot Bypass Depth (acre-feet)

Year	Total Yearly Inflow	Total Yearly Withdrawal	Total Yearly Bypass Volume
2011	805	2,225	0
2012	1,521	2,909	0
2013	10,814	8,659	2,283

The new PC-17A volume was calculated by summing the portion of flow from Garcia Farms with the daily bypassed volumes. **Figure 56**, **Figure 58**, and **Figure 60** show the existing measured PC-17A flows and the estimated PC-17A flows upon implementation of Measure #4. **Figure 57**, **Figure 59**, and **Figure 61** show the existing and predicted flows at PC-17A, as well as the predicted AGI inflows. Because the 2016 hydrologic model showed that the flows west of CR 833 are approximately half of the flows at PC-17A, the AGI inflow and predicted PC-17A flow after project implementation are very similar. In the period from June 2011 through May 2014, the estimated total reduction in PC-17A discharges is 14,691 acre-feet with the implementation of Measure #4.

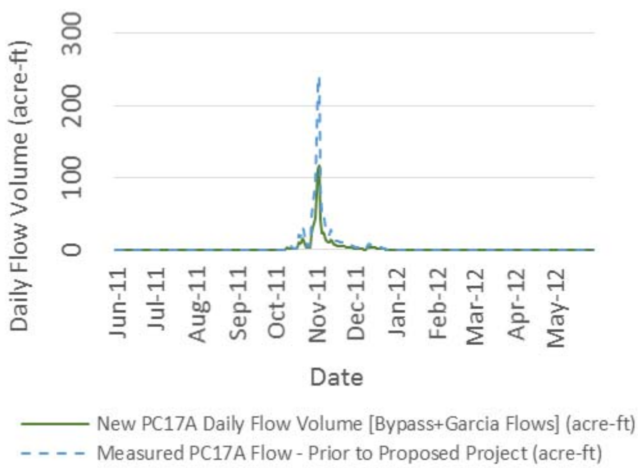

Figure 56: 2011 Existing and Predicted Flow Volumes at PC-17A

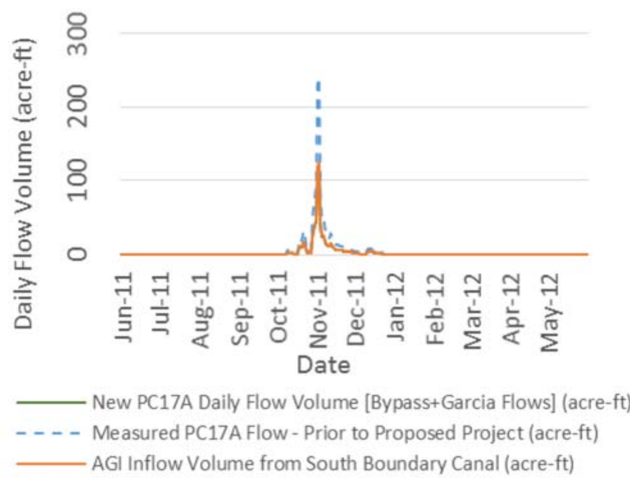

Figure 57: 2011 Existing Flow Volumes at PC-17A and Predicted Flow Volumes into AGIs

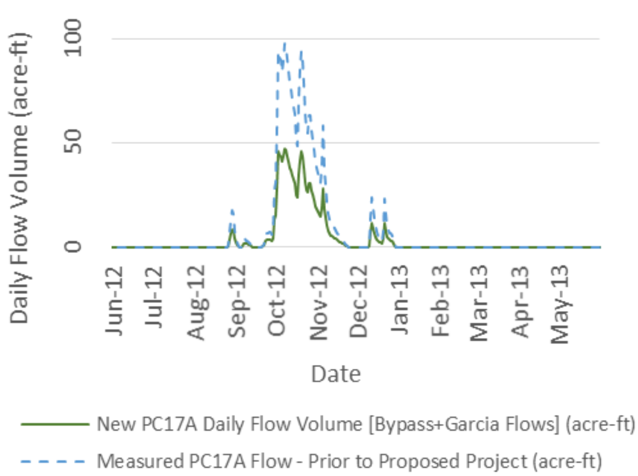

Figure 58: 2012 Existing and Predicted Flow Volumes at PC-17A

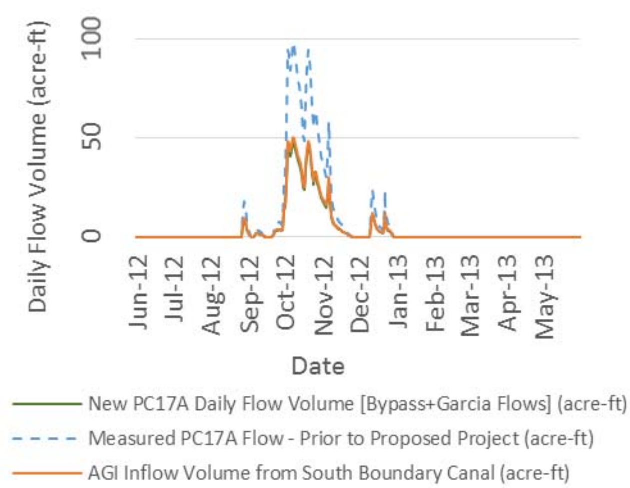

Figure 59: 2012 Existing Flow Volumes at PC-17A and Predicted Flow Volumes into AGIs

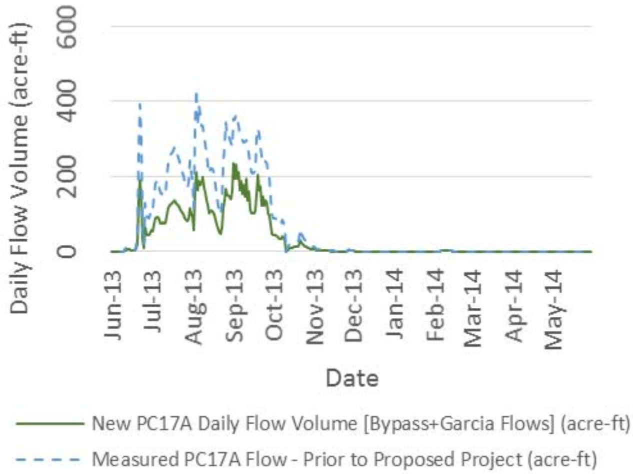

Figure 60: 2013 Existing and Predicted Flow Volumes at PC-17A

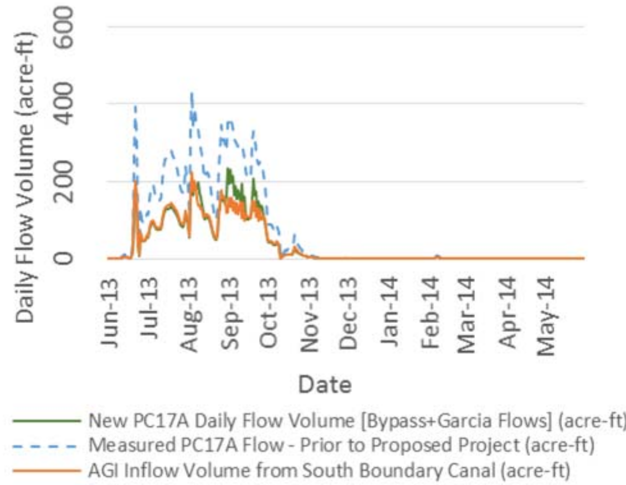

Figure 61: 2013 Existing Flow Volumes at PC-17A and Predicted Flow Volumes into AGIs

In order to estimate the water quality impact of Measure #4, EMCs published in scientific literature (Harper, 2011) were used in combination with measured values at PC-17A to predict the average TP concentration entering the AGIs, as well as a daily time series for estimated TP load at PC-17A. As was the case in Measure #1, adjusted concentrations for runoff from each contributing area were found by determining a weighting factor to reduce the EMC-predicted loads for each area. A weighting factor of 0.37 was calculated so that the sum of the loads from each contributing area during the period from June 2011 to May 2014 equals the total load through PC-17A during that same time period.

Table 36 shows the annual flow reduction by volume, annual load reduction by mass, average annual concentrations measured at PC-17A, and average annual concentrations predicted for PC-17A with the implementation of Measure #4. This result does not account for the water diverted to the AGIs south of the South Boundary Canal. The results reflect the effect on PC-17A of diverting the flows to a different receiving waterbody for consumptive use. It is important to note that because the annual flow reduction in 2012 exceeded the load reduction, the predicted TP concentration for 2012 with the implementation of Measure #4 is greater than the measured average annual TP concentration.

Table 36: Predicted Annual Reductions and Resulting Average Annual TP Concentrations at PC-17A before and after Measure #4 Implementation

Year	Annual Flow Reduction at PC-17A by Volume	Predicted Annual TP Load Reduction at PC-17A by Mass	Average Annual Concentration before Measure #4 (mg/L)	Predicted Average Annual TP Concentration after Measure #4 (mg/L)
2011	52%	74%	0.12	0.06
2012	52%	47%	0.19	0.21
2013	49%	50%	0.17	0.16

The influent TP concentration was estimated to be 0.173 mg/L by multiplying the previously discussed weighting factor by the calculated EMC for the Measure #4 contributing area. Using the same approach as Measure #1, **Table 37** shows the removal efficiencies for a period of significant flow into the AGIs from

June 15, 2013 to November 1, 2013. A range of values from 0 to 0.4 day^{-1} were evaluated (Paudel et al., 2010) in consideration of which might be the most appropriate to use for defining the treatment capacity of the AGIs. The average residence time was found by dividing the flow out by the AGI volumes each day and taking the average over the three-year period of record.

Table 37: Non-Steady State Removal Efficiency for AGIs in Measure #4 (Chapra, 1997)

Decay rate (day^{-1}) (Paudel et al., 2010)	Average TP June 15 - November 1, 2013 (mg/L)	Percent Removal	Average RT (days)
0	0.165	5%	7
0.1	0.092	47%	7
0.2	0.066	62%	7
0.3	0.053	69%	7
0.4	0.044	75%	7

Based on this calculation, a range of removal efficiencies between 5% and 75% is possible. For the purposes of this analysis, an average decay rate of 0.2 day^{-1} was used such that an average concentration of 0.066 mg/L can be estimated for the discharge from the AGIs for consumptive use by the adjacent citrus fields. Even though this water will be consumed for agricultural uses and will not discharge through PC-17A, these pathways are considered discharges to downstream users; therefore, the flows and concentrations should be combined when evaluating the overall water quality benefit of this measure. **Table 38** shows the effect of Measure #4 on downstream discharges by combining the predicted discharge and concentration at PC-17A with the predicted discharge and concentration from the AGIs.

Table 38: Predicted Annual Reductions and Resulting Average Annual TP Concentrations to the North Feeder Canal before and after Measure #4 Implementation

Year	Existing Annual Discharge Volume Downstream (ac-feet)	Predicted Annual Discharge Volume Downstream (ac-feet)	Average Annual Concentration before Measure #4 (mg/L)	Predicted Average Annual TP Concentration after Measure #4 (mg/L)
2011	1,563	3,267	0.12	0.07
2012	2,954	4,401	0.19	0.11
2013	25,433	21,867	0.17	0.12

5.3.4.2 Measure #4 – Estimating the Conceptual Implementation Cost

Based on the analysis, a maximum inflow rate of 112 cfs was observed. Higher rates may be achievable, but would increase the likelihood of exceeding the maximum depth within the AGIs resulting in bypass flow. Since there are two AGIs that are approximately equal in size, the flow would need to be diverted using two pump stations. It is recommended that each station include 2-30 cfs pumps.

Table 39: Estimated Implementation Cost for Measure #4

ITEM	UNIT	QUANTITY	PRICE	AMOUNT
Construction Costs				
30 cfs Inflow Pump Stations (2)	CFS	60	$50,000.00	$3,000,000.00
Canal Excavation	CY	40,700	$5.00	$203,500.00
Hauling and Disposal of Excavated Material	CY	40,700	$25.00	$1,017,500.00
			SUBTOTAL	**$4,221,000.00**
Mobilization, Engineering Design & Construction Administration				
Mobilization (10% of Construction Costs)	EA	1	$422,100.00	$422,100.00
Construction Management (7.5%)	LS	1	$316,575.00	$316,575.00
Engineering Planing and Design (10%)	LS	1	$422,100.00	$422,100.00
Program Management (2.5%)	LS	1	$105,525.00	$105,525.00
			TOTAL	**$5,487,300.00**

5.3.4.3 Measure #4 – Regulatory Considerations

The regulatory issues to consider for the implementation of this measure include:

a. As noted in the Restudy language one objective for the project is to, "maintain flood protection on Seminole Tribal lands, and ensure that inflows to the North and West Feeder Canals meet applicable water quality standards. Consistency with the Seminole Tribe's Conceptual Water Conservation System master plan will be maintained."
b. The Seminole Tribe has a legal agreement that targets a TP concentration of 50 ppb for discharges from PC-17A to limit the impacts of heightened nutrient levels. Based on a preliminary quantification of benefits, the effect of Measure #4 implementation will not reach the target TP concentration. The proposed diversion south from the South Boundary Canal must be considered with respect to the impacts of the terms and the responsible parties of the existing legal agreement.
c. Stakeholders downstream of the Northern Reach have consumptive use demands that require delivery of surface flows, and the proposed diversion would alter the mechanism for delivery of these flows. Therefore, coordination would be required with existing stakeholders.
d. Implementation of any measure should not negatively affect flood protection for any existing landowners; therefore, the diversion must be implemented in a manner that maintains the existing level of service for flood protection to the North Feeder Canal Sub-basin.

5.3.5 Measure #5 – Utilization of the C-139 Annex FEB

The diversion proposed in Measure #5 is intended to restore a pre-existing east-west flow path that historically connected wetlands in the North Feeder Canal Basin with wetlands in the C-139 Annex. As illustrated in **Figure 62**, there is a portion of the North Feeder Canal sub-basin that is tributary to PC-17A due to the configuration of the surface water management system that historically drained to the east. Since the State owns and is planning to construct the C-139 FEB on the adjacent land, the diversion in Measure #5 proposes to reroute the northern portion of the Garcia Farms property through the existing AGI and into the proposed C-139 FEB. The C-139 FEB is intended to be a large State owned and operated above ground reservoir that will absorb peak flows from the C-139 Basin and slowly release them to the STA-5/6 complex. This means that the facility is scheduled to be constructed irrespective of proposed Measure #5 making implementation slightly easier.

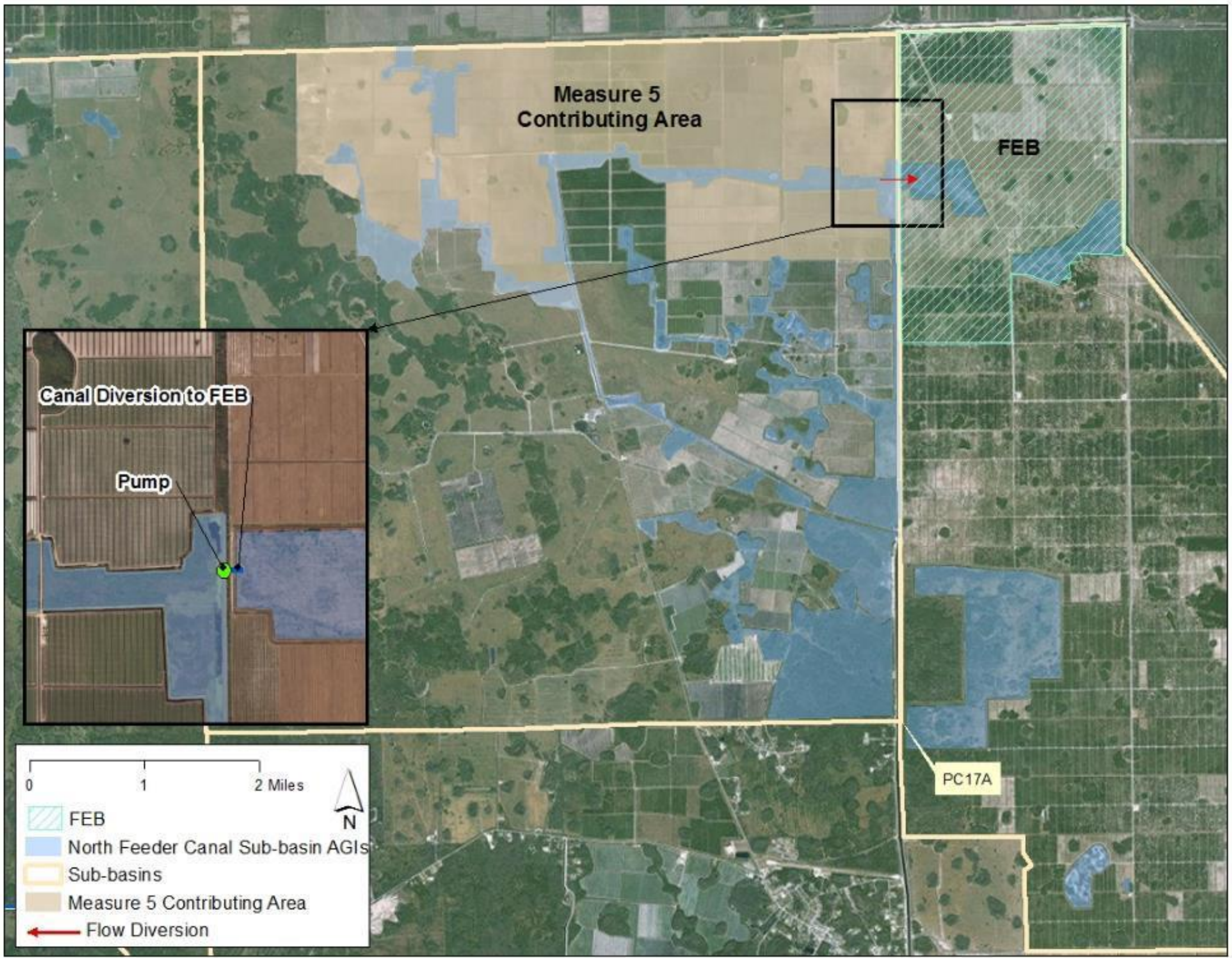

Figure 62: Contributing Area for the Proposed Measure #5 Diversion

5.3.5.1 Measure #5 – Water Quality Benefit

The C-139 Annex FEB is slated to receive flows from the Deer Fence Canal. Measure #5 proposes that a portion of the available volume within the FEB be allocated to receive flows from the northern portion of Garcia Farms, thus reducing the hydraulic loading at PC-17A. This portion or sector of the FEB was sized based on an approach of proportionality of contributing areas. If the entire FEB will accept flows from the C-139 Basin and the northern portion of Garcia Farms, then the footprint allocated to the Garcia Farms diversion should be sized based on its relative contributing area to the C-139 Basin's contributing area. The contributing area for Measure #5 comprises 4% of the total proposed contributing area to the FEB. Therefore, the sector available to the proposed diversion was sized to be 112 acres, or 4% of the available land within the FEB. A simple spreadsheet was created to calculate the amount of water routed to the proposed footprint within the FEB and the new PC-17A daily flow.

The methods used to calculate the inflow time series for the diversion and the resulting new PC-17A time series were similar to the methods used for Measure #4. The time series of flows diverted was based on the findings of the 2016 hydrologic and hydraulic model developed under Task 4 of this work order. The calibrated MIKE11 model results file was used to extract the modeled flows from Detention Area D and the modeled flows at PC-17A. For the period of June 2011 through May 2014, the modeled flow volume at the Detention Area D outlet is 48% of the modeled flow volume at PC-17A.

The potential daily diversion volume for Measure #5 was calculated based on an assumption that all area within Garcia Farms contributes equally to the outflow at Detention Area D. The contributing area to the proposed Measure #5 diversion consists of 47% of the area of Garcia Farms. Thus, the time series for daily potential inflows to be diverted is 47% of the previously devised Garcia Farms time series, which was based on a fraction of the measured PC-17A flows.

The assumed outflows from the proposed Measure #5 sector of the FEB are the daily levee seepage, daily vertical seepage, and daily estimated ET. The estimated ET was calculated based on the measurement taken at the BIG CY SIR weather station and the total proposed area of the sector within the FEB. The daily levee seepage was calculated using an assumed square perimeter of levee around the sector, beginning-of-day depth in the sector, and seepage rate of 1 cfs/ft head/mile levee. The infiltration rate was assumed to be 0.0041 (cm/d)/cm based on the average of values determined for the STA-5 and STA-6 facilities. Based on the volume of inflow, and the size of the sector allocated within the FEB, for two of the three years evaluated there is no need for withdrawal from the allocated sector. In consideration of the sizing and the potential variability of the operations of the proposed FEB, for the purposes of this analysis there was no discharge assumed from the allocated sector as part of Measure #5. The processes by which water is removed are infiltration, seepage, and ET. When the sector is at capacity, the flows from the Measure #5 contributing area are routed along their current path through the downstream Garcia Farms reservoirs and eventually out of the Detention Area D outlet, returning to the PC-17A flows. **Figure 63** shows the magnitude of the bypass volume, FEB inflow volume, and depth in the reservoir.

Subtracting the daily outflow volumes and adding the inflow volumes to the beginning of the day volume gives an end of day volume. Using the area of the sector of the FEB and the estimated daily water volume storage, the estimated depth of water in the sector of the FEB was calculated. A counting function was used to count the number of days that the volume in the sector of the FEB was such that the depth in the sector is greater than 1, 2, 3, and 4 feet. **Table 40** shows the number of days that the FEB sector exceeds depths of 1 to 4 feet.

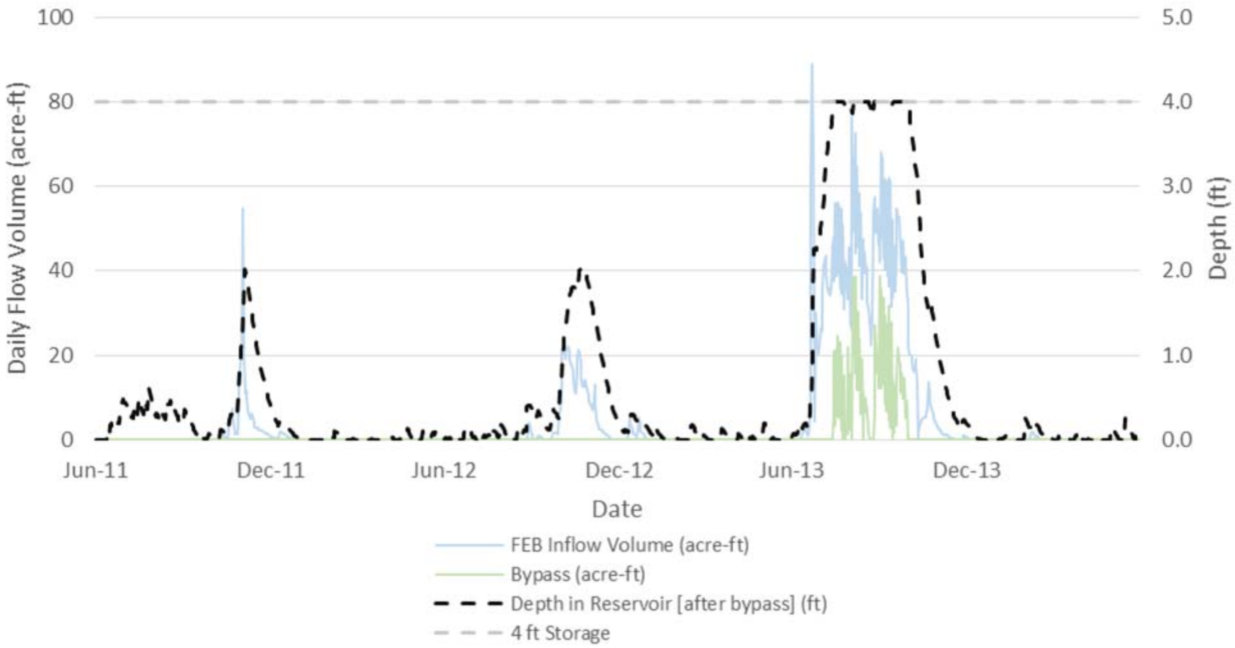

Figure 63: Inflows to, Bypass from, and Depth in Portion of FEB for Proposed Diversion Measure #5

Table 40: Depth Count for Bypass at 4-feet

Depth of Available Storage (ft)	Number of Days FEB Sector Exceeds Specified Depth
1	192
2	118
3	98
4	68

Table 41: Measure #5 Yearly Inflow, Outflow, and Bypass Volumes for 4-feet Bypass Depth (acre-feet)

Year	Total Yearly Inflow	Total Yearly Bypass Volume
2011	355	0
2012	671	0
2013	4,756	1,018

The new PC-17A volume was calculated by summing the portion of flow from the southern portion of Garcia Farms and the contributing area upstream of CR 833 with the daily bypassed volumes. **Figure 64**, **Figure 66**, and **Figure 68** show the existing measured PC-17A flows and the estimated PC-17A flows upon implementation of Measure #5. **Figure 65**, **Figure 67**, and **Figure 69** show the existing and predicted flows at PC-17A, as well as the predicted FEB inflows. For the period of June 2011 through May 2014, the estimated total reduction in PC-17A discharges is 5,782 acre-feet with the implementation of Measure #5.

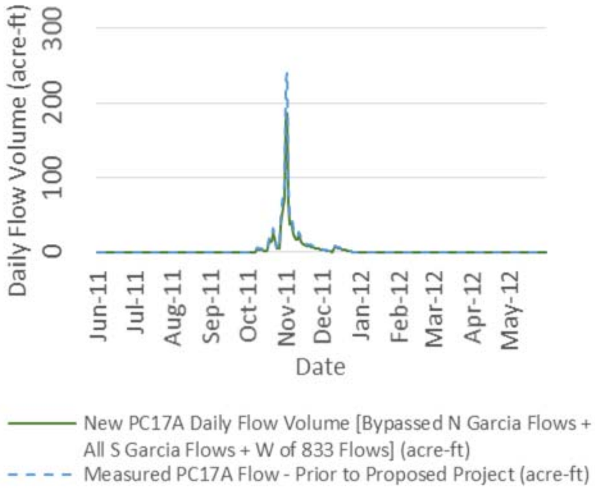

Figure 64: 2011 Potential Flow Reductions at PC-17A

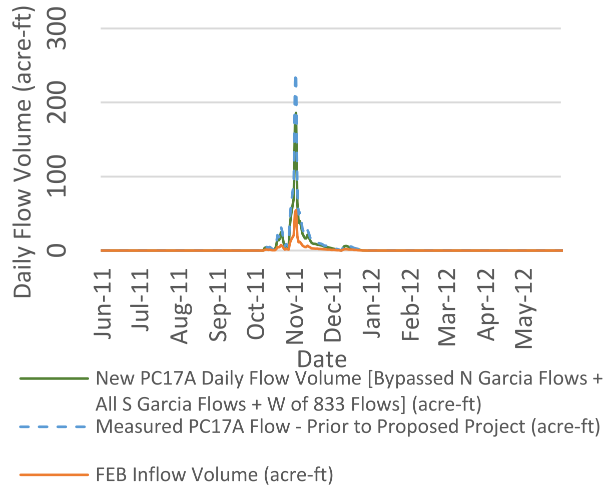

Figure 65: 2011 Potential Flow Reductions at PC-17A and FEB Inflows

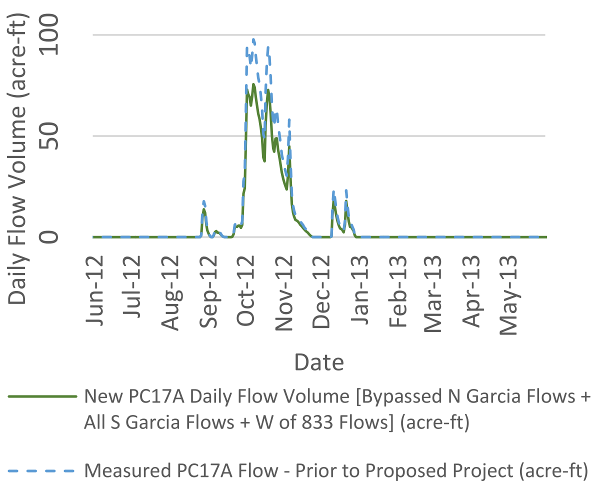

Figure 66: 2012 Potential Flow Reductions at PC-17A

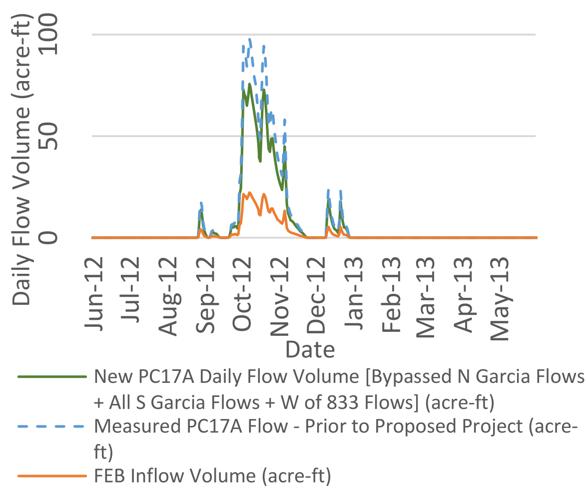

Figure 67: 2012 Potential Flow Reductions at PC-17A and FEB Inflows

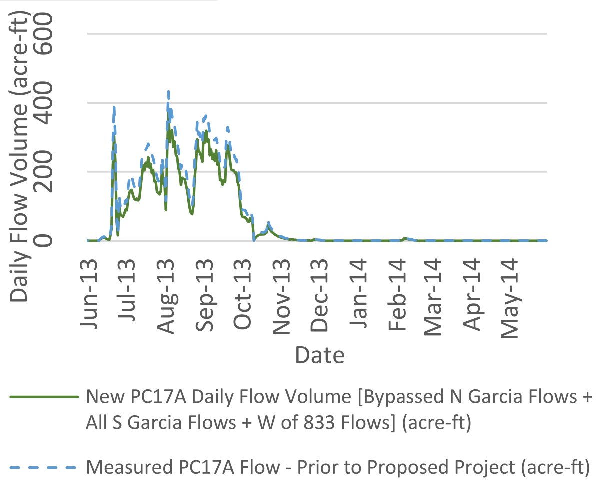

Figure 68: 2013 Potential Flow Reductions at PC-17A

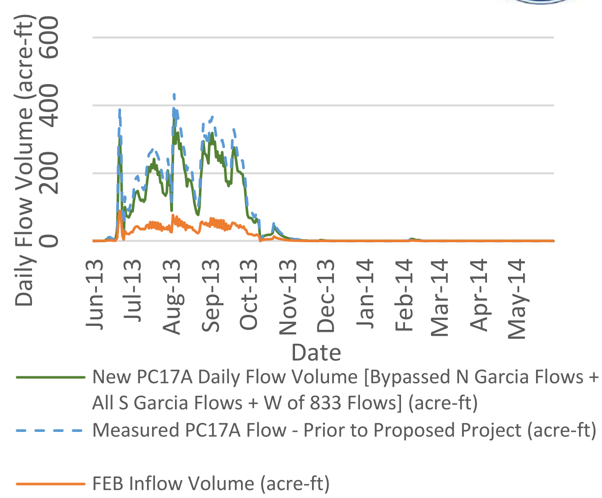

Figure 69: 2013 Potential Flow Reductions at PC-17A and FEB Inflows

In order to estimate the water quality impact of Measure #5, EMCs published in scientific literature (Harper, 2011) were used in combination with measured values at PC-17A to predict the average TP concentration entering the AGIs, as well as a daily time series for estimated TP load at PC-17A and entering the AGIs. The EMCs were adjusted by a weighting factor to match the predicted loads to measured values. A weighting factor of 0.37 was calculated so that the sum of the loads from each contributing area during the period from June 2011 to May 2014 equals the total load through PC-17A during that same time period. No attenuation was calculated for water detained in the FEB considering that no discharge from the FEB was incorporated in this analysis.

Table 42 shows the annual flow volume before and after implementation, as well as the average annual concentrations measured at PC-17A, and average annual concentrations predicted for PC-17A with the implementation of Measure #5. This illustrates the isolated effects at PC-17A of diverting a portion of the runoff in the existing contributing area east to the FEB. **Table 42** does not include the water quality and volume of water predicted to be discharged from the sector of the FEB devoted to Measure #5. Due to the fact that the annual flow reduction in 2012 exceeded load reduction, the predicted TP concentration for 2012 with the implementation of Measure #5 is greater than the measured average annual TP concentration.

Table 42: Predicted Annual Reductions and Resulting Average Annual TP Concentrations at PC-17A before and after Measure #5 Implementation

Year	Existing Annual Discharge from PC-17A Total Volume (ac-ft)	Predicted Annual Discharge from PC-17A Total Volume (ac-ft)	Average Annual Concentration before Measure #5 (mg/L)	Predicted Average Annual TP Concentration after Measure #5 (mg/L)
2011	1,563	1,208	0.120	0.105
2012	2,954	2,283	0.191	0.197
2013	25,433	20,677	0.168	0.167

The only flows and concentrations considered after the implementation of Measure #5 are those occurring from the area upstream of CR 833, the remaining area outside of Garcia Farms outside of the Measure #5 contributing area, and any bypasses occurring when the Measure #5 FEB sector volume is full.

5.3.5.2 Measure #5 – Estimating the Conceptual Implementation Cost

Because Measure #5 utilizes the proposed C-139 FEB facility to retain the diverted runoff, the costs associated with constructing levees or discharge structures are not applicable. The only infrastructure required is an inflow pump station that will discharge runoff stored in the existing Garcia Farms AGI and pump up into the proposed FEB. The topographic gradient is from west to east so there is a potential for gravity flow along the historic pathway. However, during normal operations of the FEB it is expected that there will frequently be runoff from the Deer Fence Canal and the C-139 Basin stored in a manner that will create an adverse hydraulic gradient. Considering this likelihood, the recommended discharge structure is a single 150 cfs pump station. **Table 43** shows the cost associated with the pump.

Table 43: Estimated Implementation Cost for Measure #5

ITEM	UNIT	QUANTITY	PRICE	AMOUNT
Construction Costs				
150 cfs Inflow Pump Station	CFS	150	$50,000.00	$7,500,000.00
			SUBTOTAL	**$7,500,000.00**
Mobilization, Engineering Design & Construction Administration				
Mobilization (10% of Construction Costs)	EA	1	$750,000.00	$750,000.00
Construction Management (7.5%)	LS	1	$562,500.00	$562,500.00
Engineering Planing and Design (10%)	LS	1	$750,000.00	$750,000.00
Program Management (2.5%)	LS	1	$187,500.00	$187,500.00
			TOTAL	**$9,750,000.00**

5.3.5.3 Measure #5 – Regulatory Considerations

The following regulatory issues should be considered before implementing this measure:

a. As noted in the Restudy language one objective for the project is to, "maintain flood protection on Seminole Tribal lands, and ensure that inflows to the North and West Feeder Canals meet applicable water quality standards. Consistency with the Seminole Tribe's Conceptual Water Conservation System master plan will be maintained."
b. The C-139 Basin (north of the Northern Reach) is subject to the requirements of Section 373.4592 (3)(f)5, Florida Statutes, that governs existing landowners and is restrictive on new surface inflows.
c. The C-139 Annex FEB is intended to discharge east to the STA-5/STA-6 facility and not towards the Western Basins. Stakeholders downstream of the Northern Reach have consumptive use demands that require delivery of surface flows. Runoff diverted to the C-139 Annex should be returned to the North Feeder Canal unless agreement from existing consumptive users downstream is obtained.
d. Any proposed diversions into the C-139 Annex or FEB will need to be coordinated with designers of the restoration project.
e. Low lying pasture lands to the south of the C-139 Annex are affected by seepage from water stored within the C-139 Annex. Any diversions into the C-139 Annex should consider this potential impact prior to implementation.

5.3.6 Measure #6 – Sub-regional Detention Storage Facilities (Reservoirs or STAs)

The first FAVT facility in the Feeder Canal Basin is currently permitted and expected to be constructed north of the South Boundary Canal west of CR 833. If this facility is successful in reducing TP loads in the North Feeder Canal sub-basin, additional facilities could be constructed. Measure #6 is the construction of either conventional detention and STA facilities, an appended FEB on the existing FAVT facility, or additional FAVT facilities. For this analysis, an appended FEB to the existing FAVT facility and an FAVT expansion were considered. FEBs provide operational flexibility by storing water upstream of the treatment facility at times when there is more flow than the facility can handle.

Two potential configurations were analyzed for implementing additional treatment for the western portion of the North Feeder Canal sub-basin. One configuration included the addition of an FEB to feed the FAVT with and without an expanded FAVT footprint. Another configuration included simply expanding the FAVT footprint without the addition of the FEB ahead of the system. The extent of the potential FAVT expansion and the potential FEB were drawn along the perimeters of prior farm fields flanking the FAVT slated for construction in the area. **Figure 70** shows the location of proposed Measure #6.

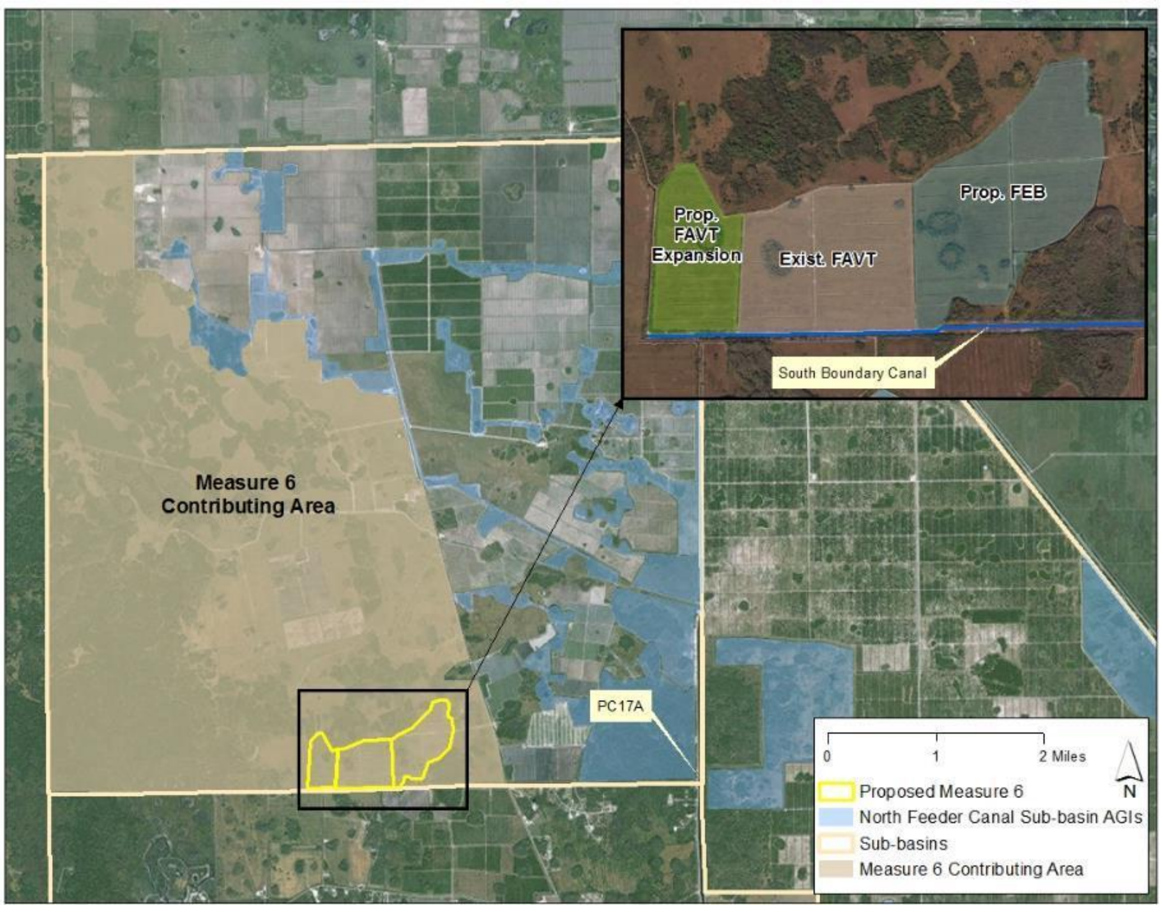

Figure 70: Contributing Area for Measure #6 FEB/FAVT Expansion

5.3.6.1 Measure #6 – Water Quality Benefit

The potential inflow time series for routing through the FEB/FAVT compound was determined in the same way as the time series for estimating the water quality benefits for Measure #4. The contributing area for runoff that can feed the FEB/FAVT compound is the area upstream of the CR 833 culvert minus the area of the proposed FEB/FAVT system. Using methods discussed in Measure #4 for the estimated runoff time series for the contributing area upstream of the CR 833 culvert, the potential inflow for Measure #6 was assumed to be 49.7% of the daily flows at PC-17A plus the rainfall directly into the FEB and FAVT footprints.

It is fundamental for an FAVT system to remain wet, and the FAVT designers used an optimum water depth of 2.0 feet. Two pumps totaling 60 cfs will pump water from the Southern Boundary Canal into the FAVT facility until the depth is achieved. If there is runoff in the basin, a 20 cfs pump will run from an adjacent farm ditch. In order for an FAVT system to function properly, a sufficient residence time must be present to allow nutrient uptake to occur. Based on the size of the FAVT facility and the inflow rate of 20 cfs, the residence time will be approximately nine days, assuming an even distribution of flow. Using this flow rate and the size of the permitted FAVT (140 acres), a formula of 0.143 cfs/acre can be applied for sizing the pump inflow of other FAVTs.

For the purpose of the analyses described below, it is assumed that the system will be maintained with a depth of 2.0 feet by the canal pumps (60 cfs) and that only 20 cfs is the assumed inflow to be treated within the FAVT facility. It is expected that most of the seepage losses will be recycled back to the FAVT facility.

For the option of including an FEB prior to the currently designed FAVT system, the FAVT facility would still accept direct runoff from the area upstream of CR 833; however, the FEB would accept any runoff that the FAVT cannot accept up to a depth of 4 feet before bypass occurs. When the 20 cfs farm pump has stopped pumping into the FAVT facility due to a lack of runoff, the FEB will then discharge to the FAVT system at the same rate of 20 cfs. Under these conditions, it is assumed that the FEB is discharging to the FAVT facility until it is empty.

The assumed outflows for the FEB are the daily levee seepage, daily vertical seepage, and daily estimated ET. The estimated ET was calculated based on the measurement taken at the BIG CY SIR weather station and the footprint of the FEB or FAVT system area. The daily levee seepage was calculated using the perimeter of the AGI levees, beginning-of-day depth in the reservoir, and seepage rate of 1 cfs/ft head/mile levee.

For the option of expansion of the FAVT system, the inflow to the FAVT system is the runoff time series for the contributing area upstream of the CR 833 culvert, which was described in the discussion of Measure #4. The outflow for the FAVT system was calculated assuming a rectangular contracted weir with a total weir length of 30 feet and a crest elevation corresponding to 2.5 feet of depth. This was assumed based on the cumulative length of the permitted discharge structures (Permit 26-01205-W) for the FAVT system that is currently slated for construction. Assuming that this length was determined to be optimal by the FAVT facility designers, the design weir length based on FAVT area is 0.214 feet/acre. Subtracting the daily outflows and adding the daily inflows to the water stored in the spreadsheet modeled FAVT system gives an end of day volume. Using the area of the FAVT system and the estimated beginning of day water volume stored in the system, the estimated depth of water in the FAVT system was calculated.

Table 44 and **Figure 71** show the differences in treatment volumes for the FAVT facility with and without expansion and with and without an FEB.

Table 44: Comparison of Treatment Volumes for Various Configurations

Configuration	Treated Volume (acre-feet)	Percent Increase of Treated Volume from Permitted Configuration
FAVT Facility as Permitted	6,810	0%
Additional FAVT Facility	8,857	30.1%
FAVT Facility As Permitted with FEB	9,019	32.4%
Additional FAVT Facility with FEB	11,230	64.9%

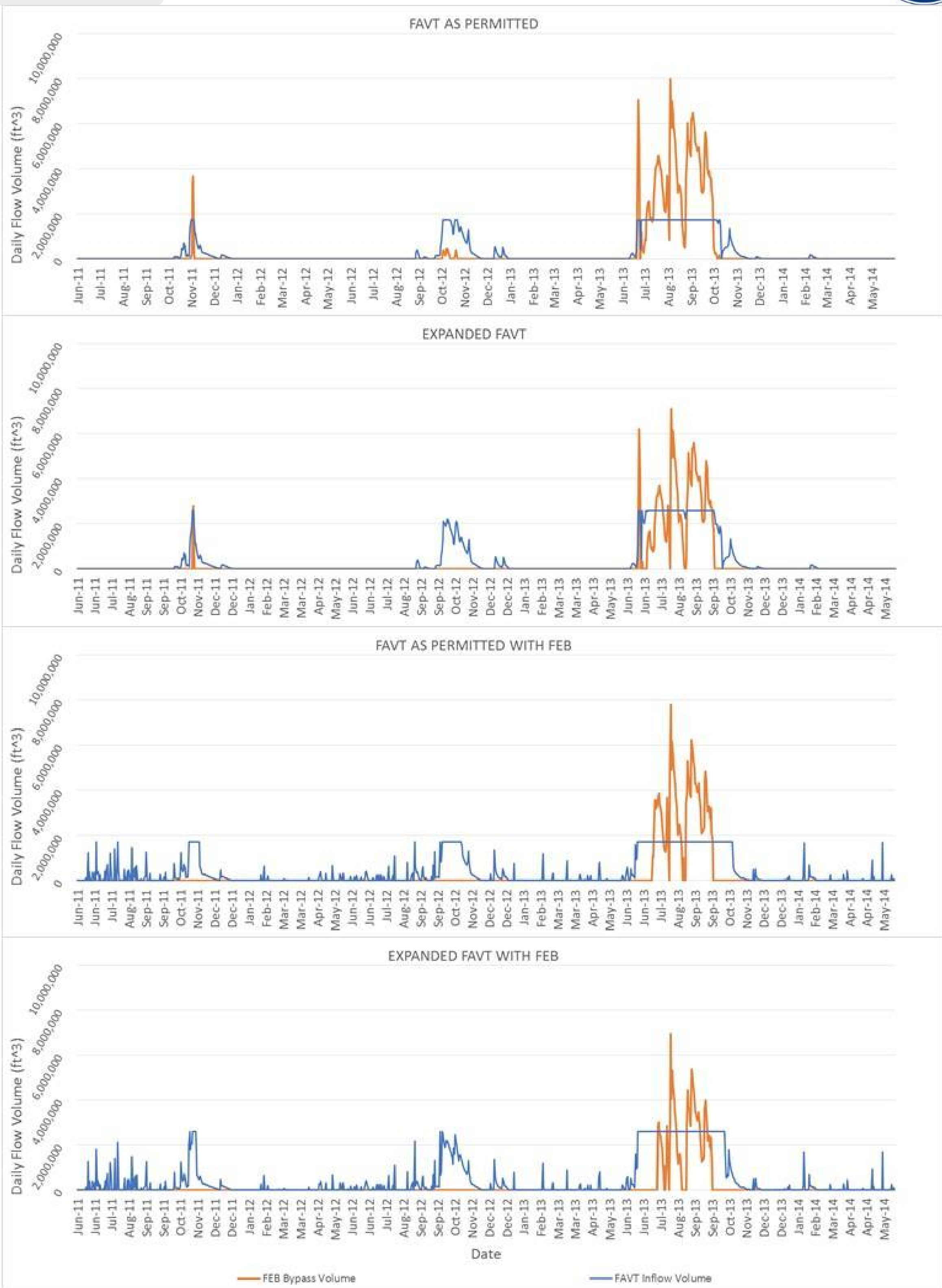

Figure 71: Treatment Volumes for Configurations of Measure #6

FAVT systems have been found to be effective at removing phosphorus from the water column. FAVT systems are most effective when the rapid growth phase of the aquatic vegetation is maintained. According to Water and Soil Solutions, LLC, vegetated-tilled mesocosms provided an average of 65% reduction in TP when compared with a TP reduction of 30% in non-vegetated control mesocosms. The full-scale East Caloosahatchee River FAVT System obtained a 61% mean reduction in TP concentration in one year following the start-up period.

Assuming that the proposed Measure #6 FAVT system has the ability to remove similar fractions of TP for water routed through it as previously built FAVT systems, a 60% TP removal ratio was assumed. Since the Measure #6 contributing area is the same as the Measure #4 contributing area, the inflow concentration for the FEB/FAVT system is assumed to be 0.173 mg/L. Assuming a simple 60% TP removal ratio, the outflow concentration from the FEB/FAVT system can be assumed to be 0.069 mg/L. **Table 45** shows the estimated annual flow and TP load reduction at PC-17A with the implementation of Measure #6 with the additional FAVT facility with FEB configuration. There is an overall predicted reduction in the annual load reduction by mass over the course of the three WYs between 2011 and 2013.

Table 45: Predicted Annual Reductions and Resulting Average Annual TP Concentrations at PC-17A before and after Measure #6 Implementation of Additional FAVT Facility with FEB Configuration

Year	Yearly Measured PC-17A Flow - Prior to Proposed Project (acre-ft)	Yearly New PC-17A Daily Flow Volume (acre-ft)	Average Annual Concentration before Measure #6 (mg/L)	Average Annual Concentration after Measure #6 (mg/L)
2011	1,563	1,671	0.12	0.12
2012	2,594	3,135	0.19	0.12
2013	25,433	23,456	0.17	0.14

5.3.6.2 Measure #6 – Estimating the Conceptual Implementation Cost

The facilities needed for the expanded FAVT system include levees, a 30 cfs pump, and an additional 84-inch wide flashboard riser. Facilities for an FEB to serve the FAVT system include levees, a 120 cfs inflow pump, a 20 cfs outfall pump, and an 84inch wide flashboard riser to serve as an emergency outfall structure. There are also operational costs to consider associated with managing an FAVT facility including water table control and periodic tilling. Maintenance and operational costs are not included herein as the conceptual estimate is focused on capital costs only.

Table 46: Estimated Implementation Cost for Measure #6

ITEM	UNIT	QUANTITY	PRICE	AMOUNT
Construction Costs				
FEB Minor Impoundment Levees	MI	1.8	$300,000.00	$540,000.00
FAVT Minor Impoundment Levees	MI	1	$300,000.00	$300,000.00
Clearing, Grubbing and Minor Earthwork	AC	240	$2,000.00	$480,000.00
FAVT Inflow Pump Station (30 cfs)	CFS	30	$50,000.00	$1,500,000.00
FAVT Outflow Flashboard Riser (84-in)	EA	1	$175,000.00	$175,000.00
FEB Inflow Pump Station (120 cfs)	CFS	120	$50,000.00	$6,000,000.00
FEB Outfall Pump Station (20 cfs)	CFS	20	$50,000.00	$1,000,000.00
FEB Emergency Overflow Riser (84-in)	EA	1	$175,000.00	$175,000.00
			SUBTOTAL	**$10,170,000.00**
Mobilization, Engineering Design & Construction Administration				
Mobilization (10% of Construction Costs)	EA	1	$1,017,000.00	$1,017,000.00
Construction Management (7.5%)	LS	1	$762,750.00	$762,750.00
Engineering Planing and Design (10%)	LS	1	$1,017,000.00	$1,017,000.00
Program Management (2.5%)	LS	1	$254,250.00	$254,250.00
			TOTAL	**$13,221,000.00**

5.3.6.3 Measure #6 – Regulatory Considerations

Besides the relative quantitative water quality benefits of some improvement measures as compared with others, there are several regulatory considerations that are relevant when assessing the viability of implementation. The hydrologic framework of the region is based on several factors including the following:

a. As noted in the Restudy language one objective for the project is to, "maintain flood protection on Seminole Tribal lands, and ensure that inflows to the North and West Feeder Canals meet applicable water quality standards. Consistency with the Seminole Tribe's Conceptual Water Conservation System master plan will be maintained."
b. The Seminole Tribe has a legal agreement that targets a TP concentration of 50 ppb for discharges from PC-17A to limit the impacts of heightened nutrient levels. The proposed additional detention facilities may help the water quality but would not change the terms or the responsible parties of the existing legal agreement.
c. Stakeholders downstream of the Northern Reach have consumptive use demands that require delivery of surface flows; therefore, any changes to the hydrology of the North Feeder Canal Sub-basin must not negatively impact surface water deliveries.
d. Implementation of any measure should not negatively affect flood protection for any existing landowners; therefore, the operation of any new detention facilities must be constrained to provide the existing level of service for flood protection.

5.4 Selection of Management Measures and Activities

Each proposed water quality improvement measure is unique and could impact the basin in a specific way. Based on the approaches described above, each of the water quality improvement measures can be evaluated using only measured data and simplifying assumptions related to contributing area and documented treatment performance.

5.4.1 Comparison of Potential Benefits and Conceptual Construction Costs

Since the Project Work Plan specifies that hydraulic routing and water quality modeling shall not be performed, spreadsheet analyses were performed ranging from simplistic volumetric balances to more detailed water budgets including a spreadsheet version of the water quality improvement algorithms. Measured data and published relationships between land use and nutrient concentrations were utilized for numeric input. These analyses provide a relative comparison between selected measures in terms of effects on runoff discharges, TP concentration reduction and conceptual implementation cost. **Table 47** shows a comparison of the measures in terms of changes in flows, estimated concentrations and conceptual capital costs for implementation. These costs are based on the information presented in above and only include construction, not operational, costs. With respect to operational costs, the facilities with pump stations are more intensive (Measures 1, 4, 5 and 6) and the FAVT described in Measure #6 requires tilling in addition to pumping making it more operationally intensive. The operational cost of Measure #3 is the least significant as it is a passive structure, while the operational cost of Measure #2 is limited to the standard costs for operating and maintaining a remotely operated gate.

Table 47: Summary of Load Reductions and Costs of Presented Measures

Measure Number	Estimated Average Annual[1] Flow Changes Downstream after Project (acre-ft)	Estimated Average Annual TP Downstream (mg/L)		Initial Cost of Measure Implementation
		Before	*After*	
1	+4,011	0.160	0.108	$9,779,250
2	N/A[2]	N/A	N/A	$4,049,500
3	-13,001	0.058	0.058	$416,000
4	-4,901	0.160	0.146	$5,487,300
5	-1,921	0.160	0.157	$9,750,000
6	-563	0.160	0.124	$13,221,000

[1] All periods of record for values in the table are water years 2011-2013 except for Measures #2 and 3. The period of record for Measure #3 is calendar years 1999 through 2015.
[2] No data available for these estimates.

For Measure #1, the addition of the contributing area for Pond 3 in the C-139 Annex increases overall discharges downstream above existing, while the attenuation effects of detaining runoff within the pond improve the water quality. For Measure #2, the effects on discharges and water quality of replacing the PC-17A structure cannot be quantified. For Measure #3, there is a significant reduction in average annual discharges caused by diverting peak flows south of the West Feeder Canal Sub-basin, but there is no proposed facility to improve water quality. Although these changes appear significant, the diverted flows are only in peak flow periods when consumptive demand is low. With respect to water quality, the West Feeder Canal Sub-basin has relatively low TP concentrations in existing runoff and does not require much treatment. For Measure #4, there is a reduction in discharges at PC-17A, but much of that water is being delivered to a downstream consumptive user in the form of flows to a citrus operation on the Seminole Tribe lands. For Measure #5 the impacts are limited this is primarily due to the smaller relative size of the contributing area being addressed by the diversion. For Measure #6, in comparison with Measure #4 that has the same contributing area, the anticipated water quality benefits of FAVT treatment is better, but the effect on downstream discharges is less significant without the impact of consumptive demand.

5.4.1.1 Potential Variability in Construction Costs

It is worth noting that the cost information presented in **Table 47** assumes that the infrastructure is built and operated by the District. Often, going through the public design and construction process generates a higher quality product with a longer life that is also more expensive than infrastructure that is privately built. As an example, in **Table 48** an alternative set of conceptual cost estimates illustrates a comparison of public construction versus private construction, if the cost of pump stations is reduced from $50,000 per cfs to $10,000 per cfs. There are examples of pump stations that have been constructed for amounts even lower than this price per cfs, such as the G-200 inflow pump for the Holeyland WMA, where a 300 cfs pump station was constructed for only $507,000 or $1,690 per cfs. G-200 is an example of how pump station construction costs can vary based on each location and situation, and as such it is valuable to investigate the conceptual implementation costs of the proposed measures with a range of potential costs for pump station construction. Because several of the measures involve the construction of a pump station, this changed assumption leads to very different total implementation costs. In evaluating the implementation of any particular measure, it is recommended that the option to have the facility privately constructed and operated with the support of grant funding be considered.

Table 48: Comparison of Potential Cost Savings for Private Construction Measures

Measure Number	Cost of Measure Implementation ***Publicly Constructed Pump Stations***	Cost of Measure Implementation ***Privately Constructed Pump Stations***	Cost Reduction Assuming Public PS = $50,000/cfs and Private PS = $10,000/cfs
1	$9,779,250	$2,499,250	74%
2	$4,049,500	$4,049,500	0%
3	$416,000	$416,000	0%
4	$5,487,300	$2,367,300	57%
5	$9,750,000	$1,950,000	80%
6	$13,221,000	$4,381,000	67%

5.4.1.2 Regulatory Assessment of Measure Implementation

Regulatory feasibility associated with the implementation of each proposed water quality improvement measure was considered in the evaluation, as well. For measures where a surface water diversion is away from downstream consumptive uses or towards the C-139 Basin, such as Measures #1, #3, and #5, there are regulatory challenges. Similarly, measures where the diverted water does not meet identified water quality targets, such as Measure #4, there are potential concerns. For Measure #6, the majority of the locations identified for implementation are in private ownership, which is a limitation. Measure #2 is the only measure with limited regulatory challenges; however, this measure is expected to have the least impact on improving water quality.

5.4.1.3 Potential for Combining Measures

Each measure is developed based on different characteristics and is anticipated to produce different affects. In considering which measures may be preferred for implementation the benefits and costs of each measure with respect to water quality, regulatory allowances, and affects to stakeholders must be considered. If more than one measure is seen as feasible there are opportunities for multiple measures to be implemented simultaneously. For instance, Measure #3 is located in the West Feeder Canal Sub-basin and is independent of the other five concepts in a manner that construction and operation could be simultaneous with any other measure. Similarly Measure #2 consists of replacing PC-17A and could be implemented independent of any of the other measures. Replacing PC-17A could prove beneficial to Measures #4 and #6 by allowing for greater operational control of the South Boundary Canal. Measures #1 and # 5 are configured in a way that address some of the same contributing area east of CR 833 in the North Feeder Canal Sub-basin, as such the two should likely not be implemented simultaneously. Measures #4 and #6 are similarly conceived to address the contributing area west of CR 833 in the North Feeder Canal Sub-basin and should not be implemented simultaneously. Based on these relationships, there are four combinations of the proposed measures that could be considered if deemed viable with respect to water quality improvement, regulatory requirements and cost (see **Table 49**).

Table 49: Potential Combinations of Proposed Water Quality Improvement Measures

Alternative Combination	Measure #1	Measure #2	Measure #3	Measure #4	Measure #5	Measure #6
1	X	X	X	X		
2	X	X	X			X
3		X	X	X	X	
4		X	X		X	X

6.0 References

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