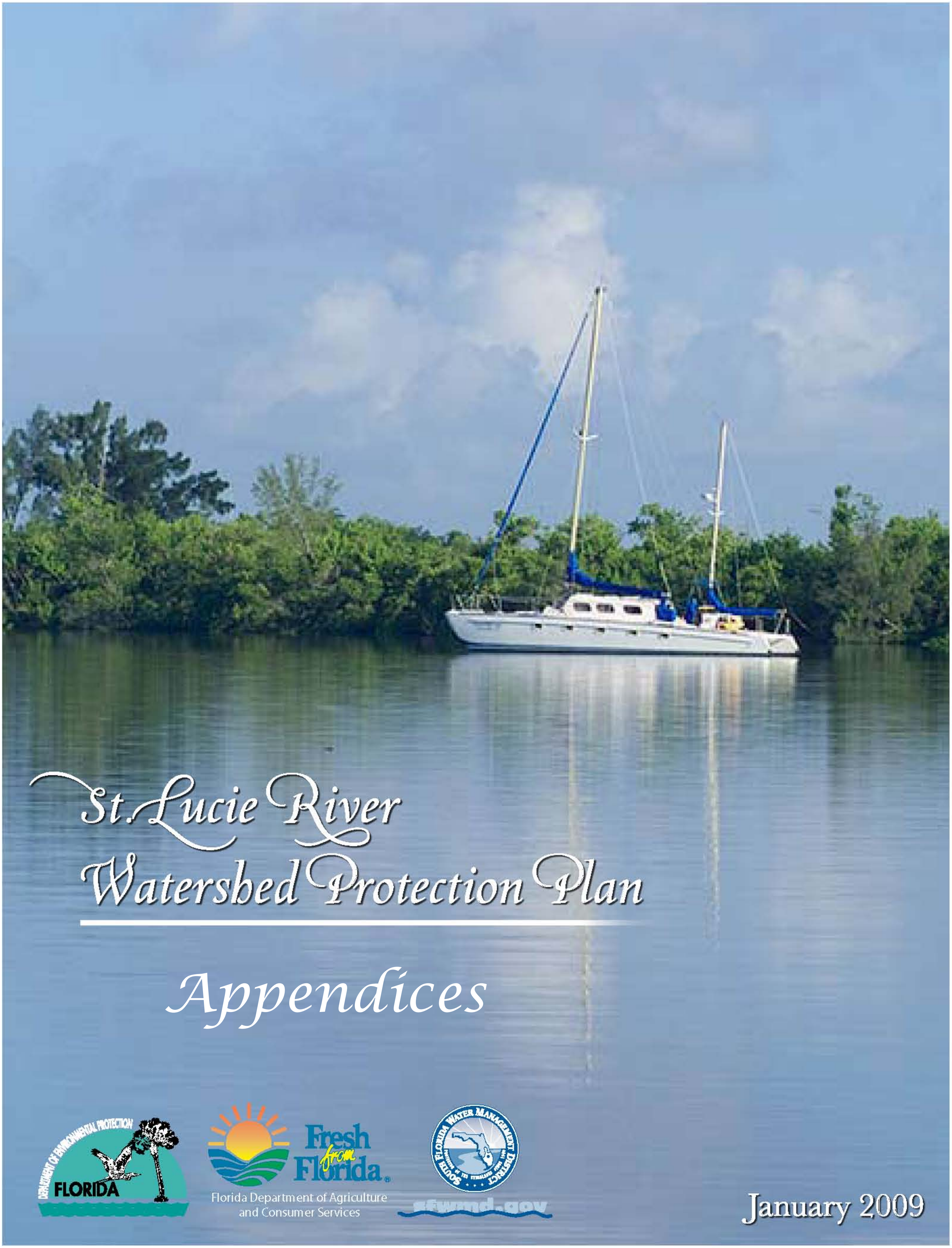


St. Lucie River Watershed Protection Plan

Appendices

DEPARTMENT OF ENVIRONMENTAL PROTECTION FLORIDA

Fresh from Florida
Florida Department of Agriculture and Consumer Services

South Florida Water Management District
sfwmd.gov

January 2009

St. Lucie River Watershed Protection Plan

APPENDICES

January 2009

APPENDICES

APPENDIX A

PERFORMANCE MEASURE AND PERFORMANCE INDICATOR FACT SHEETS

St. Lucie River and Estuary Performance Measures

Number of Times St. Lucie Estuary High Discharge Criteria Exceeded

Performance Measure: Number of Times St. Lucie River Estuary High Discharge Criteria Exceeded – Mean Monthly Flows >2,000 cfs and Mean Monthly Flows > 3,000 cfs

Description – The Lake Okeechobee WSE Regulation Schedule is applied to regulate (flood control) discharges to the St. Lucie River, and subsequently to the St. Lucie Estuary, when lake stages are high. The St. Lucie River has primary capacity for local inflows and is only utilized for St. Lucie Estuary discharges when there is secondary capacity available. The number of times that the St. Lucie Estuary high discharge criterion is exceeded must be limited to prevent destructive impacts on the estuary.

Rationale – Researchers have observed an increased rate of eutrophication in Lake Okeechobee from 1973 to the present. Symptoms of this eutrophication include the following:

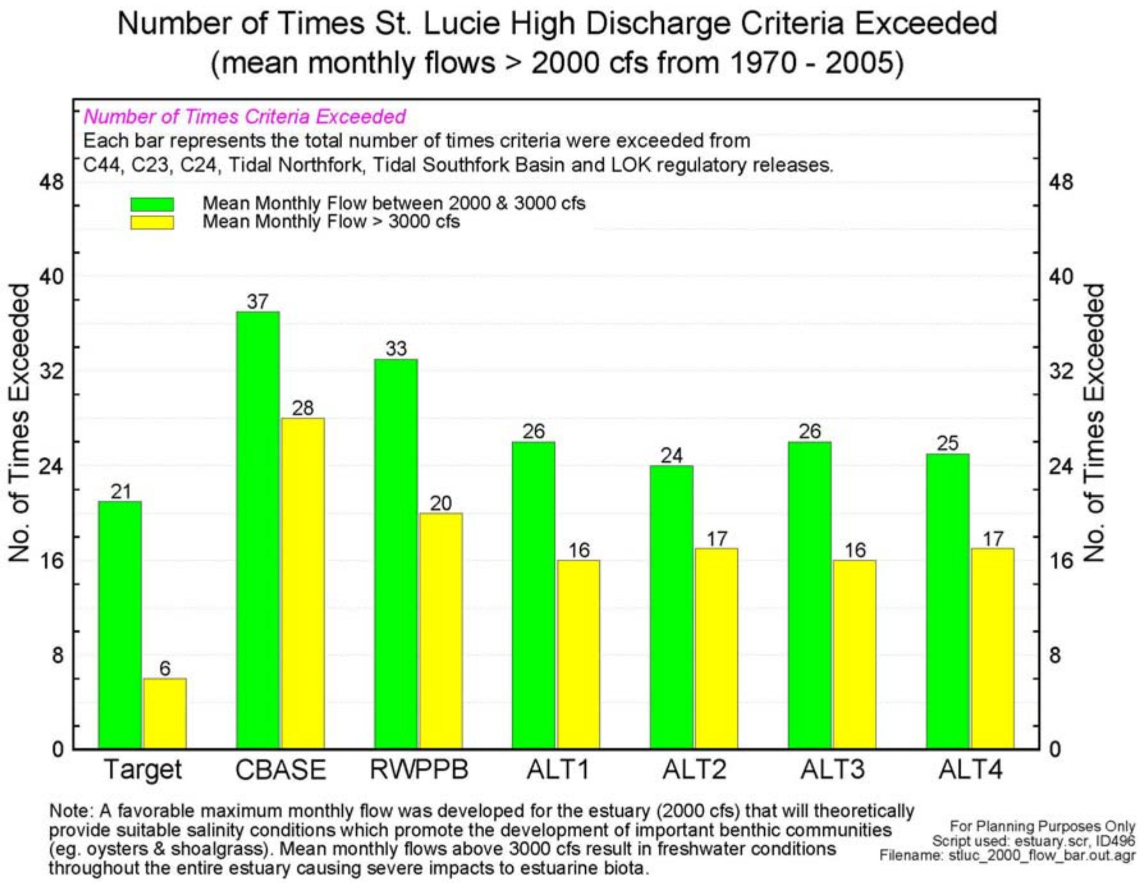
- increases in algal bloom frequency since the mid-1980s (with an algal bloom being defined as chlorophyll-*a* concentrations greater than 40 µg/L) (Maceina 1993, Carrick et al. 1994, Havens et al. 1995b),
- increases in the dominance of blue-green algae following a shift in the TN:TP ratio (Smith et al. 1995),
- increases in the lake water concentration of total phosphorus,
- increases in average chlorophyll-*a* concentrations (Havens et al. 1995).

Phosphorus is considered to be the key nutrient contributing to the eutrophication of the lake (Federico et al. 1981). Increases in total phosphorus concentrations in the lake, coupled with decreases in nitrogen loading from reduced back pumping from the EAA, have shifted the TN:TP ratio from greater than 25:1 in the 1970s to around 15:1 in the 1990s. This shift has created conditions more favorable for the proliferation of nitrogen-fixing blue-green algae, which are responsible for the blooms occurring in the lake (Smith et al. 1995).

Target – 21 or fewer occurrences of mean monthly flows between 2,000 and 3,000 cfs and no more than 6 occurrences of mean monthly flows over 3000 cfs from the St. Lucie River Watershed for the model simulated 36 years (1970 – 2005) or 432 months.

Evaluation Method – The Northern Everglades Regional Simulation Model (NERSM) will be employed for all evaluations. The evaluation will be based on the period of record from 1970 through 2005. The number of average monthly flows between 2,000 cfs and 3,000 cfs will be tallied for each alternative.

This graphic illustrates the number of times the model indicated that the high discharge criteria to the St. Lucie Estuary were exceeded for the CBASE, RWPPB, and each alternative. The base conditions (CBASE and RWPPB) and Alternatives (1 through 4) were each modeled over a 36-year period of record (432 months). The left bars represent a tally of the mean monthly flows between 2,000 and 3,000 cfs and the right bars represent a tally of the mean monthly flows greater than 3,000 cfs.



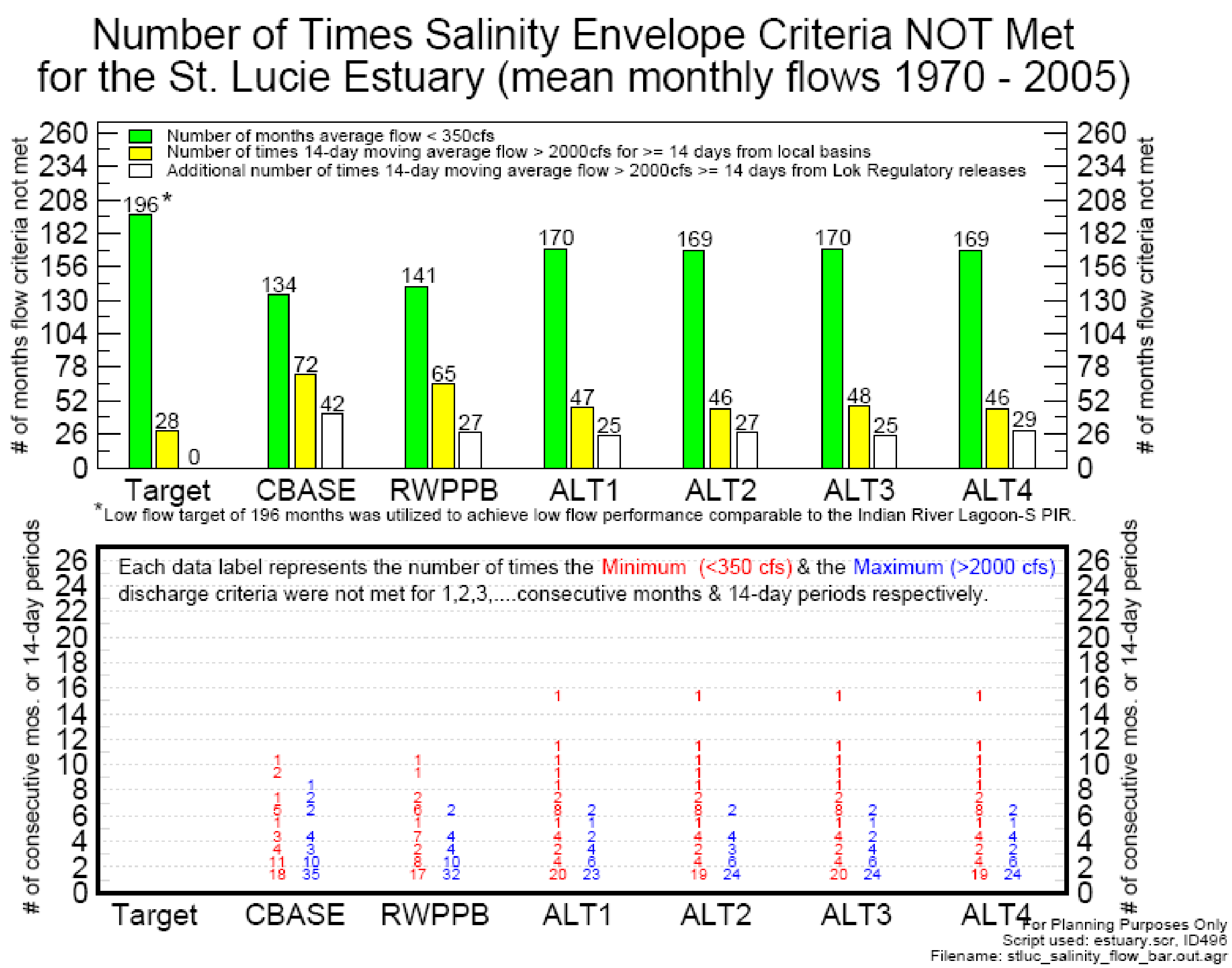
St. Lucie Estuary Salinity Envelope

Performance Measure: Number of Times Salinity Criteria Not Met for the St. Lucie Estuary – Mean Monthly Flows < 350 cfs and Mean Monthly Flows > 2,000 cfs
Description – A healthy, naturally-diverse and well-balanced estuarine ecosystem can exist only if the salinity regimes are controlled within the desirable range. Lake Okeechobee discharges have a significant impact on how well desirable salinity regimes are maintained in the St. Lucie Estuary.
Rationale – Extreme low lake stages prevent water from reaching the submerged aquatic vegetation populating the littoral zone and shoreline regions. Without submerged aquatic vegetation, the habitats of wading birds, reptiles, fish, amphibians, and apple snails are endangered as these species rely on submerged aquatic plants for foraging and recruitment activities. Invasive plant species, such as torpedo grass and Melaleuca, flourish in times of extreme low lake stage, replacing the original native vegetation. There is no proven method to control torpedo grass, except the use of a general herbicide that kills all surrounding area vegetation. Torpedo grass is poor habitat for fish and other aquatic animals as the growth is so dense there is no room for animal mobility. Nighttime dissolved oxygen levels in the grass have been recorded at zero, a condition that is not suitable for aquatic life. Recovery from the adverse impacts of extreme low lake stage requires multiple years, including the grueling process of re-establishing a healthy submerged aquatic plant community.
Target – Limit mean monthly flows below 350 cfs for 31 months or less over a 432-month period (salinity envelope low flow criterion), and limit the number of times flows from the St. Lucie River Watershed exceed 2,000 cfs for 14 days or more to 28, based on a 14-day moving average (salinity envelope high flow criterion). Because the NERSM model only accounts for surface water flows, an operational target of 196 months was used to achieve the low-flow performance comparable with the IRL-S PIR, not the ecological target of 31. Low flows are not a significant issue for the St. Lucie Estuary because the low-flow target is typically achieved through groundwater flows. It is more beneficial for the low-flow criterion to be met by groundwater flows instead of watershed runoff. The groundwater flow within the St. Lucie River Watershed provides a constant base flow to the St. Lucie Estuary and any supplemental flows needed from surface water sources to address low-flow conditions are ideally provided from the North Fork of the St. Lucie River.
Evaluation Method – The Northern Everglades Regional Simulation Model (NERSM) will be employed for all evaluations. The evaluation will be based on the period of record from 1970 through 2005. The number of mean monthly flows outside of the desirable range from 350 cfs to 2,000 cfs will be tallied for each alternative.

The performance of the base conditions and the four alternatives compared to the salinity envelope target are provided in the following graphic. Lake Okeechobee flows were not used to meet the salinity envelope low flow criteria (350 cfs); therefore, the left bars only represent flows from the St. Lucie River Watershed.

Because the NERSM model only accounts for surface water flows, an operational target of 196 months was used to achieve the low-flow performance comparable with the IRL-S PIR, not the ecological target of 31. Low flows are not a significant issue for the St. Lucie Estuary because the low-flow target is typically achieved through groundwater flows. It is more beneficial for the low-flow criterion to be met by groundwater flows instead of watershed runoff. The groundwater flow within the St. Lucie River Watershed provides a constant base flow to the St. Lucie Estuary and any supplemental flows needed from surface water sources to address low-flow conditions are ideally provided from the North Fork of the St. Lucie River.

From the St. Lucie River Watershed, the high-flow criterion was reduced by 7 occurrences with the RWPPB Condition compared to the CBASE Condition. From Lake Okeechobee regulatory releases, the high-flow criterion was reduced by 15 occurrences with the RWPPB Condition compared to the CBASE Condition. Both the high-flow criterion and the low-flow criterion improved with the alternatives. Exceedances of the high-flow criterion were reduced by 24 to 26 compared to the CBASE Condition and by 17 to 19 compared to the RWPPB Condition. However, the high flow target of 28 is exceeded with the four alternatives by 18 to 20 occurrences.



Lake Okeechobee Performance Measures

Total Surface Phosphorus Loading to Lake Okeechobee

Performance Measure: Total surface phosphorus loading to Lake Okeechobee

Description – This performance measure addresses the total surface phosphorus inflow to Lake Okeechobee on an average annual basis. FDEP (2001) has established a total maximum daily load (TMDL) for phosphorus loading to Lake Okeechobee as 140 mt/yr. Attainment of the TMDL will be calculated using a 5-year rolling average based on monthly loads calculated from measured flows and phosphorus concentrations. This includes 35 mt/yr phosphorus loading from atmospheric deposition.

Rationale – Researchers have observed an increased rate of eutrophication in Lake Okeechobee from 1973 to the present. Symptoms of this eutrophication include the following:

- increases in algal bloom frequency since the mid-1980s (with an algal bloom being defined as chlorophyll-*a* concentrations greater than 40 µg/L) (Maceina 1993, Carrick et al. 1994, Havens et al. 1995b),
- increases in the dominance of blue-green algae following a shift in the TN:TP ratio (Smith et al. 1995),
- increases in the lake water concentration of total phosphorus,
- increases in average chlorophyll-*a* concentrations (Havens et al. 1995).

Phosphorus is considered to be the key nutrient contributing to the eutrophication of the lake (Federico et al. 1981). Increases in total phosphorus concentrations in the lake, coupled with decreases in nitrogen loading from reduced back pumping from the EAA, have shifted the TN:TP ratio from greater than 25:1 in the 1970s to around 15:1 in the 1990s. This shift has created conditions more favorable for the proliferation of nitrogen-fixing blue-green algae, which are responsible for the blooms occurring in the lake (Smith et al. 1995).

Target – Maintain average annual surface phosphorus loading to Lake Okeechobee no greater than 105 mt/yr.

Evaluation Method – A spreadsheet model has been developed and applied during the development of the Lake Okeechobee Protection Plan in 2004 and the 2007 update. This spreadsheet accounts for all phosphorus reduction measures that have been implemented and calculates the remaining load reduction required to meet the TMDL. The spreadsheet has been updated to include the 2000 through 2005 period of record.

The water quality measures contained in each alternative will be added to the spreadsheet to evaluate to what extent the phosphorus reduction goal has been achieved.

Lake Okeechobee Extreme Low Lake Stage

Performance Measure: Lake Okeechobee Extreme Low Lake Stage

Description – Ideally, lake stages fluctuate within a determined envelope based on an annual hydrograph. Research (Havens 2002) has confirmed that lake stages should ideally vary seasonally between 12.5 ft, NGVD (June-July low) and 15.5 ft, NGVD (November-January high). Extreme low lake stages fall below this envelope, with lake stage below 10 ft, resulting in negative impacts on the living communities in the littoral zone, the shoreline fringing bulrush zone, and all of the lake areas that support valuable submerged aquatic vegetation.

Rationale – Extreme low lake stages prevent water from reaching the submerged aquatic vegetation populating the littoral zone and shoreline regions. Without submerged aquatic vegetation, the habitats of wading birds, reptiles, fish, amphibians, and apple snails are endangered as these species rely on submerged aquatic plants for foraging and recruitment activities.

Invasive plant species, such as torpedo grass and Melaleuca, flourish in times of extreme low lake stage, replacing the original native vegetation. There is no proven method to control torpedo grass, except the use of a general herbicide that kills all surrounding area vegetation. Torpedo grass is poor habitat for fish and other aquatic animals as the growth is so dense there is no room for animal mobility. Nighttime dissolved oxygen levels in the grass have been recorded at zero, a condition that is not suitable for aquatic life.

Recovery from the adverse impacts of extreme low lake stage requires multiple years, including the grueling process of re-establishing a healthy submerged aquatic plant community.

Target – For extreme low lake stage, below 10 ft, the target is zero weeks.

Evaluation Method – The Regional Simulation Model (RSM) will be employed for all evaluations. The evaluation will be based on the period of record from 1970 through 2005.

In the case of extreme low lake stage, the maximum value of the raw score is 52 weeks / year x 36 years = 1,872 weeks. Based on observations of the impacts of only 15 weeks of extreme low lake stage during a drought in 2001, this value can be assigned as the worst-case scenario, as it requires multiple years for full recovery. An extensive loss of apple snails and woody vegetation in shoreline areas was documented. The duration for < 10 ft stage (15 weeks / year = 540 weeks in a 36 year model run) can be set as the point equivalent to a score of 0 on the standardized scale. To convert from a raw score to a standardized score, the following regression equation is applied:

$$\text{Standardized score} = \text{raw score} * -0.185 + 100$$

A linear increase in risk of ecological damage is assumed between the optimal conditions (0 weeks) and the most severe condition (540 weeks). This method is the most conservative approach to take until more data is acquired to support a more complex relationship. Thus, the equation will need to be re-calculated if the model period is extended beyond 36 years.

Lake Okeechobee Extreme High Lake Stage

Performance Measure: Lake Okeechobee Extreme High Lake Stage
Description – Lake stages commonly fluctuate in response to a combination of seasonal, annual, and inter-annual variations in climatic conditions and water management operations. Published research (Havens 2002) states that lake stages should vary seasonally between 12.5 ft (National Geodetic Vertical Datum - NGVD, June-July low) and 15.5 ft (November-January high). Extreme high lake stage refers to a stage level above 17 ft, NGVD creating a dangerous condition prone to high waves, uplifted suspended solids, and unconsolidated mud deposition.
Rationale – Extreme high lake stages allow strong, wind-driven waves to impact the littoral emergent plant and shoreline submerged plant communities. Uprooting of submerged and shoreline plants can occur, compromising the habitats of fish, apple snails, amphibians, reptiles, and wading birds. These species all rely on a healthy population of submerged vegetation for areas of foraging and recruitment. Submerged aquatic vegetation is also at risk from the uplifting of thick suspended solids to the littoral zone from the mid-lake region where they usually settle. The suspended solids in the littoral zone reduce water quality and decrease light penetration needed for submerged aquatic vegetation to flourish (James and Havens 2005). The transfer of nutrient-rich suspended solids into the littoral zone can also affect the periphyton biomass and taxonomic structure as a result of high stage events. Cattail is known to thrive in times of extreme high lake stage, compromising plant diversity by encouraging the dominance of one specie. Finally, the deposition of unconsolidated mud over the natural peat and sand sediment at the bottom of the lake creates a shift in the balance of a healthy vegetative system. In general, extreme high lake stages result in reductions of submerged aquatic plants, prevention of germination of submerged plants, reductions in fish spawning, cattail plant dominance, compromised periphyton biomass, and an endangered habitat of amphibians, reptiles, apple snails, and wading birds.
Target – Extreme high lake stage target is zero weeks with lake stages above 17 ft, NGVD.
Evaluation Method – The Regional Simulation Model (RSM) will be employed for all evaluations. The evaluation will be based on the period of record from 1970 through 2005. For extreme high lake stage (above 17 ft NGVD), the response algorithm relates the raw scores for each component of the performance measure to a standardized scale of 0 to 100. The maximum value for the raw score is 52 weeks / year x 36 years = 1,872 weeks. It is believed that maximum impacts occur at a low frequency. In 1998 and 1999, almost 100% of the lake's submerged aquatic vegetation community and over 100 m of littoral emergent vegetation were uprooted when the lake stage was extreme high for only 16 and 7 weeks, respectively. These recordings were the most severe cases of extreme high lake stage damage in 30 years. Therefore, the duration for > 17 ft stage is set as the point equivalent to a score of 0 on the standardized scale. To convert from a raw score to a standardized score, the following regression equation is applied: Standardized score = raw score * -0.253 + 100 A linear increase in risk of ecological damage is assumed between the optimal conditions (0 weeks) and the most severe condition (396 weeks). This approach is the most conservative method to follow until data is acquired to support a more complex relationship. If the model period is extended beyond 36 years, the equation must be re-calculated. For each component of this performance measure, results for planning alternatives can be displayed as simple bar graphs. The height of the bars corresponds to standardized scores for this performance measure.

Lake Okeechobee Stage Envelope – Score Below Envelope

Performance Measure: Lake Okeechobee Stage Envelope – Score Below Envelope

Description – Lake stages fluctuate in response to a combination of seasonal, annual, and inter-annual climatic conditions and operational practices. Research (Havens 2002) has confirmed that lakes stage should ideally vary seasonally between 12.5 ft, NGVD (June-July low) and 15.5 ft, NGVD (November-January high). A healthy variation of lake stages result in annual flooding and drying of the littoral zone, promoting development of diverse plant and animal communities. Decreasing water levels toward the end of winter and spring allow wading birds to easily prey on resources in the littoral zone. However, if the lake stage falls below the envelope too frequently, the littoral zone is threatened.

Rationale – The littoral zone and shoreline areas of Lake Okeechobee support submerged plant life. If the lake stage is frequently below the envelope, the vegetation does not receive the water it requires to flourish. Without submerged aquatic vegetation, the habitats of wading birds, reptiles, fish, amphibians, and apple snails are endangered. These species rely on a surplus of aquatic plants for foraging and recruitment activities.

When the lake stage falls below the envelope, it creates optimal conditions for invasive plant species, such as torpedo grass and Melaleuca, to replace the original native vegetation. There is no proven method to control torpedo grass, except the use of a general herbicide that kills all surrounding area vegetation. Torpedo grass is poor habitat for fish and other aquatic animals as the growth is so dense there is no room for animal mobility. Nighttime dissolved oxygen levels in the grass have been recorded at zero, a condition that is not suitable for aquatic life.

When the lake stage falls below 12.56 ft, NGVD, navigation of the Okeechobee Waterway becomes impaired. At levels below 11 ft, NGVD, access to the lake for fishermen and recreational boaters becomes limited to channels and boat trails. It should be noted that the Lake Okeechobee commercial and recreational fishery is valued at over $480 million dollars (Furse and Fox 1994)

Lake stages below the envelope are beneficial in moderate occurrences. Periodic exposure of seed banks helps control plant dominance and can provide nutrition to animal communities. Low lake stage also exposes the littoral zone to oxidation of the organic material that accumulates over time, creating a healthy and clean system. Fires can arise in times of low lake stage, which - in moderation - can prevent plant dominance such as cattail. A decrease in lake level during spring time helps to concentrate prey resources and promote wading bird nesting on the lake.

Target – For deviations of lake stages below the envelope, the target is established at 192 ft weeks. This score allows for the optimal range of both dry and flooded periods to encourage a thriving and diverse community.

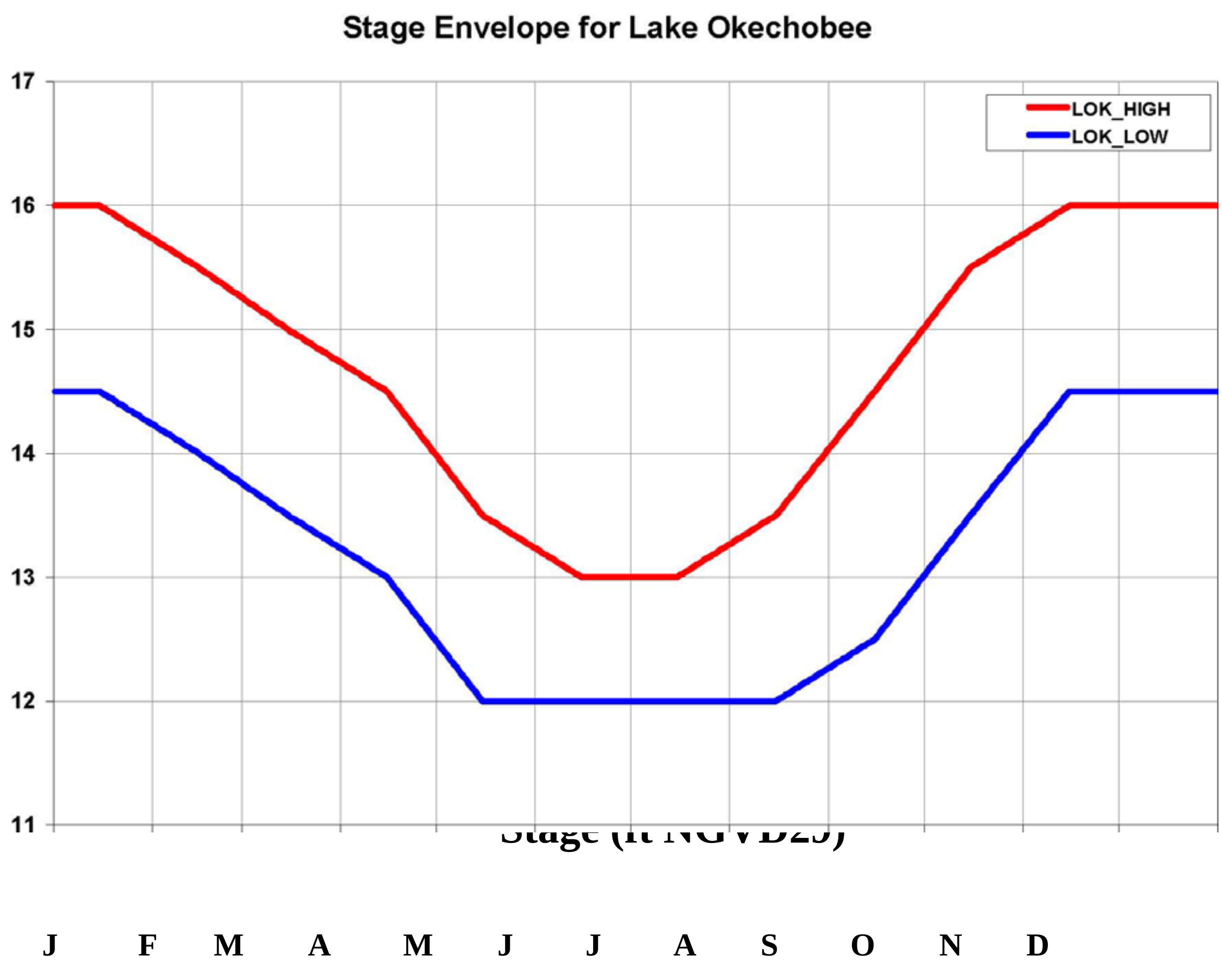
Evaluation Method – The Regional Simulation Model (RSM) will be employed for all evaluations. The evaluations will be based on simulation of the period from 1970 through 2005. For each week of the model simulation, the absolute value of the deviation (ft) of lake stage from the envelope is determined. The number of weeks below the envelope is tallied and the response curve is developed from the performance measure graphic. Zero values represent favorable conditions, the adjacent bands of 0.5 ft represent fair conditions, and the subsequent (1.0 ft) band represent poor conditions. The worst case scenario occurs when the hydrograph remains constantly in the poor zone (1,872 ft weeks). Therefore, the response curve is a line between the target (192 ft weeks) and the worst case scenario (1,872 ft weeks). Raw scores are calculated from the following equation:

$$\text{Standardized score (\%)} = \text{raw score} * -0.0595 + 111.429$$

Except where the score falls below 192, the score remains at 100%. For each component of this performance measure, results for planning alternatives can be displayed as simple bar graphs. The height of the bars corresponds to standardized scores for this performance measure.

Lake Okeechobee Stage Envelope

This graphic illustrates how the evaluation is performed for the lake stage envelope, where the vertical axis is stage in ft, NGVD and the horizontal axis is in months of the year. The shaded central area is the stage envelope. In this example, hydrograph A has a score of 86 ft-weeks for stages above the envelope and a score of 0 for stages below the envelope. Hydrograph B has a score of 22 ft-weeks for stages above the envelope and a score of 0 for stages below the envelope. Hydrograph C has a score of 0 for stages above the envelope and a score of 110 ft-weeks for stages below the envelope. Actual scoring is based on a smooth envelope boundary.



Lake Okeechobee Stage Envelope – Score Above Envelope

Performance Measure: Lake Okeechobee Stage Envelope – Score Above Envelope

Description – Lake stages fluctuate in response to a combination of seasonal, annual, and inter-annual climatic conditions and operational practices. Research (Havens 2002) has confirmed that lakes stage should ideally vary seasonally between 12.5 ft, NGVD (June-July low) and 15.5 ft, NGVD (November-January high). A healthy variation of lake stages result in annual flooding and drying of the littoral zone, promoting development of diverse plant and animal communities. However, lake stage deviations above the envelope result in over flooding, which is destructive to the littoral zone, including aquatic vegetation and specie habitat.

Rationale – Lake stages above the envelope produce an excess of water creating wind-driven waves that impact the littoral emergent plant and shoreline submerged plant communities. Uprooting of submerged and shoreline plants can occur, compromising the habitats of fish, apple snails, amphibians, reptiles, and wading birds. These species all rely on a healthy population of submerged vegetation for areas of foraging and recruitment.

Submerged aquatic vegetation is also at risk from the uplifting of thick suspended solids to the littoral zone from the mid-lake region where they usually settle. The suspended solids in the littoral zone reduce water quality and decrease light penetration needed for submerged aquatic vegetation to flourish (James and Havens 2005). Without a population of healthy submerged aquatic vegetation, the sediment cannot be stabilized and specie habitat is endangered.

The transfer of these nutrient-rich suspended solids into the littoral zone can also affect the periphyton biomass and taxonomic structure. Cattail is known to thrive in times of high lake stage, compromising plant diversity by encouraging the dominance of one species.

Finally, the deposition of unconsolidated mud over the natural peat and sand sediment at the bottom of the lake creates a shift in the balance of a healthy vegetative system. In general, high lake stage results in a reduction of submerged aquatic plants, prevention of germination of submerged plants, reductions in fish spawning, cattail plant dominance, compromised periphyton biomass, and an endangered habitat of amphibians, reptiles, apple snails, and wading birds.

Target – The target is zero weeks for deviation of lake stage above the envelope.

Evaluation Method – The Regional Simulation Model (RSM) will be employed for all evaluations. The evaluation is based on simulations for the period from 1970 through 2005. For each week of the model simulation, the absolute value of the deviation (ft) of lake stage from the envelope is determined. Zero values represent favorable conditions, the adjacent bands of 0.5 ft represent fair conditions, and the subsequent 1.0 ft band represents poor conditions.

The worst-case scenario is one in which the lake stage hydrograph is always in the poor zone. This situation equates to a total score of 1.0 ft x 52 weeks / year * 36 years 1,872 ft weeks. The response curve is a line between the target (0 weeks) and the worst-case scenario (1,872 ft weeks). Raw scores can be calculated from the following equation:

Standardized score (%) = raw score * -0.0534 + 100

For each component of this performance measure, results for planning alternatives can be displayed as simple bar graphs. The height of the bars corresponds to standardized scores for this performance measure.

Number of Times Proposed Minimum Water Level and Duration – Criteria Exceeded

Performance Measure: Number of Times Proposed Minimum Water Level & Duration – Criteria Exceeded
Description – To determine the MFL for Lake Okeechobee, the following water resource functions were considered: provide water that can be used to maintain water levels in coastal canals, meet human needs, and protect the Biscayne aquifer against saltwater intrusion; and supply water and provide water storage for the Everglades. The lake is a regionally important ecosystem that provides fish and wildlife habitat, supports commercial and sport fisheries, and maintains navigation and recreational use. Water supply to the Biscayne aquifer, Caloosahatchee River, St. Lucie Canal, the Seminole Indian Tribe, and the Everglades Agricultural Area were important considerations in the establishment of an MFL for Lake Okeechobee. Relationships were considered in defining significant harm (a loss of specific water resource functions resulting from a change in surface or groundwater hydrology) and the proposed MFL was determined.
Rationale – Lake Okeechobee is a critical source of freshwater to maintain coastal groundwater levels, preventing saltwater intrusion of the Biscayne aquifer. During dry periods, freshwater is discharged from the lake, helping to maintain a freshwater head within the coastal groundwater aquifer, which prevents inland movement of the saltwater front. Records show that when lake levels fall below 11 ft NGVD, the levels continue to decline rapidly, threatening the ability for the SFWMD to deliver water to coastal canals as a result of the physical limitations of the lake's outlet structures. During dry periods, the Everglades have been found to not be receiving sufficient water amounts to maintain viable aquatic ecosystems and to protect vegetation and wildlife from the threat of fires. The SFWMD Best Management Practice Make-Up Water Rule, Part II of Chapter 40E-63, F.A.C quantifies the necessary amount of water to ensure a healthful Everglades system. The established MFL must support the littoral zone and the following fish and wildlife values: a commercial and recreational fishery valued at over $480 million dollars; a rich avifauna community that includes wading birds, migratory waterfowl, and federally-designated endangered snail kite and wood stork; and ecotourism and recreation, including fishing, hunting, and bird and wildlife observation. When the lake stage falls below 12.56 ft NGVD, navigation of the Okeechobee Waterway becomes impaired. At levels below 11 ft NGVD, access to the lake for fishermen and recreational boaters becomes limited to channels and boat trails. However, when the lake stage reaches an extreme low condition, recreational access to the lake becomes significantly restricted, as much of the littoral zone is exposed as dry land. It is important to consider the dependency of the Everglades Agricultural Area, the Seminole Indian Tribe, and the Caloosahatchee and St. Lucie basins on freshwater flow from Lake Okeechobee. During drought conditions, agricultural water needs in these basins are determined based on weather, soil, and crop conditions.
Target – The lake level should not fall below 11 ft, NGVD for more than 80 days duration more often than once every six years.
Evaluation Method – The Regional Simulation Model (RSM) will be employed for all evaluations. The evaluation will be based on the period of record from 1970 through 2005 The number of years when Lake Okeechobee stages fall below 11 ft, NGVD for 80 days or more will be counted.

Lake Okeechobee Performance Indicators

Water Year (Oct-Sep) LOSA Demand Cutback Volumes

Performance Indicator: Water Year (Oct-Sep) LOSA Demand Cutback Volumes
Description – Lake Okeechobee is the primary source of supplemental irrigation for four major adjacent agricultural basins: North Shore, Caloosahatchee, St. Lucie and EAA. Collectively, these basins are referred to as the Lake Okeechobee Service Area (LOSA). During the dry season, when precipitation is low, local sources of irrigation become scarce and the need for supplemental irrigation becomes necessary. With the current absence of substantial off-site storage, Lake Okeechobee is presently the only source of supplemental irrigation for these basins. Average annual supplemental irrigation requirement from Lake Okeechobee amounts to about half a million acre-ft.
Rationale – Water levels in Lake Okeechobee are compared to a seasonally fluctuating Supply Side Management Zone in the WSE Regulation Schedule. If water levels fall into the Supply Side Management Zone, projections of rainfall, ET, and water supply demands are made for the remainder of the dry season and water supply cutbacks are applied as appropriate. During seven years of the 1970 to 2005 period of record, substantial water restrictions were imposed on the LOSA. These restrictions were implemented to protect the region's water resources on a long-term basis. However, the water supply demands that were not met during these drought periods resulted in significant economic impacts to the water users.
Target – Minimize the water supply cutback volumes during the seven years of the period of record with the largest cutbacks.
Evaluation Method - The Regional Simulation Model (RSM) will be employed for all evaluations. The evaluation will be based on the period of record from 1970 through 2005. The volume of water supply demand that is not met will be tallied for each of the seven years that caused the largest unmet demands.

Mean Annual EAA/LOSA Supplemental Irrigation Demands Not Met

Performance Indicator: Mean Annual EAA/LOSA Supplemental Irrigation Demands Not Met
Description – Lake Okeechobee is the primary source of supplemental irrigation for four major adjacent agricultural basins: North Shore, Caloosahatchee, St. Lucie and Everglades Agricultural Areas. Collectively, these basins are referred to as the Lake Okeechobee Service Area (LOSA).
Rationale – During the dry season when precipitation is low, local sources of irrigation become scarce and the need for supplemental irrigation becomes absolutely necessary. With the current absence of substantial off-site storage, Lake Okeechobee is presently the only source of supplemental irrigation for these basins. Average annual supplemental irrigation requirement from Lake Okeechobee amounts to about half a million acre-ft (SFWMD, 2000a). Lake Okeechobee also provides urban water supply to the Lower East Coast and to several municipalities surrounding the lake. Additionally, the Seminole Tribe of Florida is entitled to water supply based on the Water Rights Compact (Pub. L. No. 100-228, 101 Stat. 1556, and Chapter 87-292, Laws of Florida, and codified in Section 285.165, F.S.
Target – Minimize the percentage of water supply demands that are not met in the EAA and LOSA.
Evaluation Method – The Regional Simulation Model (RSM) will be employed for all evaluations. The evaluation will be based on the period of record from 1970 through 2005. The percentages of demands not met will be tallied for the EAA and LOSA.

Caloosahatchee River and Estuary Performance Measures

Number of Times Caloosahatchee Estuary High Discharge Criteria Exceeded

Performance Measure: Number of Times Caloosahatchee Estuary High Discharge Criteria Exceeded – Mean Monthly Flows >2,800 cfs and Mean Monthly Flows > 4,500 cfs

Description – The Lake Okeechobee WSE Regulation Schedule is applied to regulate (flood control) discharges to the Caloosahatchee River, and subsequently to the Caloosahatchee Estuary, when lake stages are high. The Caloosahatchee River has primary capacity for local inflows and is only utilized for CRE discharges when there is secondary capacity available. The number of times that the Caloosahatchee Estuary high discharge criterion is exceeded must be limited to prevent destructive impacts on the estuary.

Rationale – Researchers have observed an increased rate of eutrophication in Lake Okeechobee from 1973 to the present. Symptoms of this eutrophication include the following:

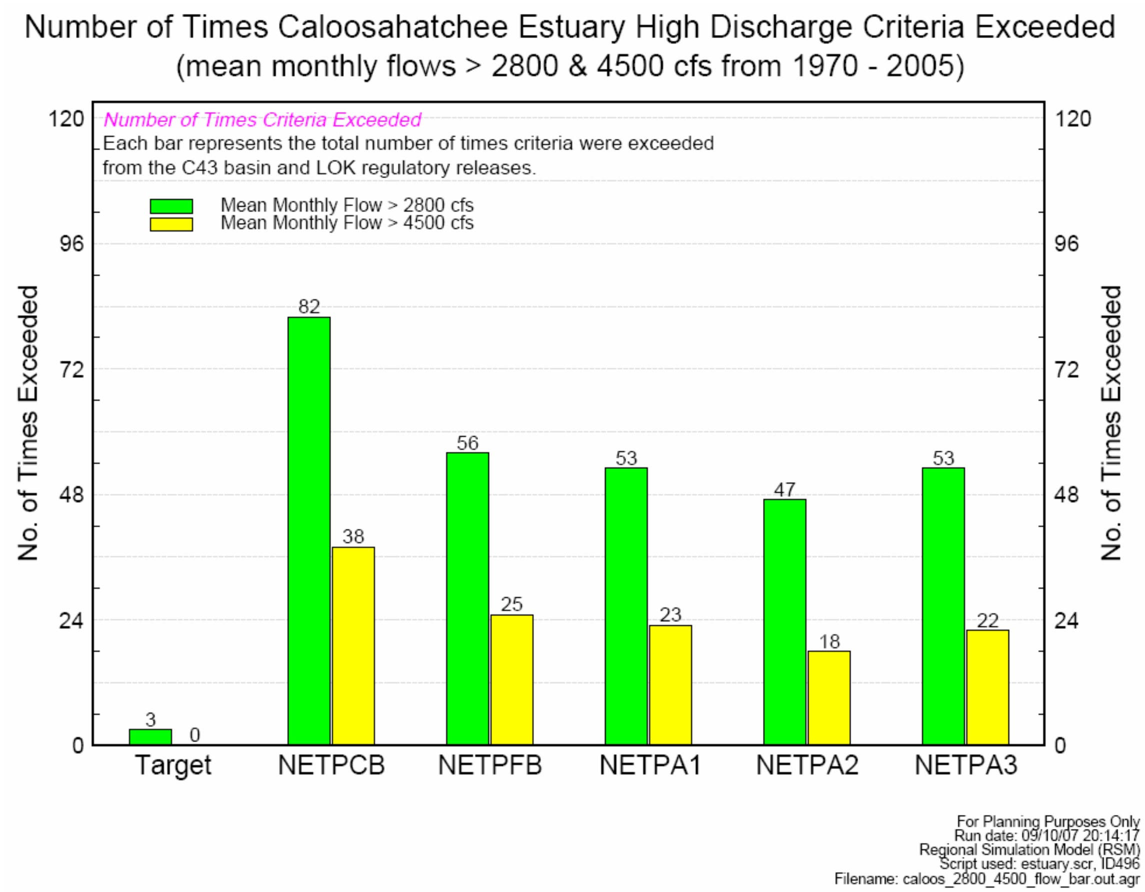
- increases in algal bloom frequency since the mid-1980s (with an algal bloom being defined as chlorophyll a concentrations greater than 40 μg/L) (Maceina 1993, Carrick et al. 1994, Havens et al. 1995b),
- increases in the dominance of blue-green algae following a shift in the TN:TP ratio (Smith et al. 1995),
- increases in the lake water concentration of total phosphorus,
- increases in average chlorophyll a concentrations (Havens et al. 1995).

Phosphorus is considered to be the key nutrient contributing to the eutrophication of the lake (Federico et al. 1981). Increases in total phosphorus concentrations in the lake, coupled with decreases in nitrogen loading from reduced back pumping from the EAA, have shifted the TN:TP ratio from greater than 25:1 in the 1970s to around 15:1 in the 1990s. This shift has created conditions more favorable for the proliferation of nitrogen-fixing blue-green algae, which are responsible for the blooms occurring in the lake (Smith et al. 1995).

Target – No more than 3 events with mean monthly flows at S-79 greater than 2,800 cfs and no events with mean monthly flows greater than 4,500 cfs.

Evaluation Method – The Northern Everglades Regional Simulation Model (NERSM) will be employed for all evaluations. The evaluation will be based on the period of record from 1970 through 2005. The number of average monthly S-79 flows between 2,800 cfs and 4,500 cfs will be tallied for each alternative.

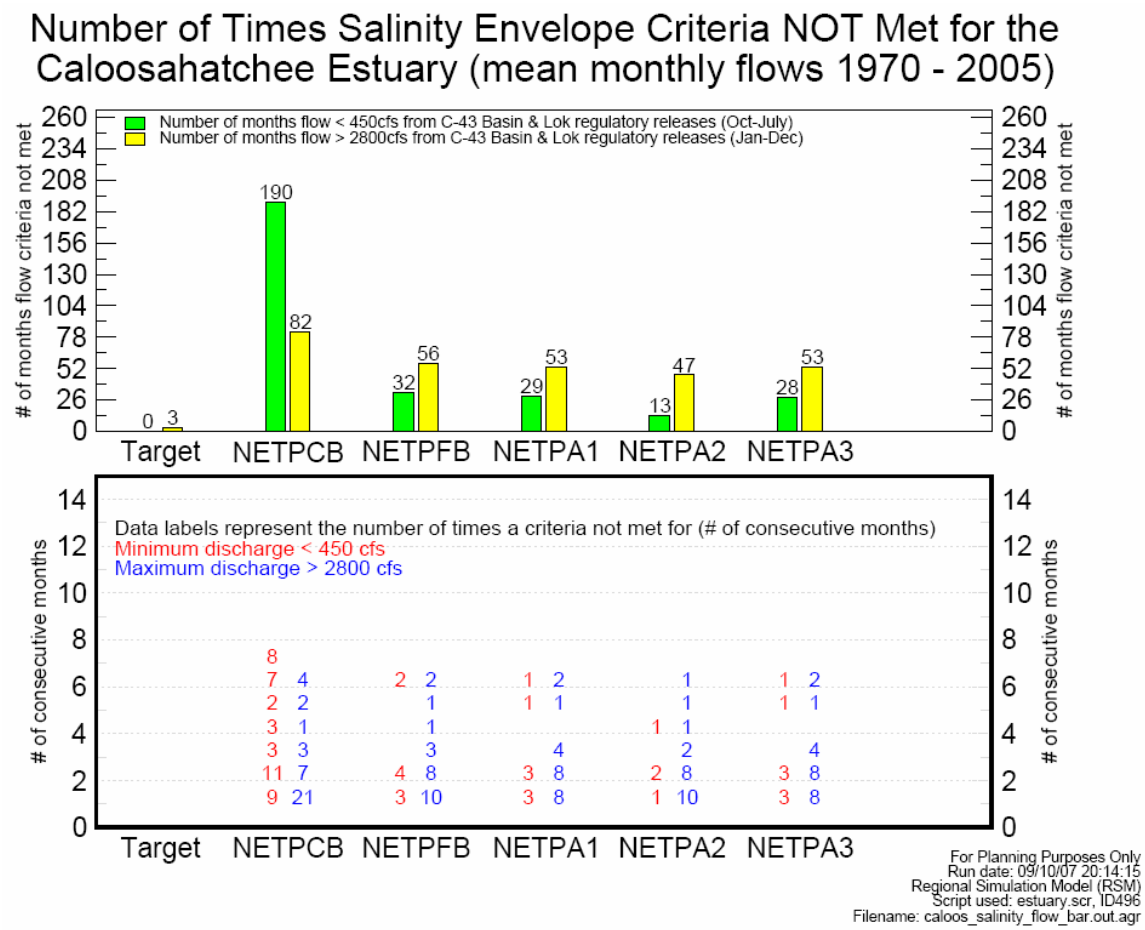
This graphic illustrates the number of times discharge criteria were exceeded from 1970-2005. Each bar represents the total number of exceedances from the C43 basin and Lake Okeechobee regulatory releases.



Caloosahatchee Estuary Salinity Envelope

Performance Measure: Number of Times Salinity Criteria Not Met for the Caloosahatchee Estuary – Mean Monthly Flows < 450 cfs and Mean Monthly Flows > 2,800 cfs
Description – A healthy, naturally-diverse and well-balanced estuarine ecosystem can exist only if the salinity regimes are controlled within the desirable range. Lake Okeechobee discharges have a significant impact on how well desirable salinity regimes are maintained in the Caloosahatchee Estuary.
Rationale – Extreme low lake stages prevent water from reaching the submerged aquatic vegetation populating the littoral zone and shoreline regions. Without submerged aquatic vegetation, the habitats of wading birds, reptiles, fish, amphibians, and apple snails are endangered as these species rely on submerged aquatic plants for foraging and recruitment activities. Invasive plant species such as torpedo grass and Melaleuca flourish in times of extreme low lake stage, replacing the original native vegetation. There is no proven method to control torpedo grass, except the use of a general herbicide that kills all surrounding area vegetation. Torpedo grass is poor habitat for fish and other aquatic animals as the growth is so dense there is no room for animal mobility. Nighttime dissolved oxygen levels in the grass have been recorded at zero, a condition that is not suitable for aquatic life. Recovery from the adverse impacts of extreme low lake stage requires multiple years, including the grueling process of re-establishing a healthy submerged aquatic plant community.
Target – Maintain mean monthly flows at S-79 between 450 cfs and 2,800 cfs with no more than 3 events with mean monthly flows greater than 2,800 cfs.
Evaluation Method – The Northern Everglades Regional Simulation Model (NERSM) will be employed for all evaluations. The evaluation will be based on the period of record from 1970 through 2005. The number of mean monthly flows outside of the desirable range from 450 cfs to 2,800 cfs will be tallied for each alternative.

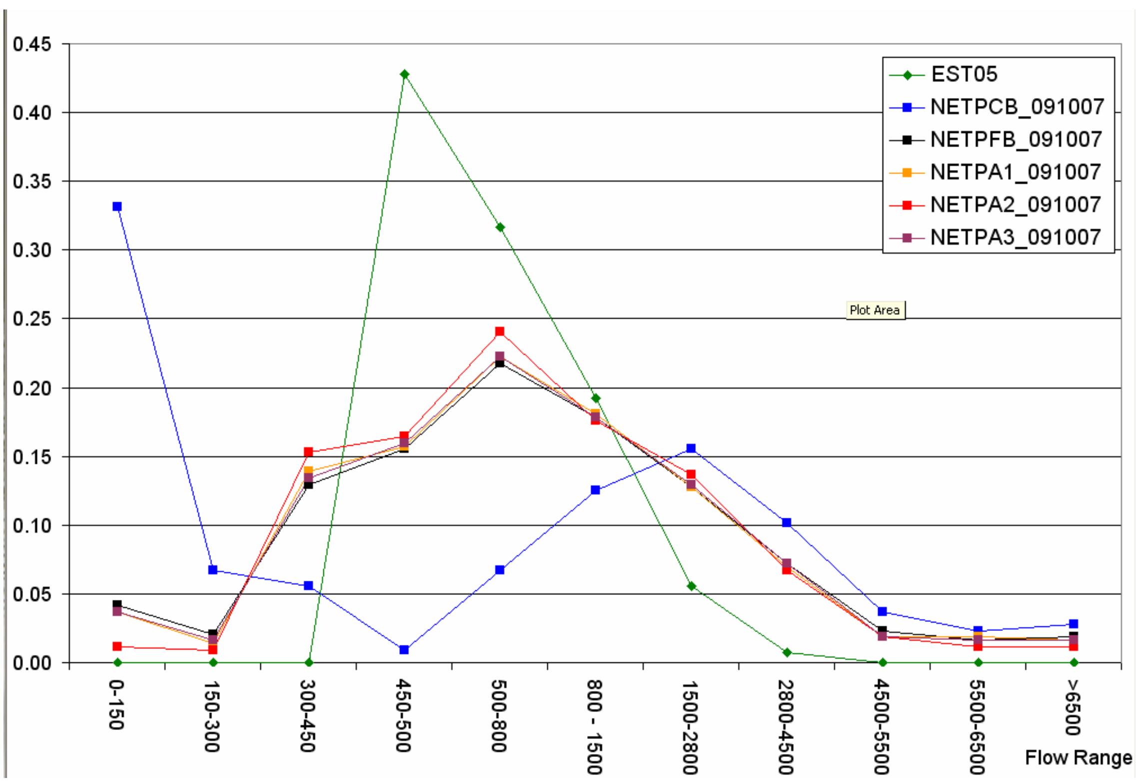
This graphic shows the number of times the modeled salinity envelope criterion was not met for the Caloosahatchee Estuary. Under the Current Base (CBASE) Condition, average flows of less than 450 cfs occurred in 189 of the 432 months and watershed flows exceeded 2,800 cfs for 80 months of the period record. Under the River Watershed Protection Plan Base (RWPPB) Condition, average flows of less than 450 cfs occurred in 12 of the 432 months and watershed flows exceeded 2,800 cfs for 55 times in the period of record.



Caloosahatchee Total Flow Index

Performance Measure: Total Flow Index
Description – Compares Alternative flow distribution to desired flow distribution
Rationale – to be determined
Target – Extreme high lake stage target is zero weeks with lake stages above 17 ft, NGVD.
Evaluation Method – The Northern Everglades Regional Simulation Model (NERSM) will be employed for all evaluations. The evaluation will be based on the period of record from 1970 through 2005.

In this graphic, the green line below represents the desired flow distribution target at S-79 which is referred to as EST-05. Alternative flow distributions are compared to the EST-05 target distribution and a score is calculated, which reflects degree of similarity between the two. A value of zero signifies a perfect match to EST-O5. The TFI progressively becomes negative as the flow deviates from the target.



APPENDIX B

MANAGEMENT MEASURE TOOL BOX

MM ID#	Page #	MM Title	MM Description	Level	Alternative			
					1	2	3	4
LO 1	B-1	Agricultural BMPs - Owner Implemented and Cost Share (Combined LO 1, 2, and 49)	Implementation of agricultural BMPs and water quality improvement projects to reduce the discharge of nutrients from the watershed.	1	√	√	√	√
LO 3	B-3	Urban Turf Fertilizer Rule (LOER)	Florida Department of Agriculture and Consumer Services (FDACS) rule, which regulates the content of phosphorus and nitrogen in urban turf fertilizers to improve water quality.	1	√	√	√	√
LO 4	B-5	Land Application of Residuals	Subsection 373.4595(4)(b)2.of the NEEPP requires that after December 31, 2007, the department may not authorize the disposal of domestic wastewater residuals within the St. Lucie River watershed unless the applicant can affirmatively demonstrate that the nutrients in the residuals will not add to nutrient loadings in the watershed.	1	√	√	√	√
LO 5	B-7	Florida Yards and Neighborhoods	Provides education about the land use and design to the citizens by promoting the Florida Yards & Neighborhood programs to minimize the pesticides, fertilizers, and irrigation water.	1	√	√	√	√
LO 7	B-9	Environmental Resource Permit (ERP) Program	The ERP program regulates activities in, on, or over wetlands or other surface waters and the management and storage of all surface waters. This includes activities in uplands that alter stormwater runoff as well as dredging and filling in wetlands and other surface waters. Generally, the program's purpose is to ensure that activities do not degrade water quality, compromise flood protection, or adversely affect the function of wetland systems. The program applies only to new activities only, or to modifications of existing activities, and requires an applicant to provide reasonable assurances that an activity will not cause adverse impacts to existing surface water storage and conveyance capabilities, and will not adversely affect the quality of receiving waters such that any applicable water quality standards will be violated.	1	√	√	√	√
LO 08	B-11	NPDES Stormwater Program	To reduce stormwater pollutant loads discharged to surface waters, especially from existing land uses and drainage systems. This is especially true for the master drainage systems owned and operated by cities, counties, FDOT, and Chapter 298 water control districts. This also can help to reduce stormwater pollutant loads from existing industrial sites and from new construction sites.	1	√	√	√	√
LO 09	B-13	Coastal and Estuarine Land Conservation Program	Protecting important coastal and estuarine areas that have significant conservation, recreation, ecological, historical, or aesthetic values, or that are threatened by conversion from their natural state or recreational status to other uses" (CELCP Final Guidelines, 2003).	1	√	√	√	√

MM ID#	Page #	MM Title	MM Description	Level	Alternative			
					1	2	3	4
LO 12f	B-15	AWS - Indiantown Citrus Growers Association	Rehabilitation and relocation of pump stations and detention of stormwater within the existing ditch system will result in 3,550 ac-ft of water storage on 1,775 acres of project area. The projects will promote water conservation and reduce the volume of surface water discharge to the St. Lucie River and Estuary.	1	√	√	√	√
LO 12j	B-17	AWS – DuPuis	The purpose of this project is to design, engineer, and implement an additional 1 foot of storage in the DuPuis Marsh before on-site stormwater enters the L-8 Canal. This project could potentially provide 2,500 ac-ft of water storage.	4	√	√	√	√
LO 12m	B-19	AWS - Waste Management St. Lucie Site	Plans are to enter into a partnership arrangement to change borrow areas into minor above ground impoundments. Preliminary hydrologic investigation is in process and water quality/quantity benefits have yet to be determined.	4	√	√	√	√
LO 12q	B-21	AWS - Caulkins	Project includes rehabilitation and relocation of internal pump stations. During regulatory releases to the St. Lucie Estuary, irrigation facilities will be utilized to draw excess stormwater into the 3,400-acre project site. The detention of stormwater within the existing ditch system will result in water quality improvements, thereby promoting water conservation and reducing the volume of surface water discharge from the site.	4	√	√	√	√
LO 12r	B-23	AWS – Private Agricultural Lands Adjacent to St. Lucie Canal	Utilize irrigation withdrawal facilities on St. Lucie Canal to remove excess stormwater from the canal and reduce freshwater to the estuary	4	-	-	-	-
LO 14	B-25	CERP – IRL S PIR: C-44 Reservoir / STA	The C44 Reservoir/ STA Project is located on approximately 12,000 acres of land owned by SFWMD. This project includes three components (Reservoir, West STA, and East STA) identified in the IRL-S PIR.	1	√	√	√	√
LO 15	B-27	St. Lucie River Watershed 40E-61 Rule Regulatory Nutrient Source Control Program	To implement a nutrient source control program utilizing BMPs for the St. Lucie River watershed. Ongoing activities include revising Chapter 40E-61, Florida Administrative Code to reflect the requirements of the Northern Everglades Protection Act and to expand the rule boundary to include the St. Lucie River watershed as defined by the Act.	2	√	√	√	√

MM ID#	Page #	MM Title	MM Description	Level	Alternative			
					1	2	3	4
LO 21	B-29	Proposed LO and Estuary Watersheds Basin Rule (LOER)	In March 2008, the South Florida Water Management District (SFWMD) initiated rule development for an ERP Basin Rule with supplemental criteria designed to result in no increase in total runoff volume from new development that ultimately discharges to Lake Okeechobee or the Caloosahatchee or St. Lucie Estuaries.	3	√	√	√	√
LO 38	B-31	C-44 Littoral	The creation of a littoral zone of native vegetation to "treat" for water entering the C-44 via the S308 can benefit Lake Okeechobee and the St Lucie Estuary. The project will maintain boat navigation through the lake.	5	-	-	-	-
LO 50	B-33	Agricultural BMPs - Additional Agricultural BMPs (Urban Rollup)	This is an advanced level of BMPs with chemical treatment, plus retention/detention pond to treat discharge from higher P loading land uses	5	-	-	-	-
LO 63	B-35	Wastewater and Stormwater Master Plans	Implement urban stormwater retrofitting projects or wastewater projects to achieve additional nutrient reductions and water storage basin-wide by working with entities responsible for wastewater and stormwater programs in the service area.	4	√	√	√	√
LO 64	B-37	Proposed Unified Statewide Stormwater Rule	Intended to increase the level of nutrient treatment of stormwater from new development and thereby reduce the discharge of nutrients and excess stormwater volume. Treatment rule will be based on a performance standard of post-development nutrient loading that does not exceed pre-development nutrient loading.	4	√	√	√	√
LO 65	B-39	L-65 Culvert to L-8 Tieback	Install a high volume (1000+/- cfs) inverted culvert under the C-44 Canal from the L-65 Canal to the L-8 Tieback Canal to facilitate the movement of low nutrient water from Stormwater Treatment Areas north of Lake Okeechobee to the L-8 Reservoir	5	-	-	-	-
LO 68	B-41	Comprehensive Planning-Land Development Regulations	Basin-wide work with state agencies, cities, and counties to review current plans and ensure promotion of low-impact design through coordinated comprehensive planning and growth management initiatives.	3	√	√	√	√

MM ID#	Page #	MM Title	MM Description	Level	Alternative			
					1	2	3	4
LO 87 Revised	B-43	Florida Ranchlands Environmental Services Project- Existing, Future, and Full Implementation	The Florida Ranchlands Environmental Services Project will design a program in which ranchers in the Northern Everglades' sell environmental services of water retention, nutrient load reduction, and wetland habitat expansion to agencies of the state and other willing buyers. A planning level estimate of the static water retention capacity of the eight projects is 8,260 ac-ft of water for a single storm event with the average ac-ft of storage per acre being 0.98 feet.	1	√	√	√	√
SLE 02	B-47	White City Drainage Improvements (Canals B, C,D, E, F, G) SLE2a and 2b	Purpose is to improve water quality of stormwater flows to the North Fork the St. Lucie River by modifying canal stages and reducing the potential for pollutant run-off from pastures using modern storm systems and BMPs. Water quality benefits are considered negligible due to the small size and nature of the project.	2	√	√	√	√
SLE 03	B-49	White City Drainage Improvements (Citrus/Saeger)	Purpose is to capture, store and treat run-off and provide controlled releases to the St. Lucie River by constructing a 4-acre stormwater detention pond with associated outfall structure. The project would result in 0.01 and 0.03 mt/yr reductions in TP and TN, respectively.	1	√	√	√	√
SLE 06	B-51	Indian River Estates/Savannas Ecosystem Management Project	Project will improve flood control and treat stormwater that currently discharges directly to the Indian River Lagoon and North Fork of the St. Lucie River by constructing a pump station, infrastructure and water detention cells within a 1,200-acre basin adjacent to the Indian River Lagoon and the North Fork. The project would result in 0.76 and 0.83 mt/yr reductions in TP and TN, respectively.	1	√	√	√	√
SLE 07	B-53	Platt's Creek Wetland Restoration	Project would improve the performance of an existing stormwater treatment system by adding Alum injection and modifying the current outfalls and discharge conveyance to be incorporated into the restoration of a prior citrus operation to floodplain forest, marsh and flatwoods. The project would result in 0.03 and 0.11 mt/yr reductions in TP and TN, respectively.	1	√	√	√	√
SLE 09	B-55	Natural Lands in CERP IRL-S PIR Project	The recommended plan includes approximately 92,000 acres of natural storage areas that will be hydrologically restored to provide a variety of project benefits including approximately 30,000 ac-ft of freshwater storage, reductions in nitrogen and phosphorus loads, increased acreage of wetlands, and aquifer recharge.	-	√	√	√	√
SLE 09a	B-57	CERP – IRL-S PIR: PalMar Complex - Natural Storage and Water Quality Area	The PalMar Complex includes approximately 17,143 acres of pastureland in the C-44 Basin that has been identified for use as alternative storage, nutrient removal, rehydration, and habitat restoration. The project will provide 5,700 ac-ft of water storage and result in 3.43 and 13.39 mt/yr reductions in TP and TN, respectively.	1	√	√	√	√

MM ID#	Page #	MM Title	MM Description	Level	Alternative 1	Alternative 2	Alternative 3	Alternative 4
SLE 09b	B-60	CERP – IRL-S PIR: Allapattah Complex - Natural Storage and Water Quality Area	The Allapattah Complex - Natural Storage and Treatment Area, is located in Martin County and includes approximately 42,348 acres of land in the C-23 Basin. This land has been identified for use as alternative storage, rehydration, habitat restoration, and to provide incidental water quality treatment. The project will provide 13,800 ac-ft of water storage and result in 8.47 and 32.73 mt/yr reductions in TP and TN, respectively.	1	√	√	√	√
SLE 09c	B-63	CERP – IRL-S PIR: Cypress Creek/Trail Ridge Complex - Natural Storage and Water Quality Area	The Cypress Creek/Trail Ridge Complex includes approximately 32,639 acres of primarily pastureland, along with some of the last remaining large tracts of forested wetland habitat in St. Lucie County that has been identified for use as alternative storage, re-hydration, habitat restoration, and water quality improvements. The project will provide 10,500 ac-ft of water storage and result in 6.49 and 25.29 mt/yr reductions in TP and TN, respectively.	2	√	√	√	√
SLE 10	B-66	St. Lucie Watershed Natural Area Registry Program	A natural area registry program is a voluntary program designed to provide support for protecting the watershed's natural lands. The voluntary cooperation of a landowner to protect the natural elements, features, and characteristics of their own property is the basis for natural area registry programs.	3	-	-	-	-
SLE 11	B-68	Creation of Suitable Oyster Substrate in the St. Lucie Estuary at Various Sites Identified in IRL-S PIR (Artificial Habitat Creation)	The project will build upon existing efforts to create suitable oyster substrate in the St. Lucie Estuary using natural or man-made conditions (i.e. "oyster balls," limestone rocks, relict shell bags, etc.) placed under docks or on open slopes. It is anticipated that the project will reduce TP and TN from within the St. Lucie Estuary; however, the magnitude of these benefits is undetermined.	1	√	√	√	√
SLE 13	B-70	On-site Sewage Treatment and Disposal System inspection and pump-out program	The project will include an incentive program to help residents identify damaged or non-functioning septic systems by providing financial assistance and technical expertise (covering approximately 10,500 eligible systems) in order to reduce the amount of water quality problems that result from failing systems. Water quality benefits are anticipated to occur as a result of this project; however, the magnitude of these benefits is undetermined.	4	-	-	√	√
SLE 16	B-72	Improved Management of Sludge Disposal in St. Lucie County (Innovative Plasma-Arc Technology)	The current disposal practices of land applying Biosolids will be phased out in favor of the Plasma Arc Gasification process to be utilized at the St. Lucie County Solid Waste Baling & Recycling facility in order to remove a major pollution source of bacteria and nutrients to area waters. Removal will start at 1,500 tons per day initially, and then expand to 3,000 tons per day. Water quality benefits are anticipated to occur as a result of this project; however, the magnitude of these benefits is undetermined.	1	√	√	√	√

MM ID#	Page #	MM Title	MM Description	Level	Alternative			
					1	2	3	4
SLE 18	B-74	Additional Reservoir Storage and WQ Treatment Areas	Additional Reservoirs and/or Stormwater Treatment Areas to capture and treat any remaining undesired releases from Lake Okeechobee and/or the local watershed to the St. Lucie River and Estuary not addressed by the proposed improvements north of the lake.	5	-	-	√	√
SLE 18a	B-75	Reservoir and/or Stormwater Treatment Area along the south side of the C-44 Canal	To capture and treat any remaining undesired releases from Lake Okeechobee to the St. Lucie River and Estuary not addressed by the proposed improvements north of the Lake	5	-	-	-	-
SLE 18b	B-77	C-23/34 Water Quality Treatment Project	Additional Reservoirs and/or Stormwater Treatment Areas along the C-23 and C-24 Canal to capture and treat any remaining undesired releases from Lake Okeechobee and/or the local watershed to the St. Lucie River and Estuary not addressed by the proposed improvements north of the Lake.	5	-	-	√	√
SLE 19	B-79	Conversion of Existing Canals into Linear Wetland Treatment Areas	Project will result in conversion of existing canals into linear wetland/shallow lake treatment areas, which will provide additional treatment of stormwater entering the North Fork and South Fork of the St. Lucie River by creating linear standing pools upstream of installed weir structures. These standing pools will create the opportunity for longer residence time resulting in nutrient assimilation and attenuation during times of base flow and low-flow conditions. The project is still in a conceptual phase; therefore, water quality benefits have yet to be determined.	4	-	-	√	√
SLE 22	B-81	North River Shores Vacuum Sewer System	Project includes a vacuum assisted gravity sewer collection system to provide service to approximately 750 single and multi-family residential units presently disposing of approximately 190,000 gallons per day of waste through septic tanks. The project will result in 2.18 and 8.57 mt/yr reductions in TP and TN, respectively.	1	√	√	√	√
SLE 24	B-83	CERP – IRL-S PIR: C-23/24 Reservoir/STA	Project includes two reservoirs (C-23/24 North and South reservoirs) totaling approximately 47,799 acres and a 2,568-acre STA in order to improve the quality, quantity, timing and distribution of water discharge to the St. Lucie River and Estuary from the local watershed. The two reservoirs and one STA will provide 94,468 ac-ft of water storage and result in 24.0 and 104.2 mt/yr reductions in TP and TN, respectively.	1	√	√	√	√
SLE 26	B-86	CERP – IRL-S PIR: North Fork Natural Floodplain Restoration	Project includes acquisition and preservation of approximately 3,100 acres of floodplain and adjacent lands, which will provide significant environmental improvement in the health of this portion of the St. Lucie River by preventing such degradation as increased stormwater runoff, increased turbidity, and increased influence of exotic plants and animals from the surrounding areas that are under significant development pressure. The project will provide approximately 0.57 and 2.23 mt/yr reductions in TP and TN, respectively.	2	√	√	√	√

MM ID#	Page #	MM Title	MM Description	Level	Alternative			
					1	2	3	4
SLE 27	B-88	CERP – IRL-S PIR: Muck Remediation	Muck remediation involves the removal of accumulated muck within the SLE from areas that are effectively “dead zones.” Muck accumulation has covered substrate that once supported a healthy SAV and oyster community. Removal of this sediment would greatly improve estuarine conditions by exposing this substrate making it suitable for colonization by target species.	3	√	√	√	√
SLE 28	B-91	Tropical Farms / Roebuck Creek Stormwater Quality Retrofit	The project is designed to capture the first inch of runoff from 540-acres and convey the runoff to a proposed Lake / Stormwater Treatment Area (STA) that will provide 39 acre-feet of stormwater attenuation and water quality treatment. The project consists of the installation of approximately 8,500 linear feet of storm pipe ranging from 18” to 48” diameter and the construction of a 1.5-acre lake and a 21 acre lake / STA system.	1	√	√	√	√
SLE 29	B-94	Old Palm City Phase III Stormwater Quality Retrofit	Phase 3 of the Old Palm City Retrofit project includes construction of two STAs that will serve 106 acres of residential land and provide 8.5 ac-feet of water quality treatment and stormwater attenuation. The project would result in 0.03 and 0.07 mt/yr reductions in TP and TN, respectively.	1	√	√	√	√
SLE 30	B-97	Manatee Pocket Dredging Project	The project will remove approximately 250,000 cubic yards of muck sediments over 47 acres within Manatee Pocket and its tributaries. It is anticipated that the project will reduce TP and TN from within the St. Lucie Estuary; however, the magnitude of these benefits is undetermined.	1	√	√	√	√
SLE 31	B-100	Stormwater Baffle Box Retrofit - City of Stuart	Project includes baffle boxes located in storm systems throughout the City of Stuart that provide sediment and floatable debris removal from storm systems before discharge to the St. Lucie River. Water quality benefits anticipated include reductions of Total Suspended Solids, with negligible TP and TN reductions.	1	-	-	√	√
SLE 32	B-102	Danforth Creek Stormwater Quality Retrofit	This project would provide approximately 4 ac-ft of additional treatment and storage for a 50-acre untreated residential development area. The project would result in 0.01 and 0.03 mt/yr reductions in TP and TN, respectively.	3	-	-	√	√
SLE 33	B-104	North St. Lucie River Water Control District Stormwater Retrofit; Structures 81-1-2 and 85-1-2	This project involves retrofitting for water control structures located within the North St. Lucie River Water Control District. The retrofits will improve the efficiency of structure operations and provide better control of flows to Ten Mile Creek during storm events while also providing control of sedimentation released downstream. Water quality/quantity benefits are anticipated to occur as a result of this project; however, the magnitude of these benefits is undetermined.	1	-	-	√	√

MM ID#	Page #	MM Title	MM Description	Level	Alternative			
					1	2	3	4
SLE 35	B-106	All American Boulevard Ditch Retrofit	The purpose of the project is to re-grade the All American Ditch and Pipe the flows to an approximately 12.5 acre Lake / Stormwater Treatment Area for water quality treatment and provide some attenuation. The goal is to provide 1 inch of treatment to the basin, resulting in 25 ac-ft of water quality treatment.	3	-	-	√	√
SLE 36	B-109	Everglades Comprehensive Plan Amendment	This amendment will require comprehensive plans to include: a conservation element for the conservation, use, and protection of natural resources in the area, including air, water, water recharge areas, wetlands, waterwells, estuarine marshes, soils, beaches, shores, flood plains, rivers, bays, lakes, harbors, forests, fisheries and wildlife, marine habitat, minerals, and other natural and environmental resources.	2	-	-	-	-
SLE 37	B-111	Living Shoreline Initiative	This is a partnership effort that could be modeled after the Living Shoreline Initiative established by the Florida Panhandle Coastal Program	3	-	-	-	-
SLE 38	B-113	Urban Best Management Practices Program (An Extension of the Florida Yards and Neighborhoods Program)	The Florida Yards and Neighborhoods Program is an environmental education program designed to improve the water quality of the Indian River Lagoon and the St. Lucie Estuary (SLE) by reducing non point sources of pollution from properties throughout the watershed.	1	√	√	√	√
SLE 39	B-115	Aquifer Storage & Recovery	Aquifer Storage and Recovery (ASR) involves injecting water into an aquifer through wells and then pumping it out from the same aquifer when needed. The aquifer essentially functions as a water bank. Deposits are made in times of surplus, typically during the rainy season, and withdrawals occur when available water is needed, typically during a dry period	4	-	-	-	-
SLE 40	B-117	CERP – IRL-S PIR: Southern Diversion C-23 to C-44 Interconnect	The project would result in the canal directing excess water from the C-23, C-24, C-25 Canal system through the C-44 STA and into the St. Lucie Canal (C-44) where it could be diverted to Lake Okeechobee anytime the lake was below 14.5 feet mean sea level, used to meet local irrigation demands, or sent to tide at a point less damaging than the C-23. The IRL-S PIR estimates that, in an average year 31,000 ac-ft could be gravity discharged to Lake Okeechobee via S-308 and 22,000 ac-ft could be sent to tide through the S-80 structure. Final water quality/quantity benefits have yet to be determined.	1	√	√	√	√

MM ID#	Page #	MM Title	MM Description	Level	Alternative			
					1	2	3	4
SLE 41	B-119	Martin County Baffle Boxes	Currently, Martin County has identified and prioritized nearly 30 locations for potential baffle box installations to provide sediment and debris traps to prevent discharges directly into either the Indian River Lagoon or the St. Lucie River. Water quality benefits anticipated include reductions of Total Suspended Solids, with negligible TP and TN reductions.	4	-	-	√	√
SLE 42	B-121	Jensen Beach Retrofit	This project proposes to provide detention and/or retention for stormwater runoff in vaults and/or in exfiltration for an older developed area in downtown Jensen Beach, Florida. The project would result in 0.01 and 0.03 mt/yr reductions in TP and TN, respectively.	1	√	√	√	√
SLE 43	B-123	Leilani Hts/ Warner Creek Retrofit - Phase 1, 2, and 3	The purpose of this three-phase project is to provide treatment to current standards for runoff from existing sub-standard development, to resolve conveyance capacity within the system to reduce flooding, to provide attenuation of increased flows resulting from internal conveyance improvements, and to recharge groundwater with runoff that currently flows directly to the St. Lucie Estuary. This three-phase project would result in 0.16 and 0.41 mt/yr reductions in TP and TN, respectively.	1	√	√	√	√
SLE 44	B-126	Manatee Creek Water Quality Retrofit; PhII & PhIII; New Monrovia, Dixie Park	The Manatee Creek drains is approximately 833 acres. The basin is located; south of Cove Road, north of the Mariner Sands subdivision, west of Dixie Highway (CR A1A), and extends one-half mile west of US Highway 1. Phase 1 of the Manatee Creek Retrofit is complete and constructed 10 acre ft of storage and STA marsh filtration. Phases II and III of the project will provide an additional 15.3 ac-ft of water quality treatment in wet detention and STA marsh filtration.	1	√	√	√	√
SLE 45	B-128	10 Mile Creek – Reservoir and Stormwater Treatment Area	The intent of the Ten Mile Creek Water Preserve Area project is to attenuate summer stormwater flows into the North Fork of the St. Lucie River, which originate in the Ten Mile Creek basin by capturing and storing the passing stormwater. The sedimentation of suspended solids that occurs in the storage reservoir will reduce sediment loads delivered to the estuary. In addition, it is the intention that the captured stormwater be passed through a polishing cell for additional water quality treatment before being released into the North Fork of the St. Lucie River.	1	√	√	√	√
SLE 46	B-131	Small Acreage Manure Management	The purpose of the project is to reduce the amount of nutrients released into the regional system from landowner storage of manure on the banks of the creeks in these watersheds. A centrally located and properly managed facility for the collection and/or composting of manure waste will be developed. Water quality benefits are anticipated to occur as a result of this project; however, the magnitude of these benefits was not determined due to unknown loading rates to the St. Lucie River watershed from manure.	3	-	-	√	√

MM ID#	Page #	MM Title	MM Description	Level	Alternative			
					1	2	3	4
SLE 47	B-133	Deep Well Injection at the following selected locations in watershed	Construction of deep, high-capacity injection wells for water disposal. Wells would be constructed in "clusters" along C-44 canal right-of-way	5	-	-	-	-
SLE 48	B-135	Danforth Creek Muck Removal Dredging project	The project would result in removal of approximately 20,000 cubic yards of accumulated muck sediments from Danforth Creek in order to improve estuarine habitat as well as improve water quality conditions. It is anticipated that the project will reduce TP and TN from within the St. Lucie Estuary; however, the magnitude of these benefits is undetermined. This project will partially implement MM SLE 27.	2	-	-	√	√
SLE 49	B-137	Warner Creek Muck Removal Dredging Project	The project will result in removal of approximately 16,000 cubic yards of accumulated muck sediments from Warner Creek in order to improve estuarine habitat as well as improve water quality conditions. It is anticipated that the project will reduce TP and TN from within the St. Lucie Estuary; however, the magnitude of these benefits is undetermined. This project will partially implement MM SLE 27.	2	-	-	√	√
SLE 50	B-139	Hidden River Muck Removal Dredging Project	The project would result in removal of accumulated muck sediments from Hidden River (exact volume to be determined) in order to improve estuarine habitat as well as improve water quality conditions. It is anticipated that the project will reduce TP and TN from within the St. Lucie Estuary; however, the magnitude of these benefits is undetermined. . This project will partially implement MM SLE 27.	2	-	-	√	√
SLE 51	B-141	Residential Canal Weirs Along the North and South Forks of the St. Lucie River	To provide detention storage for existing residential areas presently draining directly to the North and South Forks via uncontrolled canals. The detention will be achieved by providing weirs with a crest elevation of one foot above the existing mean wet season water level in the canals at the weir location. A bleeder in the weir will be included to allow the detention volumes to be restored after runoff events.	5	-	-	-	-
SLE 52	B-143	City of Port St. Lucie – E-8 Canal Stormwater Retrofit	The treatment area will reduce sediment and nutrient loading to the North Fork of the St. Lucie River by reducing the flow rate and implementing bioremediation.	1	√	√	√	√
SLE 53	B-145	Frazier Creek Water Quality – City of Stuart	The 3.6 ac-ft detention pond is located south of the Roosevelt Bridge in the northwest quadrant of the city within the Frazier Creek drainage basin (approximately 500 acres). The detention pond services approximately 75 acres of single family residential and light commercial property.	1	√	√	√	√

MM ID#	Page #	MM Title	MM Description	Level	Alternative			
					1	2	3	4
SLE 54	B-147	Haney Creek Wetland Restoration	This project includes restoration of wetland area within the approximately 1,200-acre Haney Creek Watershed serving approximately 436 acres of upstream development. The project will provide conservation and water quality enhancement within the watershed. Reductions in both TP and TN would be negligible.	1	√	√	√	√
SLE 55	B-149	Poppleton Creek	This project involves an on-line regional detention basin (30.0 ac-ft) providing storage treatment for approximately 170 acres within the Poppleton Creek drainage basin. The project would result in 0.09 and 0.16 mt/yr reductions in TP and TN, respectively.	1	√	√	√	√
SLE 56	B-151	Farm and Ranchland Partnerships	There are two U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) programs that help farmers and ranchers keep their land in agriculture: the Farm and Ranchlands Protection Program) and the Wetlands Reserve Program. Both programs provide funds to purchase conservation easements.	4	-	-	-	√
SLE 57	B-153	Septage Disposal Requirements	Entities disposing of septage within the watersheds must develop and submit an agricultural use plan that limits applications, based upon nutrient loading to the Department of Health.	1	√	√	√	√
SLE 58	B-155	Animal Manure Application Rule	Landowners who apply more than one ton per acre of manure must develop conservation plans, approved by the US Department of Agriculture/National Resource Conservation Service (USDA/NRC), that specifically address the application of animal waste and include soil testing to demonstrate the need for manure application.	1	√	√	√	√

LO 01-02-49

Northern Everglades- Potential Management Measure

Project Feature/Activity: Agricultural BMPs

Level: 1

General Description/Background: Since 2002, considerable effort has been expended on the implementation of agricultural BMPs and water-quality improvement projects to immediately reduce the discharge of P from the watershed to the lake. Agricultural Nutrient Management Plans (AgNMPs) for the 22 active dairies in the watershed were completed in 2002, covering more than 31,000 acres (12,545 ha). Detailed planning, engineering, and design for implementing the stormwater component of the AgNMPs, at four of the dairies, will be completed by June 2007. Implementation of all of the dairy AgNMPs is expected to be completed by FY 2015.

Completed conservation plans now cover approximately 474,200 acres (191,902 ha) in the watershed, and BMPs are in various stages of implementation. The majority of this acreage lies within the four priority basins. Plans are being developed for an additional approximately 600,000 acres (242,811 ha) of agricultural operations. These figures reveal that more than half of the agricultural acreage in the entire watershed is currently under voluntary FDACS programs to plan and implement practices to control offsite movement of P. At the current rate of participation, FDACS is on schedule to complete BMP-based plans for the remainder of the agricultural acreage in the watershed by July 2010, and fully implement BMPs by 2015, as required by the Lake Okeechobee Protection Plan.

Purpose: Improve water quality by reducing transport of nutrients via runoff and leaching into regional system from agricultural and non-agricultural land uses

Location/Size/Capacity: Primarily within Lake Okeechobee watershed; expanding into estuary watersheds

Initiative Status:

Agricultural- underway; need update from FDACS

Urban- underway; need update from FDEP

Estimate of Water Quality Benefits

- Minimum: 72 mt/yr
- Maximum: 72 mt/yr
- Most Likely: 72 mt/yr
- Level of Certainty: Conceptual
- Assumptions: Water quality benefits will be rolled up into a single “urban” category

Estimate of Water Quantity Benefits

- Minimum: Unknown
- Maximum: Unknown
- Most Likely: Unknown
- Level of Certainty: Unknown
- Assumptions: NA

Screening Criteria

- Proof of Concept: 1
- Other Impacts: 0

Contact: Rich Budell; FDACS; 850-488-6249.

Final Water Quality Method and Summary: N/A
Final Water Quantity Method and Summary: N/A

Method: Included in the BMP load reduction estimates (Soil and Water Engineering Technology Inc. 2008).

LO 03

Northern Everglades- Potential Management Measure

Project Feature/Activity: Urban Turf Fertilizer Rule (LOER)

Level: 1

General Description/Background: In August 2007, FDACS adopted a statewide Urban Turf Fertilizer Rule [5E-1.003(2) F.A.C]. The rule limits the P and N content in fertilizers for urban turf and lawns, thereby reducing the amount of P and N applied in urban areas and limiting the amount of those compounds reaching Florida's water resources. It requires that all fertilizer products labeled for use on urban turf, sports turf, and lawns be limited to the amount of P and N needed to support healthy turf maintenance. FDACS expects a 20 to 25 percent reduction in N and a 15 percent reduction in P in every bag of fertilizer sold to the public.

The rule was developed by FDACS with input from UF/IFAS, FDEP, the state's five water management districts, the League of Cities, the Association of Counties, fertilizer manufacturers, and concerned citizens. It enhances efforts currently underway to address excess nutrients in the northern and southern Everglades. As a component of the Lake Okeechobee and Estuary Recovery (LOER) Plan established in October 2005 by former Governor Jeb Bush, the new rule is an essential component to improve water quality through nutrient source control.

Purpose: Improve water quality by reducing phosphorus and nitrogen runoff and leaching resulting from application of fertilizers to urban turf.

Location/Size/Capacity: Statewide within urban settings.

Initiative Status: Rule adopted in August 2007

Cost: Not applicable

Documentation: Urban Turf Fertilizer Rule [5E-1.003(2) F.A.C]

Estimate of Water Quality Benefits

- Minimum: Urban Rollup
- Maximum: Urban Rollup
- Most Likely: Urban Rollup
- Level of Certainty: Conceptual
- Assumptions: Water quality benefits will be rolled up into a single "urban" category

Estimate of Water Quantity Benefits

- Minimum: N/A
- Maximum: N/A
- Most Likely: N/A

- Level of Certainty: Final
- Assumptions: N/A

Screening Criteria

- Proof of Concept: N/A
- Other Impacts: N/A

Contact: Rich Budell; FDACS; 850-617-1704

Final Water Quality Method and Summary: N/A
Final Water Quantity Method and Summary: N/A

Method: Included in the BMP load reduction estimates (Soil and Water Engineering Technology Inc. 2008).

LO 04

Northern Everglades Potential Management Measures

Project Feature/Activity: Land Application of Residuals

Level: 1

General Description/Background: Subsection 373.4595(4)(b)2.of the NEEPP requires that after December 31, 2007, the department may not authorize the disposal of domestic wastewater residuals within the St. Lucie River watershed unless the applicant can affirmatively demonstrate that the nutrients in the residuals will not add to nutrient loadings in the watershed. This demonstration shall be based on achieving a net balance between nutrient imports relative to exports on the permitted application site. Exports shall include only nutrients removed from the St. Lucie River watershed through products generated on the permitted application site. This prohibition does not apply to Class AA residuals that are marketed and distributed as fertilizer products in accordance with department rule.

Purpose: Improve water quality by reducing transport of nutrients via run-off and leaching into the regional system from land application of residuals

Location/Size/Capacity: Basin wide

Initiative Status: effort underway

Cost: To be determined **(**TBD)

Estimate of Water Quality Benefits

- Minimum: Urban Rollup
- Maximum: Urban Rollup
- Most Likely: Urban Rollup
- Level of Certainty: Conceptual
- Assumptions: N/A

Estimate of Water Quantity Benefits

- Minimum: N/A
- Maximum: N/A
- Most Likely: N/A
- Level of Certainty: Final
- Assumptions: N/A

Screening Criteria

- Proof of Concept: N/A
- Other Impacts: N/A

Contact: Maurice Barker; FDEP; 850-245-8614

Final Water Quality Method and Summary: N/A
Final Water Quantity Method and Summary: N/A

Method: Included in the BMP load reduction estimates (Soil and Water Engineering Technology Inc. 2008).

LO 05

Northern Everglades Potential Management Measures

Project Feature/Activity: Florida Yards & Neighborhoods

Level: 1

General Description/Background: The Florida Yards & Neighborhoods program is an excellent example of a nonstructural program that is helping to minimize the use of pesticides, fertilizers, and irrigation water by educating citizens and builders about proper landscape design. This promotes "right plant-right place" and minimizes the amount of fertilizer, pesticide, and irrigation needed for a successful landscape. FDEP has an ongoing monitoring program to determine the effectiveness of this program in reducing nutrient loads.

Purpose: Reduce the use of nutrients and pesticides, and irrigation, thereby reducing nutrient loading and reducing water use.

Location/Size/Capacity: Statewide

Initiative Status: On-going

Cost: TBD

Documentation: For more information, please see

Estimate of Water Quality Benefits

- Minimum: Urban Rollup
- Maximum: Urban Rollup
- Most Likely: Urban Rollup
- Level of Certainty: Conceptual
- Assumptions: Projected benefits will roll up under urban category

Estimate of Water Quantity Benefits

- Minimum: Unknown
- Maximum: Unknown
- Most Likely: Unknown
- Level of Certainty: Unknown
- Assumptions: N/A

Screening Criteria

- Proof of Concept: N/A
- Other Impacts: N/A

Contact: Michael Scheinkman, FDEP Environmental Specialist - Clean Lakes program, lake management. Florida Yards and Neighborhoods. Phone 850-267-2075
Eric Livingston, FDEP, on monitoring project for FYN

Final Water Quality Method and Summary: N/A
Final Water Quantity Method and Summary: N/A

Method: Included in the BMP load reduction estimates (Soil and Water Engineering Technology Inc. 2008).

LO 07

Northern Everglades – Potential Management Measure

Project Feature/Activity: ERP Regulatory Program

Level: 1

General Description/Background: The Environmental Resource Permit (ERP) program regulates activities involving the alteration of surface water flows. This includes activities in uplands that alter stormwater runoff, as well as dredging and filling in wetlands and other surface waters. ERP applications are processed by either the Department or the water management districts, in accordance with the division of responsibilities specified in operation agreements between the Department and the water management districts.

Purpose: The purpose of this measure is to ensure that activities do not degrade water quality, impact flood protection or adversely impact the function of wetland systems.

Location/Size/Capacity: SFWMD jurisdiction

Initiative Status: Existing Program Activity

Cost: N/A

Estimate of Water Quality Benefits

- Minimum: Urban Rollup
- Maximum: Urban Rollup
- Most Likely: Urban Rollup
- Level of Certainty: Conceptual
- Assumptions: No increase in nutrient loads resulting from new development; Applies to new development only; Conversion of intense agricultural uses (dairies, row crops, improved pasture, sod, citrus) with little or no water quality treatment to urban uses with modern surface water management systems with treatment; Projected benefits will roll up under the urban category

Estimate of Water Quantity Benefits

- Minimum: Unknown
- Maximum: Unknown
- Most Likely: Unknown
- Level of Certainty: Conceptual
- Assumptions: Applies to new development only; Conversion of intense agricultural uses (dairies, row crops, improved pasture, sod, citrus) with little or no stormwater storage to urban uses with modern surface water management systems with storage; Projected benefits will roll up under urban category

Screening Criteria

- Proof of Concept: N/A
- Other Impacts: N/A

Contact: Damon Meiers; SFWMD; 561-682-6876

Final Water Quality Method and Summary: N/A
Final Water Quantity Method and Summary: N/A

Method: Included in the BMP load reduction estimates (Soil and Water Engineering Technology Inc. 2008).

LO 08

Northern Everglades Potential Management Measures

Project Feature/Activity: NPDES Stormwater Program

Level: 1

General Description/Background: In 1987, the Federal Clean Water Act was amended requiring the U.S. Environmental Protection Agency (EPA) to develop rules to implement the federal National Pollutant Discharge Elimination System (NPDES) stormwater permitting program. Phase I, promulgated in 1990, addresses the following sources:

"Large" and "medium" **municipal separate storm sewer** systems (MS4s) located in incorporated places and counties with populations of 100,000 or more, and eleven categories of **industrial activity**, one of which is large **construction activity** that disturbs 5 or more acres of land.

Phase II, promulgated in 1999, addresses additional sources, including MS4s not regulated under Phase I, and small construction activity disturbing between 1 and 5 acres.

In October 2000, EPA authorized the Florida Department of Environmental Protection (DEP) to implement the NPDES stormwater permitting program in the State of Florida (in all areas except Indian Country lands). FDEP's authority to administer the NPDES program is set forth in Section 403.0885, Florida Statutes (F.S.).

Important note**:** The NPDES stormwater permitting program is separate from the State's stormwater/environmental resource permitting programs (found under Part IV, Chapter 373, F.S. (593KB) and Chapter 62-25, F.A.C. and local stormwater/water quality programs, which have their own regulations and permitting requirements.

Purpose: To reduce stormwater pollutant loads discharged to surface waters, especially from existing land uses and drainage systems. This is especially true for the master drainage systems owned and operated by cities, counties, FDOT, and Chapter 298 water control districts. This also can help to reduce stormwater pollutant loads from existing industrial sites and from new construction sites.

Location/Size/Capacity: Basin wide

Initiative Status: Being implemented by FDEP

Cost: TBD

Documentation: For more information, please see:
http://www.dep.state.fl.us/water/stormwater/npdes/index.htm

Estimate of Water Quality Benefits

- Minimum: Urban Rollup
- Maximum: Urban Rollup
- Most Likely: Urban Rollup
- Level of Certainty: Conceptual
- Assumptions: Projected benefits will roll up under urban category

Estimate of Water Quantity Benefits

- Minimum: Unknown
- Maximum: Unknown
- Most Likely: Unknown
- Level of Certainty: Conceptual
- Assumptions: Depends if infiltration BMPs or stormwater reuse is done; Projected benefits will roll up under urban category

Screening Criteria

- Proof of Concept: N/A
- Other Impacts: N/A

Contact: Steven Kelly, Program Administration, NPDES Stormwater Section, Tallahassee, 850-245-7518

Final Water Quality Method and Summary: N/A
Final Water Quantity Method and Summary: N/A

Method: Included in the BMP load reduction estimates (Soil and Water Engineering Technology Inc. 2008).

LO 09

Northern Everglades – Potential Management Measure

Project Feature/Activity: Coastal and Estuarine Land Conservation Program

Level: 1

General Description/Background: The Coastal and Estuarine Land Conservation Program (CELCP) was established in 2002. The Federal Office of Ocean and Coastal Resource Management (OCRM) will administer the program which provides up to $3 million dollars for each eligible project. CELCP federal funds will be provided for eligible activities related to state planning, program administration and project acquisition. Any project approved through the program must provide non-federal matching dollars.

Purpose: Protecting important coastal and estuarine areas that have significant conservation, recreation, ecological, historical, or aesthetic values, or that are threatened by conversion from their natural or recreational state to other uses" (CELCP Final Guidelines, 2003).

Location/size/capacity: Statewide

Initiative Status: On-going

Cost: $3 million dollars for each eligible project.

Documentation: For more information, please see: http://coastalmanagement.noaa.gov/land/welcome.html

Estimate of Water Quality Benefits

- Minimum: Unknown
- Maximum: Unknown
- Most Likely: Unknown
- Level of Certainty: Unknown
- Assumptions: N/A

Estimate of Water Quantity Benefits

- Minimum: Incidental
- Maximum: Incidental
- Most Likely: Incidental
- Level of Certainty: Unknown
- Assumptions: N/A

Screening Criteria

- Proof of Concept: N/A

- Other Impacts: N/A

Contact: W. Kennedy; FDEP; 561-681-6706

Final Water Quality Method and Summary: Incidental
Final Water Quantity Method and Summary: Incidental

Method: The main purpose of this project is land conservation. Incidental water quality and quantity benefits are anticipated to occur as a result of this project; however, the magnitude of these benefits was not determined due to the nature of the project.

LO 12f

Northern Everglades – Potential Management Measure

Project Feature/Activity: Alternative Water Storage (LOER) – Indiantown Citrus Growers Association

Level: 1

General Description/Background: The 2005 Lake Okeechobee Estuary and Recovery (LOER) action plan was developed to help restore the ecological health of Lake Okeechobee and adjoining estuaries, through a series of fast-track water quality improvement projects and several other far-reaching and innovative components. Among these additional components is an initiative to identify options for storage and/or disposal of excess surface water to aid in reducing lake levels and high discharge volumes to the estuaries. Assessments of available public and tribal lands for storage of excess surface water have been completed for the watershed, with assessments continuously ongoing for private lands. Eight water storage/disposal projects have been completed including Lykes Basinger Grove and Phase II Indiantown Citrus Growers Association. Additional water storage projects are under way (i.e. Avon Park Air Force Range, Kissimmee Prairie Preserve State Park, etc.), with investigations and designs continuing for additional water storage projects with a goal of 450,000 ac-ft.

Purpose: To assess, plan, design, and construct water storage/disposal projects on public, private, and tribal lands.

Location/Size/Capacity: Indiantown Citrus Growers Association (ICGA) – Phase I of the project consisted of the rehabilitation and relocation of pump stations. The association will utilize their irrigation pumps at the St. Lucie Canal to draw regulatory regional lake releases into their site for disposal which will reduce freshwater volumes to the estuary. Phase II of the project included widening ditches in the ICGA ditch system is also complete. The detention of stormwater within the existing ditch system will result in water quality improvements thereby promoting water conservation and reducing the volume of surface water discharge to the St. Lucie Canal and Estuary. Phase III: 77 control structures will be installed.

Initiative Status: Phase I and II: 3,550 ac-ft of water storage on 1,775 acres of project area. Phase III: 3,450 ac-ft of water storage to install 77 water control structures.

Cost: Phase I & II: Total $831,531 (District contributed $220,758; ICGA contributed $322,965; and FDACS contributed $287,808). Phase III: $625,000 (Treasure Coast RC&D Council through a SLRIT grant will pay $312,500 and the remaining $312,500 will be paid by USDA NRCS through the EQIP program and by the Indiantown Citrus Growers.

Estimate of Water Quality Benefits

- Minimum: Unknown
- Maximum: Unknown
- Most Likely: Unknown
- Level of Certainty: Unknown
- Assumptions: Unknown

Estimate of Water Quantity Benefits

- Minimum: 3,550 ac-ft
- Maximum: 3,550 ac-ft
- Most Likely: 3,550 ac-ft
- Level of Certainty: Final
- Assumptions: N/A

Screening Criteria:

- Proof of Concept: 1
- Other Impacts: 1

Contact: Benita Whalen; SFWMD; 561-682-2957

Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): Uncalculated
Total Nitrogen Reduction (metric tons/year): Uncalculated

Method: To be determined at a later date.

Final Water Quantity Method and Summary

Capacity (acre-feet): Uncalculated

Method: To be determined at a later date.

LO 12j

Northern Everglades – Potential Management Measure

Project Feature/Activity: Alternative Water Storage (LOER) – DuPuis

Level: 4

General Description/Background: The 2005 Lake Okeechobee Estuary and Recovery (LOER) action plan was developed to help restore the ecological health of Lake Okeechobee and adjoining estuaries, through a series of fast-track water quality improvement projects and several other far-reaching and innovative components. Among these additional components is an initiative to identify options for storage and/or disposal of excess surface water to aid in reducing lake levels and high discharge volumes to the estuaries. Assessments of available public and tribal lands for storage of excess surface water have been completed for the watershed, with assessments continuously ongoing for private lands. Eight water storage/disposal projects have been completed including Lykes Basinger Grove and Phase II Indiantown Citrus Growers Association. Additional water storage projects are under way (i.e. Avon Park Air Force Range, Kissimmee Prairie Preserve State Park, etc.), with investigations and designs continuing for additional water storage projects with a goal of 450,000 ac-ft.

Purpose: To assess, plan, design, and construct water storage/disposal projects on public, private, and tribal lands.

Location/Size/Capacity: Design, engineer, and implement additional 1 foot of storage in the DuPuis marsh before on-site stormwater enters the L-8 Canal. This project could potentially store 2,500 ac-ft of water.

Cost: Cost for final design and implementation is approximately $1.76 million.

Estimate of Water Quality Benefits

- Minimum: Unknown
- Maximum: Unknown
- Most Likely: Unknown
- Level of Certainty: Unknown
- Assumptions: Not determined

Estimate of Water Quantity Benefits

- Minimum: 0 ac-ft
- Maximum: 2,5000 ac-ft
- Most Likely: 1,250 ac-ft
- Level of Certainty: Conceptual
- Assumptions: N/A

Screening Criteria:

- Proof of Concept: 1
- Other Impacts: 1

Contact: Benita Whalen; SFWMD; 561-682-2957

Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): Uncalculated
Total Nitrogen Reduction (metric tons/year): Uncalculated

Method: To be determined at a later date.

Final Water Quantity Method and Summary

Capacity (acre-feet): Uncalculated

Method: To be determined at a later date.

LO 12m

Northern Everglades – Potential Management Measure

Project Feature/Activity: Alternative Water Storage (LOER) – Waste Management St. Lucie Site

Level: 4

General Description/Background: The 2005 Lake Okeechobee Estuary and Recovery (LOER) action plan was developed to help restore the ecological health of Lake Okeechobee and adjoining estuaries, through a series of fast-track water quality improvement projects and several other far-reaching and innovative components. Among these additional components is an initiative to identify options for storage and/or disposal of excess surface water to aid in reducing lake levels and high discharge volumes to the estuaries. Assessments of available public and tribal lands for storage of excess surface water have been completed for the watershed, with assessments continuously ongoing for private lands. Eight water storage/disposal projects have been completed including Lykes Basinger Grove and Phase II Indiantown Citrus Growers Association. Additional water storage projects are under way (i.e. Avon Park Air Force Range, Kissimmee Prairie Preserve State Park, etc.), with investigations and designs continuing for additional water storage projects with a goal of 450,000 ac-ft.

Purpose: To assess, plan, design, and construct water storage/disposal projects on public, private, and tribal lands.

Location/Size/Capacity: Enter into a partnership arrangement to modify borrow areas into minor above ground impoundment(s). Preliminary hydrologic investigation is in process. Details are being developed.

Cost: To be determined

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:
- Most Likely: Level of Certainty:
- Assumptions:

Screening Criteria:

- Proof of Concept: 1

- Other Impacts: 1

Contact: Benita Whalen; SFWMD; 561-682-2957

Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): Uncalculated
Total Nitrogen Reduction (metric tons/year): Uncalculated

Method: To be determined at a later date.

Final Water Quantity Method and Summary

Capacity (acre-feet): Uncalculated

Method: To be determined at a later date.

LO 12q

Northern Everglades – Potential Management Measure

Project Feature/Activity: Alternative Water Storage (LOER) – Caulkins

Level: 4

General Description/Background: The 2005 Lake Okeechobee Estuary and Recovery (LOER) action plan was developed to help restore the ecological health of Lake Okeechobee and adjoining estuaries, through a series of fast-track water quality improvement projects and several other far-reaching and innovative components. Among these additional components is an initiative to identify options for storage and/or disposal of excess surface water to aid in reducing lake levels and high discharge volumes to the estuaries. Assessments of available public and tribal lands for storage of excess surface water have been completed for the watershed, with assessments continuously ongoing for private lands. Eight water storage/disposal projects have been completed including Lykes Basinger Grove and Phase II Indiantown Citrus Growers Association. Additional water storage projects are under way (i.e. Avon Park Air Force Range, Kissimmee Prairie Preserve State Park, etc.), with investigations and designs continuing for additional water storage projects with a goal of 450,000 ac-ft.

Purpose: To assess, plan, design, and construct water storage/disposal projects on public, private, and tribal lands.

Location/Size/Capacity: Rehabilitation and relocation of internal pump stations. During regulatory releases to the St. Lucie Estuary irrigation facilities will be utilized to draw excess stormwater into the 3,400 acre project site. The detention of stormwater within the existing ditch system will result in water quality improvements thereby promoting water conservation and reducing the volume of surface water discharge from the site.

Cost: TBD The cost of this conceptual project is approximately $300,000 with a 50/50 match.

Estimate of Water Quality Benefits

- Minimum: TBD
- Maximum: TBD
- Most Likely: TBD
- Level of Certainty: Conceptual
- Assumptions: TBD

Estimate of Water Quantity Benefits

- Minimum: TBD
- Maximum: TBD
- Most Likely: TBD
- Level of Certainty: Conceptual
- Assumptions: TBD

Screening Criteria:

- Proof of Concept: 1
- Other Impacts: 1

Contact: Benita Whalen; SFWMD; 561-682-2957

Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): Uncalculated
Total Nitrogen Reduction (metric tons/year): Uncalculated

Method: To be determined at a later date.

Final Water Quantity Method and Summary

Capacity (acre-feet): Uncalculated

Method: To be determined at a later date.

LO 12r

Northern Everglades – Potential Management Measures

Project Feature/Activity: Alternative Water Storage (LOER) – Private Agricultural Lands Adjacent to St. Lucie Canal

Level: 4

General Description/Background: The 2005 Lake Okeechobee Estuary and Recovery (LOER) action plan was developed to help restore the ecological health of Lake Okeechobee and adjoining estuaries, through a series of fast-track water quality improvement projects and several other far-reaching and innovative components. Among these additional components is an initiative to identify options for storage and/or disposal of excess surface water to aid in reducing lake levels and high discharge volumes to the estuaries. Assessments of available public and tribal lands for storage of excess surface water have been completed for the watershed, with assessments continuously ongoing for private lands. Eight water storage/disposal projects have been completed including Lykes Basinger Grove and Phase II Indiantown Citrus Growers Association. Additional water storage projects are under way (i.e. Avon Park Air Force Range, Kissimmee Prairie Preserve State Park, etc.), with investigations and designs continuing for additional water storage projects with a goal of 450,000 ac-ft.

Purpose: Utilize irrigation withdrawal facilities on St. Lucie Canal to remove excess stormwater from the canal and reduce freshwater to the estuary.

Location/Size/Capacity: Indiantown Citrus Growers Association (ICGA) – Phase 1 of the project consisted of the rehabilitation and relocation of pump stations. The association will utilize their irrigation pumps at the St. Lucie Canal to draw regulatory regional lake releases into their site for disposal which will reduce freshwater volumes to the estuary. Phase 2 of the project included widening ditches in the ICGA ditch system is also complete. The detention of stormwater within the existing ditch system will result in water quality improvements thereby promoting water conservation and reducing the volume of surface water discharge to the St. Lucie Canal and Estuary. Similar cooperative arrangements may be possible with the additional agricultural lands adjacent to St. Lucie Canal that have irrigation facilities.

Initiative Status: Assessing and planning.

Cost: TBD

Estimate of Water Quality Benefits

- Minimum: Unknown
- Maximum: Unknown
- Most Likely: Unknown
- Level of Certainty: Unknown
- Assumptions: Unknown

Estimate of Water Quality Benefits

- Minimum: TBD
- Maximum: TBD
- Most Likely: TBD
- Level of Certainty: TBD
- Assumptions: NA

Screening Criteria:

- Proof of Concept: 1
- Other Impacts: 1

Contact: Benita Whalen, SFWMD; 561-682-2957

Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): Uncalculated
Total Nitrogen Reduction (metric tons/year): Uncalculated

Method: To be determined at a later date.

Final Water Quantity Method and Summary

Capacity (acre-feet): Uncalculated

Method: To be determined at a later date.

LO 14
RWPP Base Condition

Northern Everglades- Potential Management Measure

Project Feature/Activity: CERP – IRL South: C-44 Reservoir / STA

Level: 1 (This feature is part of the future base RSM simulation)

General Description/Background: The C44 Reservoir/ STA Project is located on approximately 12,000 acres of land owned by SFWMD. This project comprises three components (Reservoir, West STA, and East STA) identified in the Indian River Lagoon south (IRL-S) Project Implementation (PIR).

Purpose: The project objectives, as defined in the PIR, are to capture local runoff from the C44 Basin, treat some or all of it via sedimentation and natural transformation of nutrients, and return it to the C-44 Canal when there is a need. The components are designed for flow attenuation to the St. Lucie Estuary, water quality benefits from reduced loading of nutrients, pesticides, herbicides, and other pollutants contained in runoff presently discharged to the estuary, and water supply benefits. Additional future benefits include the ability to remove the increased nutrient load in the C-23 diverted water.

Location/Size/Capacity: The project is located in Martin County, directly north of the C-44 Canal (St. Lucie Canal), halfway between Lake Okeechobee and the Atlantic Ocean. The project components include a reservoir, a pump station, stormwater treatment areas, canals, embankments, structures, roads, and the temporary reconfiguration of TIWCD canals:

- Reservoir
  - Acreage 3,400 acres
  - Water Depth ~ 15 ft
  - Storage volume 50,600 to 55,000 ac-ft
  - Embankment length 48,600 linear ft

- Pump Station
  - Capacity 1,100 cfs

- TIWCD Irrigation Pump Station
  - 85,000 gallons per minute (gpm)

- STA
  - Acreage 6,300 acres
  - Intake/Discharge Canals 20,000 linear ft
  - Perimeter Canals 92,500 linear ft
  - Conveyance/Control Structures 19
  - Storage Volume: 8,505 ac-ft (based on 90 percent footprint area available for storage and 1.5 ft standard operating depth)

Initiative Status: Final plans and specs submitted June 29, 2007

Cost: Pre-final Design Opinion of Probable Construction Cost is $339.8 million

Documentation: For more information, please see Formal BODR and Final Design Report and calculations.

Estimate of Water Quality Benefits

- Minimum: 4 mt/yr
- Maximum: 4 mt/yr
- Most Likely: 4 mt/yr
- Level of Certainty: Conceptual
- Assumptions: This is the load reaching Lake Okeechobee. Period of Record for Modeling is 1968-2000.

Estimate of Water Quantity Benefits

- Minimum: Reservoir (55,000 ac-ft); STA (8,505 ac-ft)
- Maximum: Reservoir (55,000 ac-ft); STA (8,505 ac-ft)
- Most Likely: Reservoir (55,000 ac-ft); STA (8,505 ac-ft)
- Level of Certainty: Conceptual
- Assumptions: STA storage volume based on 90 percent footprint area X 1.5 ft standard operating depth

Screening Criteria

- Proof of Concept: 1
- Other Impacts: 1

Contact: Sue Ray; SFWMD; 561-242-5520 *4019

Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): 26.1
Total Nitrogen Reduction (metric tons/year): 85.0

Method: Phosphorus reductions were based on 77 percent of the IRL-S PIR total phosphorous reduction target of 33,902 kg/yr. Nitrogen reduction rates were 79 percent of the reported total nitrogen reduction taken directly from the IRL-S PIR. These percentages represent the portions of the C-44 loads going to the St. Lucie Estuary versus Lake Okeechobee.

Final Water Quantity Method and Summary

Capacity (acre-feet): 50,250 ac-ft

Method: 97,000 acres with 1060/1060 cfs inflow/outflow capacity

LO 15

Northern Everglades – Potential Management Measure

Project Feature/Activity: Proposed St. Lucie River Watershed Regulatory Nutrient Source Control Program

Level: 2

General Description/Background: To develop a nutrient source control program for the St. Lucie River Watershed by amending Chapter 40E-61, F.A.C. Ongoing activities include revising Chapter 40E-61 to reflect the requirements of the Northern Everglades Protection Act and to expand the rule boundary to include the St. Lucie River Watershed as defined by the Northern Everglades Protection Act. A program for verifying and optimizing permitted BMPs will also be developed.

Purpose: To implement a nutrient source control program utilizing best management practices for the St. Lucie River Watershed complementary to the Coordinating Agencies collective efforts.

Location/Size/Capacity: The location is the St. Lucie River Watershed as defined by the Northern Everglades Protection Act.

Initiative Status: The Governing Board has authorized staff to initiate rule amendments to Chapter 40E-61 to reflect recent changes in the legislation. Staff will need to obtain authorization to expand the program to the St. Lucie River Watershed. Rule amendments will incorporate permitting, monitoring and BMP implementation verification program.

Cost: FY08 $891,986 (LOK program) Ad Valorem

Estimate of Water Quality Benefits

- Minimum – TBD
- Maximum- TBD
- Most Likely- TBD
- Level of Certainty- conceptual/final/unknown - unknown
- Assumptions leading to benefit estimate- N/A (Based on experience in other predominately agricultural areas with BMP programs, we might expect to accomplish a 25% load reduction when comparing pre and post BMP periods. Less reduction would be anticipated for urban areas.)

Estimate of Water Quantity Benefits

- Minimum – Unknown
- Maximum- Unknown
- Most Likely- Some changes may result from implementation of water management BMPs, but not quantifiable at this time.
- Level of Certainty- conceptual/final/unknown - unknown
- Assumptions leading to benefit estimate- n/a

Screening Criteria

- Proof of Concept: 0
- Other Impacts: 0

Contact: Steffany Gornak; SFWMD; 561-682-6600

Final Water Quality Method and Summary: N/A
Final Water Quantity Method and Summary: N/A

Method: Included in the BMP load reduction estimates (Soil and Water Engineering Technology Inc. 2008).

LO 21

Northern Everglades – Potential Management Measure

Project Feature/Activity: Lake Okeechobee and Estuary Watershed Basin Rule (LOER)

Level: 3

General Description/Background: This management measure originated as a component of the Lake Okeechobee and Estuary Recovery (LOER) plan and was originally titled Environmental Resource Permit (ERP) Revisions. The intent is to develop specific supplemental permit criteria for new permitted projects to demonstrate that no increase in total runoff volume will occur from new development that ultimately discharges to Lake Okeechobee or the Caloosahatchee or St. Lucie estuaries.

Purpose: The purpose of this measure is to not increase total runoff volume from new development that discharge ultimately to Lake Okeechobee or the Caloosahatchee or St. Lucie estuaries.

Location/size/capacity: The basin rule would cover the Lake Okeechobee Watershed and the Caloosahatchee and St. Lucie Estuary Watersheds

Initiative Status: In March 2008, the South Florida Water Management District (SFWMD) initiated rule development for an ERP Basin Rule with supplemental criteria designed to result in no increase in total runoff volume from new development that ultimately discharges to Lake Okeechobee or the Caloosahatchee or St. Lucie Estuaries.

Cost: TBD

Documentation: Lake Okeechobee and Estuary Watersheds Basin Rule

Estimate of Water Quality Benefits

- Minimum: Unknown
- Maximum: Unknown
- Most Likely: Unknown
- Level of Certainty: Unknown
- Assumptions: Projected benefits will roll up under urban category

Estimate of Water Quantity Benefits

- Minimum: Unknown
- Maximum: Unknown
- Most Likely: Unknown
- Level of Certainty: Unknown
- Assumptions: NA

Screening Criteria

- Proof of Concept: 0
- Other Impacts: 0

Contact: Damon Meiers; SFWMD; 561-682-6876

Final Water Quality Method and Summary: N/A
Final Water Quantity Method and Summary: N/A

Method: Included in the BMP load reduction estimates (Soil and Water Engineering Technology Inc. 2008).

LO 38

Northern Everglades – Potential Management Measure

Project Feature/Activity: C-44 Littoral

Level: 5

General Description/Background: The creation of a littoral zone of native vegetation to "treat" for water entering the C-44 via the S308 can benefit Lake Okeechobee and the St Lucie Estuary. The project will maintain boat navigation through the lake.

Purpose: The C-43 canal receives a significantly larger volume of water the C44. However the loads entering the C44 are higher than the C43 because the C43 water passes through the Lakes natural littoral zone before leaving Lake Okeechobee. The manmade littoral zone for the C44 will uptake nutrients, remove particulate and provide wildlife benefits.

Location/size/capacity: Inside and parallel to the Herbert Hoover Dike from the S308 structure to the North (see photo)

Initiative Status: Idea.

Cost: TBD

Estimate of Water Quality Benefits

- Minimum: Unknown
- Maximum: Unknown
- Most Likely: Unknown
- Level of Certainty: Unknown
- Assumptions: NA

Estimate of Water Quantity Benefits

- Minimum: NA
- Maximum: NA
- Most Likely: NA
- Level of Certainty: Final
- Assumptions: NA

Screening Criteria

- Proof of Concept: 0
- Other Impacts: 0

Contact: Chad Kennedy; FDEP; 561-681-6706

Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): Undetermined
Total Nitrogen Reduction (metric tons/year): Undetermined

Method: Project is in the conceptual stage and information was insufficient to evaluate water quality benefits.

Final Water Quantity Method and Summary: N/A

LO 50

Northern Everglades – Potential Management Measure

Project Feature/Activity: Agricultural BMPs - Additional Agricultural BMPs (Urban Rollup)

Level: 5

General Description/Background: This is an advanced level of BMPs with chemical treatment, plus retention/detention pond to treat discharge from higher P loading land uses.

Purpose: To treat water and reduce nutrient loads at source

Location/Size/Capacity: All basins within the St. Lucie watershed as defined by the NEEPP

Initiative Status: Starting implementation in 2010

Cost: 143.6 million capital and 86.1 O&M cost from 2010 to 2015

Documentation: For more information, please see Table 6 from 2007 LOPP Update.

Estimate of Water Quality Benefits

- Minimum: 36 mt/yr
- Maximum: 36 mt/yr
- Most Likely: 36 mt/yr
- Level of Certainty: Conceptual
- Assumptions: It was calculated based on nutrient concentrations after implementing typical cost-share BMPs. It was applied to citrus, dairy, row crop, ornamentals, and sod

Estimate of Water Quantity Benefits

- Minimum: Unknown
- Maximum: Unknown
- Most Likely: Unknown
- Level of Certainty: Unknown
- Assumptions: NA

Screening Criteria

- Proof of Concept: 1
- Other Impacts: 0

Contact: Joyce Zhang; SFWMD; 561- 682-6341

Final Water Quality Method and Summary: N/A
Final Water Quantity Method and Summary: N/A

Method: Included in the BMP load reduction estimates (Soil and Water Engineering Technology Inc. 2008).

LO 63

Northern Everglades- Potential Management Measure

Project Feature/Activity: Wastewater & Stormwater Master Plans

Level: 4

General Description/Background: Initiative to work with entities (e.g. Cities and Counties) in the St. Lucie watershed responsible for wastewater & stormwater programs. Work with those entities to review existing wastewater & stormwater Master Plans to identify planned or possible projects that will provide additional nutrient reductions that could be implemented in the service area.

Purpose: Implement urban stormwater retrofitting projects or wastewater projects to achieve addition nutrient reductions and water storage.

Location: St. Lucie watershed

Initiative Status: Not initiated

Cost: TBD

Estimate of Water Quality Benefits

- Minimum: Urban Rollup
- Maximum: Urban Rollup
- Most Likely: Urban Rollup
- Level of Certainty: Unknown
- Assumptions: Projected benefits will roll up under urban category

Estimate of Water Quantity Benefits

- Minimum: Unknown
- Maximum: Unknown
- Most Likely: Unknown
- Level of Certainty: Unknown
- Assumptions: Projected benefits will roll up under urban category

Screening Criteria

- Proof of Concept:
- Other Impacts:

Contact: Frank Nearhoof; FDEP

Final Water Quality Method and Summary: N/A
Final Water Quantity Method and Summary: N/A

Method: Included in the BMP load reduction estimates (Soil and Water Engineering Technology Inc. 2008).

LO 64

Northern Everglades- Potential Management Measure

Project Feature/Activity: Unified Statewide Stormwater Rule

Level: 4

General Description/Background: Florida's stormwater treatment rules are technology-based and rely upon BMP design criteria that are presumed to achieve a specified level of stormwater treatment. The rule's original performance standard was "secondary treatment", or 80 percent average annual load reduction of Total Suspended Solids (TSS). However, the minimum level of treatment in Chapter 62-40, F.A.C., is "80 percent average annual load reduction of pollutants that cause or contribute to violations of water quality standards". Nutrients are the biggest source of water body impairment throughout the state and the Governor has directed FDEP to increase the level of stormwater nutrient treatment. Accordingly, FDEP and SFWMD staff are working on a statewide stormwater treatment rule that will be based on a performance standard of post-development nutrient loading does not exceed pre-development nutrient loading.

Purpose: To increase the level of nutrient treatment of stormwater from new development and thereby reduce the discharge of nutrients and excess stormwater volume.

Location: St. Lucie watershed

Initiative Status: Beginning July 07, Rule in effect mid to late 2010

Cost: TBD

Estimate of Water Quality Benefits

- Minimum: Unknown
- Maximum: Unknown
- Most Likely: Unknown
- Level of Certainty: Conceptual
- Assumptions: Rule will be adopted

Estimate of Water Quantity Benefits

- Minimum: Unknown
- Maximum: Unknown
- Most Likely: Unknown
- Level of Certainty: Conceptual
- Assumptions: Depends on how much infiltration and reuse is done

Screening Criteria

- Proof of Concept:
- Other Impacts:

Contact: Eric Livingston, FDEP, Tallahassee, 850/245-8430

Final Water Quality Method and Summary: N/A
Final Water Quantity Method and Summary: N/A

Method: Included in the BMP load reduction estimates (Soil and Water Engineering Technology Inc. 2008).

LO 65

Northern Everglades- Potential Management Measure

Project Feature/Activity: L-65 Culvert to L-8 Tieback

Level: 5

General Description/Background: Install a high volume (1000+/- cfs) inverted culvert under the C-44 Canal from the L-65 Canal to the L-8 Tieback Canal to facilitate the movement of low nutrient water from Stormwater Treatment Areas north of Lake Okeechobee to the L-8 Reservoir.

Purpose: To route STA-treated water from the Taylor Creek/Nubbin Slough area to the L-8 Reservoir via a new connection between the L-65 and L-8 Canals. The isolated connection prevents treated water from coming in contact with un-treated C-44 Canal water.

Location/Size/Capacity: Isolated connection of up to 1,000 cfs.

Initiative Status: Conceptual

Cost: TBD

Estimate of Water Quality Benefits

- Minimum: 0 mt/yr
- Maximum: 38.4 mt/yr
- Most Likely: 3.84 mt/yr
- Level of Certainty: Conceptual
- Assumptions: Assume all proposed improvements within the Taylor Creek/Nubbin Slough area are completed to provide 38.4 mt/yr of remaining P load. Assume that L-8 system could only take approximately 10 percent of average annual discharge of 187,583 ac-ft. This provides approximately 18,758 ac-ft of water and 3.84 mt/yr of P diverted from Lake Okeechobee

Estimate of Water Quantity Benefits

- Minimum: 0 ac-ft
- Maximum: 187,583 ac-ft
- Most Likely: 18,758 ac-ft (diverted from Lake Okeechobee)
- Level of Certainty: Conceptual
- Assumptions: An evaluation of the L-8 Basin system would need to be performed to determine the amount of water that could be brought into this system.

Contact: South Florida Water Management District

Final Water Quality Method and Summary: Undetermined

Final Water Quantity Method and Summary: Undetermined

Method: Water quality and quantity benefits are anticipated to occur as a result of this project; however, the magnitude of these benefits was not determined due to the conceptual status of the project.

LO 68

Northern Everglades- Potential Management Measure

Project Feature/Activity: Comprehensive Planning – Land Development Regulations (LDR)

Level: 3

Description: Initiative to work with entities (e.g. Cities and Counties) in the St. Lucie watershed responsible for comprehensive planning and land development approvals. Work with those entities to review current comprehensive plans and associated land development regulations to assure that they promote low impact design and proper stormwater treatment.

Purpose: Implement low impact design measures in St. Lucie watershed to achieve additional nutrient reductions and water storage.

Location: St. Lucie watershed

Initiative Status: Not initiated

Cost: TBD

Estimate of Water Quality Benefits

- Minimum: Unknown
- Maximum: Unknown
- Most Likely: Unknown
- Level of Certainty: Unknown
- Assumptions: Assume LDRs are changed to promote LID

Estimate of Water Quantity Benefits

- Minimum: Unknown
- Maximum: Unknown
- Most Likely: Unknown
- Level of Certainty: Unknown
- Assumptions: Assume LDRs are changed to promote LID

Screening Criteria

- Proof of Concept:
- Other Impacts:

Contact: Eric Livingston; FDEP; 850/245-8430

Final Water Quality Method and Summary: Incidental
Final Water Quantity Method and Summary: Incidental

Method: The main purpose of this project is to update land development regulations. Incidental water quality and quantity benefits are anticipated to occur as a result of this project; however, the magnitude of these benefits was not determined due to the nature of the project.

LO 87 Revised

Northern Everglades – Potential Management Measure

Project Feature/Activity: Florida Ranchlands Environmental Services Project (FRESP)

a. Existing Pilots
b. Future Pilots (none in the SLRW)
c. Full Implementation

Level: 1

General Description/Background: Launched in October 2005, the Florida Ranchlands Environmental Services Project (FRESP) will design a program in which ranchers in the Northern Everglades' sell environmental services of water retention, nutrient load reduction and wetland habitat expansion to agencies of the state and other willing buyers.

These ranches can bring services on line quickly as compared to other options and will complement public investment in regional water storage and water treatment facilities. The sale of the services will be additional income for ranchers who face low profit margins and will provide an incentive against selling land for more intensive agriculture and urban development—land uses that will further aggravate water flow, pollution, and habitat problems.

FRESP is being implemented through collaboration between World Wildlife Fund (WWF), 8 participating ranchers, USDA's Natural Resources Conservation Service and state agencies – the Florida Department of Agriculture and Consumer Services, the South Florida Water Management District, and the Florida Department of Environmental Protection. Technical support is being provided by scientists from the MacArthur Agro-Ecology Research Center and the University of Florida. Funding from Federal, state and private sources exceeds $5 mil for Phase One – pilot project implementation and program design.

Key Accomplishments

Developed procedures to compare different protocols for documenting environmental services from ranchlands. FRESP will field test different methods of using monitoring and modeling of hydrology, water and soil chemistry, and vegetation change to document the level of environmental services provided by ranch water management projects.

Completed the design, permitting and construction of water management projects on 4 ranches; additional water management projects will be implemented by four additional ranchers. Projects include rehydrating drained wetlands, water table management, and pumping water from a nearby canal through existing ranch wetlands and flowing back into the canal. Based on available information the 8 water management projects occupy some 8,500 acres not including drainage acres. A planning level estimate of the static water retention capacity of the eight projects is 8,260 ac-ft of water for a single storm event with the average ac-ft of storage per acre being 0.98 ft.

a. Existing Pilots: Four Ranchlands Environmental Services Pilot Projects (FRESPP) have been constructed with Alderman-Deloney Ranch (43 ac-ft of on-site water storage and treatment, 0.078 mt/yr, C-25), Williamson Cattle Company (150 ac-ft of on-site water storage, 0.09 mt/yr, S-191), Buck Island Ranch (967 ac-ft of on-site water storage and treatment, 0.37 mt/yr, C-41), and Lykes Bros., Inc. (5,000 ac-ft of regional water storage and treatment, 0.2 mt/yrC-40). Total $1,000,000 (District contributed $500,000 through Highlands Soil & Water Conservation District, FDACS $500,000 through Okeechobee Soil & Water Conservation District). $1,000,000 Conservation Innovation Grant is funding the monitoring and pay-for-performance program development.

b. Future Pilots (none in the SLRW): Four additional Rancher Agreements for implementation of FRESPP have been developed with C. M. Payne & Son, Inc. (932 ac-ft of on-site water storage, Fisheating Creek) - total of $298,489; Lightsey Cattle Company (135 ac-ft of on-site water storage, Fisheating Creek) - total of $137,280; Syfrett Ranch West (140 ac-ft of regional water storage, C-41A) - total of $183,500; and Rafter T Ranch (1,145 ac-ft of on-site water storage, Arbuckle Creek) - total of $609,151. The District provided State Community Budget Issue Request (CBIR) funding which was specifically appropriated by the State through the CBIR process for additional pilot projects implementing water management alternatives to store and treat runoff on private lands.

Developing the design of a pay for services program. Essential program design questions—such as how to assure a dedicated, multiyear funding source to meet contract payment obligations; how to establish what prices that will be paid for services and how to integrate a new pay-for-services program with other state and federal programs will be addressed and answered though the deliberations of the collaboration team, in cooperation with multiple stakeholders and with state agency officials.

c. Full Implementation- Watershed Static Water Retention Potential: Planning level estimates generated by the existing pilot projects were used to derive conservative estimates of potential static storage – maximum capacity to hold water from a single storm event. If FRESP contracts covered only 15 percent of improved pasture acreage in the Northern Everglades, using the average ac-ft/acre estimate of the 8 existing FRESP sites of 0.98, the potential storage estimate is 118,000 ac-ft of water (800,500 X 15 percent = 120,000 acres X 0.98 ac-ft / ac). If 15 percent of the unimproved pasture acreage is included the potential storage is 151,800 ac-ft (1,029,500 X 15 percent = 154,400 acres X 0.98 ac-ft /ac). Because these estimates are for a single storm event, they are conservative estimates of annual on-ranch water retention.

Location/Size/Capacity:

	Improved Pasture in LOPP Watershed	Acre-Ft Static Storage on Improved Pasture (0.98 ac-ft/ac)	Improved and Unimproved Pasture	Acre Ft Static Storage on Improved & Unimproved Pasture (0.98 ac-ft/ac)
Total Acres	800,464		1,029,509	
Assumptions re percent Acres in FRESP for Different Land Use Combinations				
10%	80,046	78,706	102,951	101,226
15%	120,070	118,058	154,426	151,840
20%	160,093	157,411	205,902	202,453

Initiative Status: Developed procedures to compare different protocols for documenting environmental services from ranchlands. FRESP will field test different methods of using monitoring and modeling of hydrology, water and soil chemistry, and vegetation change to document the level of environmental services provided by ranch water management projects.

Completed the design, permitting and construction of water management projects on 4 ranches; additional water management projects will be implemented by four additional ranchers. Projects include rehydrating drained wetlands, water table management, and pumping water from a nearby canal through existing ranch wetlands and flowing back into the canal. Based on available information the 8 water management projects occupy some 8,500 acres not including drainage acres. A planning level estimate of the static water retention capacity of the eight projects is 8,260 ac-ft of water for a single storm event with the average ac-ft of storage per acre being 0.98 ft.

Developing the design of a pay for services program. Essential program design questions—such as how to assure a dedicated, multiyear funding source to meet contract payment obligations; how to establish what prices that will be paid for services and how to integrate a new pay-for-services program with other state and federal programs will be addressed and answered though the deliberations of the collaboration team, in cooperation with multiple stakeholders and with state agency officials.

Estimate of Water Quantity Benefits

- Minimum: TBD
- Maximum: TBD
- Most Likely: TBD
- Level of Certainty: conceptual/final/unknown
- Assumptions: Planning level estimates generated by the existing pilot projects were used to derive conservative estimates of potential static storage – maximum capacity to hold water from a single storm event. If FRESP contracts covered only 15 percent of improved pasture acreage in the Northern Everglades, using the average ac-ft/acre estimate of the 8 existing FRESP sites of 0.98, the potential storage estimate is 118,000 ac-ft of water (800,500 X 15 percent = 120,000 acres X 0.98 ac-ft / ac). If 15 percent of the unimproved pasture acreage is included the potential storage is

151,800 ac-ft (1,029,500 X 15 percent = 154,400 acres X 0.98 ac-ft / ac). Because these estimates are for a single storm event, they are conservative estimates of annual on-ranch water retention.

Contact: Benita Whalen; SFWMD; 863-462-5260

LO 87a

Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): 0.078
Total Nitrogen Reduction (metric tons/year): Undetermined

Method: Water quality benefits were based on results of existing pilots. Nitrogen reductions were not provided.

Final Water Quantity Method and Summary

Capacity (acre-feet): 43

Method: Water quantity benefits were provided and based on existing pilots.

LO 87c

Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): Undetermined

Total Nitrogen Reduction (metric tons/year): Undetermined

Method: Water quality benefits are anticipated to occur as a result of this project; however, the magnitude of these benefits was not determined due to the nature of the project.

Final Water Quantity Method and Summary

Capacity (acre-feet): 15,629

Method: Assumed 15% of the unimproved pasture in the SLR Estuary watershed is the effective area (106,321 acres X 15% = 15,948 acres) and storage was 0.98 ac-ft/ac based on the average of existing pilot projects (15,948 X 0.98ac-ft/ac = 15,629 acre-feet).

SLE 2

Northern Everglades- Potential Management Measure

Project Feature/Activity: White City Drainage Improvements
(a) Canal D
(b) Canals B, C, E, F, G

Level:
(a) 1
(b) 2

General Description/Background: Improve/retrofit various direct discharges to St. Lucie River from basin

Purpose: To improve water quality of storm water flows to the North Fork the St. Lucie River by modifying canal stages and reducing the potential for pollutant run-off from pastures using modern storm systems and Best Management Practices.

Location/Size/Capacity: Various locations within the 50 acre basin

Initiative Status:
(a) Approved and ongoing by St. Lucie County
(b) Approved and pending authorization; will most likely result in multiple small retrofits in area

Cost: $3.4 million

Documentation: Master Plan, CERP, SWIM, TMDL efforts

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely: (Reductions) ~10% coliform; 20% - 50% nutrients and solids
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Contact: Jason Bessey, Stormwater Program, St. Lucie County Public Works, 772-462-1668

Final Water Quality Method and Summary: Negligible

Method: Water quality benefits were considered negligible due to the small size and nature of the project.

Final Water Quantity Method and Summary: N/A

SLE 3

Northern Everglades- Potential Management Measure

Project Feature/Activity: White City Drainage Improvements (Citrus/Saeger)

Level: 1

General Description/Background: Construction of 4 acre storm water detention pond with associated outfall structure

Purpose: Capture, store and treat run-off and provide controlled release to the St. Lucie River

Location/Size/Capacity: The project is in St. Lucie County at the intersection of Citrus and Saeger. The project would utilize a portion of a 50 acre basin.

Initiative Status: Approved and on-going by St. Lucie County

Cost: $300,000

Documentation: Master Plan, CERP, SWIM, TMDL efforts

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely: (Reductions) 30% - 50% Nutrients and Solids
    - 33 lbs P
    - 163 lbs N
- Level of Certainty: 80%
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:
- Most Likely: Capture first 1” of run-off (~22 acre-ft)
- Level of Certainty:
- Assumptions:

Contact: Jason Bessey, Stormwater Program, St. Lucie County Public Works, 772-462-1668

Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): 0.01

Total Nitrogen Reduction (metric tons/year): 0.03

Method: Loading rates were determined by applying estimated loading rates (Soil and Water Engineering Technology Inc. 2008) based on land use type (medium density residential) and acreage of effective area (50 acres). Load reductions were determined using estimated reduction factors based on literature review (Harper 2007).

Final Water Quantity Method and Summary: N/A

SLE 6

Northern Everglades- Potential Management Measure

Project Feature/Activity: Indian River Estates/Savannas Ecosystem Management Project

Level: 1

General Description/Background: Construction of a pump station, infrastructure and water detention cells to manage and treat run-off from a 1200 acre residential basin

Purpose: To improve flood control and treat stormwater that currently discharges directly to the Indian River Lagoon and North Fork of the St. Lucie River

Location/Size/Capacity: The project is a 1200 acre basin in St. Lucie County adjacent to the Savannahs Preserve and Indian River Lagoon

Initiative Status: approved and on-going by St. Lucie County

Cost: $8 Million

Documentation: Master Plan, CERP, SWIM, TMDL efforts

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely: Reductions TP 952 lbs. (0.48 MT), TN 4760 lbs (2.4 MT per year)
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:
- Most Likely: 32 acre-feet of storage
- Level of Certainty: 80%
- Assumptions:

Contact: Jason Bessey, Stormwater Program, St. Lucie County Public Works, 772-462-1668

Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): 0.76
Total Nitrogen Reduction (metric tons/year): 0.83

Method: Loading rates were determined by applying estimated loading rates (Soil and Water Engineering Technology Inc. 2008) based on land use type (medium density residential) and acreage of effective area (1,200 acres). All run-off water is diverted away from the SLR Estuary; therefore, load reductions are 100% of the estimated loads.

Final Water Quantity Method and Summary: N/A

SLE 7

Northern Everglades- Potential Management Measure

Project Feature/Activity: Platt's Creek Alum Enhancement &Hybrid Wetland

Level: 1

General Description/Background: Add Alum injection to an existing Stormwater treatment system and modify the current outfall(s) and discharge conveyance to be incorporated into the restoration of a prior citrus operation to floodplain forest, marsh and flatwoods.

Purpose: Improve the performance of an existing Stormwater treatment system by: Management of aquatic plants for nutrient uptake, Chemical injection, Increasing capture volume and residency time, and creation of a suitable discharge conveyance to complement the restoration and preservation of the native habitat along the shoreline of the North Fork of the St. Lucie River.

Location/Size/Capacity: The 100 acre project site is in St. Lucie County located North of Platt's Creek tributary and directly adjacent to the river. The Stormwater treatment system covers 20 acres with a treatment capacity of 59 Ac/Ft or first 0.66" of runoff. Proposed modifications will increase capacity by 16 Ac/Ft and double residency time.

Initiative Status: Alum enhancement will be complete August 2008. Outfall modifications and site restoration are approved and in design by St. Lucie County.

Cost: $6 Million

Documentation: Master Plan, CERP, SWIM, TMDL efforts

Estimate of Water Quality Benefits

- Minimum: 40% TN reduction, 50% TP reduction, 90% FC reduction
- Maximum: 50% TN reduction, 90% TP reduction, 100% FC reduction
- Most Likely: see maximum above
- Level of Certainty: 90%
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:
- Most Likely: Capture and attenuate 90% of rainfall events.
- Level of Certainty: 90%
- Assumptions:

Contact: Jason Bessey, Stormwater Program, St. Lucie County Public Works, 772-462-1668

Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): 0.03
Total Nitrogen Reduction (metric tons/year): 0.11

Method: Loading rates were determined by applying estimated loading rates (Soil and Water Engineering Technology Inc. 2008) based on land use type (citrus agriculture) and acreage of effective area (80 acres). Load reductions were determined using estimated reduction factors for wet detention projects with Alum from England *et.al*.

Final Water Quantity Method and Summary: N/A

SLE 9

<u>Northern Everglades- Potential Management Measure</u>

Project: Natural Lands in IRL-S CERP Project:
a. PalMar Area
b. Allapattah Area
c. Cypress Creek/Trail Ridge Area

Level: see specific project

Description: The recommended plan includes a component called natural storage areas. These are currently drained pasture lands that will be hydrologically restored to provide a variety of project benefits. The purposes of the natural areas have been identified for use as alternative storage, rehydration, and habitat restoration. This land currently consists primarily of native and improved pasture. Some of the existing land is classified as wetlands, and the remainder of the land is classified as a type of upland. The natural areas have been broken down into three components. These include: Palmar Area, Allapattah Area, and Cypress Creek/Trail Ridge Area.

Purpose: By restoring the natural hydropattern in these areas, large volumes of water that now rapidly drain off these lands can be retained in wetlands. The natural areas will provide approximately 30,000 acre-feet of freshwater storage for the project through this onsite retention of stormwater. Onsite retention in these areas will also reduce phosphorus and nitrogen loads to the estuaries while providing increased spatial extent of natural wetlands and upland habitat for wildlife. Finally, onsite retention will recharge the superficial aquifer.

Location/Size/Capacity: 92,000 acres in Martin, St. Lucie, and Okeechobee Counties

Initiative Status: Approximately 30,000 acres have been protected through mitigation programs, conservation easements, and acquisition. There are 62,000 acres remaining to be protected through this project.

Cost: TBD. We note that land values reflected in the current real estate market may provide an opportunity for protection now before property values escalate.

Documentation: For more information, please see the IRL-S PIR. Additional assessment of this project has been vetted through public agencies in the South Florida Ecosystem Restoration Task Force's Natural Lands Report provided to Congress in 2006.

Estimate of Water Quality Benefits:
Minimum –
Maximum-
Most Likely-
Level of Certainty- conceptual/final/unknown
Assumptions leading to benefit estimate

Estimate of Water Quantity Benefits:
Minimum –
Maximum-
Most Likely-
Level of Certainty- conceptual/final/unknown
Assumptions leading to benefit estimate

Contact: South Florida Water Management District

SLE 09a

Northern Everglades- Potential Management Measure

Project Feature/Activity: CERP - IRL South: PalMar Complex - Natural Storage and Water Quality Area

Level: 1

General Description/Background: Approximately 17,143 acres of pastureland in the C-44 basin has been identified for use as alternative storage, nutrient removal, rehydration and habitat restoration. This land currently consists primarily of improved pasture with degraded wetlands. The location of this land is south and east of C-44. Establishing this land as a natural storage and treatment area is consistent with the ecological enhancement goal for the Comprehensive Everglades Restoration Plan (CERP) by increasing the spatial extent of functional natural areas, improving habitat and functional quality, and improving native plant and animal species abundance and diversity. This land also provides a "low tech" solution to water storage and water quality improvement needs in the basin, and its size and location will add to the greenway concept by providing close proximity to other public lands such as Jonathan Dickenson State Park, Atlantic Ridge, Corbett Wildlife Management Area, DuPuis Reserve and Palmar. Greenways are critical to reestablishing diverse wildlife populations of some keystone and threatened and endangered species.

The natural storage and water quality treatment areas have been disturbed to varying degrees by previous or current land uses. Specifically, swales, ditches, and canals have been constructed to drain some areas and irrigate others. In order to restore a more natural hydrology on these sites, swales and ditches will need to be filled and/or culverts will need to be plugged. In this preliminary design, the drainage features will all be filled. Filling provides the most conservative construction cost estimate. During detailed design, additional topographical and drainage feature data will be collected to determine where simply plugging culverts would provide an effective means of hydro-pattern restoration.
A comprehensive land management plan will be developed for each of the natural areas. The plan will include the control or eradication of exotic and nuisance plant species within the project feature, appropriate fire management, and appropriate cattle management to include either the complete removal of cattle or a minimal stocking density of cattle.

This water storage and treatment function provided by this project is consistent with the Corps policy regarding eligibility for Federal cost sharing of water quality features necessary for the restoration of the greater Everglades ecosystem (modifying the final use of runoff to meet ecosystem restoration targets). The treatment function provided by the natural storage area is intrinsic to the water storage function (i.e., a passive result); no special features were incorporated into the feasibility-level design to enhance water quality treatment functions. However, the reduction of nutrient loads to the estuary associated with storing watershed runoff is an important additional benefit provided by the natural storage and treatment areas and is consistent with the ecosystem restoration objectives for the St. Lucie Estuary and Indian River Lagoon.

Purpose: By restoring the natural hydro-pattern in this area, large volumes of water that now rapidly drain off these lands can be retained in wetlands. The natural areas will provide freshwater storage for the project through this onsite retention of stormwater. Onsite retention in these areas will also reduce phosphorus and nitrogen loads to the estuaries while providing increased spatial extent of natural wetlands and upland habitat for wildlife. Finally, onsite retention will recharge the superficial aquifer.

Location/Size/Capacity: 17,143 acres

Initiative Status: Indian River Lagoon – Project Implementation Report and Environmental Impact Statement (February 2004) was authorized by the U.S. Congress as described in the Water Resource Development Act of 2007

Cost: $107,761,857 (IRL-S PIR/EIS, Feb. 2004)

Documentation: Indian River Lagoon – Project Implementation Report and Environmental Impact Statement (February 2004)

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Contact: SFWMD

Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): 3.43
Total Nitrogen Reduction (metric tons/year): 13.39

Method: Reduction estimates for IRL-S PIR natural areas include SLE 09 a, b, and c, and SLE 26. Reductions were estimated using the total reduction estimates for natural areas from the IRL-S PIR (19.08 Mt/yr P and 74.38 Mt/yr N) multiplied by the percentage (18%) of acres of this MM (17,143 acres) to the total acres of natural areas (95,230 acres).

Final Water Quantity Method and Summary

Capacity (acre-feet): 5,700

Method: Storage estimates for IRL-S PIR natural storage and water quality areas included SLE 09 a, b, and c. The capacity was estimated using the total capacity estimates for natural storage and water quality areas from the IRL-S PIR (30,000 acre-feet) multiplied by the percentage (19%) of acres of this MM (17,143 acres) to the total acres of natural storage and water quality areas (92,130 acres).

SLE 09b

Northern Everglades- Potential Management Measure

Project Feature/Activity: CERP - IRL South: Allapattah Complex - Natural Storage and Water Quality Area

Level: 1

General Description/Background: The Allapattah Complex - Natural Storage and Treatment Area, is located in Martin County and includes approximately 42,348 acres of land in the C-23 basin. This land has been identified for use as alternative storage, rehydration, habitat restoration, and to provide incidental water quality treatment. This land currently consists primarily of improved pasture, degraded wetlands and some impacted native upland habitat. The large size, location along the C-23 canal and contiguous nature of these parcels make it the most important alternative storage area. The Allapattah Ranch, which encompasses 22,000 of the 42,348 acres, has been extensively drained for cattle grazing and other farming practices over the years. These drained hydric soils provide an excellent opportunity for restoration. By rehydrating these lands in a very cost effective manner, large volumes of water, which currently drain off the property during the rainy season, will be attenuated on-site. The western portion of the ranch also contains the last remaining large tract of forested wetlands in Martin County. The two parcels directly to the east of the ranch contain some of the largest remaining pine flatwood wet prairie habitat in the basin. These remaining forested areas will provide for habitat diversity until more forested communities can be reestablished on the ranch.

The natural storage and water quality treatment areas have been disturbed to varying degrees by previous or current land uses. Specifically, swales, ditches, and canals have been constructed to drain some areas and irrigate others. In order to restore a more natural hydrology on these sites, swales and ditches will need to be filled and/or culverts will need to be plugged. In the preliminary design, the drainage features will all be filled. Filling provides the most conservative construction cost estimate. During detailed design, additional topographical and drainage feature data will be collected to determine where simply plugging culverts would provide an effective means of hydropattern restoration.

A comprehensive land management plan will be developed for each of the natural areas. The plan will include the control or eradication of exotic and nuisance plant species within the project feature, appropriate fire management, and appropriate cattle management to include either the complete removal of cattle or a minimal stocking density of cattle.

This water storage and treatment function provided by this project is consistent with the Corps policy regarding eligibility for Federal cost sharing of water quality features necessary for the restoration of the greater Everglades ecosystem (modifying the final use of runoff to meet ecosystem restoration targets). The treatment function provided by the natural storage area is intrinsic to the water storage function (i.e., a passive result); no special features were incorporated into the feasibility-level design to enhance water quality treatment functions. However, the reduction of nutrient loads to the estuary associated with storing watershed runoff is an important additional benefit provided by the natural storage and treatment areas and is consistent with the ecosystem restoration objectives for the St. Lucie Estuary and Indian River Lagoon.

Purpose: By restoring the natural hydro-pattern in this area, large volumes of water that now rapidly drain off these lands can be retained in wetlands. The natural areas will provide freshwater storage for the project through this onsite retention of stormwater. Onsite retention in these areas will also reduce phosphorus and nitrogen loads to the estuaries while providing increased spatial extent of natural wetlands and upland habitat for wildlife. Finally, onsite retention will recharge the superficial aquifer.

Location/Size/Capacity: 42,348 acres

Initiative Status: Indian River Lagoon – Project Implementation Report and Environmental Impact Statement (February 2004) was authorized by the U.S. Congress as described in the Water Resource Development Act of 2007

Cost: $179,542,351 (IRL-S PIR/EIS, Feb. 2004)

Documentation: Indian River Lagoon – Project Implementation Report and Environmental Impact Statement (February 2004)

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Contact: SFWMD

Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): 8.47
Total Nitrogen Reduction (metric tons/year): 32.73

Method: Reduction estimates for IRL-S PIR natural areas include SLE 09 a, b, and c, and SLE 26. Reductions were estimated using the total reduction estimates for natural areas from the IRL-S PIR (19.08 Mt/yr P and 74.38 Mt/yr N) multiplied by the percentage (44.5%) of acres of this MM (42,348 acres) to the total acres of natural areas (95,230 acres).

Final Water Quantity Method and Summary

Capacity (acre-feet): 13,800

Method: Storage estimates for IRL-S PIR natural storage and water quality areas included SLE 09 a, b, and c. The capacity was estimated using the total capacity estimates for natural storage and water quality areas from the IRL-S PIR (30,000 acres-feet) multiplied by the percentage (46%) of acres of this MM (42,348 acres) to the total acres of natural storage and water quality areas (92,130 acres).

SLE 09c

Northern Everglades- Potential Management Measure

Project Feature/Activity: CERP - IRL South: Cypress Creek/Trail Ridge Complex - Natural Storage and Water Quality Area

Level: 2

General Description/Background: The Cypress Creek Complex - Natural Storage and Treatment Area, is located in St. Lucie and Okeechobee Counties and includes 32,639 acres of primarily pastureland, along with some of the last remaining large tracts of forested wetland habitat in St. Lucie County. This land has been identified for use as alternative storage, rehydration, habitat restoration, and water quality improvements. The parcels consist primarily of the V-2 Ranch, lands around Cypress Creek and remnants of Bluefield Ranch. This area is one of the most important and highly valued properties included in the study for natural storage, water quality improvement and habitat restoration. However, a portion of the ranch has been impacted through many years of agricultural use. These properties contain an excellent mixture of both drained pasturelands and areas of lightly impacted upland and wetlands. By rehydrating these drained pastures, large volumes of water will be attenuated on-site during the rainy season, providing a low cost alternative to reservoir storage. The less impacted areas will help the overall reestablishment of native plant and animal species, including some listed as threatened and endangered.

The natural storage and water quality treatment areas have been disturbed to varying degrees by previous or current land uses. Specifically, swales, ditches, and canals have been constructed to drain some areas and irrigate others. In order to restore a more natural hydrology on these sites, swales and ditches will need to be filled and/or culverts will need to be plugged. In this preliminary design, the drainage features will all be filled. Filling provides the most conservative construction cost estimate. During detailed design, additional topographical and drainage feature data will be collected to determine where simply plugging culverts would provide an effective means of hydropattern restoration.

A comprehensive land management plan will be developed for each of the natural areas. The plan will include the control or eradication of exotic and nuisance plant species within the project feature, appropriate fire management, and appropriate cattle management to include either the complete removal of cattle or a minimal stocking density of cattle.

This water storage and treatment function provided by this project is consistent with the Corps policy regarding eligibility for Federal cost sharing of water quality features necessary for the restoration of the greater Everglades ecosystem (modifying the final use of runoff to meet ecosystem restoration targets). The treatment function provided by the natural storage area is intrinsic to the water storage function (i.e., a passive result); no special features were incorporated into the feasibility-level design to enhance water quality treatment functions. However, the reduction of nutrient loads to the estuary associated with storing watershed runoff is an important additional benefit provided by the natural storage and treatment areas and is consistent with the ecosystem restoration objectives for the St. Lucie Estuary and Indian River Lagoon.

Purpose: By restoring the natural hydro-pattern in this area, large volumes of water that now rapidly drain off these lands can be retained in wetlands. The natural areas will provide freshwater storage for the project through this onsite retention of stormwater. Onsite retention in these areas will also reduce phosphorus and nitrogen loads to the estuaries while providing increased spatial extent of natural wetlands and upland habitat for wildlife. Finally, onsite retention will recharge the superficial aquifer.

Location/Size/Capacity: 32,639 acres

Initiative Status: Indian River Lagoon – Project Implementation Report and Environmental Impact Statement (February 2004) was authorized by the U.S. Congress as described in the Water Resource Development Act of 2007

Cost: $180,971,792 (IRL-S PIR/EIS, Feb. 2004)

Documentation: Indian River Lagoon – Project Implementation Report and Environmental Impact Statement (February 2004)

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Contact: SFWMD

Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): 6.49
Total Nitrogen Reduction (metric tons/year): 25.29

Method: Reduction estimates for IRL-S PIR natural areas include SLE 09 a, b, and c, and SLE 26. Reductions were estimated using the total reduction estimates for natural areas from the IRL-S PIR (19.08 Mt/yr P and 74.38 Mt/yr N) multiplied by the percentage (35%) of acres of this MM (32,639 acres) to the total acres of natural areas (95,230 acres).

Final Water Quantity Method and Summary

Capacity (acre-feet): 10,500

Method: Storage estimates for IRL-S PIR natural storage and water quality areas included SLE 09 a, b, and c. The capacity was estimated using the total capacity estimates for natural storage and water quality areas from the IRL-S PIR (30,000 acre-feet) multiplied by the percentage (34%) of acres of this MM (32,639 acres) to the total acres of natural storage and water quality areas (92,130 acres).

SLE 10

Northern Everglades- Potential Management Measure

Project: St. Lucie Watershed Natural Area Registry Program

Level: 3

Description: A natural area registry program is a voluntary program designed to provide support for protecting the watershed's natural lands. The voluntary cooperation of a landowner to protect the natural elements, features, and characteristics of their own property is the basis for natural area registry programs. Through a "handshake" agreement the landowner agrees to conserve his or her land to the best of their abilities. In return, they can receive a survey of the plants, animals, and natural features on the property and be provided information on stewardship practices.

Purpose: The purpose of the natural areas registry is to protect and conserve natural lands within the St. Lucie watershed; educate landowners about the natural resource values and the value in protecting them; establish and maintain a relationship with landowners to assure that communication channels are kept open for sharing information about land values, land availability, conservation options, landowner appreciation, etc.

Location/Size/Capacity: Natural lands within the St. Lucie River watershed.

Initiative Status:

Cost: TBD. There would be only program cost as this is not a construction project or a land acquisition project.

This program could also be coordinated with the FWC Florida Landowner Incentive Program (LIP) which works with private landowners to educate and encourage land management activities that will maintain or enhance habitat conditions that benefit the needs of listed species. This is a 50% cost share program. Management practices could include hydrology enhancement projects, mechanical & chemical vegetation treatments, native vegetation restoration and prescribed fire.

A possible federal funding source is the NRCS Wildlife Habitat Incentives Program. This is a voluntary program that provides technical and financial assistance to landowners and others to develop upland, wetland, riparian and aquatic habitat. The focus in Florida is to enhance or restore native vegetative communities and to conserve declining or imperiled species. While funding for this program is unavailable in the present budget, it is an option for future years of the St. Lucie Watershed Protection Plan.

Documentation: The Nature Conservancy is a partner in similar programs in other states and can provide additional information. This is a non-binding, voluntary program.

Estimate of Water Quality Benefits:
Minimum –
Maximum-
Most Likely-
Level of Certainty- conceptual/final/unknown
Assumptions leading to benefit estimate

Estimate of Water Quantity Benefits:
Minimum –
Maximum-
Most Likely-
Level of Certainty- conceptual/final/unknown
Assumptions leading to benefit estimate

Contact: The Nature Conservancy

Final Water Quantity Method and Summary: Incidental
Final Water Quantity Method and Summary: Incidental

Method: The primary purpose of this MM is to conserve land. Water quality and quantity benefits are anticipated to occur as a result of this project; however, the magnitude of these benefits was not determined due to the nature of this project.

SLE 11

Northern Everglades- Potential Management Measure

Project Feature/Activity: Creation of suitable oyster substrate in the St. Lucie Estuary at various sites identified in IRL-South PIR (Artificial Habitat Creation)

Level: 1

General Description/Background: Build upon existing efforts to create suitable oyster substrate in the St. Lucie Estuary using natural or made-made conditions (i.e. "oyster balls", limestone rocks, relict shell bags, etc.) placed under docks or on open slopes. (NOTE: previous efforts have indicated that a total of 180 acres of artificial habitat should be created in the SLE via this means: 135 acres of oyster shell hash and 45 acres of prefabricated reef balls). Martin County has constructed 1 small demonstration project (2004-2005) and a subsequent ½ acre project in 2006. Monitoring of the ½ acre site indicates the current filtering capacity to be 25M gallon/day.

Purpose: Established oyster reefs provide many ecological benefits including improvement of water quality. Oysters are a vital species in achieving restoration of the St. Lucie Estuary. They are a key indicator of the health of the system and are also very effective bio-filters of fine sediments and nutrients in the water column. Creating additional oyster habitat area is essential because it aids in the restoration process by providing a location for oyster larvae to settle thus increasing the population filtering base. In addition, the St Lucie could use some substrate to help jumpstart the oyster recruitment process. Currently, there are very few acres of oyster reefs remaining.

Location/Size/Capacity: Ultimately, many sites in the middle estuary could be created. Each site could be approximately 20 acres in area and could include 15 acres of shell hash and 5 acres of prefabricated 2-foot diameter concrete reef balls.

Previous research has identified areas that historically supported oyster growth, but were lost as a result of degraded water quality. Constructed projects would be located by referencing the research, and creating/restoring oyster growth in these historic areas. The construction layout will be comprised of patch reefs that are separated by approximately 30 ft. (10 m). Patches will be of approximate equal size (area = 316 ft^2 (30 m^2), volume = 6 ft^3 (0.6 m^3) each) and will be 6-in (15.24 cm) thick. High levels of success in prior projects have indicated that this construction method is the most productive. In habitats with sufficient depth these patch reefs may include the addition of prefabricated 2-foot diameter concrete reef balls.

Initiative Status: Previous projects have been constructed by Martin County using the design described above. These projects have met with a high degree of success. Permits will be required with a turn around for these projects at typically 3-4 months based on permitting for the 2 prior projects. Although this management measure was included in the Final PIR for IRL-South, it was not included in the Chief of Engineer's Report and therefore was not authorized in WRDA 2007. This is a critical measure to ensure habitat restoration. Substrate is a limiting factor in the SLE and is declining each year.

Cost:	Total project cost per acre:	$270,000
	St. Lucie Estuary Protection Plan funding request per acre	$180,000

Documentation: CERP Indian River Lagoon – South PIR - August, 2002; Martin County Artificial and Oyster Reef Monitoring in the St. Lucie River and Indian River Lagoon, Florida – September, 2007

Estimate of Water Quality Benefits

- Minimum: At 1 year growth, filter 50M gal/day/acre
- Maximum: At 1 year growth, filter 100 M gal/day/acre
- Most Likely: 75M gal/day/acre
- Level of Certainty: High- based on performance of existing projects in Middle Estuary
- Assumptions: Natural salinity conditions are maintained, however monitoring of sites established at times of high release rates (2004 & 2005) have shown excellent natural recruitment on constructed substrate. Good resilience of oyster population overall in the Middle Estuary has been demonstrated.

Estimate of Water Quantity Benefits

- Minimum: N/A
- Maximum: N/A
- Most Likely: N/A
- Level of Certainty: N/A
- Assumptions: N/A

Contact: Kathy Fitzpatrick, P.E., Martin County, 772-288-5429

Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): Undetermined
Total Nitrogen Reduction (metric tons/year): Undetermined

Method: This project is located in the SLR Estuary and does not contribute to reduction in loads from the SLR Watershed. It is anticipated that the project will reduce total phosphorous and nitrogen from within the SLR Estuary.

Final Water Quantity Method and Summary: N/A

SLE 13

Northern Everglades- Potential Management Measure

Project Feature/Activity: Develop an On-site Sewage Treatment and Disposal System (OSTDS) inspection and pump-out program within designated areas of concern

Level: 4

General Description/Background: EPA recommends an inspection and pump-out every 3-5 years for an OSTDS. Most older urban areas within the St. Lucie River watershed both have a septic system and are located in close proximity to impaired waters. These areas of concern are also in low lying or flood prone developments which further necessitates periodic OSTDS maintenance. An incentive program could help residents identify damaged or non-functioning septic systems by providing financial assistance and technical expertise. Valuable data could be obtained by this program and area waters would benefit from increased maintenance and repair.

Purpose: To reduce the amount of water quality problems related to damaged or non-functioning septic systems

Location/Size/Capacity: Martin and St. Lucie Counties (specific locations to be determined), areas of concern will be delineated using existing WQ data and prioritized. There are approx. 70,000 OSTDS in the basin. Assuming 15% are in areas of concern, there would be 10,500 systems eligible for the program.

Initiative Status: conceptual

Cost: (Initial estimate) $2.5M for 10,500 systems over 5 years

Documentation: Department of Health data, Wekiva River area study

Estimate of Water Quality Benefits: source reduction of 2.3M gallons of untreated septage entering the ground. Assuming: 15% participation, 15% of those found failing, 40 gal./person/day for a year.

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits: N/A

- Minimum:
- Maximum:
- Most Likely:

- Level of Certainty:
- Assumptions:

Contact: St. Lucie and Martin County Health Departments

Final Water Quality Method and Summary: Undetermined

Method: Water quality benefits are anticipated to occur as a result of this project; however, the magnitude of these benefits was not determined due to the nature of this project.

Final Water Quantity Method and Summary: N/A

SLE 16

Northern Everglades- Potential Management Measure

Project Feature/Activity: Improved management of sludge disposal in St. Lucie County through the use of an innovative technology (Plasma-Arc)

Level: 1

General Description/Background: The current disposal practices of land applying Biosolids will be phased out in favor of the Plasma Arc Gasification process to be utilized at the St. Lucie County Solid Waste Baling & Recycling facility.

Purpose: To remove a major pollution source of bacteria and nutrients to area waters by providing an alternative disposal method.

Location/Size/Capacity: St. Lucie County, FL 1500 Tons/day initial, then expanded to 3000 Tons/day.

Initiative Status:

Cost: $0.00 (project is privately funded)

Documentation: FDEP Residuals Annual Summary Report, 2004; Dr. Lou Circeo, "Engineering & Environmental Applications of Plasma Arc Technology"

Estimate of Water Quality Benefits:

- Minimum: 22 Tons Nitrogen, 17 Tons Phosphorus Removed annually.
- Maximum: The source removal and ultimate immobilization of well over 1000 Tons Nitrogen and 700 Tons Phosphorus per year.
- Most Likely:
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits: N/A

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Contact: Jason Bessey, Stormwater Program, St. Lucie County Public Works, 772-462-1668

Final Water Quality Method and Summary: Undetermined

Method: Water quality benefits are anticipated to occur as a result of this project; however, the magnitude of these benefits was not determined because the actual loading from manure to the watershed is unknown.

Final Water Quantity Method and Summary: N/A

SLE 18

Northern Everglades- Potential Management Measure

Project Feature/Activity: Additional Reservoirs and/or Stormwater Treatment Areas to capture and treat any remaining undesired releases from Lake Okeechobee and/or the local watershed to the St. Lucie River and Estuary not addressed by the proposed improvements north of the lake.

Level: various for each option/opportunity

General Description/Background: The proposed projects in the Lake Okeechobee Protection Plan and the CERP Indian River Lagoon Project Implementation Report will provide significant reduction in the amount of undesirable discharges from the lake and/or local watershed to the estuary. Any remaining undesirable discharges could be addressed through the construction of additional reservoirs and/or stormwater treatment areas to capture and treat these remaining lake discharges.

Purpose: To provide storage and treatment of water that is discharged from the lake and/or the local watershed to the estuary at undesirable times and amounts.

Location/Size/Capacity: To be determined

Initiative Status: conceptual

Cost: To be determined

Documentation:

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Contact: South Florida Water Management District

SLE 18a

Northern Everglades- Potential Management Measure

Project Feature/Activity: Reservoir and/or Stormwater Treatment Area along the south side of the C-44 Canal to capture and treat any remaining undesired releases from Lake Okeechobee to the St. Lucie River and Estuary not addressed by the proposed improvements north of the lake.

Level: 5

General Description/Background: The proposed projects in the Lake Okeechobee Protection Plan will provide significant reduction in the amount of undesirable discharges from the lake to the estuary. Any remaining undesirable discharges could be addressed through the construction of a reservoir and/or stormwater treatment area to capture and treat these remaining lake discharges.

Purpose: To provide storage and treatment of water that is discharged from the lake to the estuary at undesirable times and amounts.

Location/Size/Capacity: To be determined

Initiative Status: conceptual

Cost: To be determined

Documentation:

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Contact: South Florida Water Management District

Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): To be determined
Total Nitrogen Reduction (metric tons/year): To be determined

Method: Water quality benefits are to be determined.

Final Water Quantity Method and Summary

Capacity (acre-feet): To be determined

Method: Water quantity benefits are to be determined.

SLE 18b

Northern Everglades- Potential Management Measure

Project Feature/Activity: Additional Reservoirs and/or Stormwater Treatment Areas along the C-23 and C-24 Canal to capture and treat any remaining undesired releases from Lake Okeechobee and/or the local watershed to the St. Lucie River and Estuary not addressed by the proposed improvements north of the lake.

Level: 5

General Description/Background: The proposed projects in the Lake Okeechobee Protection Plan and the CERP Indian River Lagoon Project Implementation Report will provide significant reduction in the amount of undesirable discharges from the lake and/or local watershed to the estuary. Any remaining undesirable discharges could be addressed through the construction of additional reservoirs and/or stormwater treatment areas to capture and treat these remaining lake discharges.

Purpose: To provide storage and treatment of water that is discharged from the lake and/or the local watershed to the estuary at undesirable times and amounts.

Location/Size/Capacity: To be determined

Initiative Status: Conceptual

Cost: To be determined

Documentation:

Estimate of Water Quality Benefits

- Minimum:
- Maximum: 30 mt/yr of TP and 100 mt/yr of TN
- Most Likely:
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Contact: SFWMD – Phone # 561-681-2563

Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): 8.47
Total Nitrogen Reduction (metric tons/year): 32.73

Method: Reduction estimates for IRL-S PIR natural areas include SLE 09 a, b, and c, and SLE 26. Reductions were estimated using the total reduction estimates for natural areas from the IRL-S PIR (19.08 Mt/yr P and 74.38 Mt/yr N) multiplied by the percentage (44.5%) of acres of this MM (42,348 acres) to the total acres of natural areas (95,230 acres).

Final Water Quantity Method and Summary

Capacity (acre-feet): 13,800

Method: Storage estimates for IRL-S PIR natural storage and water quality areas included SLE 09 a, b,

SLE 19

Northern Everglades- Potential Management Measure

Project Feature/Activity: Conversion of existing secondary drainage ditches into “linear wetland/shallow lake treatment areas” (i.e. similar to St. James Canals)

Level: 4

General Description/Background: There are large number of existing secondary drainage ditches which receive runoff from surrounding residential areas along the North Fork and South Fork of the St. Lucie River. Several of these drainage ditches convey stormwater, uncontrolled, directly into the North Fork and South Fork of the St. Lucie River. Installation of weir structures at the outfall locations of the uncontrolled drainage ditches will create a standing pool of water upstream of the weir structure. Weir structures will be set at an elevation that will not cause a headwater effect resulting in upstream flooding.

Purpose: Conversion of existing canals into “linear wetland/shallow lake treatment areas” will provide additional treatment of stormwater entering the North Fork and South Fork of the St. Lucie River. Currently there are several uncontrolled drainage ditches that discharge directly into the St. Lucie Estuary. Installation of a weir structure will create linear standing pools upstream of the weir. These standing pools will create the opportunity for longer residence time resulting in nutrient assimilation and attenuation during times of base flow and low flow conditions. Depending on the water depth behind the weir, it is anticipated that linear shallow lakes or wetlands will become established. Removal of excess nutrients will improve water quality in the North Fork and South Fork of the St. Lucie River and the St. Lucie Estuary downstream.

Location/Size/Capacity: Drainage canal outfall locations in the North Fork and South Fork Basins. Locations are to be determined.

Initiative Status: conceptual

Cost: tbd

Documentation:

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Contact: SFWMD

Final Water Quality Method and Summary: Undetermined

Method: Water quality benefits are anticipated to occur as a result of this project; however, the magnitude of these benefits was not determined due to the conceptual status of the project.

Final Water Quantity Method and Summary: N/A

SLE 22

Northern Everglades- Potential Management Measure

Project Feature/Activity: North River Shores Vacuum Sewer System

Level: 1

General Description/Background: Vacuum assisted gravity sewer collection system to provide service to approximately 750 single and multi family residential units.

Purpose: Septic Tank Elimination

Location/Size/Capacity: Along the banks of the east side of the North Fork of the St. Lucie River, North of the Roosevelt Bridge, West of U.S. 1 and South of Britt Road. It will service approximately 750 single and multi-family residential units, presently disposing of approximately 190,000 gallons per day of waste through septic tanks.

Initiative Status:

Cost: approximately $10,000,000 (estimate as of 1/15/07) 2-year project

Documentation: 60% construction drawings and St. Lucie River Septic Tank/Water Quality Study from the Harbor Branch Oceanographic Institution.

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely: Eliminate nutrient loading from septic tanks @ 3.5 lbs TN per month and .89 lbs TP per month per septic tank as per FDEP study.
- Level of Certainty: 90% - State law requires residential connection to sewer system within 365 days of its availability.
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:
- Most Likely: Increased wastewater flow @ 190,000 gpd from homes to be converted to reuse
- Level of Certainty: 90% - State law requires residential connection to sewer system within 365 days of its availability.
- Assumptions:

Contact: St Lucie County, Utilities/Solid Waste (772) 223-7977

Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): 2.18
Total Nitrogen Reduction (metric tons/year): 8.57

Method: Reductions based on LBFH, Inc. data and February 2007 letter referencing FDEP credits to septic systems.

Final Water Quantity Method and Summary: N/A

SLE 24

Northern Everglades- Potential Management Measure

Project Feature/Activity: CERP - IRL South: C-23/24 Reservoir/STA

Level: 1

General Description/Background: This project consists of three components described as follows:

C-23/24 North Reservoir: This feature is located in St. Lucie County on the west side of C-24 between control structures G-81 and G-79 and includes a 4,399-acre aboveground reservoir with a maximum depth of 12-feet. The total storage capacity of the reservoir is approximately 48,500 acre-feet.
The purpose of this component is to capture local runoff from the C-23 and C-24 Basins. The pump station will be designed to provide up to 900-cfs removal rate from C-24 canal. This water can then be routed to the C-23/24 STA or returned to C-23 or C-24 when there is a need to reclaim storage capacity or meet a water supply demand. The component is designed for stormwater attenuation to the estuary to control salinity and to provide an additional source of agricultural water supply. This component is also expected to provide incidental water quality benefits by reducing loads of nutrients, pesticides, and other pollutants.

This component also can be operated to contribute flow to the diversion canal. It allows stormwater originating in the C-23 and C-24 basins to be directed into the C-23/C-24 STA to be treated and then discharged from the STA into Ten Mile Creek. Ten Mile Creek forms the headwaters of the Northfork of the SLR. Thus, stormwater presently discharged from C-23 and C-24 directly into the SLR at points considered most harmful can be redirected to the headwaters of the St. Lucie River producing a more desirable salinity gradient within the river and estuary.

C-23/24 South Reservoir: This feature is located in St. Lucie County north and west of C-23 between control structures G-78 and G-79 and includes a 4,155-acre aboveground reservoir with a maximum depth of 12-feet. The total storage capacity of the reservoir is approximately 43,400 acre-feet.
This component functions very much like the C-23/24 North reservoir. A sag culvert or inverted siphon crossing under State Highway 70 will connect the two reservoirs. In fact, if it were not for Highway 70, these two reservoirs would be one. The pump station will be designed to remove up to 900 cfs from the C-23 canal. The intake and discharge points on the reservoir have been separated to prevent short-circuiting, which would negatively impact incidental water quality performance. Approximately 10,560 feet of Canal C-23 will be re-routed around the reservoir levee as part of the seepage canal system. The abandoned section of the canal will be left in place as an approach to the drawdown structure S-413 and as a fish refuge area.

C-23/24 Stormwater Treatment Area: This feature is located in St. Lucie County and includes a 2,568-acre Stormwater Treatment Area with a maximum depth of 4 feet and a normal operating depth of 2 feet. It is designed to remove 80% of the phosphorus from stormwater entering the C-23/24 reservoirs. The STA is located east of C-24 between control structures G-81 and G-79.

This facility will be a multi-cell STA covering approximately four square miles. The primary discharge from the STA will be into the header canal of the North SLR Water Control District. A 250-cfs pump station will transfer water from the C-23/24 North Reservoir into the STA. It is expected that the STA will be operated to discharge primarily into the header canal and then directed toward Ten Mile Creek. Other discharge options include C-25 and C-24. Approximately one mile of Sneed Road (State Road 613) will be abandoned.

This component of the recommended plan includes water quality features considered essential to Everglades restoration. This feature will be operated to reuse C-23/C-24 basin water to meet water quantity and nutrient targets for the SLE. These components capture water currently discharged to tide and store it to meet water quantity, quality, timing, and distribution targets for this portion of the Everglades ecosystem.

Purpose: The purpose of this project is to improve the quality, quantity, timing and distribution of water discharge to the St. Lucie River and Estuary from the local watershed.

Location/Size/Capacity: Storage – 91,900 acre-feet (total for both reservoirs); STA – 2568 acre-feet

Initiative Status: Indian River Lagoon – Project Implementation Report and Environmental Impact Statement (February 2004) was authorized by the U.S. Congress as described in the Water Resource Development Act of 2007

Cost: $332,145,375 (IRL-S PIR/EIS, Feb. 2004)

Documentation: Indian River Lagoon – Project Implementation Report and Environmental Impact Statement (February 2004)

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Contact: SFWMD

Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): 24.0
Total Nitrogen Reduction (metric tons/year): 104.2

Method: IRL PIR Appendix A P (A-369) for C23 Res/STA. Per the ACOE the C23/24 reservoirs north and south reservoirs and STA were lumped into the C23Res/STA.

Final Water Quantity Method and Summary

Final Capacity (acre-feet): 94,468 ac-ft (two reservoirs and 1 STA)

Method: IRL-S PIR/EIS

SLE 26

Northern Everglades- Potential Management Measure

Project Feature/Activity: CERP - IRL South: Northfork Natural Floodplain Restoration

Level: 2

General Description/Background: The North Fork lands are extremely important in linking the estuary to the watershed. Preservation will provide such water quality and environmental benefits as removing nutrients, maintaining valuable wading bird habitat, and serving as a nursery for many of the recreationally and commercially important fish species that spend certain life stages in this area. This feature includes acquisition and preservation of approximately 3,100 acres of floodplain and adjacent lands, which will receive an additional 64,500 acre-feet of flow via the northern diversion efforts. (Although it was assumed North Fork lands would be acquired in fee, during the PED phase other lesser estates will be given consideration, including a Conservation Easement, Flowage Easement, channel improvement easement, temporary construction easement or some combination of these estates.)

Purpose: Preserving lands within the North Fork corridor provides significant environmental improvement in the health of this portion of the river by preventing such degradation as increased stormwater runoff, increased turbidity, and increased influence of exotic plants and animals from the surrounding areas that are under significant development pressure.

Location/Size/Capacity: 3,100 acres of floodplain and adjacent lands

Initiative Status: Indian River Lagoon – Project Implementation Report and Environmental Impact Statement (February 2004) was authorized by the U.S. Congress as described in the Water Resource Development Act of 2007

Cost: $13,016,700 (IRL-S PIR/EIS, Feb. 2004)

Documentation: Indian River Lagoon – Project Implementation Report and Environmental Impact Statement (February 2004)

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:

- Most Likely:
- Level of Certainty:
- Assumptions:

Contact: SFWMD

Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): 0.57
Total Nitrogen Reduction (metric tons/year): 2.23

Method: IRL PIR with modifications. Load reductions were determined by ACOE based natural lands. SLE 27 and SLE 09 a-c were lumped into the category of natural lands. The load reductions were determined based on a ratio of area for each MM. SLE 26 is 3 % of the total area

Final Water Quantity Method and Summary: Incidental

SLE 27

Northern Everglades- Potential Management Measure

Project Feature/Activity: CERP - IRL South: Muck Remediation

Level: 3

General Description/Background: Muck remediation involves the removal of accumulated muck within the SLE from areas that are effectively "dead zones." Muck accumulation has covered substrate that once supported a healthy SAV and oyster community. Removal of this sediment would greatly improve estuarine conditions by exposing this substrate making it suitable for colonization by target species. Removing the muck would also improve water quality conditions for target species by improving the clarity of the water and reducing sunlight attenuation, especially critical for re-colonization and growth of SAV.

It is strongly believed that Lake Okeechobee is not a significant source of sediments delivered to the SLE and IRL. Lake Okeechobee, due to its size, behaves as a very large settling basin. Total suspended solids measured at the C-44 discharge point out of the Lake are normally in the 8-12 mg/l range, which is quite low. Therefore, there are few solids in the water to be delivered to the SLE and IRL. The soils in the C-44 canal are overwhelmingly fine sands and do not contribute significantly to muck in the SLE and IRL. Deposits left by high flow events from Lake Okeechobee consist almost entirely of fine sands. Analysis of the muck sediments and the soils of the watershed confirm that the principal source of the muck is erosion from the watershed. Improved land and watershed management practices are certain to result in reduced delivery of sediments to the SLE and IRL. The construction of reservoirs and STAs will further reduce muck forming sediments in the SLE and IRL.

Muck remediation can occur at several locations and offers the same benefits from alternative to alternative without regard to the configuration of the balance of the components included in that alternative. This component provides specific benefits to the SLE and the target species of the study but cannot be simulated through the use of models used for evaluation of the multipurpose alternative plans. This component is critical for restoring the estuary to a sustainable condition.

The four areas targeted in this study for remediation correspond closely with those identified in Haunert (1988) as "hot spots". Two areas are located in the North Fork, one in the South Fork, and one in the Mid-Estuary. Muck is accumulating in the study area at a rate 2.5 times faster than historically in the SLE. The excessive muck deposits cover a vast expanse of the SLR and SLE. This study chose to address only those 4 "hot spot" areas identified in Haunert (1988) that includes the majority of estuary muck.

Removal of SLE muck sediments has been identified as a component that may bring about an immediate, and potentially dramatic, improvement in water quality, as well as improvements in habitat quality and extent. A Corps survey conducted in 2000 with transects 500 feet apart in the SLE estimated removal of 5.5 million cubic yards of muck. Recent re-evaluation of the muck feature in 2003 has further refined the estimate to 7.9 million cubic yards of muck removal from the North and South Forks and Middle St. Lucie Estuary.

Excavation of deep cuts in the deepest layers of muck is the preferred method for removal and will provide sequestering potential for muck suspended by any cause such as wind, high currents, or boat traffic. Pilot cuts dredged to 13 feet in fine muck sediments in the South Fork of the SLR in 2002 and 2003 demonstrated the ability of the excavations to act as sediment traps, filling with muck accumulations within one year. The excavated cuts have the potential to collect fluid muck under appropriate hydraulic conditions, pulling muck from nearby shallower areas, as well as to trap muck moving along with currents. Realizing the importance of clearing muck from the shallower zones of the SLR and SLE that serve as habitat for oysters and SAV, final muck removal methods, locations, and accumulation rates will be determined with more detailed water quality and sediment transport modeling during the Pre-Construction Engineering and Design phase. The act of dredging itself is not likely to be a significant cause of re-suspension due to the vacuuming action of the dredge. Most disturbed material will be pulled into the suction flow of the dredge and removed from the SLR and SLE water column. The recommended disposal method is via a permanent upland spoil disposal site. The site is located just south of C-23 and just west of the Florida Turnpike in Martin County. It has been under intense agricultural use for many years as a sod farm. The recommended location is central to the major muck deposit locations and enables supernatant return via gravity to below the salinity control structure in C-23, a distance of approximately 2 miles east of the site. The disposal site is one square mile in area (640 acres). It would be bounded by an earthen levee approximately 18 feet high and dredged sediments would be pumped into the confined space and allowed to desiccate and consolidate in place. As consolidation occurs, space may be made available to future dredging disposal.

Purpose: Muck remediation involves the removal of accumulated muck within the SLE from areas that are effectively "dead zones." Muck accumulation has covered substrate that once supported a healthy SAV and oyster community. Removal of this sediment would greatly improve estuarine conditions by exposing this substrate making it suitable for colonization by target species. Removing the muck would also improve water quality conditions for target species by improving the clarity of the water and reducing sunlight attenuation, especially critical for re-colonization and growth of SAV.

Location/Size/Capacity: The four areas targeted in this study for remediation correspond closely with those identified in Haunert (1988) as "hot spots". Two areas are located in the North Fork, one in the South Fork, and one in the Mid-Estuary.

Initiative Status: Indian River Lagoon – Project Implementation Report and Environmental Impact Statement (February 2004) was authorized by the U.S. Congress as described in the Water Resource Development Act of 2007

Cost: $92,028,000 (IRL-S PIR/EIS, Feb. 2004)

Documentation: Indian River Lagoon – Project Implementation Report and Environmental Impact Statement (February 2004)

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely:

- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Contact: SFWMD

Final Water Quality Method and Summary: Undetermined

Method: This project is located in the SLR Estuary and does not contribute to reduction in loads from the SLR Watershed. It is anticipated that the project will reduce total phosphorous and nitrogen from within the SLR Estuary.

Final Water Quantity Method and Summary: N/A

SLE 28

Northern Everglades- Potential Management Measure

Project Feature/Activity: Tropical Farms / Roebuck Creek Stormwater Quality Retrofit

Level: 1

General Description/Background: The project is designed to capture the first inch of runoff from 540-acres and convey the runoff to a proposed Lake / Stormwater Treatment Area (STA) that will provide 39 acre-feet of stormwater attenuation and water quality treatment. The project consists of the installation of approximately 8,500 linear feet of stormpipe ranging from 18" to 48" diameter and the construction of a 1.5-acre lake and a 21 acre lake / STA system.

Purpose: To provide 39.2 acre-feet of water quality treatment and stormwater attenuation to 540 acres of Roebuck Creek.

Location/Size/Capacity: The Roebuck Creek basin is located in east, central Martin County, Florida more specifically, in Sections 1, 12 & 13 of Township 39 South, Range 40 East and Sections 5-8 and 18 of Township 39 South, Range 41 East. The total basin size is 1,915 acres. A 1.5 acre lake and a 21.1 acre Lake / STA system is proposed to provide 39.2 acre feet of attenuation and water quality treatment.

Initiative Status: Approved and on-going by Martin County

Cost: Total Project Cost is estimated to be over $4.0 million, of which Martin County is requesting a total of $600,000 from the State & SFWMD. Martin County will provide $300,000 in match.

Documentation: Tropical Farms Stormwater Quality Retrofit Study, Capital Improvement Plan, TMDL efforts

Estimate of Water Quality Benefits
- Minimum:
- Maximum:
- Most Likely: Reduce TSS 70-85% (10,852 kg/yr); TP 60-70% (90kg/yr); TN 35-45% (603 kg/yr)
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits
- Minimum:
- Maximum:
- Most Likely: Providing additional 39.2 acre-feet of storage within basin
- Level of Certainty:
- Assumptions:

Contact: Gary Roderick, Chief Office of Water Quality, Martin County

<u>Additional Project Information:</u> TROPICAL FARMS / ROEBUCK CREEK

Payment and Delivery Schedule:

Task	Deliverable	Schedule	Payment
Construction	Pay Requests / Engineer's Certification	Sep '08 to Apr '09	$600,000

How much project work has already occurred?

Design is 70% complete.
Permitting is on-going, it is anticipated that a permit will be issued in March 2008.
Only four (4) easements are necessary and acquisition has started and is on-going.

How much funding has already been obtained and from what sources?

Year	Source	Grant Amount	Martin County Match
FY06	SLRIT	$ 512,000	$ 512,000
FY07	SLRIT	$ 400,500	$ 400,500
FY08	SLRIT	$ 500,000	$ 500,000
FY07-08	TMDL	$1,412,500	$1,412,500

Breakdown of Martin County matching funds?

See above.

For the multi year projects, would Martin County need all funding in Year 1 or could it be spread over the project life?

Majority of any 5/5/5 funding would be for construction. The majority of funding would be needed in the first year of the grant.

How much work of the multi year project would be completed in Year 1?

If a 5/5/5 grant is obtained, the majority of funding would be for construction. Construction of this project is scheduled to begin in Sep - Oct 2008 and continue for 6-8 months. So the majority of funding would be needed in Year 1 of the 5/5/5 grant.

Where would the remaining funding for future years come from?

Other grants, County ad valorem taxes

Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): 0.04
Total Nitrogen Reduction (metric tons/year): 0.21

Method: Loading rates were determined by applying estimated loading rates (Soil and Water Engineering Technology Inc. 2008) based on land use type (low density residential) and acreage of effective area (540 acres). Load reductions were determined using estimated reduction factors based on literature review (Harper 2007).

Final Water Quantity Method and Summary: N/A

SLE 29

Northern Everglades- Potential Management Measure

Project Feature/Activity: Old Palm City Phase III Stormwater Quality Retrofit

Level: 1

General Description/Background: Phase 3 of the Old Palm City Retrofit project is to construct two (2) Stormwater Treatment Areas that will serve 106 acres of residential land that was first platted in the 1920's. The project proposes an East STA and West STA.

Purpose: To provide a total of 8.5 ac-feet of water quality treatment and stormwater attenuation to a total of 106 acre basin of residential lands developed prior to today's standards.

Location/Size/Capacity: This project is located in Palm City, Florida more specifically in Sections 17 & 20, Township 38 South, Range 41 East. The project consists of an East and West STA which are 4.8 acres and 6.9 acres in aerial extent, respectively. The East STA has 1.89 acre-feet of storage and the West STA has 6.64 acre-feet of storage.

Initiative Status: Approved and on-going by Martin County

Cost: Total Project Cost is estimated at $3.9 million, of which Martin County is requesting a total of $1.2 million from the State & SFWMD. Martin County will provide $600k in match.

Documentation: Old Palm City Phase 3 Engineering Design Report, CIP, TMDL efforts

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely: Capture and treat 1"+ over the 87 acre west basin and 1.2" over the 19 acre east basin
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:
- Most Likely: Providing additional 8.5 ac-ft of storage within basin
- Level of Certainty:
- Assumptions:

Contact: Gary Roderick, Chief Office of Water Quality, Martin County

Additional Project Information: OLD PALM CITY PHASE 3

Payment and Delivery Schedule:

Task	Deliverable	Schedule	Payment
Land Acquisition	Deeds and Easements	Mar '08 to Sep '08	$1,200,000

How much project work has already occurred?

Design is 85% complete, awaiting land acquisition to finalize.
Permitting is 95% complete, awaiting land acquisition to finalize.

How much funding has already been obtained and from what sources?

Year	Source	Grant Amount	Martin County Match
FY06	SLRIT	$ 411,800	$ 411,800
FY07	SLRIT	$ 400,000	$ 400,000
FY08	SLRIT	$ 244,500	$ 244,500
Phase 1	HMGP	$ 198,274	$ 64,050
Phase 2*	HMGP	$1,311,251	$ 439,125

- Phase 2 HMGP Grant is still pending.

Breakdown of Martin County matching funds?

See above.

For the multi year projects, would Martin County need all funding in Year 1 or could it be spread over the project life?

Any 5/5/5 funding would be allocated to land acquisition. Land acquisition is scheduled for March through September 2008. The funding is needed in the first year of the grant.

How much work of the multi year project would be completed in Year 1?

Since the 5/5/5 grant would be allocated to land acquisition, and the acquisition is scheduled for Year 1 of the grant then all the work is scheduled in Year 1.

Where would the remaining funding for future years come from?

Other grants, (SLRIT and FEMA HMGP), County ad valorem taxes

Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): 0.03

Total Nitrogen Reduction (metric tons/year): 0.07

Method: Loading rates were determined by applying estimated loading rates (Soil and Water Engineering Technology Inc. 2008) based on land use type (medium density residential) and acreage of effective area (106 acres). Load reductions were determined using estimated reduction factors based on literature review (Harper 2007).

Final Water Quantity Method and Summary: N/A

SLE 30

Northern Everglades- Potential Management Measure

Project Feature/Activity: Manatee Pocket Dredging Project

Level: 1

General Description/Background:
Shoaling and sedimentation in Manatee Pocket has been an ongoing process, accelerated during extreme storm events and fueled by upstream construction a development. Martin County has completed three separate storm water retrofit projects designed to remove the muck sediment from water entering Manatee Pocket. The total cost of these three projects exceeded $10M. Grant funds from the St. Lucie River Issues Team contributed to each of the projects. The Manatee Pocket Dredging Project will be the capstone of these projects by removing a large volume (approximately 250,000 cubic yards) of the previously deposited muck sediments. The sediments are to be hydraulically dredged from a 100 ft wide X 10 ft. deep channel along the axis of Manatee Pocket and includes a loop access channel and detrital trap area. Additionally, material will be removed from the four main water bodies that drain to the Manatee Pocket: Crooked Creek entrance, Salerno Creek, Manatee Creek and Chapman Creek. Finally muck will be removed in selected locations to uncover clean sandy substrate, creating areas likely to recruit benthic flora and fauna. Dredged material will be pumped directly to a dikes containment area at Martin County's Witham Field, where the sediment will be allowed to dry prior to moving to a final destination.
A series of public meetings have been conducted to educate and receive input from waterfront property owners. Sediment and water quality testing, bathymentric surveys and environmental assessments have been completed. State and federal regulatory agencies have issued the required permits for the project. Baseline environmental surveys will be conducted prior to project initiation and periodically subsequent to project completion to allow scientific analysis of project impacts.

Purpose:
The environmental need for this project was stated in the Manatee Pocket Dredging Feasibility Study (Applied Technology Management, Inc., November 2005). That concluded Manatee Pocket "exhibited a generally degraded habitat with silt (muck) conditions predominating over the majority of the pocket…. Dredging represents the only practical engineering approach to address the current conditions within the pocket, both in terms of habitat quality and vessel navigation. Removal of significant volumes of fine (muck) sediments has the potential to expose bottom sediments more suitable to seagrass colonization. The net result of this action would be an improved marine habitat within the pocket."
Muck sediments are easily suspended in storm conditions and may move from Manatee Pocket into the St. Lucie River. Reducing the source of the sediments within the Pocket will result in a positive impact on the River. A monitoring program will allow quantification of project effects, and provide important data for future de-mucking projects.
An increased channel depth, coupled with the installation of channel markers will provide increased safety for Manatees, and also reduce muck suspension boat propellers. Signage will also be installed to educate boaters on manatee safety and seagrass protection.

Manatee Pocket/Port Salerno has been designated as a Working Waterfront by the State of Florida. The creation of a dedicated navigation channel through the waterway will create improved navigation and provide a much needed economic stimulus for the area.

Location/Size/Capacity:
Manatee Pocket is located in Martin County, near confluence of the St. Lucie River and the Indian River Lagoon. The project will remove approximately 250,000 cubic yards of muck sediments over 47 acres within Manatee Pocket and its tributaries.

Initiative Status:
Permits are in hand, final design/bid documents are under development.

Cost:
Initial estimates place this project at: $12M
Northern Everglades funding request: $4M

Documentation: Manatee Pocket Feasibility Study, ATM 2006; Conceptual design, Tetra Tech EC, 2007; 2007 and 2008 SLRIT applications (funded 2007, ranked #1 for 2008); Pre project baseline studies and post project monitoring will allow reports to quantify impact of the project.

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely: Estimates of water quality benefits have not been quantified but his project will lead to improved water quality by:
    1. Restoring up to 5 acres of seagrass habitat by removing accumulated muck to expose suitable substrate at a depth conducive to seagrass growth;
    2. Removing up to 230,000 cubic yards of muck, some of which contains elevated levels of metals and organics;
    3. Creating three (3) sediment traps at the main tributaries to isolate future deposited sediment.

  The quantity of muck and associated metals and organics will be reported upon project completion.
- Level of Certainty: High
- Assumptions:

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Contact: Kathy Fitzpatrick, Coastal Engineer, Martin County

Final Water Quality Method and Summary: Undetermined

Method: This project is located in the SLR Estuary and does not contribute to reduction in loads from the SLR Watershed. It is anticipated that the project will reduce total phosphorous and nitrogen from within the SLR Estuary.

Final Water Quantity Method and Summary: N/A

SLE 31

Northern Everglades- Potential Management Measure

Project Feature/Activity: Stormwater Baffle Box Retrofit - City of Stuart

Level: 1

General Description/Background: The City of Stuart has 32 outfalls to the St. Lucie River and 30 baffle boxes in service. There were twenty-three original 1, 2, and 3 chamber boxes installed in years 2000-2006. Seven second generation Continuous Deflective Separation (CDS) devices were installed in 2007.

Purpose: To provide sediment and floatable debris removal from storm systems before discharge to the St. Lucie River. Also provides some removal of TN and TP trapped in sediments.

Location/Size/Capacity: The baffle boxes are located in storm systems throughout the city that discharge to the St. Lucie River

Initiative Status: Project is in progress

Cost:

Documentation: City of Stuart CIP's, MS4 NPDES Stormwater Permit, and TMDL efforts

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Contact: City of Stuart, Stormwater Team (772) 214-7514

Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): Negligible
Total Nitrogen Reduction (metric tons/year): Negligible

Method: Water quality benefits anticipated include reductions of Total Suspended Solids, with negligible TP and TN reductions.

Final Water Quantity Method and Summary: N/A

SLE 32

Northern Everglades- Potential Management Measure

Project Feature/Activity: Danforth Creek Stormwater Quality Retrofit

Level: 3

General Description/Background: This portion of Palm City was platted and developed prior to today's standards for water quality treatment and storm attenuation. Danforth Creek has been identified by Martin County and SFWMD as one of the highest nutrient pollutant creeks in Martin County. This project is to provide some additional water quality treatment and attenuation for a 50 acre residential basin that currently has no treatment.

Purpose: The purpose of this project is to provide approximately 4 acre-feet of additional treatment and storage for a 50 acre untreated residential development area.

Location/Size/Capacity: This project is located in Palm City, Florida more specifically in part Sections 18 & 19, Township 38 South, Range 41 East and Sections 13 & 24, Township 38 South, Range 40 East. The project includes the construction of a 3.5 – 6.0 acre lake / Stormwater Treatment Area and the installation of 5 second generation baffle boxes.

Initiative Status: Approved and on-going by Martin County

Cost: Total Project cost is estimated to be over $4.0 million, of which Martin County is requesting a total of $1.0 million for the State & SFWMD. Martin County will provide $500,000 in match.

Documentation: Capital Improvement Plan scheduled to start in FY08, TMDL efforts

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely: (Reduction) ~10% coliforms, 70-80% TSS, 60-70% TP, 20-35% TN
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Contact: Gary Roderick, Chief Office of Water Quality, Martin County

<u>Additional Project Information:</u> DANFORTH CREEK

Payment and Delivery Schedule:

Task	Deliverable	Schedule	Payment
Construction	Pay Requests / Engineer's Certification	Jun '09 to Jan '10	$1,000,000

How much project work has already occurred?

Preliminary conceptual designs and feasibility studies have been addressed.

How much funding has already been obtained and from what sources?

Year	Source	Grant Amount	Martin County Match
FY07	SLRIT	$ 1,000,000	$ 1,000,000
FY08	SLRIT	$ 1,000,000	$ 1,000,000

Breakdown of Martin County matching funds?

See above.

For the multi year projects, would Martin County need all funding in Year 1 or could it be spread over the project life?

Funding could be spread out over subsequent years

How much work of the multi year project would be completed in Year 1?

Design and permitting.

Where would the remaining funding for future years come from?

Other grants, County ad valorem taxes

Final Water Quality Method and Summary
Total Phosphorous Reduction (metric tons/year): 0.01
Total Nitrogen Reduction (metric tons/year): 0.03

Method: Loading rates were determined by applying estimated loading rates (Soil and Water Engineering Technology Inc. 2008) based on land use type (medium density residential) and acreage of effective area (50 acres). Load reductions were determined using estimated reduction factors based on literature review (Harper 2007).

Final Water Quantity Method and Summary: N/A

SLE 33

Northern Everglades- Potential Management Measure

Project Feature/Activity: North St. Lucie River Water Control District (NSLRWCD) Stormwater Retrofit; Structures 81-1-2 and 85-1-2

Level: 1

General Description/Background: This project involves retrofitting for water control structures located within the NSLRWCD. The structures controlled discharge in canals which ultimately outfall to Ten Mile Creek. The structure retrofit involves replacement of the Board function which operates gates. Two operable gates will be installed at each of the following four (4) structures:

1. Structure 81-1-2
2. Structure 85-1-2
3. Structure 83-2-2
4. Structure 82-2-2

Structures 81-1-2 and 85-1-2 will provide better control over a combined 1640 acre drainage area, and secondary benefits to an approximately 9175 acre water management system. Structures 83-2-2 and 82-2-2 will provide better control over a combined 1560 acre drainage area, and secondary benefits to an approximate 7475 acre water management system.

Purpose: The NSLRWCD canal system was constructed in the early part of the 20th century, with Ten Mile Creek as the primary outfall for drainage and reclamation of lands. The current configuration is similar to the original design, and has over 200 miles of canals, numerous water control structures, and limited water storage capacity. Aging structures contain manual riser boards for control, which are difficult to manipulate due to age and head pressure, especially during storm events. The resulting loss of control effects the timing and volume of flows to Ten Mile Creek, which ultimately outfalls to the St. Lucie River. The retrofits will improve the efficiency of structure operations and provides better control of flows to Ten Mile Creek during storm events. Better weir control also provides control of sedimentation released downstream.

Location/Size/Capacity:

Initiative Status: St. Lucie River Issues Team 50-50 cost share. To be installed in the Fall of 2008.

Cost: $120,000

Documentation:

Estimate of Water Quality Benefits: Undetermined

- Minimum:
- Maximum:

- Most Likely:
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits: Undetermined

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Contact: North St. Lucie River Water Control District

Final Water Quality Method and Summary: Undetermined
Final Water Quantity Method and Summary: Undetermined

Method: Water quality and quantity benefits are anticipated to occur as a result of this project; however, the magnitude of these benefits was not determined due to insufficient information.

SLE 35

<u>Northern Everglades- Potential Management Measure</u>

Project Feature/Activity: All American Boulevard Ditch Retrofit

Level: 3

General Description/Background: This portion of Old Palm City was first platted and developed in the 1920's before today's standards. The homes are serviced with individual septic systems that leach into the All American ditch and the All American Ditch drains uncontrolled into the South Fork of the St. Lucie River. The overall basin is about 300 acres and comprised mostly of medium density residential areas.

Purpose: The purpose of the project is to re-grade the All American ditch and pipe the flows to an approximately 12.5 acre Lake / Stormwater Treatment Area for water quality treatment and provide some attenuation. The goal is to provide 1 inch of treatment to the basin, resulting in 25 ac-ft of water quality treatment.

Location/Size/Capacity: This project is located in Palm City, Florida more specifically in Sections 20, Township 38 South, Range 41 East and Hanson Grant.

Initiative Status: Approved and on-going by Martin County

Cost: Total project cost is estimated to be $2.3 million, of which Martin County is requesting a total of $1.0 million from the State and SFWMD. Martin County will provide $500,000 in match.

Documentation: Capital Improvement Plan scheduled to begin in FY09, and TMDL efforts

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely: (Reduction) ~10% coliforms, 70-80% TSS, 60-70% TP, 20-35% TN
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Contact: Gary Roderick, Chief Office of Water Quality, Martin County

<u>Additional Project Information:</u> ALL AMERICAN DITCH

Payment and Delivery Schedule for proposed 5/5/5 funding:

Task	Deliverable	Schedule	Payment
Design & Permitting	Permit	Nov '08 to Jun '09	$127,500
Construction	Pay Requests & Engineer's Certification	Aug '09 to Jan '10	$872,500

How much project work has already occurred?

Preliminary conceptual designs and feasibility studies have been addressed.

How much funding has already been obtained and from what sources?

Year	Source	Grant Amount	Martin County Match
FY08	SLRIT	$ 650,000	$ 0

Breakdown of Martin County matching funds?

See above.

For the multi year projects, would Martin County need all funding in Year 1 or could it be spread over the project life?

The 5/5/5 funding would be allocated for design/permitting and construction. Funding for design / permitting would be needed in Year 1 and funding for construction could be spread out over subsequent years.

How much work of the multi year project would be completed in Year 1?

Design / permitting would be completed in Year 1.

Where would the remaining funding for future years come from?

Other grants, and County ad valorem taxes

Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): 0.08
Total Nitrogen Reduction (metric tons/year): 0.20

Method: Loading rates were determined by applying estimated loading rates (Soil and Water Engineering Technology Inc. 2008) based on land use type (medium density residential) and acreage of effective area (300 acres). Load reductions were determined using estimated reduction factors based on literature review (Harper 2007).

Final Water Quantity Method and Summary: N/A

SLE 36

Northern Everglades- Potential Management Measure

Project Feature/Activity: Everglades Comprehensive Plan Amendment

Level: 2

General Description/Background: The Florida Department of Community Affairs (DCA) is leading an effort to ensure that county comprehensive plans include environmental protection for the Everglades. An amendment has been drafted, and is currently being revised, which states that for the areas within the jurisdiction of the South Florida Water Management District each comprehensive plan shall include goals, objectives and policies that ensure protection of the land, water, and biological resources necessary for the long-term viability of the Florida Everglades. The goals, objectives and policies to protect the Florida Everglades shall be adopted into comprehensive plans within one year of the effective date of this law.

Purpose: This amendment will require comprehensive plans to include: a conservation element for the conservation, use, and protection of natural resources in the area, including air, water, water recharge areas, wetlands, waterwells, estuarine marshes, soils, beaches, shores, flood plains, rivers, bays, lakes, harbors, forests, fisheries and wildlife, marine habitat, minerals, and other natural and environmental resources.

Location/Size/Capacity: Areas within the jurisdiction of the South Florida Water Management District

Initiative Status: DCA is currently working within the legislative process to draft/revise this amendment.

Cost: N/A

Documentation:

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:

- Assumptions:

Contact: Florida Department of Community Affairs

Final Water Quality Method and Summary: Incidental
Final Water Quantity Method and Summary: Incidental

Method: The primary purpose of this management measure is to update comprehensive plans. Incidental water quality and quantity benefits are anticipated to occur as a result of this project; however, the magnitude of these benefits was not determined due to the nature of this project.

SLE 37

Northern Everglades- Potential Management Measure

Project Feature/Activity: Living Shoreline Initiative

Level: 3

General Description/Background: The primary goal of the Living Shoreline Initiative is to provide landowners and contractors with "softer" and more natural alternatives to shoreline hardening. In addition to providing erosion control, living shorelines help filter stormwater runoff, and provide important habitat for plants and animals.

This is a partnership effort that could be modeled after the Living Shoreline Initiative established by the Florida Panhandle Coastal Program. In the Panhandle program, partners include: Apalachicola Riverkeeper, Choctawhatchee Basin Alliance, Florida Department of Environmental Protection (Ecosystem Restoration Section, and Office of Coastal and Aquatic Managed Areas), Florida Fish and Wildlife Conservation Commission, National Oceanic and Atmospheric Administration, PBS&J, Pensacola Gulf Coast Keepers, Sea Grant Extension, University of Florida, University of West Florida, U.S. Fish and Wildlife Service, and West Florida Regional Planning Council.

Purpose: To protect shorelines from erosion using natural habitat elements, such as native vegetation and oyster shells, rather than armoring. Living shorelines create nursery and foraging habitat, enhance natural processes and improve water quality.

Location/Size/Capacity: TBD

Initiative Status: A coordinated effort to implement this program within the St. Lucie Estuary is not yet underway

Cost: TBD

Documentation: "A Living Shoreline Initiative for the Florida Panhandle: Taking a Softer Approach," Melody Ray Culp, USFWS, National Wetlands Newsletter, vol. 29, no. 6, Copyright 2007.

Estimate of Water Quality Benefits

- Minimum: Undetermined and Incidental
- Maximum: Undetermined and Incidental
- Most Likely: Undetermined and Incidental
- Level of Certainty: Undetermined and Incidental
- Assumptions: N/A

Estimate of Water Quantity Benefits

- Minimum: Undetermined and Incidental

- Maximum: Undetermined and Incidental
- Most Likely: Undetermined and Incidental
- Level of Certainty: Undetermined and Incidental
- Assumptions: N/A

Screening Criteria

- Proof of Concept:
- Other Impacts:

Contact: Andrea Povinelli, The Nature Conservancy, 561-744-6668

Final Water Quality Method and Summary: Undetermined and Incidental
Final Water Quantity Method and Summary: N/A

Method: The primary purpose of this management measure is to maintain natural shorelines. Undetermined and incidental water quality benefits are anticipated to occur as a result of this project; however, the magnitude of these benefits was not determined due to the nature of this project.

SLE 38

Northern Everglades- Potential Management Measure

Project Feature/Activity: Urban Best Management Practices Program (An Extension of the Florida Yards and Neighborhoods Program)

Level: 1 (Existing Program within the St. Lucie Watershed)

General Description/Background: The Florida Yards and Neighborhoods Program is an environmental education program designed to improve the water quality of the Indian River Lagoon and the St. Lucie Estuary (SLE) by reducing non point sources of pollution from properties throughout the watershed. The program is a key component of the Urban Best Management Practices (BMP) initiative and an excellent complement to the Agricultural BMP Program.

Purpose: This program is designed to reduce pollution flowing into the river from urban landscapes. The homeowner is the only group that has no regulations regarding the use and application of nutrients and pesticides. Consequently, materials may be applied by them indiscriminately. The goal of the FYN Program is to provide collaborative educational programming about environmental landscape management (ELM), integrated pest management (IPM), soil and water conservation and sustainable development that will address non point source pollution at a primary source: residential yards and commercial landscapes in the rapidly expanding suburban areas of the watershed that impact water quality through inappropriate maintenance. This is one of the fastest growing metropolitan areas in the U.S. which indicates that a continuous educational program must be in operation in order to inform and train home gardeners, youth, and landscape professionals in the correct use of pesticides, the selection and placement of plant materials, fertilization, and proper irrigation methods. By reducing the amount of possible pollutants used in landscapes, the FYN program will greatly enhance water quality in the Indian River Lagoon and the St. Lucie Estuary.

Location/Size/Capacity: Martin County, St. Lucie County, Port St. Lucie and the City of Stuart

Initiative Status: The Florida Yards and Neighborhoods program has been active and successful in Martin County, St Lucie County and the city of Stuart for the last nine years

Cost: $98,000 per year

Documentation: Quarterly reports presented to funding agencies in addition to a multiagency/multi stakeholder advisory board.

Estimate of Water Quality Benefits

- **Minimum**: reduction in nutrients, metals, pesticides and herbicides from urban landscapes reaching the St. Lucie Estuary.
- **Maximum**: help in reaching the soon to be adopted TMDL's for the SLE
- **Most Likely**: net benefit to the SLE with proven cost savings to the homeowner

- **Level of Certainty:** reductions based on level of acceptance and implementation within the watershed
- **Assumptions**: requires other initiatives to also be implemented: state-wide fertilizer rule, mandatory training for landscape professionals, environmental, education and outreach, etc.

Estimate of Water Quantity Benefits

- **Minimum**: reduction in the amount of water leaving the property
- **Maximum**: total on-site retention
- **Most Likely**: enhanced retention with aquifer recharge but not total on-site retention
- **Level of Certainty:** moderate for reducing water quantity
- **Assumptions**: continues research from IFAS and Cooperative Extension on improvements to program

Contact: Fred Burkey IFAS Extension, Martin and St Lucie County

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Final Water Quality Method and Summary: N/A
Final Water Quantity Method and Summary: N/A

Method: Included in the BMP load reduction estimates (Soil and Water Engineering Technology Inc. 2008).

SLE 39

Northern Everglades- Potential Management Measure

Project Feature/Activity: Aquifer Storage & Recovery

a. C-44 Reservoir (IRL South)
b. C-23/24 Reservoir (IRL South)

Level: 4

General Description/Background: Aquifer Storage and Recovery (ASR) involves injecting water into an aquifer through wells and then pumping it out from the same aquifer when needed. The aquifer essentially functions as a water bank. Deposits are made in times of surplus, typically during the rainy season, and withdrawals occur when available water is needed, typically during a dry period.

Interest and activity in aquifer storage and recovery (ASR) in southern Florida has greatly increased over the past 10 to 15 years. In South Florida, ASR wells have typically been used to store excess freshwater during the wet season and subsequently recover it during the dry season for use as an alternative drinking-water supply source. Many utility-operated ASR facilities now have wells completed in deep confined aquifers for this purpose. Large scale application of the ASR technology is under evaluation as a storage option in the Comprehensive Everglades Restoration Plan.

Purpose: Water Storage. The aquifer essentially functions as a water bank. Deposits are made in times of surplus, typically during the rainy season, and withdrawals occur when available water is needed, typically during a dry period.

Location/Size/Capacity: To Be Determined

Initiative Status: Conceptual for these locations but proven technology

Cost: To Be Determined

Documentation:

Estimate of Water Quality Benefits: N/A

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits: To Be Determined

- Minimum:

- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Contact: SFWMD

Final Water Quality Method and Summary: To be determined
Final Water Quantity Method and Summary: To be determined

Method: To be determined

SLE 40

Northern Everglades- Potential Management Measure

Project Feature/Activity: CERP – IRL South: Southern Diversion C-23 to C-44 interconnect

Level: 1

General Description/Background: An important component of the IRL South Plan. It greatly expands the flexibility of where to direct excess flows from the C-23 canal system which scientists tell us is the most damaging point of entry for freshwater into the St. Lucie Estuary.

Purpose: The canal would direct excess water from the C-23, C-24, C-25 canal system through the C-44 STA and into the St. Lucie Canal (C-44) where it could be diverted to Lake Okeechobee anytime the Lake was below 14.5'MSL, used to meet local irrigation demands, or sent to tide at a point less damaging than the C-23.

Location/Size/Capacity: The proposed canal would link the C-23 canal at a point two miles west of the S48 fix crested weir (the coastal structure) run south along the east side of Allapattah and link up into the northeastern corner of the proposed C-44 STA. Under current operational rules, 53,000 acre-feet of water could be harvested annually from the C-23, undergo water quality enhancements in the STA and then be discharged to the C-44. The PIR estimates that, in an average year 31,000 acre-feet could be gravity discharged to Lake Okeechobee via S-308 and 22,000 acre-feet could be sent to tide through the S-80 structure. Discharges handled in this manner are very close to achieving the Natural System Model, or pre-drainage, distribution of stormwater flows at C-23.

Initiative Status: The land has been purchased as part of the Allapattah and C-44 acquisitions. Design and permitting have not yet begun.

Cost:

Documentation: IRL SOUTH CERP PIR

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:

- Most Likely:
- Level of Certainty:
- Assumptions:

Contact:

Final Water Quality Method and Summary: Water diversion, no reduction to loading
Final Water Quantity Method and Summary: Water diversion, no reduction to flows

Method: N/A

SLE 41

Northern Everglades- Potential Management Measure

Project Feature/Activity: Martin County Baffle Boxes

Level: 4

General Description/Background: Currently Martin County has identified and prioritized nearly 30 locations for potential baffle box installations. The County has secured grants to install eight baffle boxes along Indian River Drive in Jensen Beach that discharge directly into the Indian River. With Northern Everglades funding the remaining baffle boxes can be installed.

Purpose: To provide sediment and debris traps to discharges directly into either the Indian River or St Lucie Rivers within Martin County.

Location/Size/Capacity: This project is located through out Martin County. The County has identified and prioritized nearly 30 locations for potential baffle box installations at locations that discharge within one-half mile of either the Indian River or the St Lucie Rivers.

Initiative Status: Approved and on-going by Martin County

Cost: Total Project Cost is estimated to be approximately $2.5 million, of which Martin County is requesting a total of $500k from the State & SFWMD. Martin County will provide $250k in match.

Documentation: Martin County CIP, and TMDL efforts

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely: Provide sediment and debris traps on various sized basins
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:
- Most Likely: None
- Level of Certainty:
- Assumptions:

Contact: Gary Roderick, Chief Office of Water Quality, Martin County

<u>Additional Project Information:</u> Martin County Baffle Boxes

Payment and Delivery Schedule:

Task	Deliverable	Schedule	Payment
Construction	Payment Requests / Engineer's Certification	FY09 – FY10	$500,000

How much project work has already occurred?

Planning is 75% complete
No design or permitting has been done.

How much funding has already been obtained and from what sources?

Year	Source	Grant Amount	Martin County Match
FY08	SLRIT	$ 187,000	$ 187,000
FY08	FL Forever	$ 394,000	$ 394,000

Breakdown of Martin County matching funds?

See above.

For the multi year projects, would Martin County need all funding in Year 1 or could it be spread over the project life?

Any 5/5/5 funding would be allocated to construction. The funding could be spread out over multiple years.

How much work of the multi year project would be completed in Year 1?

Not known at this time.

Where would the remaining funding for future years come from?

Other grants, County ad valorem taxes

Final Water Quality Method and Summary
Total Phosphorous Reduction (metric tons/year): Negligible
Total Nitrogen Reduction (metric tons/year): Negligible
Method: Water quality benefits anticipated include reductions of Total Suspended Solids, with negligible TP and TN reductions.

Final Water Quantity Method and Summary: N/A

SLE 42

Northern Everglades- Potential Management Measure

Project Feature/Activity: Jensen Beach Retrofit

Level: 1

General Description/Background: This project proposes to provide detention and/or retention for stormwater runoff in vaults and/or in exfiltration for an older developed area in downtown Jensen Beach, FL

Purpose: Development within this 20+ acre basin is primarily commercial. All of the development occurred before required water quality treatment. and the area discharges directly to the Indian River Lagoon without water quality treatment. Retention and detention are commonly used stormwater BMP's to remove pollutants from stormwater runoff including; particulates, metals, and some nutrients. This project proposes to utilize vaults and or exfiltration beneath a parking lot, at the bottom of the hill, directly adjacent to the outfall and lagoon to remove pollutants from untreated runoff.

Location/Size/Capacity: This Jensen Beach basin is steeply sloped towards the river and drains approximately 20 acres. The basin is located; east of Skyline Drive, south of Ricou Terrace, west of the Indian River and north of an E-W line approximately 250 ft south of Jensen Beach Blvd. The basin is 95 % impervious consisting of roadway, parking, and retail commercial properties, and office buildings. The only remaining area to provide treatment is in the SE corner of the intersection of Indian River Drive and Jensen Beach Blvd. and is approximately 16000 sf. Utilization of detention vaults alone are capable of providing .24 ins of detention for the treated area while 2500 lf of exfiltration could provide as much as 1.5 ins of detention or the amount required to provide treatment to today's standards based on an assumed absorption capacity for the soils.
Initiative Status: This project is currently in the Martin County CIP, negotiations are complete for engineering design, and discussions have begun for acquisition of rights to construct the facility beneath the existing parking lot.

Cost: Construction of vaults and plumbing are estimated in 2008 dollars as $2.25 M assuming that r/w is donated. Cost for exfiltration is estimated at $850K based on assumption of donated r/w and absorption capacity.

Documentation: Martin County Capital Improvement Plan

Estimate of Water Quality Benefits

- Minimum: 50%-70% TSS reduction, 60%-70% TP reduction, 20%-35% TN reduction
- Most Likely: 80%-95% TSS reduction, 60%-70% TP reduction, 20%-35% TN reduction
- Maximum: 70%-80% TSS reduction, 60%-70% TP reduction, 20%-35% TN reduction
- Level of Certainty: 90% certain that pollutant removals will be between the minimum & maximum.

- Assumptions: Maximum - Due to dry season retention of runoff due to percolation and evapotranspiration from open water and vegetated STA area 100% of removal is expected for some portion of the year. Most Likely – Presumptive regulatory standard based on NURP studies will perform as expected. Minimum - Presumptive regulatory standards do not work

Estimate of Water Quantity Benefits

- Minimum: Adopted LOS for flood protection is not achieved, retention/detention results in all runoff discharged to tide
- Most Likely: Adopted SFWMD LOS for flood protection is achieved, retention/detention results in percolation of 50% of runoff to groundwater which would otherwise have discharged to tide
- Maximum: Adopted County LOS for flood protection is achieved, retention/detention results in percolation of 80% of runoff to groundwater which would otherwise have discharged to tide
- Level of Certainty: 90% certain that LOS and water storage will be between minimums and maximums
- Assumptions: Maximum- Discharge rates from existing contributing areas are less than and percolation to groundwater is greater than expected; Most Likely - under normal rainfall conditions the system will perform as designed; Minimum - Antecedent conditions to events allowed no pre event storage to reduce LOS and groundwater tables are elevated in wet years such that percolation does not occur.

Contact: Mr. Gary Roderick – Water Quality Chief, Office of Water Quality

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Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): 0.01
Total Nitrogen Reduction (metric tons/year): 0.03

Method: Loading rates were determined by applying estimated loading rates (Soil and Water Engineering Technology Inc. 2008) based on land use type (commercial) and acreage of effective area (20 acres). Load reductions were determined using estimated reduction factors based on literature review (Harper 2007).

Final Water Quantity Method and Summary: N/A

SLE 43

Northern Everglades- Potential Management Measure

Project Feature/Activity: Leilani Hts/ Warner Creek Retrofit

Level: 1 (Ph 1)
3 (Ph 2)
4 (Ph 3)

General Description/Background: *Phase 1-* constructs 2400 lf exfiltration with inlet sediment traps within Leilani Hts. to provide 6.3 ac-ft of retention to treat runoff from 112 ac. contributing sub-basin which currently discharges directly to the St Lucie River, improvements to hydraulic capacity at Pinelake Boulevard to reduce structure and roadway flooding, sediment removal from 2000 ft of Warner Creek upstream of existing weir to provide sediment storage, construction of 2800lf exfiltration with inlet sediment traps within Jensen Highlands to provide 6.7 ac-ft of retention for the 160 ac contributing sub-basin which currently discharges directly to the St Lucie River.
Phase II – Acquires 1.8 acres of a parcel adjacent to Warner Creek directly downstream of Leilani Hts. and construct a 2 ac-ft dry detention area to treat runoff from Leilani Hts. not served by exfiltration.
Phase III – Acquires 28 acres of land adjacent to Warner Creek, directly upstream of the FEC RR and tidal influence and constructs a 43 ac-ft STA marsh to provide treatment for runoff to the St. Lucie not currently receiving treatment from areas not treated today and not served by Phases 1 & 2, enables proposed flood reduction improvements upstream by providing attenuation to flows before discharge to the St. Lucie River.

Purpose: The purpose of this 3 Phase project is to provide treatment to today's standards for runoff from existing sub-standard development, to resolve conveyance capacity within the system to reduce flooding, to provide attenuation of increased flows resulting from internal conveyance improvements and to recharge groundwater with runoff which currently flows directly to the St. Lucie Estuary.

Location/Size/Capacity: The Warner Creek Basin is approximately 5100 acres in size and is bounded by Walton Rd in Port St. Lucie to the north, the Atlantic coastal Ridge to the east and Pineapple Plantation/ Jensen Beach Golf and Country Club to the west. Development in the basin which ranges from the undeveloped Savannas State Preserve to highway, commercial, and residential development such as Leilani Hts. and mobile homes which receive no stormwater runoff treatment. Approximately 704 acres of the basin are deficient in water quality treatment and to bring the basin up to today's treatment standards are required an estimated additional 59 ac-ft of storage. Some of the older areas adjacent to the creek have also suffered structure and roadway flooding which compromises access to hundreds of residential units.

Initiative Status: This project is currently in the Martin County CIP. Martin County has dedicated $1.6M in advalorem taxes toward the project, the SLRIT has awarded $1.53M in grants, and EPA Sec 319 has awarded $0.56 M in grants toward the project. Hydrologic & hydraulic studies are complete and design of Phase 1 work is complete. Construction of Phase 1 improvements imminent as permitting of most of this work can be handled under FAC 40E-400.215 (No Notice General Permit). Phases 2 & 3 require land acquisition and has only begun as of January 2008.

Cost: Based on Engineer's preliminary estimate of costs and staff estimate of land costs in 2008 dollars the overall project is estimated to cost as follows: Phase I- $3.96M, Phase II- $1M, Phase III- $7.0M. Grant requests are as follows : Phase I- $2.66 M, Phase II -$0.55M, Phase III -$5.1M

Documentation: Martin County Capital Improvement Plan, "Leilani Hts. / Warner Creek Basin Stormwater Quality Retrofit, Stormwater Management Study, January 2008"

Estimate of Water Quality Benefits

- Minimum: 50% TSS reduction, 60% TP reduction, 20% TN reduction
- Most Likely: 70% TSS reduction, 71 % TP reduction, 70%-35% TN reduction
- Maximum: 80% TSS reduction, 800 % TP reduction, 35% TN reduction
- Level of Certainty: 90% certain that pollutant removals will be between the minimum & maximum.
- Assumptions: Maximum - Due to dry season retention of runoff due to percolation by exfiltration and evapotranspiration from open water and vegetated STA area 100% of removal is expected for some portion of the year. Most Likely – Presumptive regulatory standard based on NURP studies will perform as expected. Minimum - Presumptive regulatory standards do not work

Estimate of Water Quantity Benefits

- Minimum: Adopted LOS for flood protection is not achieved, retention/detention results in all runoff discharged to tide
- Most Likely: Adopted SFWMD LOS for flood protection is achieved, retention/detention results in percolation of 50% of runoff to groundwater which would otherwise have discharged to tide
- Maximum: Adopted County LOS for flood protection is achieved, retention/detention results in percolation of 80% of runoff to groundwater which would otherwise have discharged to tide
- Level of Certainty: 90% certain that LOS and water storage will be between minimums and maximums
- Assumptions: Maximum- Discharge rates from existing contributing areas are less than and percolation to groundwater is greater than expected; Most Likely - under normal rainfall conditions the system will perform as designed; Minimum - Antecedent conditions to events allowed no pre event storage to reduce LOS and groundwater tables are elevated in wet years such that percolation does not occur.

Contact: Mr. Gary Roderick – Water Quality Chief, Office of Water Quality

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Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): 0.16
Total Nitrogen Reduction (metric tons/year): 0.41

Method: Loading rates were determined by applying estimated loading rates (Soil and Water Engineering Technology Inc. 2008) based on land use type (medium density residential) and acreage of effective area (704 acres). Load reductions were determined using estimated reduction factors based on literature review (Harper 2007).

Final Water Quantity Method and Summary: N/A

SLE 44

Northern Everglades- Potential Management Measure

Project Feature/Activity: Manatee Creek Water Quality Retrofit; PhII & PhIII; New Monrovia, Dixie Park

Level: 1

General Description/Background: This project proposes to provide wet detention and STA marsh nutrient removal at the confluence of 2 sub-basins of the Manatee Creek prior to discharge to the Manatee Pocket.

Purpose: Development within this sub-basin consists of; residential, commercial, industrial, and highway.. Much of the development occurred before required water quality treatment. area and discharges to the Manatee Pocket of the Indian River Lagoon without water quality treatment. Wet and dry detention are commonly used stormwater BMP's to remove pollutants from stormwater runoff including; particulates, metals, and some nutrients. This project proposes to utilize these BMP's to remove pollutants from untreated runoff in the basin.

Location/Size/Capacity: The Manatee Creek drains is approximately 833 acres. The basin is located; south of Cove Road, north of the Mariner Sands subdivision, west of Dixie Highway (CR A1A), and extends one-half mile west of US Highway 1. Phase 1 of the Manatee Creek Retrofit is complete and constructed 10 acre ft of storage and STA marsh filtration. Phases II and III of the project will provide an additional 15.3 ac-ft of water quality treatment in wet detention and STA marsh filtration.

Initiative Status: The Manatee Creek is as an Impaired water on the State 303d list. Martin County has completed Phase I and has acquired much of the land required for PH II & III through purchase of parcels, dedication of the decommissioned Dixie Park WWTP and use of road right of way. The project has been designed, permits have been issued, is listed in the Martin County CIP, and is funded by; advalorem taxes, SRF loan, FDEP TMDL grant, & SLRIT (SFWMD) grants.

Cost: PI – $2.8M (Complete), PII - $2.5M , PIII – $3.4M

Documentation: Martin County Capital Improvement Plan

Estimate of Water Quality Benefits

- Minimum: 50%-70% TSS reduction, 60%-70% TP reduction, 20%-35% TN reduction
- Most Likely: 80%-95% TSS reduction, 60%-70% TP reduction, 20%-35% TN reduction
- Maximum: 70%-80% TSS reduction, 60%-70% TP reduction, 20%-35% TN reduction
- Level of Certainty: 90% certain that pollutant removals will be between the minimum & maximum.
- Assumptions: <u>Maximum</u> - Due to dry season retention of runoff due to percolation and evapotranspiration from open water and vegetated STA area 100% of removal is expected for some portion of the year. <u>Most Likely</u> – Presumptive regulatory standard based on NURP studies will perform as expected. <u>Minimum</u> - Presumptive regulatory standards do not work

Estimate of Water Quantity Benefits

- Minimum: Adopted LOS for flood protection is not achieved, retention/detention results in all runoff discharged to tide
- Most Likely: Adopted SFWMD LOS for flood protection is achieved, retention/detention results in percolation of 50% of runoff to groundwater which would otherwise have discharged to tide
- Maximum: Adopted County LOS for flood protection is achieved, retention/detention results in percolation of 80% of runoff to groundwater which would otherwise have discharged to tide
- Level of Certainty: 90% certain that LOS and water storage will be between minimums and maximums
- Assumptions: Maximum- Discharge rates from existing contributing areas are less than and percolation to groundwater is greater than expected; Most Likely - under normal rainfall conditions the system will perform as designed; Minimum - Antecedent conditions to events allowed no pre event storage to reduce LOS and groundwater tables are elevated in wet years such that percolation does not occur.

Contact: Mr. Gary Roderick – Water Quality Chief, Office of Water Quality

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Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): 0.08
Total Nitrogen Reduction (metric tons/year): 0.20

Method: Loading rates were determined by applying estimated loading rates (Soil and Water Engineering Technology Inc. 2008) based on land use type (medium density residential) and acreage of effective area (833 acres). Load reductions were determined using estimated reduction factors based on literature review (Harper 2007).

Final Water Quantity Method and Summary: N/A

SLE 45
RWPP Base Condition

<u>Northern Everglades- Potential Management Measure</u>

Project Feature/Activity: 10 Mile Creek – Reservoir and Stormwater Treatment Area

Level: 1

General Description/Background: Project includes all required planning and design activities, land acquisition, operational and best management practice plans for the successful design, construction, and operation of an above-ground reservoir with a pump station for filling the reservoir from Ten Mile Creek and a gated water-level control structure for the release of water back to the creek. The foot-print of the reservoir is anticipated to be approximately 550 acres in size with the remaining acreage being utilized as a polishing cell and a natural preserve area. Based upon existing topography, stored water depths average ten feet. Total storage capacity will be approximately 5,000 acre-feet. The height of the reservoir levee will range from about 12 to 15 feet above surrounding natural ground. Side slopes for the levees will be about 1 vertical to 4 horizontal.

The intent of the Ten Mile Creek Water Preserve Area project is to attenuate summer stormwater flows into the North Fork of the St. Lucie River, which originate in the Ten Mile Creek basin by capturing and storing the passing stormwater. The sedimentation of suspended solids that occurs in the storage reservoir will reduce sediment loads delivered to the estuary. In addition, it is the intention that the captured stormwater be passed through a polishing cell for additional water quality treatment before being released into the North Fork of the St. Lucie River. Stored water can be released in the drier winter months to augment current insufficient flows.

Stabilizing the salinity concentration will greatly enhance the SLE's ability to support seagrasses, oysters, and nursery grounds for marine fish. Commercial and recreational fishing are very important activities in this region and will be benefited by an improved estuary. The West Indian Manatee, an endangered species, is dependent on seagrasses as a primary food source. This project, coupled with ongoing Water Quality improvement projects, will help to reduce future decline of seagrasses in the area.

The project is expected to provide relief to the SLE from damaging freshwater discharges. Implementation of this project would greatly enhance the ability to maintain appropriate salinities in the North Fork Aquatic Preserve and offset the damaging effects of Lake Okeechobee flood releases until other components of the Comprehensive Plans for the C&SF Project can be implemented. Stormwater runoff collected in project flood control canals C-23, C24, C44 and regulatory releases from Lake Okeechobee cause dramatic changes in salinity within the SLE. Maintenance of groundwater levels by project control structures also prevents adequate dry season baseflows from reaching the estuary during the dry season.

Current evaluations of alternative Comprehensive Plans for the C&SF Project indicate that, in addition to a much needed change in Lake Okeechobee operations, storage facilities within the SLE watershed are needed to maintain desirable salinities. The proposed project lies within a basin that contributes the second largest volume of stormwater amongst the estuary's five tributary basins. In addition, the project is ideally situated at the headwaters of the North Fork of the St. Lucie River Aquatic Preserve. The Preserve is one of the last remaining freshwater/estuarine wilderness areas in this region of Florida and supports a wide variety of fish and wildlife.

The Indian River Lagoon Surface Water Improvement and Management Plan (SWIM Plan) determined that the major pollutant to the IRL and SLE is stormwater. The salinity concentration is drastically reduced in the rainy summer months by massive and rapid stormwater inflows. In the dry winter months, this same efficient drainage system limits normal base flow because it has substantially lowered groundwater tables in the region. Lowered base flow causes the salinity concentration to rise above the desirable level. In addition to salinity disturbances, stormwater discharges also carry undesirable concentrations of sediments and nutrients that are washed from urban and agricultural lands.
This project meets all applicability criteria for critical restoration projects. Restoration benefits will include cleaning stormwater runoff entering Ten Mile Creek, as well as creating a more natural salinity range in the SLE. These hydrologic changes will create conditions favoring seagrass (shoal grass), oysters, and juvenile recreational/ commercial fish (red drum, croaker, snook, etc.) nursery grounds in the SLE and IRL. The project is consistent with the Governor's Commission Conceptual Plan and will be initiated before September 1999. The local sponsor will be the South Florida Water Management District. Lastly, the project is not an authorized feature of the C&SF Project.

Purpose: The purpose of this water preserve area (WPA) is the seasonal or temporary storage of stormwater from the Ten Mile Creek Basin. Ten Mile Creek is the largest subbasin delivering water to the North Fork of the St. Lucie River Estuary (SLE) which has been established as an Outstanding Florida Water (OFW). The SLE discharges into the Indian River Lagoon (IRL) which is also an OFW. The IRL is the most biologically diverse estuary in North America. The entire lagoon is endangered from increased runoff from watershed drainage enhancements. Excess stormwater due to drainage improvements is causing radical fluctuations of the salinity concentration in the SLE. Adverse salinity concentrations are eliminating viable habitat in the SLE suitable for oysters, seagrasses, and marine fish spawning. Storage of excess stormwater will allow its measured release, and hence, a more natural salinity regime. Sediment and nutrient uptake processes that will occur in the WPA will reduce pollution loads delivered to the estuary. The reduction in sediment delivery is expected to improve the long-term water quality outlook in the estuary and thus enhance and restore habitat for a wide variety of fish and wildlife.

There is no known alternative to a water preserve area for storage of water in this basin. Water cannot be feasibly routed to Lake Okeechobee or to more southerly receiving bodies such as the Water Conservation Areas. The addition of Aquifer Storage Recovery (ASR) to increase storage potential may be a consideration as part of the next phase of design, but will not be included in the scope of this project.

Location/Size/Capacity: The proposed site is southwest of Ft. Pierce, in St. Lucie County. It is situated just south of Ten Mile Creek and is the most easterly location for a Water Preserve Area in this Basin. It is located immediately west of the crossing of Florida's Turnpike and Interstate-95 and south of Highway 70 (Okeechobee Road) and north of Midway Road. The site is currently in two ownerships and consists of 1559 acres. Ten Mile Creek runs west to east across the northern portion of the site. The low level salinity control structure for Ten Mile Creek is less than one-half mile east of the proposed water preserve area site.

Initiative Status: Initial Construction Complete – modifications/improvements currently under development and review

Cost: $30,808, 500 (USACE Letter Report – April 1998)

Documentation: Section 528 of The 1996 Water Resources Development Act

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Contact: SFWMD/USACE

Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): 4.45
Total Nitrogen Reduction (metric tons/year): 18.5

Method: Loading rates were based on "10-Mile Creek WPA-Updated Water Quality Assessment-Wetlands Solutions", June 2002 and CERP IRL-S PIR (p. J-68).

Final Water Quantity Method and Summary

Capacity (acre-feet): 7,310

Method: Based on IRL design depths; 524 acre reservoir at 13 ft deep and 132 acre STA at 2 feet deep

SLE 46

Northern Everglades- Potential Management Measure

Project Feature/Activity: Small Acreage Manure Management

Level: 3

General Description/Background: Danforth Creek and Bessey Creek watershed basins located in western Martin County are home to a large community of small acreage horse owners and a few larger scale facilities. An average 1,000-pound horse produces 9 tons of manure a year (50 pounds per day) containing high levels of nutrients and potential pathogens. Add to that an additional cubic foot of bedding material and the result is you get 730 cubic feet/year of waste from one horse. How the manure is stored and treated has a substantial impact on the environment. This project involves creating a central collection and/or composting facility for manure waste from the community.

Purpose: Reduce the amount of nutrients released into the regional system from landowner storage of manure on the banks of the creeks in these watersheds by providing a centrally located and properly managed facility for the collection and/or composting of manure waste.

Location/Size/Capacity: 15,055 acres (Bessey Creek and Danforth Creek basins)

Initiative Status: Conceptual. The FDEP and Martin County and other local agencies are working together to develop a plan for the collection and/or composting of manure waste within the watershed

Cost: TBD

Documentation:
http://www.mcstoppp.org/acrobat/Horse%20Manure%20Mangement.PDF
http://www.ext.colostate.edu/PUBS/LIVESTK/01219.html
http://panutrientmgmt.cas.psu.edu/pdf/G97.pdf
http://extension.unh.edu/Pubs/AgPubs/aahr1050.pdf
http://www.clemson.edu/psapublishing/Pages/ADVS/LL53.pdf

Estimate of Water Quality Benefits

- Minimum: Minimum nutrient content of horse manure – N/ton = 12 lbs; P_2O_5/ton = 5 lbs x 9 tons/horse x 800 horses (approximately)
- Maximum: Maximum nutrient content of horse manure – N/ton = 19 lbs; P_2O_5/ton = 14 lbs x 9 tons/horse x 800 horses (approximately)
- Most Likely: Unknown
- Level of Certainty: Conceptual
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum: NA
- Maximum: NA
- Most Likely: NA
- Level of Certainty: NA
- Assumptions: NA

Contact: Dianne Hughes, FDEP

Final Water Quality Method and Summary: Undetermined

Method: Water quality benefits are anticipated to occur as a result of this project; however, the magnitude of these benefits was not determined due to unknown loading rates to the SLR Watershed from manure.

Final Water Quantity Method and Summary: N/A

SLE 47

Northern Everglades- Potential Management Measure

Project Feature/Activity: Deep Well Injection at the following selected locations in watershed:

a. C44 St. Lucie Canal (same as LO 96)

Level: 5

General description/Background: Construction of deep, high-capacity injection wells for water disposal. Wells would be constructed in "clusters" along C-44 canal right-of-way.

Purpose: Disposal of water at selected locations in the watershed.

Location/size/capacity: C-44 at St. Lucie

Initiative status: Conceptual

Cost: TBD

Estimate of Water Quality Benefits

- Minimum: NA (Completely eliminates water (and nutrients) from the system)
- Maximum: NA
- Most Likely: NA
- Level of Certainty: Conceptual
- Assumptions: NA

Estimate of Water Quantity Benefits

- Minimum: NA (Completely eliminates water (and nutrients) from the system)
- Maximum: NA
- Most Likely: NA
- Level of Certainty: NA
- Assumptions: Conceptual

Screening Criteria

- Proof of Concept: 1
- Other Impacts: 0

Contact: Bob Verrastro; SFWMD; 561-682-6139

Final Water Quality Method and Summary: To be determined
Final Water Quantity Method and Summary: To be determined

Method: To be determined

SLE 48

Northern Everglades- Potential Management Measure

Project Feature/Activity: Danforth Creek Muck Removal Dredging project

Level: 2

General Description/Background: Over the years this site has been used for storm water runoff and drainage. As a result, the Creek has experienced an influx of silty organic material. The accumulated sediments have created shoals and are now also restricting water flow and access to the creek. The shoals extend well into the St. Lucie River. This project would remove a large percentage of these accumulated sediments.

Purpose: Removal of muck sediments from Danforth Creek. Left unaddressed, these sediments will continue to move into the St. Lucie River. Additionally the quality of water entering the St. Lucie River from Danforth Creek will be improved.

Location/Size/Capacity: Removal of approximately 20,000 cy of accumulated sediments over an area of 142,000 sq. ft.

Initiative Status: A feasibility report has been completed and initial contacts have been made with the permitting agencies. It is similar to other projects conducted by the County. The project will move forward when funding becomes available.
Cost: $6,000,000

Documentation: Danforth Creek Feasibility Report, July 24, 2007 by Applied Technology and Management.

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely: Improved water quality of water leaving Warner Creek and entering the St. Lucie River.
- Level of Certainty: High
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Contact: Kathy Fitzpatrick
Martin County BOCC
2401 SE Monterey, Stuart FL
772 288 5429

Final Water Quality Method and Summary: Undetermined

Method: This project is located in the SLR Estuary and does not contribute to reduction in loads from the SLR Watershed. It is anticipated that the project will reduce total phosphorous and nitrogen from within the SLR Estuary.

Final Water Quantity Method and Summary: N/A

SLE 49

Northern Everglades- Potential Management Measure

Project Feature/Activity: Warner Creek Muck Removal Dredging Project

Level: 2

General Description/Background: Over the years this site has been used for storm water runoff and drainage. As a result, the Creek has experienced an influx of silty organic material. The accumulated sediments have creates shoals and are now also restricting water flow and access to the creek. The shoals extend into the St. Lucie River and have restricted 60% of the entrance. This project would remove a large percentage of these accumulated sediments.

Purpose: Removal of muck sediments from Warner Creek. Left unaddressed, these sediments will continue to move into the St. Lucie River. Additionally the quality of water entering the St. Lucie River from Warner Creek will be improved.

Location/Size/Capacity: This project would be conducted in and near Warner Creek. Approximately 16,000 cy of material would be removed in this project.

Initiative Status: A feasibility report has been completed and initial contacts have been made with the permitting agencies. It is similar to other projects conducted by the County. The project will move forward when funding becomes available.

Cost: $850,000

Documentation: Warner Creek Dredging Feasibility Report, March 20, 2006 by Applied Technology and Management.

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely: Improved water quality of water leaving Warner Creek and entering the St. Lucie River.
- Level of Certainty: High
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:

- Assumptions:

Contact: Kathy Fitzpatrick
Martin County BOCC
2401 SE Monterey, Stuart FL
772 288 5429

Final Water Quality Method and Summary: Undetermined

Method: This project is located in the SLR Estuary and does not contribute to reduction in loads from the SLR Watershed. It is anticipated that the project will reduce total phosphorous and nitrogen from within the SLR Estuary.

Final Water Quantity Method and Summary: N/A

SLE 50

Northern Everglades- Potential Management Measure

Project Feature/Activity: Hidden River Muck Removal Dredging Project

Level: 2

General Description/Background: Over the years this site has been used for storm water runoff and drainage. As a result, the River has experienced an influx of silty organic material and sand. The accumulated sediments have creates shoals and are now also restricting water flow and access to the River. The shoals extend into Bessey Creek which connects directly to the St. Lucie River. This project would remove a large percentage of these accumulated sediments.

Purpose: Removal of muck sediments from Hidden River. Left unaddressed, these sediments will continue to move into Bessey Creek and ultimately the St. Lucie River. Additionally the quality of water entering the St. Lucie River from Hidden River will be improved.

Location/Size/Capacity: This project would be conducted in and near Hidden River. The project volume has not yet been estimated.

Initiative Status: A feasibility report has been completed and initial contacts have been made with the permitting agencies. It is similar to other projects conducted by the County. The project will move forward when funding becomes available.

Cost: Unknown at this time

Documentation: Hidden River Dredging Assessment Report, March 3, 2008 by Applied Technology and Management.

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely: Improved water quality of water leaving Hidden River and entering the St. Lucie River.
- Level of Certainty: High
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:

- Assumptions:

Contact: Kathy Fitzpatrick
Martin County BOCC
2401 SE Monterey, Stuart FL
772 288 5429

Final Water Quality Method and Summary: Undetermined

Method: This project is located in the SLR Estuary and does not contribute to reduction in loads from the SLR Watershed. It is anticipated that the project will reduce total phosphorous and nitrogen from within the SLR Estuary.

Final Water Quantity Method and Summary: N/A

SLE 51

Northern Everglades- Potential Management Measure

Project Feature/Activity: Residential Canal Weirs Along the North and South Forks of the St. Lucie River

Level: 5

General Description/Background: Existing canals receive runoff from the residential areas along the North and South Forks. These canals convey the stormwater, uncontrolled, directly to the St. Lucie North and South Forks. A one-foot surcharge of wet detention would be provided within the canals via a weir structure.

Purpose: To provide detention storage for existing residential areas presently draining directly to the North and South Forks via uncontrolled canals. The detention will be achieved by providing weirs with a crest elevation of one foot above the existing mean wet season water level in the canals at the weir location. A bleeder in the weir will be included to allow the detention volumes to be restored after runoff events.

Location/Size/Capacity: TBD

Initiative Status: Conceptual

Cost: TBD

Documentation:

Estimate of Water Quality Benefits: TBD

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits: N/A

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Contact: M. Voich, SFWMD

Final Water Quality Method and Summary: Undetermined

Method: Water quality benefits are anticipated to occur as a result of this project; however, the magnitude of these benefits was not determined due to the conceptual status of this project.

Final Water Quantity Method and Summary: Incidental

SLE 52

Northern Everglades- Potential Management Measure

Project Feature/Activity: City of Port St. Lucie – E-8 Canal Stormwater Retrofit

Level: 1

General Description/Background: The City of Port St. Lucie is currently constructing the E-8 canal stormwater retrofit. This retrofit will force stormwater through a treatment area with littoral shelves and plantings to assist in nutrient uptake prior to reaching the C-24 canal, and eventually the North Fork of the St. Lucie River.

Purpose: To provide stormwater quality treatment to untreated stormwater currently entering the C-24 canal and eventually the North Fork of the St. Lucie River. The treatment area will reduce sediment and nutrient loading to the North Fork of the St. Lucie River by reducing the flow rate and through bioremediation.

Location/Size/Capacity:

Initiative Status: Currently under construction (May 2008).

Cost:

Documentation:

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum: N/A
- Maximum: N/A
- Most Likely: N/A
- Level of Certainty:
- Assumptions:

Contact: Dale Majewski, City of Port St. Lucie - NPDES Program Manager, Ph: 772-344-4128

Final Water Quality Method and Summary: Undetermined

Method: Water quality benefits are anticipated to occur as a result of this project; however, the magnitude of these benefits was not determined due to insufficient information.

Final Water Quantity Method and Summary: N/A

SLE 53

Northern Everglades- Potential Management Measure

Project Feature/Activity: Frazier Creek Water Quality – City of Stuart

Level: 1

General Description/Background: This project consists of an on line regional detention pond and storm sewer retrofit.

Purpose: To provide water quality treatment and discharge attenuation.

Location/Size/Capacity: The 3.6 ac-ft detention pond is located south of the Roosevelt Bridge in the northwest quadrant of the city within the Frazier Creek drainage basin (approximately 500 acres). The detention pond services approximately 75 acres of single family residential and light commercial property.

Initiative Status: The project is complete

Cost: $273,077

Documentation: City of Stuart CIP's, Stormwater Management Plan, and TMDL efforts

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Contact: City of Stuart, Bill Griffin (772) 600-1264

Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): Negligible
Total Nitrogen Reduction (metric tons/year): 0.02

Method: Loading rates were determined by applying estimated loading rates (Soil and Water Engineering Technology Inc. 2008) based on land use type (low density residential) and acreage of effective area (75 acres). Load reductions were determined using estimated reduction factors based on literature review (Harper 2007).

Final Water Quantity Method and Summary: N/A

SLE 54

Northern Everglades- Potential Management Measure

Project Feature/Activity: Haney Creek Wetlands Restoration – City of Stuart

Level: 1

General Description/Background: Restoration of wetland area within the approximately 1,200 acre Haney Creek Watershed serving approximately 436 acres of upstream development.

Purpose: To provide conservation and water quality enhancement in the Haney Creek Watershed.

Location/Size/Capacity: The site is located on both the north and south side of Baker Road, east of US1 and west of Felix Williams Elementary School in northern Martin County and consists of approximately 38 acres. The detention pond provides storage for single family residential and light commercial property. Stormwater generally flows from north to south toward the St. Lucie River.

Initiative Status: The project was completed approximately 3 years ago

Cost:

Documentation: City of Stuart CIP's, Stormwater Management Plan, and TMDL efforts

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Contact: City of Stuart, Bill Griffin (772) 600-1264

Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): Negligible
Total Nitrogen Reduction (metric tons/year): Negligible

Method: Loading rates were determined by applying estimated loading rates (Soil and Water Engineering Technology Inc. 2008) based on land use type (low density residential) and acreage of effective area (436 acres). Load reductions were determined using estimated reduction factors based on literature review (Harper 2007).

Final Water Quantity Method and Summary: N/A

SLE 55

Northern Everglades- Potential Management Measure

Project Feature/Activity: Poppleton Creek – City of Stuart

Level: 1

General Description/Background: This project involves and on-line regional detention basin.

Purpose: To provide water quality treatment and discharge attenuation.

Location/Size/Capacity: The detention basin (30.0 ac-ft) is generally located in the southern area of the City within the Poppleton Creek drainage basin (approximately 629 acres). The detention pond will provide storage treatment for approximately 170 acres of single family/multi-family residential and light commercial property.

Initiative Status: The project is currently under construction and is approximately 30% complete.

Cost: $735,566

Documentation: City of Stuart CIP's, Stormwater Management Plan, and TMDL efforts

Estimate of Water Quality Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits

- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Contact: City of Stuart, Bill Griffin (772) 600-1264

Final Water Quality Method and Summary

Total Phosphorous Reduction (metric tons/year): 0.09
Total Nitrogen Reduction (metric tons/year): 0.16

Method: Loading rates were determined by applying estimated loading rates (Soil and Water Engineering Technology Inc. 2008) based on land use type (medium density residential) and acreage of effective area (170 acres). Load reductions were determined using estimated reduction factors based on literature review (Harper 2007).

Final Water Quantity Method and Summary: N/A

SLE 56

Northern Everglades – Potential Management Measure

Project Feature/Activity: Farm and Ranchland Partnerships

Level: 4

General Description/Background: There are two USDA Natural Resources Conservation Service (NRCS) programs that help farmers and ranchers keep their land in agriculture: the Farm and Ranchlands Protection Program (FRPP) and the Wetlands Reserve Program (WRP). Both programs provide funds to purchase conservation easements. The proposal is that the NRCS, the District, local agricultural landowners, and other partners enter into agreements to contribute funding and resources toward a long-term partnership.

Purpose: The partnership would acquire easements on private lands to remain in agriculture and provide water quality and storage benefits in support of the Northern Everglades initiative.

Location/Size/Capacity: St. Lucie River Watershed

Initiative Status: FRPP and WRP are established programs and landowners are waiting to participate pending federal appropriations.

Cost: The proposal is that the NRCS, the District, and local agricultural landowners enter into agreements to contribute funding and resources toward a long-term partnership. The partnership would leverage existing federal and state funding.

Estimate of Water Quality Benefits

- Minimum: Unknown
- Maximum: Unknown
- Most Likely: Unknown
- Level of Certainty: Unknown
- Assumptions: NA

Estimate of Water Quantity Benefits

- Minimum: Unknown
- Maximum: Unknown
- Most Likely: Unknown
- Level of Certainty: Unknown
- Assumptions:

Screening Criteria

- Proof of Concept: NA
- Other Impacts: NA

Contact: SFWMD

Final Water Quality Method and Summary: Undetermined
Final Water Quantity Method and Summary: Undetermined

Method: Water quality and quantity benefits are anticipated to occur as a result of this project; however, the magnitude of these benefits was not determined due to the nature of the project.

SLE 57

Northern Everglades – Potential Management Measure

Project Feature/Activity: Septage Disposal Requirements

Level: 1

General Description/Background: In response to the new provisions of Section 373.4592(4)(a)2.f. and (b)2.f., F.S., regarding application of septage in the Caloosahatchee and St. Lucie rivers, respectively, FDOH has notified all county permitting authorities in the watersheds of another requirement regarding septage disposal. Entities disposing of septage within the watersheds must develop and submit to DOH an agricultural use plan that limits applications, based upon nutrient loading. At this time, there are no known septage application sites in these watersheds. Once SFWMD or FDEP has promulgated nutrient concentration limits for runoff from sites in these watersheds, through the SFWMD's 40E-61 Regulatory Nutrient Source Program or another validly adopted rule, FDOH will notify all county permitting authorities in the watersheds that nutrient concentrations originating from these application sites may not exceed the established limits.

Purpose: Improve water quality by reducing nutrient runoff and leaching resulting from the land application of septage within the St. Lucie watershed.

Location/Size/Capacity: St. Lucie River Watershed

Initiative Status:

Cost: Not applicable

Documentation: NEEPP

Estimate of Water Quality Benefits
- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits
- Minimum: N/A
- Maximum: N/A
- Most Likely: N/A
- Level of Certainty: N/A
- Assumptions: N/A

Contact: Florida Department of Health

Final Water Quality Method and Summary: N/A
Final Water Quantity Method and Summary: N/A

Method: Included in the BMP load reduction estimates (Soil and Water Engineering Technology Inc. 2008).

SLE 58

Northern Everglades – Potential Management Measure

Project Feature/Activity: Animal Manure Application Rule

Level: 1

General Description/Background: In February 2008, FDACS initiated rule development to control the land application of animal wastes in the St. Lucie River Watershed. The proposed rule includes minimum application setbacks from wetlands and all surface waters. Landowners who apply more than one ton per acre of manure must develop conservation plans, approved by the US Department of Agriculture/National Resource Conservation Service (USDA/NRC), that specifically address the application of animal wastes and include soil testing to demonstrate the need for manure application. All use of animal manure must be recorded and included in the operation's overall nutrient management plan. FDACS expects to complete rule making for this effort by the fall of 2008.

Purpose: Improve water quality by reducing nutrient runoff and leaching resulting from the land application of manure.

Location/Size/Capacity: Statewide for one acre applications or greater.

Initiative Status: rule under development

Cost: Not applicable

Documentation: Proposed Rule 5M-10 F.A.C.

Estimate of Water Quality Benefits
- Minimum:
- Maximum:
- Most Likely:
- Level of Certainty:
- Assumptions:

Estimate of Water Quantity Benefits
- Minimum: N/A
- Maximum: N/A
- Most Likely: N/A
- Level of Certainty: N/A
- Assumptions: N/A

Screening Criteria
- Proof of Concept: N/A
- Other Impacts: N/A

Contact: Rich Budell; FDACS; 850-617-1704

Final Water Quality Method and Summary: N/A
Final Water Quantity Method and Summary: N/A

Method: Included in the BMP load reduction estimates (Soil and Water Engineering Technology Inc. 2008).

APPENDIX C

NORTHERN EVERGLADES REGIONAL SIMULATION MODEL

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C1.0 NORTHERN EVERGLADES REGIONAL SIMULATION MODEL

A customized modeling tool, the Northern Everglades Regional Simulation Model (NERSM), was used to guide the formulation and evaluation of alternative plans during the River Watershed Protection Plan (RWPP) process. Key information about the model, model simulations, and application of simulation output was previously presented in Section 6; additional details from the modeling exercise are presented in this Appendix. This appendix is an update to Appendix B of the Lake Okeechobee Watershed Construction Project Phase II Technical Plan (LOP2TP) report (SFWMD, 2008).

South Florida is a unique environment requiring specialized models to simulate regional operations. South Florida has a complex regional hydrologic system that includes thousands of miles of primary and secondary networked canals, nearly 300 man-made flow-regulation structures, thousands of square miles of nearly flat terrain much of which are wetlands, and permeable surficial soils that enhance groundwater-surface water interactions. Hydrologic and hydraulic analyses of this complex system require a computational model that can run quickly, offer flexibility, and generate output that can be clearly interpreted. Because of the region's highly variable hydrology (extreme rain events and periods of extended droughts), it is imperative that models be capable of running regional simulations of decades covering wet, dry and average rainfall conditions. Finally, land use changes and water demands for this extended period of time requires the user to easily modify input data sets, as well as an ability to use generalized data sets to optimize performance.

The Regional Simulation Model (RSM) was developed by the South Florida Water Management District (SFWMD) to overcome these limitations. RSM provides the computational framework for developing more complete and numerically sound integrated surface water and groundwater models where both components receive equal attention.

The RSM uses advanced computational techniques such as efficient sparse matrix solver and a finite volume method to simulate 2-D surface water and groundwater flow (SFWMD, 2005b). In addition, the RSM model uses an object oriented programming approach which allows new objects to be inserted or existing objects to be removed from the model without compromising the functionality of existing modules.

When used in a meshed system, RSM has two principal components, the Hydrologic Simulation Engine (HSE) and the Management Simulation Engine (MSE). The HSE simulates natural hydrology, water conveyance systems such as canals and natural bodies of water. The HSE component solves the governing equations of water movement through both the natural hydrologic system and the man-made structures. The MSE component consists of a multi-level hierarchical control scheme, which includes both the local and regional control of hydraulic structures. These two components work seamlessly to conduct the long term modeling necessary for this complex region.

RSM can be used as a node-link model when implemented in a study area that can be conceptualized as a lumped system, as in the case of NERSM. RSM produces complete water budgets given appropriate boundary conditions and simplified operating rules. Initial usage of NERSM was in the LOP2TP process. A refined version of the NERSM was utilized during the

RWPP planning process. More advanced capabilities of RSM such as 1-D canal flow routing and 2-D overland flow/groundwater flow calculations were not used in NERSM.

In summary, to support both the LOP2TP and the RWPP planning processes, RSM was applied to create NERSM, a customized hydrologic model. This model is used to simulate hydrologic conditions in the Northern Everglades Technical Plan study area (**Figure C-1**) under varying scenarios such as Current Base, Future Base, and alternative plans. It should be noted that the recommended plan from the LOP2TP project became the basis for the RWPP Future Base (RWPPB). In other words, the RWPP assumes that the LOP2TP is implemented and all RWPP alternatives build upon the improved conditions resulting from LOP2TP implementation. Comparison of the Current Base and the RWPPB is provided in Section 6.2 of the RWPP, while comparison of the RWPPB and the RWPP alternatives is given in Section 6.5. Subsequent reference to a Future Base in this Appendix corresponds to RWPPB.

C1.1 Spatial Representation

The model area covers the Lake Okeechobee Watershed, Caloosahatchee River Watershed, and the St. Lucie River Watershed. The Lake Okeechobee Watershed consists of five sub-watersheds north of the lake: the Upper Kissimmee Basin (KUB), Lower Kissimmee Basin (LKB), Taylor Creek / Nubbin Slough (TCNS), Lake Istokpoga (LI), and Fisheating Creek (FEC).The model also represents the Water Supply and Environment (WSE) Regulation Schedule for regulatory releases to the Caloosahatchee (C-43) Estuary through S-77 and the St. Lucie (C-44) Estuary via S-308. The Caloosahatchee River Watershed consists of the East Caloosahatchee (ECAL) and West Caloosahatchee (WCAL) sub-watersheds, while the St. Lucie River Watershed consists of the C-23, C-24, C-44, Ten Mile Creek and Tidal sub-watersheds.

The study area is represented in NERSM by a series of links and nodes (**Figure C-2**). Each node represents a distinct drainage basin or hydrologic feature for which a water balance is simulated. Links represent the processes that convey water from one node to another. The combined link-node diagram illustrates the spatial distribution and movement of water as it is conveyed within a sub-watershed and between sub-watersheds. Larger, more complex sub-watersheds like the KUB and LKB are represented using multiple links and nodes. Others, TCNS, LI, and FEC are represented by a single node linked to Lake Okeechobee. Although Lake Okeechobee is represented as a single node, its water balance is influenced by links to each of the tributary watersheds and the inter-basin transfers of water (**Figure C-2**).

The model uses an object-oriented approach, which allows new objects (i.e. software modules) to be added without the need to edit the previous code or functionality of existing modules. For example, the addition and operation of a new reservoir would be simulated as a discrete “object” – there would be no need to modify the coding for other elements of the water management system. In this application, NERSM receives boundary conditions from two existing models – Upper Kissimmee Chain of Lakes Routing Model (UKISS) and the South Florida Water Management Model (SFWMM). NERSM uses some output from the UKISS as input to the model representing the LKB Sub-watershed.

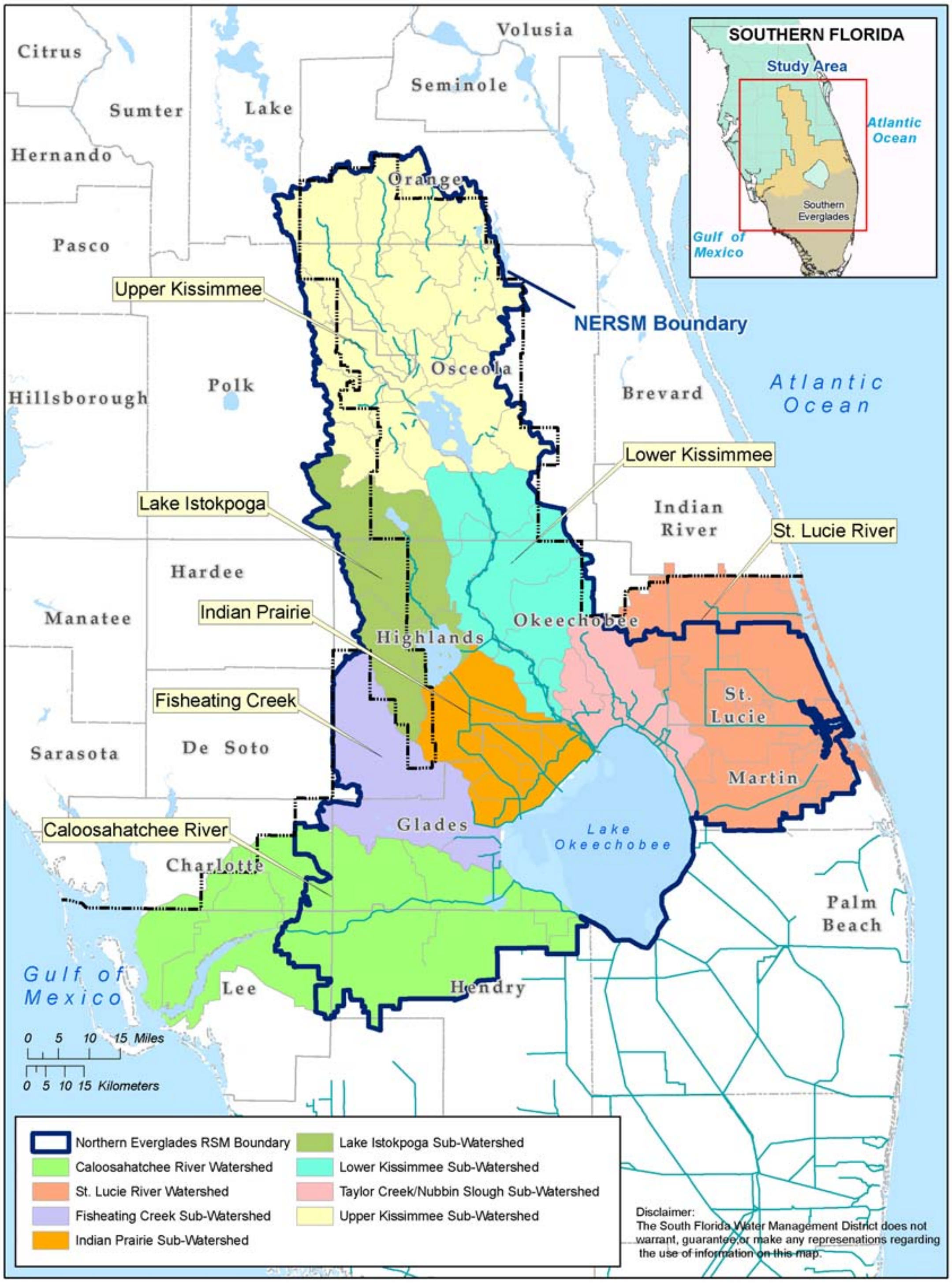


Figure C-1. Watersheds modeled in the NERSM

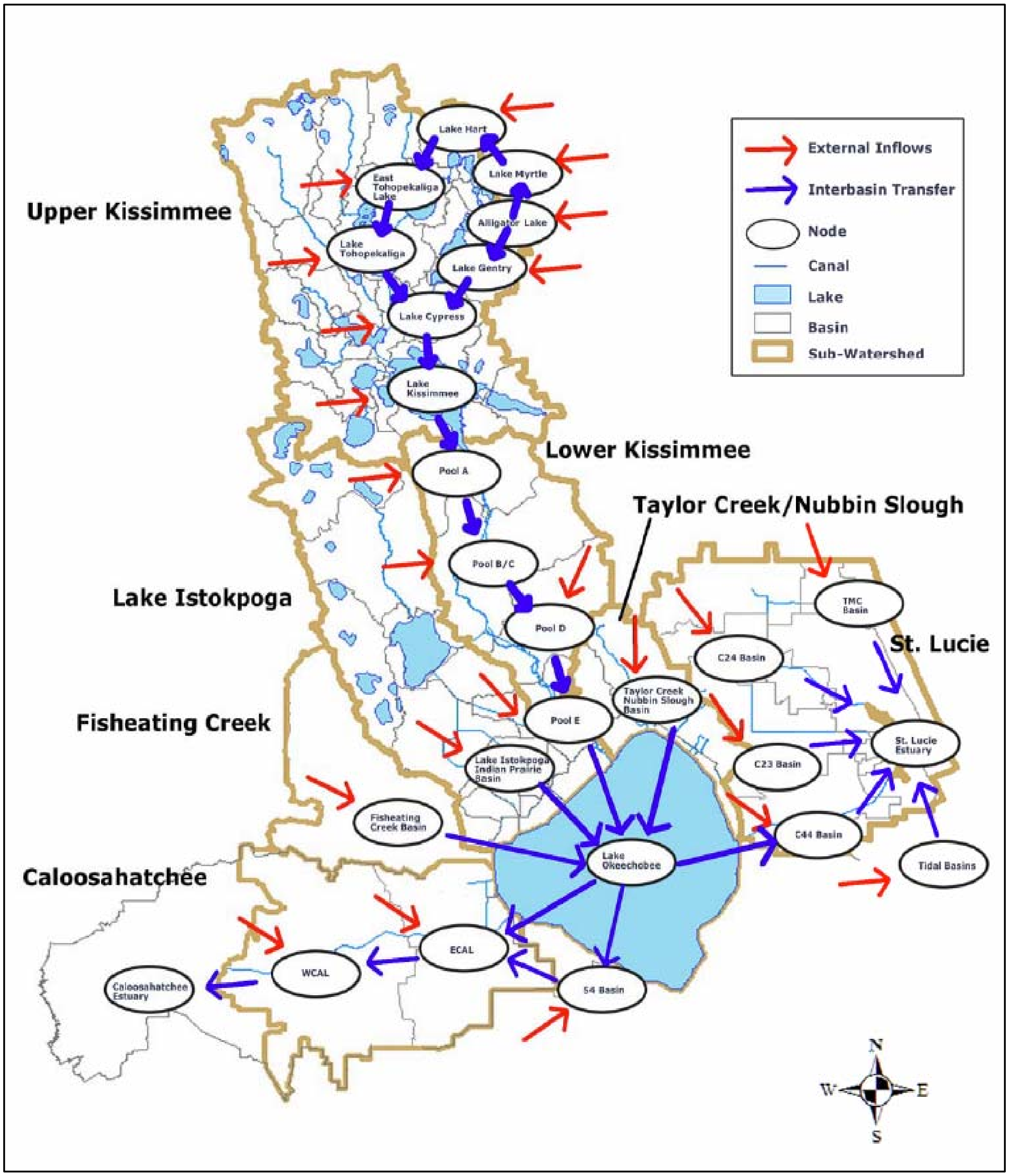


Figure C-2. Node-link diagram representation of NERSM

C1.2 Simulation Period

NERSM is a transient model that calculates a water balance for each node on a time interval of one day. A simulation period spanning 36 years from January 1, 1970 through December 31, 2005 was selected for evaluating various water management scenarios. All management scenarios evaluated using NERSM are based on the same 36-year simulation period.

The simulation period selected for the NERSM is slightly different from the 36-year period typically used by SFWMM (1965 to 2000). For the NERSM simulation, the inclusion of the last five years (2001-2005) was driven by the desire to include extreme events such as Hurricanes Charlie, Frances, and Jeanne in 2004, and Hurricane Wilma in 2005.

C1.3 Theoretical Assumptions and Limitations

Major assumptions and limitations of NERSM are as follows:

- The simulation period is sufficiently long, such that the hydrologic conditions in existence during this period and used as model input varied sufficiently to adequately characterize the performance measures considered in the evaluation of RWPP management alternatives.

- Water is routed through storage features assuming a level pool with negligible slope in the water surface. The assumption is valid as long as the volume entering a storage feature during the one-day time step is small relative to the volume of water in storage.

  - The model simulates the management of the system according to a set of operational criteria referred to as management rules. These rules are expressed in regulation schedules, gate-operation criteria, and established rules governing the operation of the structures. It is assumed that the management rules prescribed for the various simulation scenarios are reasonable for the variety of hydrologic conditions represented by the period of simulation. Under unusual conditions, the actual operation may differ from the established rules and can lead to differences between calculated and observed conditions.

- A daily time step is assumed to be adequate for planning purposes and the evaluation of RWPP performance measures. Most measures are expressed in terms of annual, monthly, and weekly statistics. A possible exception is the extreme low and high stages calculated for Lake Okeechobee. This assumption should be valid because the difference between an instantaneous minimum (or maximum) and the model-calculated daily value is small compared to the year-to-year variability in range of extreme stages calculated for a daily simulation spanning 36 years.

- Historical inflows to TCNS, LI, and FEC, based on monitoring, are assumed to produce historical outflows from these sub-watersheds into Lake Okeechobee. Referred to as the "flow pass-through method," this eliminates the need to develop stage-volume relationships for existing storage features within the sub-watersheds or to simulate the rainfall-runoff process for the sub-watershed.

- It is assumed that a change in management rules will not change the historical hydrologic variables.

- Sub-watershed areas are reduced in size for proposed future management measures (MMs) such as reservoirs and stormwater treatment areas (STAs). It is assumed that the historical sub-watershed inflow discharged to Lake Okeechobee can be reduced in proportion to the ratio of the effective footprint "taken" by the management measure relative to the overall area of the sub-watershed.

- Other than the footprint associated with MMs considered in the Future Base and alternative scenarios, it is assumed that changes in land use or land cover within the study area, e.g. conversion to natural lands, will require some runoff modification in order to account for increased evapotranspiration (ET) and attenuation.

- No flow-regulation structures exist in the Fisheating Creek Sub-watershed. The creek has an open connection with Lake Okeechobee. The link between the sub-watershed and Lake Okeechobee is simulated by an assumed "dummy" structure that has a very high flow conveyance capacity.

- The lower Kissimmee River and floodplain between consecutive water control structures is assumed to be hydrologically similar to a level-pool reservoir with a unique stage-volume relationship. Lock operations are not simulated.

- It is assumed there is no connection between Lake Istokpoga and the Kissimmee River. Structure G-85 is simulated as being closed.

- The Caloosahatchee Estuary target is the ecologically-based EST05 time series which establishes the desired temporal distribution of surface water discharges via S-79 into the estuary. Lake Okeechobee is used to meet this target.

- The St. Lucie Estuary target was established using an updated version of the optimization model (OPTI) used to size reservoir and establish optimal operations as recommended in the IRL-South project (SFWMD, 2004). NERSM attempted to mimic the OPTI-6 generated flows into the St. Lucie Estuary in order to mimic the performance of the IRL-S PIR. The option to explicitly make Lake Okeechobee releases to meet these operational targets is turned off in all RWPP scenarios.

- Elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD). Units of measure for input, output and calculations are from the English Customary System which includes measures such as inches, feet, miles, gallons, and acres.

C1.4 Model Input

The following types of data are provided as input to NERSM.

- **Hydrologic boundary conditions**: These are system "state variables" used to describe inflow to and discharge from the sub-watersheds. Boundary conditions are based on daily time series of historical flow records collected at control structures and hydrometeorologic data. Boundary conditions for watersheds simulated using the flow pass-through method are based on daily historical flow records obtained from the SFWMD's DBHYDRO database for the 36 year simulation period. The water balance for other sub-watersheds is based on daily records of rainfall, pan evaporation, and other hydrometeorologic data compiled from a variety of data sources.

- **Watershed and system characteristics:** Models such as UKISS, SFWMM and WaSh - which consider discrete components of the hydrologic cycle such as ET, surface runoff, and groundwater seepage - require additional input for watershed characteristics such as soil porosity, direct runoff-routing coefficients, channel roughness, etc. and parameters used to calculate ET, such as leaf area index. Stage-volume relationships are used to represent the storage of water within the surficial aquifer; water bodies such as lakes, reservoirs, and STAs; and other storage systems, such as aquifer storage and recovery (ASR) wells.

- **Hydraulic variables:** The flow of water through open channels, gated hydraulic structures, and pumps is governed by empirical equations called "ratings" that relate flow to system state variables. Some examples of state variables are stage (the water level in a canal, stream, lake or reservoir), and physical characteristics, such as channel and gate geometry, pump diameter, and pump operating speed. Model input includes site-specific parameters for the equations associated with the specific hydraulic controls that are being simulated.

- **Management variables:** Regulation schedules represent the management aspect of the system aimed at multiple objects, such as optimizing flood control, water conservation, and environmental enhancement. A regulation schedule contains zones of time within which flow releases are prescribed depending on the "state" the system is in. Regulation schedules for existing structures have evolved over time in response to hydrologic conditions, such as the recent hurricanes and alterations in flow-management objectives.

C1.5 Model Output

Although NERSM can be set up to output a variety of information, the primary variable of interest are calculated stages and flows at specific structures, and sub-watershed water balances. Output can be recorded at user-selected time intervals, although daily output is the most common. Post-simulation processing algorithms are used to aggregate the daily output into summary formats such as the average annual sub-watershed volumes of rainfall, tributary inflow, ET, and flow releases. Post processing is used to generate information for quantifying specific performance measures designated for the various project MMs (**Table C-1**).

C1.6 Model Validation

To ensure that the NERSM was performing as intended, Current Base and Future Base conditions were also simulated using the SFWMM and the Upper Kissimmee Model. Consistent input series were used for all model simulations.

NERSM output for Lake Okeechobee and the two estuaries were compared to SFWMM output for the same regions. NERSM output for the Lower Kissimmee sub-watershed was compared to UKISSWIN output.

C1.6.1 South Florida Water Management Model (SFWMM)

The SFWMM has been extensively used in previous SFWM modeling efforts. The major operational components of Lake Okeechobee that are common to both SFWMM and NERSM are the WSE schedule and Lake Okeechobee Service Area (LOSA) water supply procedure. For both sets of operations, outlet flows from individual structures were compared to the results from the equivalent SFWMM run in order to validate the operational methodology in the NERSM simulations. In both cases, the comparison showed good correlation in terms of the timing and magnitude of the flows in the two models.

Table C-1. Performance Measures Used to Evaluate Current and Future Base Conditions and Alternatives

Sub-Watershed	Performance Measure
Lake Okeechobee	Total surface P Loading to Lake Okeechobee
	Extreme high lake stage > 17 ft
	Extreme low lake stage < 10 ft
	Lake stage envelope – weeks below
	Lake stage envelope – weeks above
	Number of times proposed min water level & duration – criteria exceeded
Caloosahatchee Estuary	Number of times salinity envelope criteria NOT met
	Number of times estuary high discharge criteria exceeded (between 2,800 and 4,500 cfs)
	Number of times estuary high discharge criteria exceeded (>4,500 cfs)
	Target Flow distribution based on EST05 time series established for S-79
St. Lucie Estuary	Number of times estuary high discharge criteria exceeded (between 2,000 & 3,000 cfs)
	Number of times estuary high discharge criteria exceeded (>4,500 cfs)
	Number of times salinity envelope criteria NOT met
Water Supply	LOSA demand cutback volumes for 7 yrs with largest cutbacks
	Mean annual EAA/LOSA supplemental irrigation demands not met

C1.6.2 UKISSWIN Model

The UKISSWIN model was developed by the SFWMD to simulate the operation of the lake system in the Upper Kissimmee River Basin. UKISSWIN was used to supply boundary conditions to NERSM. The UKISSWIN model area covers the following lakes: Alligator, Myrtle, Hart, and Mary Jane, Gentry, East Tohopekaliga, and Tohopekaliga, Cypress, Hatchineha, and Kissimmee. The model is capable of simulating both the hydrology and management of the lake system in three modes: simulation, calibration, and forecasting. The model is well calibrated and undergoes continuous updates. It is routinely used to forecast the monthly lake stages, using rainfall as the conditional independent variable.

NERSM treated the simulation of the lake system in the Upper Kissimmee Sub-watershed the same way UKISSWIN did, using the same routing scheme, identical rainfall data, and same ET model. NERSM used watershed inflow data from UKISSWIN output as one of its boundary conditions. The major differences between the two models are the stage-area and stage-volume relationships. NERSM adopted the most updated data available (developed as part of the Kissimmee Basin Modeling and Operations Study (KBMOS). In general, the modeling results are very similar between the NERSM and UKISSWIN models.

C1.6.3 Validation Results

NERSM performance was shown to match SFWMM (2X2) (**Figure C-3)** and UKISSWIN (**Figures C-4** and **C-5**). The NERSM was therefore considered suitable for making planning level decisions.

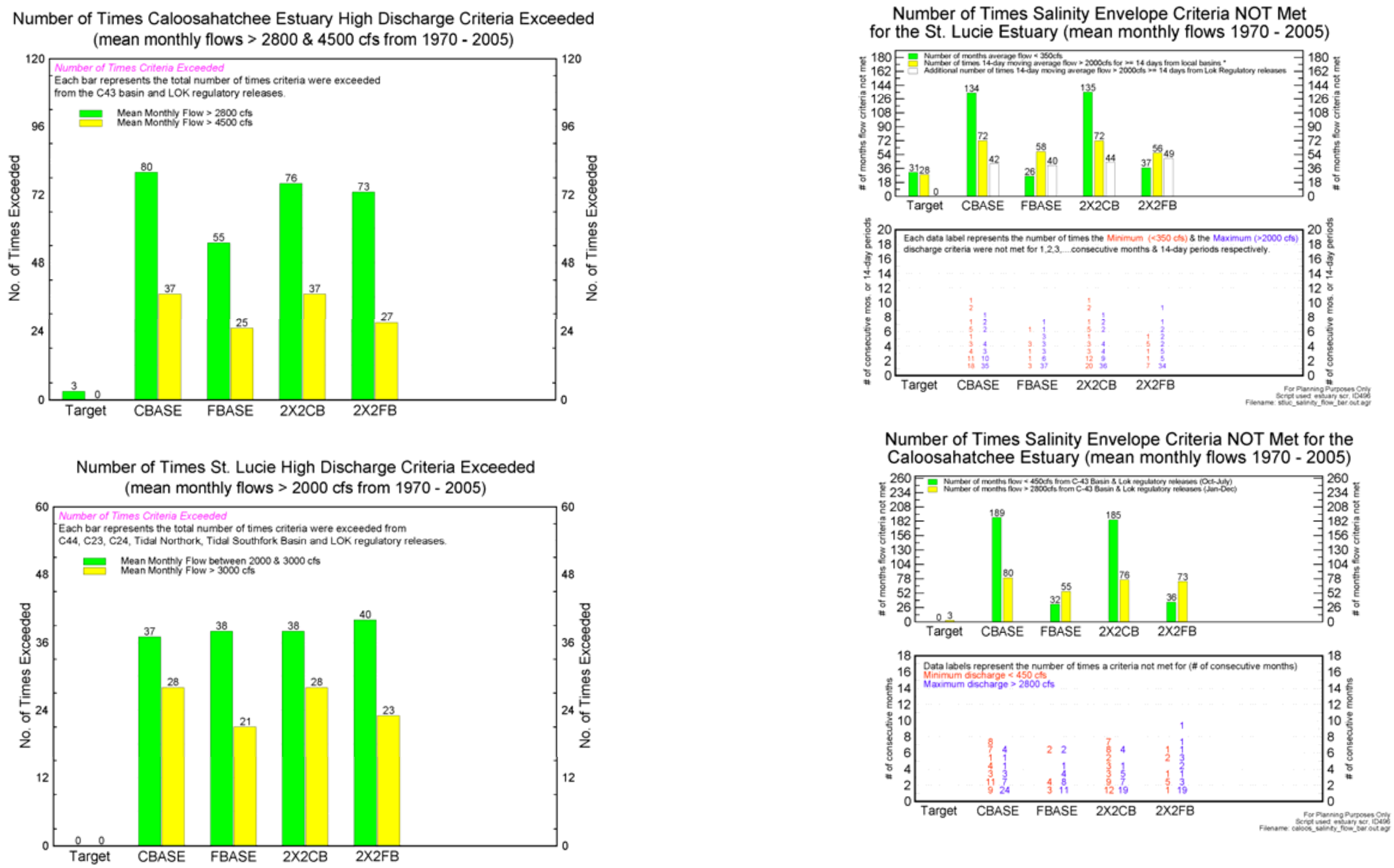


Figure C-3. Comparison of NERSM and SFWMM (2x2) Model outputs for selected performance measures

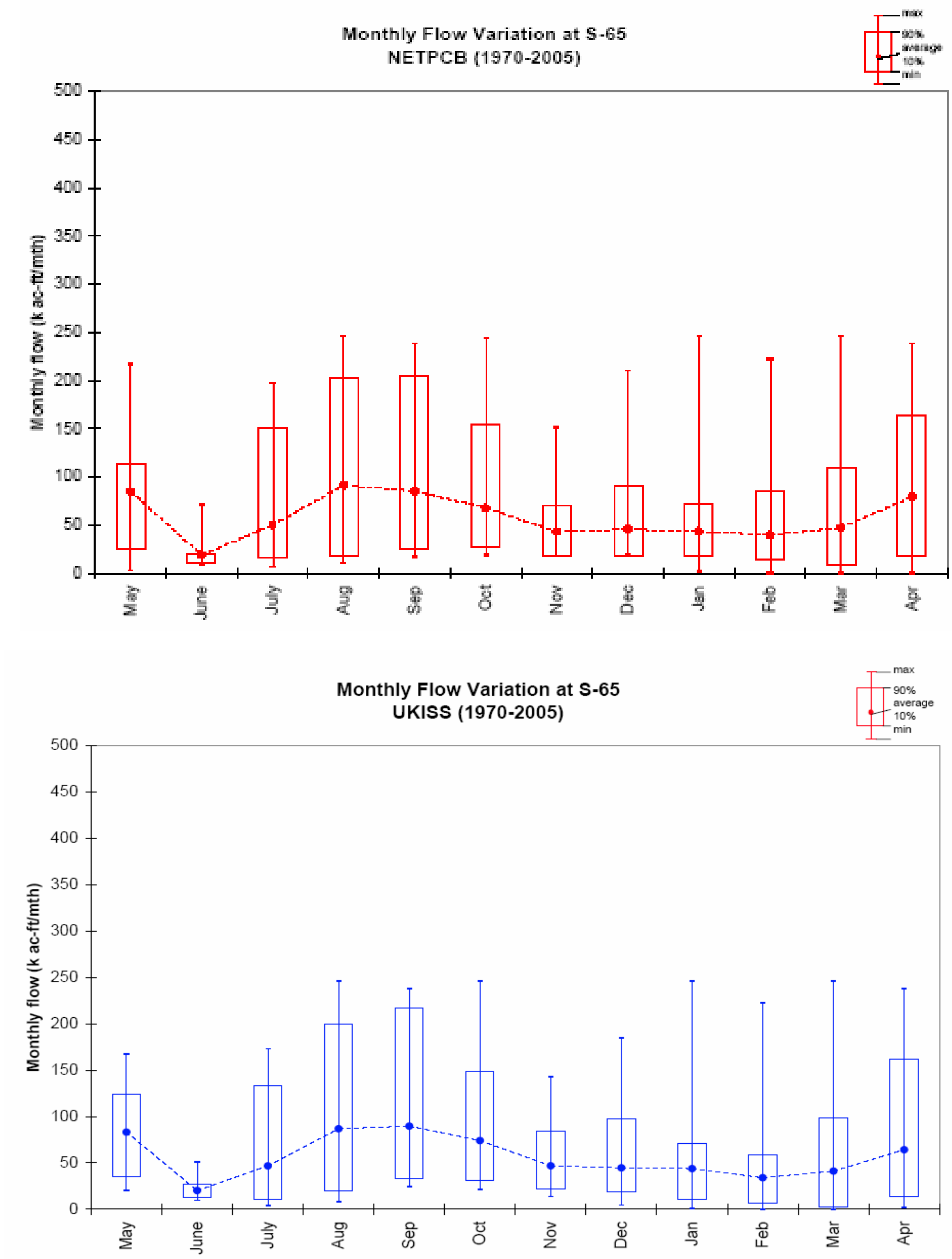
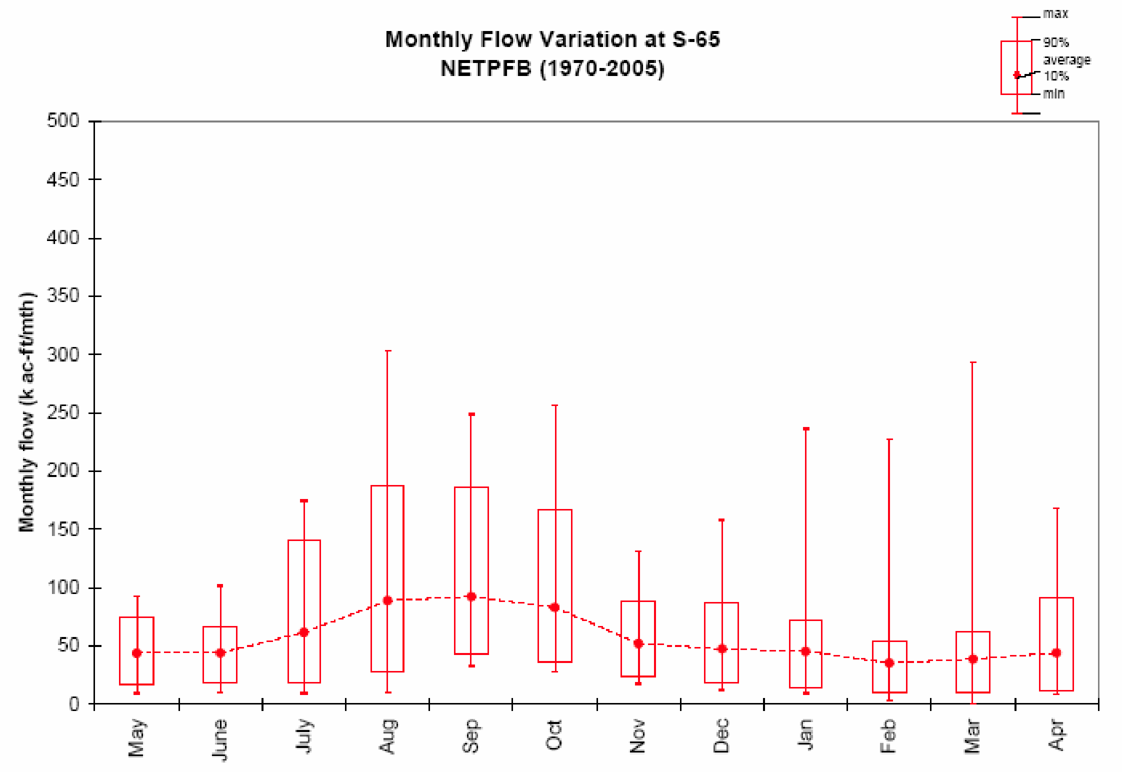


Figure C-4a and b. Monthly flow variation at S-65 in NERSM and UKISSWIN models for Current Base



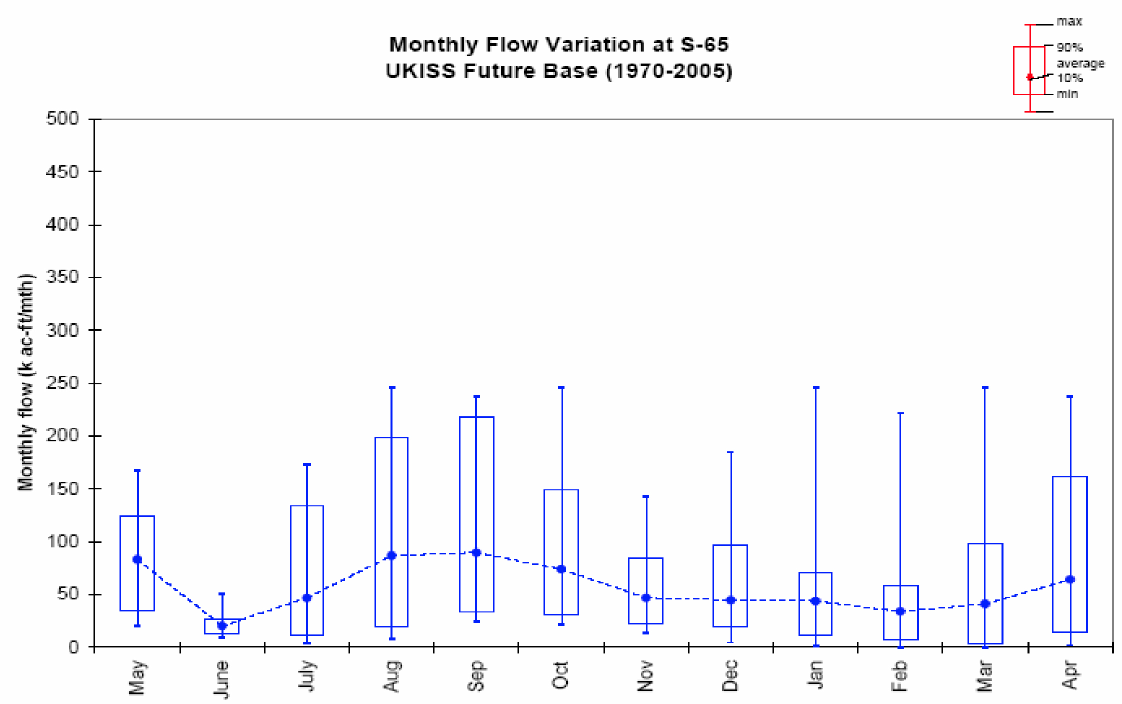


Figure C-5a and b. Monthly flow variation at S-65 in NERSM and UKISSWIN models for Future Base

C2.0 NERSM APPLICATION

C2.1 Modeling Scenarios

The following scenarios were evaluated using the NERSM:

- **Current Base** – This scenario represents sub-watershed and management conditions that existed in the Lake Okeechobee Watershed in 2005. The condition assumes that no CERP projects had been implemented for a sufficient time to reflect impacts of implementation. The more recent records of historical flow used for the Lower Kissimmee Basin (LKB) Sub-watershed model reflect to some degree the effects of incremental restoration associated with Phase I of the Kissimmee River Restoration (KRR) through 2005. In addition, the effects of STAs constructed recently prior to 2005 in the TCNS Sub-watershed have not been demonstrated because of dry conditions and a lack of data to characterize performance. Regulatory (flood control) releases from Lake Okeechobee to the estuaries and to the Water Conservation Areas (WCAs) are simulated based on the WSE Regulation Schedule consistent with the SFWMM 2005 base run.

- **RWPP Future Base (RWPPB)** – This scenario represents the Current Base scenario plus planned conditions likely to exist in the Lake Okeechobee Watershed following the implementation of three Acceler8 projects; two Kissimmee River water resources projects and recommendations from the LOP2TP project (note: this scenario should not be confused with the LOP2TP Future Base). The following projects were included in the RWPPB scenario:

  - **Acceler8 Projects**: C-43 Caloosahatchee River Reservoir, C-44 St. Lucie Canal Reservoir and STA, and A-1 Everglades Agricultural Area Reservoir.

  - **Kissimmee Projects**: KRR Project and the Kissimmee River Headwaters Revitalization

  - **LOP2TP Recommended Projects**: Combined Reservoir storage, STA storage and ASR capacity equal to 914,000 acre-feet, 54,000 acre-feet and 66 million gallons per day (MGD), respectively. Additional details can be found in the LOP2TP Technical Plan (SFWMD, FDEP, and FDACS, 2008).

  - **Ten Mile Creek Reservoir Project**

  The same sub-watershed inflow time series used in the Current Base simulation are used in the Future Base simulation. Pools B, C, and D in the Current Base simulation are combined to form pool BCD in the Future Base simulation. Regulatory (flood control) releases from Lake Okeechobee to the estuaries and to the WCAs are simulated based on the WSE Regulation Schedule, consistent with the SFWMM 2010A8 run.

  – This scenario is essentially the same as the LOP2TP Future Base plus LOP2TP recommended MMs, and enhancements to the Caloosahatchee River and St. Lucie River watershed simulation. The NERSM version used in LOP2TP treated several hydrologic variables in both river watersheds as boundary conditions, e.g. C-44 Reservoir operations, backflow to Lake Okeechobee, etc. This version also lumped the contribution of the basins that comprise each watershed. The version of NERSM used in the RWPPs, on the other hand, treats the basins upstream of S-79: East Caloosahatchee, West Caloosahatchee and S-4 as separate computational nodes with different associated demand and runoff characteristics. Likewise, St. Lucie River Watershed basins outside the C-44 Basin were treated separately in order to simulate the different water quantity and quality features during alternative plan development and analysis phase of the project. A summary of the MMs recommended during the LOP2TP planning process is shown in **Table C-2**. Management measure numbers correspond to those in the LOP2TP Technical Plan (SFWMD, FDEP, and FDACS, 2008).

- **RWPP Alternative Plans (ALTs 1 through 4) –** The RWPP planning process formulated and evaluated four alternative plans for achieving project goals and objectives. Each scenario represents the RWPPB scenario, plus a variety of MMs from three general categories – reservoir storage, water quality treatment, and wetland/natural land restoration. MMs meeting the following criteria were selected to be included in the model:

  1. The MM should have water quantity benefits to the regional system. Some MMs, like on-site treatment, are too small to make an imprint on the regional performance measures and, thus, were not included in the model.
  2. A conceptual design should exist for the MM. If none exists, sufficient documentation should exist where the purpose, relative storage capacity and reasonable linkage to the regional system can be roughly established.

  The combinations of specific MMs are summarized in **Tables C-3** and **C-4** for the Caloosahatchee River and St. Lucie River watersheds, respectively. These combinations are also described in other sections of the report. The alternative plans are summarized as follows:

  Alternative 1 – This alternative is defined as the "common elements" that are included in all subsequent alternatives. It includes (MMs) that were either already constructed/implemented or their construction/implementation was imminent, or MMs, in the opinion of the working team, with construction/implementation imminent, pending resolution of certain issues. The MMs in Alternative 1 range from Level 1 to Level 4. (Refer to Section 6.1.1 for a description of the MM levels). For the Caloosahatchee River Watershed, the MMs in Alternative 1, as simulated by NERSM, are as follows: C-43 Water Quality Treatment and Demonstration Project (BOMA property), C-43 Distributed Reservoirs, and Clewiston STA. For the St. Lucie River Watershed, the MMs in Alternative 1, as simulated by NERSM, are as follows: C23/24 Reservoir (North and South), C23/C24 STA, and natural lands in CERP IRL-S Project.

  The water quantity benefits of Alternative 1 are quantified by the combined capacities of reservoir storage and STA storage at 47,913 acre-feet for Caloosahatchee River Watershed and 95,946 acre-feet for St. Lucie River Watershed.

Alternative 2 –The primary objective of this alternative is to maximize the storage capacity. In addition to MMs included in Alternative 1, Alternative 2 provides a substantial increase in acreage for additional and enlarged reservoirs in the ECAL sub-watershed. The MMs in ECAL could potentially create an additional 100,000 acre-feet of above ground storage from a series of distributed reservoirs, and another 21,490 acre-feet can be realized using a proposed reservoir and stormwater treatment area in the vicinity of Lake Hicpochee. No new MMs were proposed for the other sub-watersheds in the study area.

Alternative 3 – The primary objective of this alternative is to maximize nutrient load reductions in the Caloosahatchee River Watershed. Using Alternative 1 as the basis, new MMs were added for further nutrient load reduction. Three MMs were incorporated in NERSM to simulate this alternative. The West Caloosahatchee Water Quality Treatment Area consists of a constructed wetland designed to treat water from the reservoir to reduce nutrient concentrations from the Caloosahatchee River and nutrient loading to the downstream estuary. The Caloosahatchee Ecoscape Water Quality Treatment Area consists of a constructed wetland designed for optimal removal of nitrogen from the Caloosahatchee River. The Caloosahatchee Area Lakes Restoration (Lake Hicpochee) involves restoring the historical lake bed of Lake Hicpochee that could be used to treat runoff from agricultural canals that currently flow into Lake Hicpochee and the Caloosahatchee River.

Approximately 7,500 acres of land would be involved in above three MMs. No additional MMs were included in the St. Lucie River Watershed.

Alternative 4 – Alternative 4 is a hybrid of Alternative Plans 2 and 3, thus increasing the storage and nutrient load reduction potential relative to all previous alternatives. The East Caloosahatchee storage is increased to 150,000 acre-feet, a 50,000 acre-feet increase from Alternative 2. The basis for this increase was partially determined by performing a sensitivity analysis of the storage capacity in Alternative 2. Section C6.0 of this appendix provides the results of the sensitivity analysis. All treatment facilities in Alternative 3 are included in Alternative 4.

Table C-2. Summary of Management Measures Simulated in NERSM RWPPB

Sub-Watershed	Management Measure		Reservoir			STA			ASR / Deep Well Injection
	MM ID #	**MM ID**	**Effective Area (acre)**	**Capacity (ac-ft)**	**Inflow / outflow Capacity (cfs)**	**Effective Area (acre)**	**Capacity (ac-ft)**	**Inflow / Outflow Capacity (cfs)**	**Inflow / Outflow Capacity (MGD)**
TCNS	16 24 17 99 100	Lakeside Ranch STA[a], Brady Ranch STA[a], Lemkin Creek STA[a], Taylor Creek Critical Project STA (CP)[a], Nubbin Slough Critical Project STA (CP)[a]				**5,096** (2400, 1600, 205, 118, 773)	**7,863** (3240, 2430, 500, 147, 1546)	**744 /** **~744[b]** (300, 200, 100, 24, 120)	
	113	Taylor Creek STA				1,800	2,700	300 & 300[d] / ~600[b]	
	19	Taylor Creek ASR							6/6
LKB	26	Paradise Run ASR							50/50
	29	Kissimmee Reservoir	10,079	161,263	1,500 / 1,500				
	93	Kissimmee River ASR Pilot							5/5
	107	Kissimmee Reservoir East	12,500	200,000	1,000 / 300[f] & 2,500[g]				
	114	Istokpoga/Kissimmee RASTA	8,100	129,600	1,000 & 1,500[c] / 1,500[h] & 2,500[g]				
LI	18	Seminole Brighton Reservation ASR							5/5
	30	Istokpoga Reservoir	4,973	79,560	500 / 2,500				
	31	Istokpoga STA				7,240	10,860	2,000 / ~2,000[b]	
	111	S-68 STA				2,400	3,240	250 / ~250[b]	
	114	Istokpoga/Kissimmee RASTA: Reservoir	9,000	144,000	750 & 750[c] / 1,500				
	114	Istokpoga/Kissimmee RASTA: STA				7,200	10,800	1,500 & 1,500[e] / ~3,000[b]	
FEC	 61 77 115	Reservoirs: FEC RASTA I, FEC RASTA II, Nicodemus Slough RASTA	13,815	199,980	2,450 & 1,500[c] / 1,100				

	 61 77 115	STAs: FEC RASTA I, FEC RASTA II, Nicodemus Slough RASTA				14,355	21,533	1,100 / ~1,100[b]	

Notes:

[a] – Combined into a single STA

[b] – Assumed passive weir

[c] – Receives inflow (second priority) from Lake Okeechobee in addition to watershed inflow

[d] – Receives inflow from Kissimmee East reservoir

[e] – Receives inflow from Istokpoga/Kissimmee reservoirs

[f] – Sends outflow (first priority) to Taylor Creek Reservoir converted to STA

[g] – Sends outflow (second priority) back to Kissimmee River

[h] – Sends outflow (first priority) to Istokpoga Canal RASTA: STA

Table C-3. Summary of Management Measures Simulated in NERSM for CRWPP

Mgmt Measure Number	Sub-Watershed	Description	Model Implementation	Specifications				
				Footprint (acre)	Effective Area (acre)	Capacity (ac-ft)	Operating Depth (ft)	Inflow/outflow (cfs)
RWPPB								
	FSW	C-43 Reservoir	reservoir storage	varies	varies	178600	20-42 ft NGVD	1500/1200
Alternative 1		add-ons to RWPPB						
CRE10	FSE	C-43 Water Quality Treatment Demonstration Project (BOMA Property)	water quality treatment	1335	1000	4500	4.50	99/99
CRE-LO 41	FSE, FNE	C-43 Distributed Reservoirs	reservoir storage; ALT1 MM adopted from LO Plan	6600	5280	42400	8.03	500/500
CRE-LO 92	S-4	Clewiston STA	water quality treatment; post-processing analysis only	766	700	1013	n/a; see description	40/40
Alternative 2		add-ons to Alternative 1						
CRE 128	FSE	East Caloosahatchee Storage	reservoir storage; combined with CRE-LO 41	8,800	7,040	100,000	see description	750/750
CRE-LO 40	FNE	West Lake Hicpochee Project	reservoir storage; ALT2 MM adopted from LO Plan, combined with CRE-LO 41	7,500	6,000	21,490	see description	250/250
Alternative 3		add-ons to Alternative 1						
CRE 04	FNE	Caloosahatchee Area Lakes Restoration	restoration; runoff adjustment in ECAL	5,300	5,300	10,600	n/a; see description	103/103

Mgmt Measure Number	Sub-Watershed	Description	Model Implementation	Specifications				
				Footprint (acre)	Effective Area (acre)	Capacity (ac-ft)	Operating Depth (ft)	Inflow/outflow (cfs)
		Project (Lake Hicpochee)						
CRE 11	FSW	Caloosahatchee Ecoscape Water Quality Treatment Area	water quality; combined with CRE 13	1,220	1,000	4,000	see description	99/99
CRE 13	FSW	West Caloosahatchee Water Quality Treatment Area	water quality; combined with CRE 11	1,530	1,200	4,800	see description	99/99
Alternative 4		add-ons to Alternative 1						
CRE 12a	FSE	Caloosahatchee Storage - Additional	reservoir storage; combined with CRE-LO 41	11,719	9,375	150,000	see description	500/500
CRE-LO 40	FNE	West Lake Hicpochee Project	reservoir storage; ALT2 MM adopted from LO Plan, combined with CRE-LO 41	7,500	6,000	21,490	see description	250/250
CRE 04	FNE	Caloosahatchee Area Lakes Restoration	restoration; runoff adjustment in ECAL	5,300	5,300	10,600	n/a; see description	103/103
CRE 11	FSW	Caloosahatchee Ecoscape Water Quality Treatment Area	water quality; combined with CRE 13	1,220	1,000	4,000	see description	99/99
CRE 13	FSW	West Caloosahatchee Water Quality Treatment Area	water quality; combined with CRE 11	1,530	1,200	4,800	see description	99/99

Sub-Watersheds:

S-4 - S-4 sub-basin
FNE - Caloosahatchee River Freshwater Northeast of S-78
FSE - Caloosahatchee River Freshwater Southeast of S-78
FNW - Caloosahatchee River Freshwater Northwest of S-78
FSW - Caloosahatchee River Freshwater Southwest of S-78

Table C-4. Summary of Management Measures Simulated in NERSM for SLRWPP

Mgmt Measure Number	Sub-Watershed	Description	Model Implementation	Specifications				
				Footprint (acre)	Effective Area (acre)	Capacity (ac-ft)	Operating Depth (ft)	Inflow/outflow (cfs)
RWPPB								
LO14	C44	C-44 Reservoir/STA	combined reservoir and STA		9,700	50,246	5.18	1060 / 550
	Ten-Mile Creek	TMC Reservoir/STA	combined reservoir and STA		656	7,078	10.79	360 / 200
Alternatives								
SLE09	C23/C24/C44	Natural Lands in CERP IRL-S Project	runoff adjustment					
SLE24	C24	C23/24 STA	stormwater treatment area		2,568	3,852	1.50	200 / 200
SLE24	C24	C-23/24 Reservoir (North & South)	reservoir storage; combined with C23		6,940	92,094	13.27	900 / 800
SLE40	C23/C44	C-23/44 Interconnection	via 250 cfs pump					

C2.2 Model Setup

The following sub-sections explain how the different sub-watersheds were conceptualized and the input requirements of the model. Additional discussions are provided, specific to how the RWPPB and alternative scenarios were created.

C2.2.1 Upper Kissimmee Basin Sub-watershed

The Upper Kissimmee (KUB) Sub-watershed model covers nine interconnected lakes (Alligator, Myrtle, Hart, Gentry, East Tohopekaliga, Tohopekaliga, Cypress, Hatchineha and Kissimmee) or Lake Management Areas (LMAs), as shown in **Figure C-6** The lakes are interconnected with canals and flow is strictly regulated using water control structures at the outlet of each lake. The NERSM model for the KUB area is based on the Upper Chain of Lakes Routing Model (KROUTE) developed by SFWMD (Fan, 1986) to simulate the operations of the lake system in the Upper Kissimmee River Basin.

In the nine-lake system, Alligator Lake is the uppermost lake, with no clearly defined surface water inflow. The outflow from Lake Alligator to the north is through a chain of small lakes to East Lake Tohopekaliga, and to the south through Lake Gentry to Lake Cypress. East Lake Tohopekaliga discharges south to Lake Tohopekaliga, which discharges into Lake Cypress. The lower three lakes - Lake Cypress, Lake Hatchineha and Lake Kissimmee tend to equalize in stage, since there are no hydraulic structures in the canals connecting the three lakes. The natural creeks Boggy, Shingle, Reedy and Catfish provide tributary flows to East Lake Tohopekaliga, Lake Tohopekaliga, Lake Cypress and Lake Hatchineha (**Figure C-6)**. The lakes are shallow and range in depth from 8 feet in Lake Kissimmee to 13 feet in Lake Alligator. The lakes cut into the surficial aquifer, which has a thickness ranging from 50 to 100 feet. The permeability of the aquifer is estimated to be low; hence, seepage is normally small as compared to the surface inflows.

The KUB lakes are assumed in the NERSM model to be level pools, and storage routing based on mass balance is performed on a daily time step, starting from the uppermost lake (Lake Alligator) to the lowermost lake (Lake Kissimmee). The water control structures which interconnect the lakes include six spillways (S-60, S-62, S-59, S-61, S-63 and S-65), two culverts (S-57 and S-58) and two open channel connections (C-36 and C-37). The flows through the gated spillway water control structures were computed using the daily headwater and tailwater values and gate openings modeled at the water control structure, as defined by the spillway and culvert equations used in the KROUTE model, and are similar to SFWMD's FLOW program (Ansar, 2003).

The maximum allowable gate openings for a set of headwater and tailwater conditions at the spillway were computed using the "Riprap Control" criteria, established by the U. S. Army Corps of Engineers (C&SF Project, Master Water Control Manual, 1994) to protect the structures from high velocity flow, resulting in downstream erosion. The two gated culvert structures S-57 and S-58 do not have any gate operation criteria. However the discharge capacities of the two culvert structures are relatively small as compared to the spillways, and the S-58 culvert has seldom been used during the period of record. The flow through the open channel canals C-36 and C-37 connecting lakes Cypress and Hatchineha, and lakes Hatchineha and Kissimmee is modeled using a variation of the Manning's equation, using stage and water surface slope as independent variables, and is outlined in the KROUTE model.

Figure C-6. Chain of lakes and control structures in Upper Kissimmee Sub-watershed

Watershed inflows to the lakes, which include direct runoff and base flows, were based on data sets that came out of the calibration effort for the UKISSWIN model (PBS&J, Christ et al., 2001). These were imposed as flow boundary conditions for the nine lakes. Historical flows obtained from U.S. Geological Survey (USGS) for Shingle, Boggy, Reedy and Catfish creeks were also imposed as boundary conditions for the lakes Toho, East Toho, Cypress and Hatchineha. For Shingle Creek, the flow split was assumed to be 70 percent into Lake Hatchineha and 30 percent into Lake Cypress. Rainfall and ET data derived from the time series developed for the SFWMM for the climatic period of record 1970-2005, was used as model boundary conditions, with open water evaporation assumed for the nine lakes.

The KUB lakes are regulated by tight management schedules, and the regulation schedules are aimed at optimizing flood control, water supply and environmental enhancement. Though the trend of the regulation schedules is to attain the maximum and minimum stage at the beginning and end of the wet season, the schedules themselves have been frequently modified in the past based on real time water management needs. In the NERSM model, the actual lake regulation schedules for the simulation time period are entered as rule curves. The model simulates the management of the KUB lakes and canal system with a set of management rules. These rules are implemented in the model as regulation schedules, gate operation criteria, and rules of operation of the water control structures.

C2.2.2 Lower Kissimmee Basin Sub-watershed

The Current Base setup for the LKB Sub-watershed reflects conditions post-Phase I of the KRR project. The sub-watershed is partitioned into 4 major basins separated by water control structures. **Figure C-7** illustrates the node-link diagram for the LKB Sub-watershed in the Current Base NERSM scenario. In NERSM, the C-38 canal, Kissimmee River and floodplain portions of the Pools A, BC, D, and E are simulated as level-pools linked by water control structures. Only the major gated spillway structures in place post-Phase I of the KRR are simulated: S-65A, S-65C, S-65D, and S-65E. Auxiliary culverts and overflow weirs next to the major spillways are not modeled since flow through these is expected only under extreme conditions, the simulation of which is beyond the scope of this project. Weirs 1, 2, 3, though still in place in 2005, are not modeled. Locks at these structures are also not modeled.

Stage-volume and stage-area relationships for the canal/river/floodplain were developed as part of the KBMOS project. For the restored portion of the Kissimmee River (Pool BC), these relationships were further manipulated and defined in terms of average heads at the upstream and downstream ends of the pool. To be consistent with the SFWMM methodology for translating S-65 into S-65E flows, sub-watershed inflows (runoff) into the C-38 canal, the Kissimmee River, and floodplain were estimated based on historical flow data at LKB Sub-watershed boundary structures (i.e. S-65E – S-65 flows). Runoff was prorated based on each basin area and the resulting time series was imposed as the boundary condition to each level-pool.

For the Future Base and alternative scenarios, S-65C is removed as part of the full KRR (phases I-IV) and only three level-pools are simulated: Pools A, BCD, and E. Stage-volume and stage-area relationships were developed for Pool BCD as part of this modeling effort (EarthTech, 2007a). The capacity of S-65D is also increased. The modeled structure operations for S-65D are based on the current level of understanding of the fully restored system (EarthTech, 2007b).

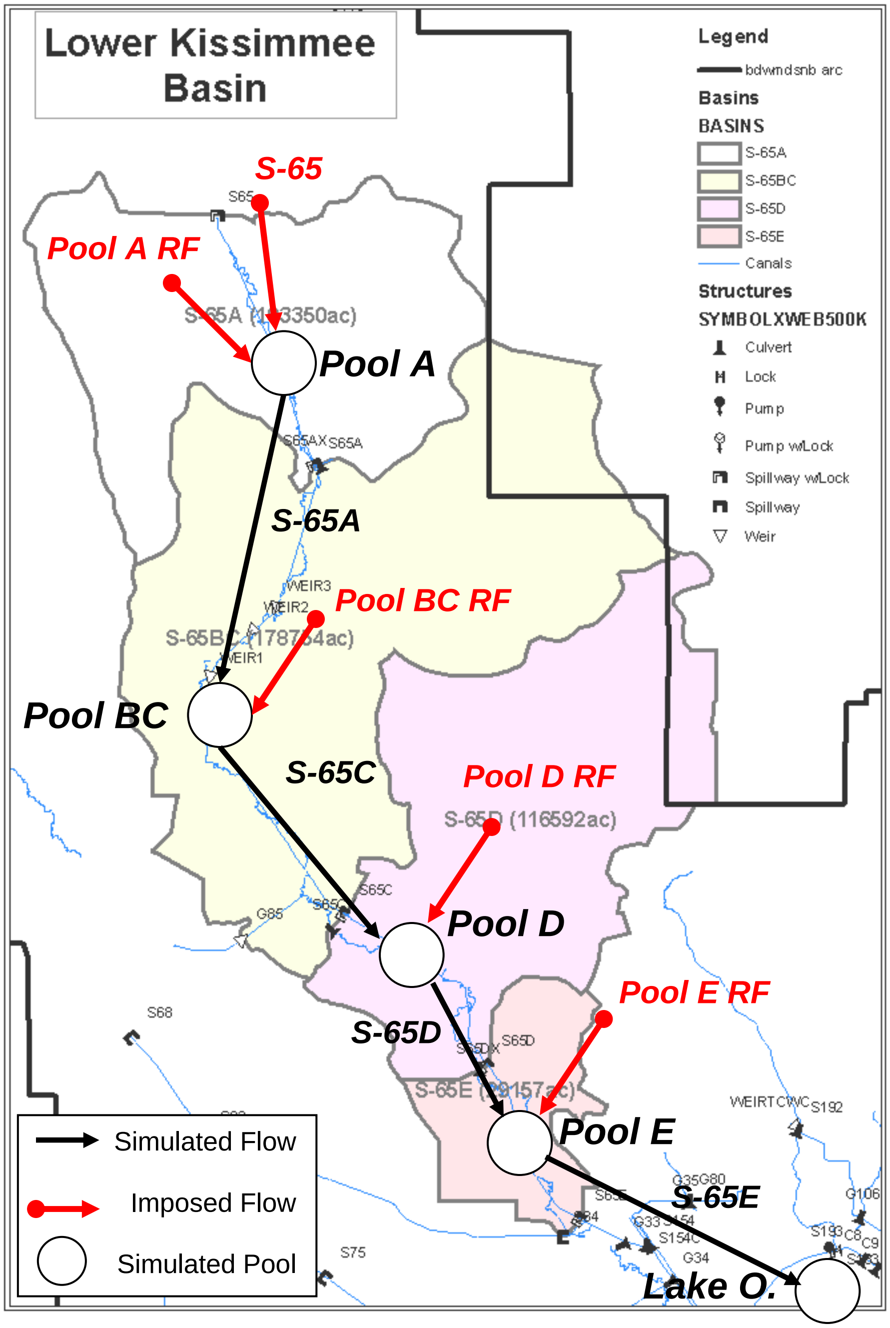


Figure C-7. Node-link diagram representation of Current Base condition for Lower Kissimmee Sub-watershed in NERSM

C2.2.2.1 Lower Kissimmee Sub-watershed Configuration for RWPPB

Figure C-8 is a schematic showing how MMs in the Lower Kissimmee Sub-watershed were simulated in RWPPB. Descriptions of how Lower Kissimmee MMs and basin flows were simulated for RWPPB are provided below:

Pool E

- 3 outlet structures: 1) Structure to Kissimmee Reservoir East; 2) Structure to Paradise Run ASR; and 3) S-65E
- When Lake Okeechobee is above the high envelope stage and Pool E has excess (i.e. Pool E is above its optimum of 21.0 feet as defined in the Future Base simulation), water will be sent to Kissimmee Reservoir East first (subject to capacity and available storage below maximum depth), then to Paradise Run ASR (subject to capacity), and any remaining excess will be sent downstream thru S-65E (subject to capacity).
- When Lake Okeechobee is below the low envelope stage, water will be sent from Kissimmee Reservoir East to Lake Okeechobee through Taylor Creek STA (subject to capacity) as first priority, and back to Pool E as second priority (subject to capacity). When Lake Okeechobee is below the low envelope stage, water will be sent from Paradise Run ASR to Pool E (subject to capacity). From Pool E water will be discharged by S-65E (subject to capacity) once Pool E exceeds its optimum of 21.0 feet.
- An emergency flood control operation is added to discharge water from Kissimmee Reservoir East, regardless of the Lake Okeechobee stage, to ensure that the reservoir depth does not exceed 16.5 feet (which corresponds to its maximum depth, plus a buffer).
- During times when Lake Okeechobee is within the stage envelope, S-65E will move local excess plus any inflows coming from upstream (subject to capacity).

Dummy Node

- Four outlet structures: (1) Structure to Kissimmee Reservoir, (2) Structure to Istokpoga/ Kissimmee Reservoir, (3) Structure to Kissimmee River ASR Pilot, and (4) Bypass to Lake Okeechobee
- When Lake Okeechobee is above the high envelope stage, water will be sent from the dummy node to Kissimmee Reservoir first (subject to capacity and available storage below maximum depth), then to Istokpoga/Kissimmee Reservoir (subject to capacity and available storage below maximum depth), then to Kissimmee River ASR Pilot (subject to capacity), and any remaining water will be sent downstream to Lake Okeechobee.
- When Lake Okeechobee is above the high envelope stage, water may also be sent directly from Lake Okeechobee into the Istokpoga/Kissimmee Reservoir. Flows from Lake Okeechobee are subject to capacity and available storage below maximum depth, once inflows from Lower Kissimmee into these reservoirs are considered (i.e. basin water has priority over Lake Okeechobee water).
- When Lake Okeechobee is below the low envelope stage, water will be sent from the Istokpoga/Kissimmee Reservoir to Istokpoga STA (subject to capacity) as first priority, and downstream to Lake Okeechobee as second priority (subject to capacity). When Lake Okeechobee is below the low envelope stage, water will be sent from the Kissimmee

Reservoir and the Kissimmee River ASR Pilot (subject to capacity) downstream to Lake Okeechobee.

- An emergency flood control operation is added to discharge water from the Kissimmee and the Istokpoga/Kissimmee Reservoirs, regardless of the Lake Okeechobee stage, to ensure that the reservoirs do not exceed a depth of 16.5 feet (which corresponds to its maximum depth, plus a buffer). Note that inflows to both reservoirs are cutoff once it reaches its maximum depth of 16 feet; however, rainfall may bring it above 16 feet.
- Regardless of the Lake Okeechobee stage, any water remaining in the dummy node that is not diverted to either project feature will be sent directly to Lake Okeechobee

#26: 10 Well ASR System (Paradise Run ASR)

- Inlet: capacity: 50 MGD (77.5 cubic feet per second (cfs)), source: C-38 Pool E
- Outlet: capacity: 50 MGD (77.5 cfs), destination: C-38 Pool E
- Efficiency loss: 30 percent (70 percent recovery rate)

#107: Kissimmee Reservoir East

- Location: Lower Kissimmee Basin Pool E
- Storage capacity: 200,000 acre-feet
- Footprint: 14,000 acres
- Effective storage area: 12,500 acres = 200,000 acre-feet / 16 feet
- Maximum depth: 16 feet
- Emergency discharge when depth reaches 16.5 feet
- Inlet: capacity: 1,000 cfs pump, source: Upstream of S-65E (Pool E) (1st source priority for discharge)
- Outlet: capacity: 300 cfs pump, destination: Taylor Creek STA (1st source priority for discharge, 2nd destination priority for discharge)
- Outlet: capacity: 2,500 cfs pump, destination: Upstream of S-65E (Pool E) (2nd source priority for discharge)
- Will receive ET & rainfall representative of Pool E
- No seepage loss assumed

#29: Kissimmee Reservoir

- Location: Indian Prairie/Istokpoga Sub-watershed
- Storage capacity: 161,263 acre-feet
- Footprint: 10,281 acres
- Effective storage area: 10,079 acres = 161,263 acre-feet / 16 feet
- Approximate bottom elevation: 33 feet NGVD29
- Maximum depth: 16 feet (49 feet NGVD29)
- Emergency discharge when depth reaches 16.5 feet
- Inlet: capacity: 1,500 cfs pump, source: Downstream of S-65E
- Outlet: Modeled as a 1,500 cfs pump.
- Will receive ET & rainfall representative of Indian Prairie/Istokpoga Sub-watershed

- No seepage loss assumed

#108: Istokpoga/Kissimmee Reservoir

- Location: Indian Prairie/Istokpoga Sub-watershed
- Storage capacity: 129,600 acre-feet
- Footprint: 9,000 acres
- Effective storage area: 8,100 acres = 129,600 acre-feet / 16 feet
- Maximum depth: 16 feet
- Emergency discharge when depth reaches 16.5 feet
- Inlet: capacity: 1,000 cfs pump, source: Downstream of S-65E (1st source priority for inflow into Istokpoga/Kissimmee Reservoir, 1st destination priority)
- Inlet: capacity: 1,500 cfs pump, source: Lake Okeechobee (2nd destination priority for inflow into Istokpoga/Kissimmee Reservoir)
- Outlet: capacity: 1,500 cfs pump, destination: Istokpoga STA (1st source priority for discharge, 2nd destination priority for discharge)
- Outlet: capacity: 2,500 cfs pump, destination: Downstream of S-65E (2nd source priority for discharge)
- Will receive ET & rainfall representative of Indian Prairie/Istokpoga Sub-watershed
- No seepage loss assumed

#93: Kissimmee River ASR

- Inlet: capacity: 5 MGD (7.75 cfs), source: Downstream of S-65E
- Outlet: capacity: 5 MGD (7.75 cfs), source: Downstream of S-65E
- Efficiency loss: 30 percent (70 percent recovery rate)

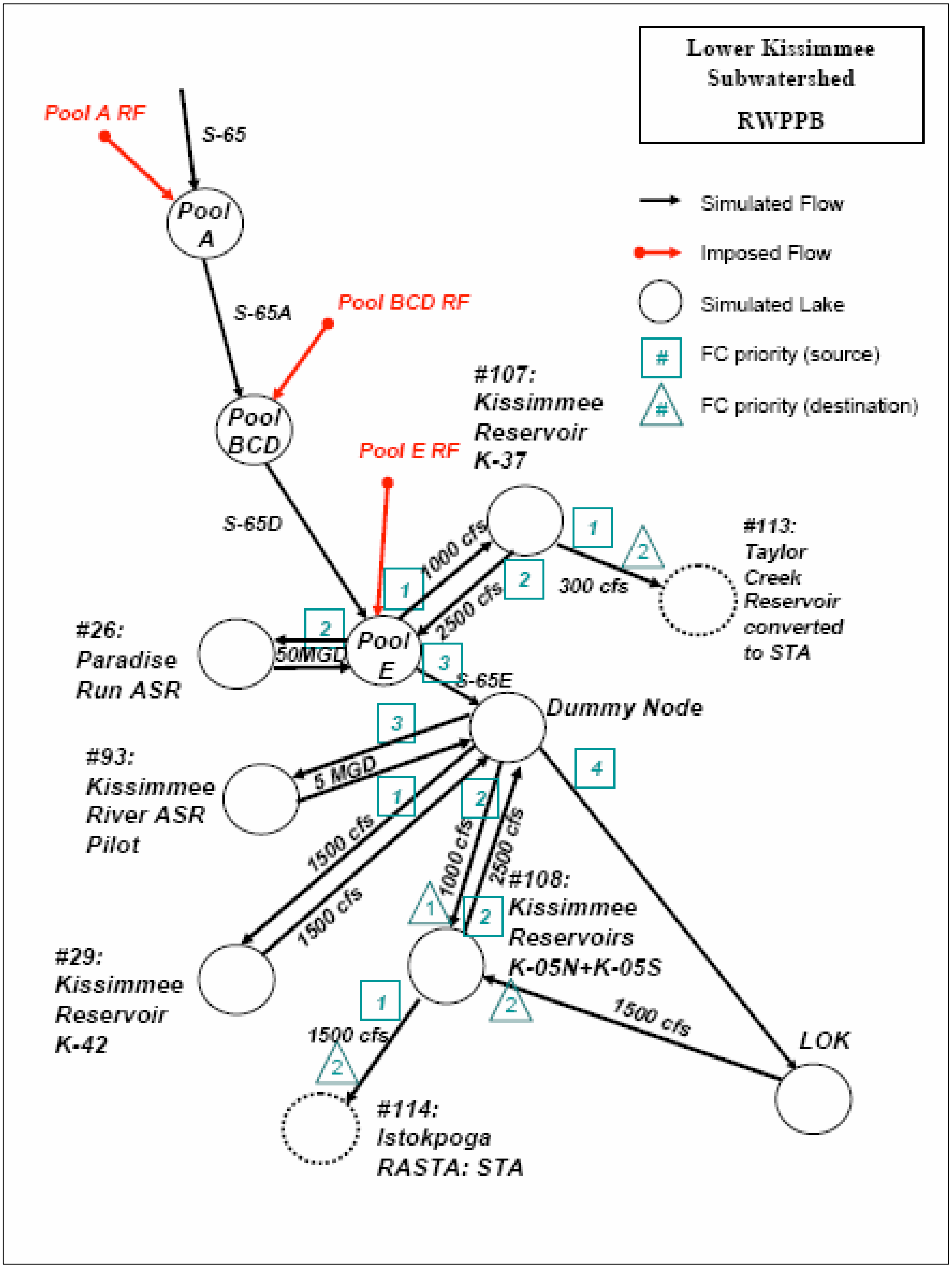


Figure C-8. Lower Kissimmee Sub-watershed simulation configuration for RWPPB.

C2.2.2.2 Taylor Creek/Nubbin Slough Sub-watershed

It is assumed that the runoff from Taylor Creek/Nubbin Slough (TCNS) Sub-watershed is equal to the total historical outflow from the sub-basins in this region. Hence, historical flow from S-191 Basin and S-133 Basin (TCNSQ in DBHYDRO), S-135 Basin (S135 in DBHYDRO) and S-154 Basin (S154 in DBHYDRO) are imposed as boundary conditions to TCNS Sub-watershed. This is the total outflow from TCNS basin to Lake Okeechobee in Current and Future Base scenarios.

Management measures such as reservoirs, STAs and ASRs are modeled as level pools. A portion of the total outflow from the TCNS Sub-watershed would be intercepted by these MMs before reaching Lake Okeechobee. Rainfall and ET are simulated for each management measure. Inflow and outflow through structures (pump stations, weir or spillways) are simulated according to operating rules that control movement of water among these MMs and Lake Okeechobee.

C2.2.2.3 Taylor Creek/Nubbin Slough Sub-watershed Configuration for RWPPB

Figure C-9 is a schematic showing how MMs in the TCNS Sub-watershed were simulated in RWPPB. Descriptions of how TCNS MMs and basin flows were simulated in RWPPB are provided below:

#113: Taylor Creek STA

- Location: TCNS Sub-watershed (North of City of Okeechobee)
- Trigger: Lake Okeechobee stage envelope.
- Storage capacity: 24,00 acre-feet
- Footprint: 1600 acres
- Approximate bottom elevation: 35.5 feet NGVD29
- Maximum depth: 15 feet (50.5 feet NGVD29)
- Inlet 1: capacity: 300 cfs pump, source: TCNS Basin;
- Inlet 2: capacity: 300 cfs pump, source: Kissimmee Reservoir East
- Outlet: weir width 200 feet, starts releasing at 1.5 feet depth; destination: Lake Okeechobee.
- Operation:
  - When Lake Okeechobee is above the high envelope stage, water will be sent from the TCNS basin to Tailor Creek Reservoir first (subject to capacity)
  - When Lake Okeechobee is below the low envelope stage (in dry period), water will be sent from Tailor Creek Reservoir to Lakeside Ranch STA (subject to capacity) for treatment before sending to Lake Okeechobee
- Will receive ET & rainfall representative of TCNS Sub-watershed
- Seepage loss: 1 cfs (deep cutoff wall in place).

#16: Lakeside Ranch, #24 Brady Ranch STA; #99: Taylor Creek Critical Project STA; #100: Nubbin Slough Critical Project STA; #17: Lemkin Creek STA

- Location: TCNS Sub-watershed

- Brady Ranch STA in western Martin County, between the Beeline Highway and Lake Okeechobee, immediately east of Lakeside Ranch; 2430 acre-feet; 1800 acres; 1.5 feet
- Taylor Creek STA in Grassy Island Ranch; 147 acre-feet; 118 acres; 1.25 feet; 29.1feet NGVD29
- Nubbin Slough STA in New Palm/Newcomer Dairy; 1546 acre-feet; 773 acres; 2 feet; 21.9 feet NGVD29
- Lemkin Creek STA in Southwest of the city of Okeechobee. 500 acre-feet; 240 acres; 3 feet
- Storage capacity: 3240 + 2,430 +147+1546+500 = 7863 acre-feet
- Footprint: 1,600 (1,800 acres in one pager) 2160 + 1600 + 118+773+205 (240 acres in one pager)=4856 acres
- Approximate bottom elevation: 24.0 feet NGVD29
- Maximum depth: 4 feet At 2.5 feet, stops getting inflow; at 1.5 feet, start outflow
- Inlet: capacity: 300 + 200 +24+120+100 =744 cfs pump, source: TCNS Sub-watershed
- Outlet: weir width 250 feet, weir height 1.5 feet, crest elevation at 25.5 feet NGVD29 (starts releasing at 1.5 feet) destination: Lake Okeechobee – seepage will be sent to Lake Okeechobee via special water mover
- Will receive ET & rainfall representative of TCNS Sub-watershed
- seepage loss: [{ (4856-205)/ 2160 }* 7] =15.1 cfs (to Lake Okeechobee)

#19: Taylor Creek ASR

- Location: TCNS Sub-watershed (adjacent to L63N canal in Okeechobee)
- Inlet: capacity: 6 MGD (9.3 cfs), source: Dummy node1
- Outlet: capacity: 6 MGD (9.3 cfs), destination: Lake Okeechobee
- Operation:
  - When Lake Okeechobee is above the low envelope stage, 100 percent water will be sent to recharge Floridian aquifer well
  - When Lake Okeechobee is below the low envelope stage, 70 percent of water will be sent from the Tailor creek ASR to Lake Okeechobee
- Efficiency loss: 30 percent (70 percent recovery rate)

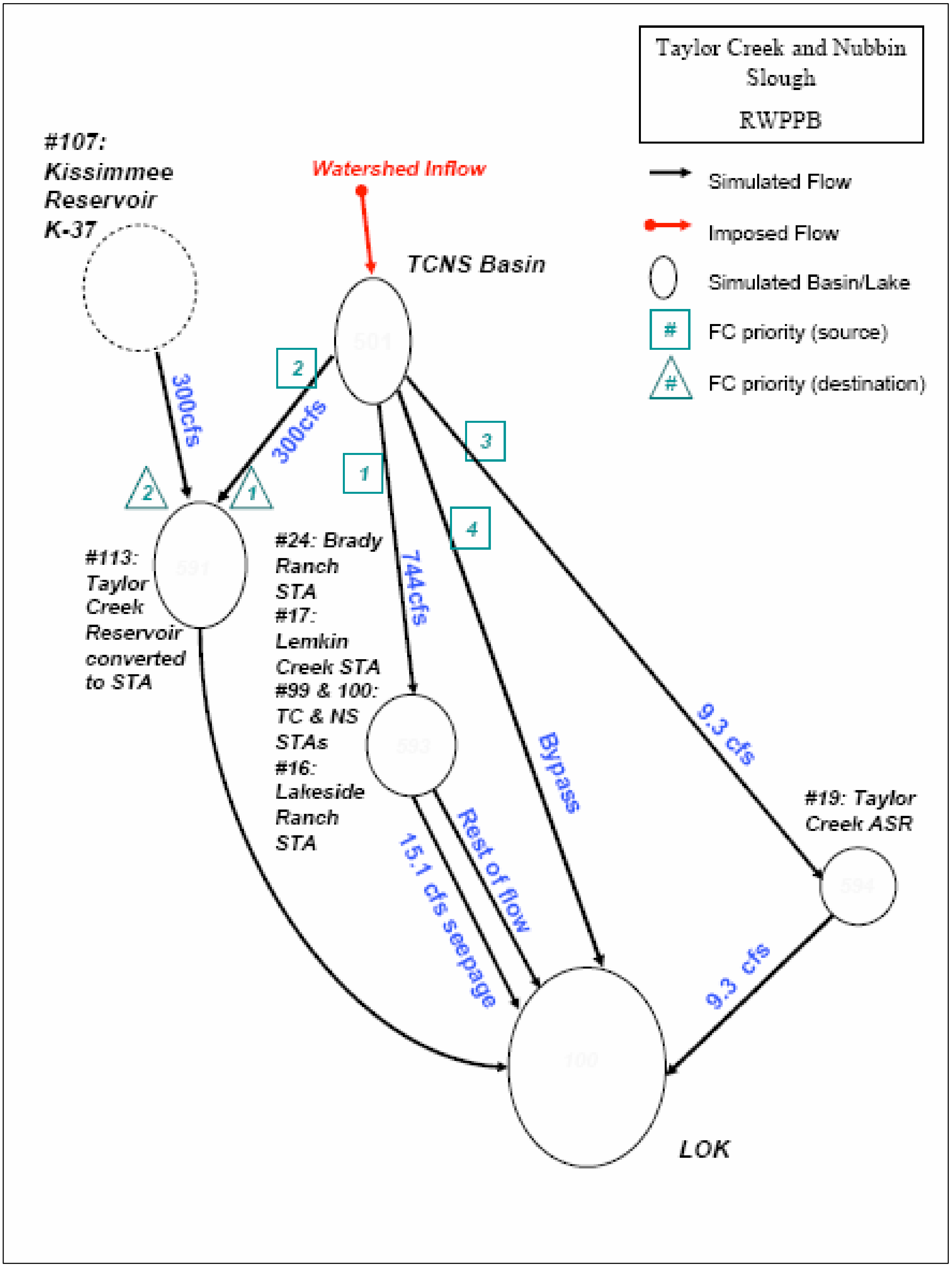


Figure C-9. Taylor Creek/Nubbin Slough Sub-watershed simulation configuration for RWPPB.

C2.2.3 Lake Istokpoga Sub-watershed

The Lake Istokpoga (LI) Sub-watershed was modeled in the NERSM as a flow pass through basin. The flows imposed as boundary conditions include the sum of the flows through SFWMD outflow structures S71, S72, S84, S127, S129 and S131 into Lake Okeechobee. The historical flow data for these structures were obtained from DBHYDRO for the time period 1970-2005.

Since the sub-watershed is modeled as a flow pass through basin, no other boundary conditions were imposed in the model. For simulating MMs such as reservoirs, STAs and ASRs in the alternative scenarios, the outflow (runoff) to Lake Okeechobee was reduced in proportion to the ratio of the effective footprint taken by the management measure to the total area of the sub-watershed. An inherent assumption in this approach is that open waterbodies exhibit the same amount of net rainfall as the corresponding runoff generated during pre-management measure.

C2.2.3.1 Lake Istokpoga Sub-watershed Configuration for RWPPB

Figure C-10 is a schematic showing how MMs in the LI Sub-watershed were simulated in RWPPB. Below are descriptions of how LI MMs and basin flows were simulated in RWPPB.

Istokpoga Flows

- The total Istokpoga flows will pass through the MMs with the following priorities 1) S-68 STA, 2) Istokpoga reservoir, 3) Istokpoga/Kissimmee RASTA 4) Istokpoga STA, and 5) Seminole Brighton Reservation ASR, subject to feature capacity and Lake Okeechobee stage envelope.
- The downstream Istokpoga RASTA: STA will receive flows from the Istokpoga/Kissimmee RASTA, and the Istokpoga/Kissimmee Reservoir as a secondary source.
- If Lake Okeechobee is above the high envelope stage and there is capacity in the Istokpoga Reservoir Complex, water from Lake Okeechobee will be back pumped into the Istokpoga/Kissimmee RASTA.
- Flows not utilized by the MMs will by bypass to Lake Okeechobee as last priority irrespective of the lake stage.

#18: Seminole Brighton Reservation ASR

- Inlet: capacity: 5 MGD (7.75 cfs), source: C-41 canal
- Outlet: capacity: 5 MGD (7.75 cfs), destination: C-41 canal
- Efficiency loss: 30 percent (70 percent recovery rate)

#30: Istokpoga Reservoir

- Location: LI Sub-watershed (C-40A/C-41A basins)
- Storage capacity: 79,560 acre-feet
- Effective area: 5,416 acres
- Approximate bottom elevation: 29 feet NGVD29
- Maximum depth: 16 feet

- Inlet: capacity: 500 cfs pump, source: C-41A canal downstream of S-83
- Outlet: Pump with outflow capacity of 2500 cfs
- No seepage loss assumed

#31: Istokpoga STA

- Location: LI Sub-watershed (L-49 basins)
- Storage capacity: 10,860 acre-feet
- Effective area: 7,240 acres
- Approximate bottom elevation: 17 feet NGVD29
- Maximum depth: 1.5 feet
- Inlet: capacity: 2000 cfs pump, source: C-41 canal downstream of S-71
- Outlet: Two weirs with outflow capacity of 1000 cfs each, invert elevation 18.5 feet NGVD
- No seepage loss assumed

#111: S68 STA

- Location: LI Sub-watershed (L-49 basins)
- Storage capacity: 3,240 acre-feet
- Effective area: 2,400 acres
- Approximate bottom elevation: 17 feet NGVD29
- Maximum depth: 1.35 feet
- Inlet: capacity: 250 cfs pump, source: C-41 canal downstream of S-68
- Outlet: One weir with outflow capacity of 250 cfs each, invert elevation 18.35 feet NGVD
- No seepage loss assumed

#114: Istokpoga/Kissimmee RASTA: Reservoir

- Location: Indian Prairie/LI Sub-watershed
- Storage capacity: 144,000 acre-feet
- Footprint: 10,000 acres
- Effective area: 9,000 (90 percent of 10,000)
- Maximum depth: 16 feet
- Inlet 1: capacity: 750 cfs pump, source: C-41A canal downstream of S-83
- Inlet 2: capacity: 750 cfs pump, source: Lake Okeechobee (2nd priority for inflow)
- Outlet: Pump with outflow capacity of 1,500 cfs into Istokpoga/Kissimmee RASTA: STA
- No seepage loss assumed

#114: Istokpoga/Kissimmee RASTA: STA

- Location: LI Sub-watershed
- Storage capacity: 10,800 acre-feet
- Effective area: 7,200 acres
- Approximate bottom elevation: 17 feet NGVD29

- Maximum depth: 1.5 feet
- Inlet 1: capacity: 1500 cfs pump, source: Istokpoga/Kissimmee RASTA
- Inlet 2: capacity 1500 cfs pump, source: Istokpoga/Kissimmee RASTA
- Outlet: Three weirs with outflow capacity of 1000 cfs each, invert elevation 18.5 feet NGVD
- No seepage loss assumed

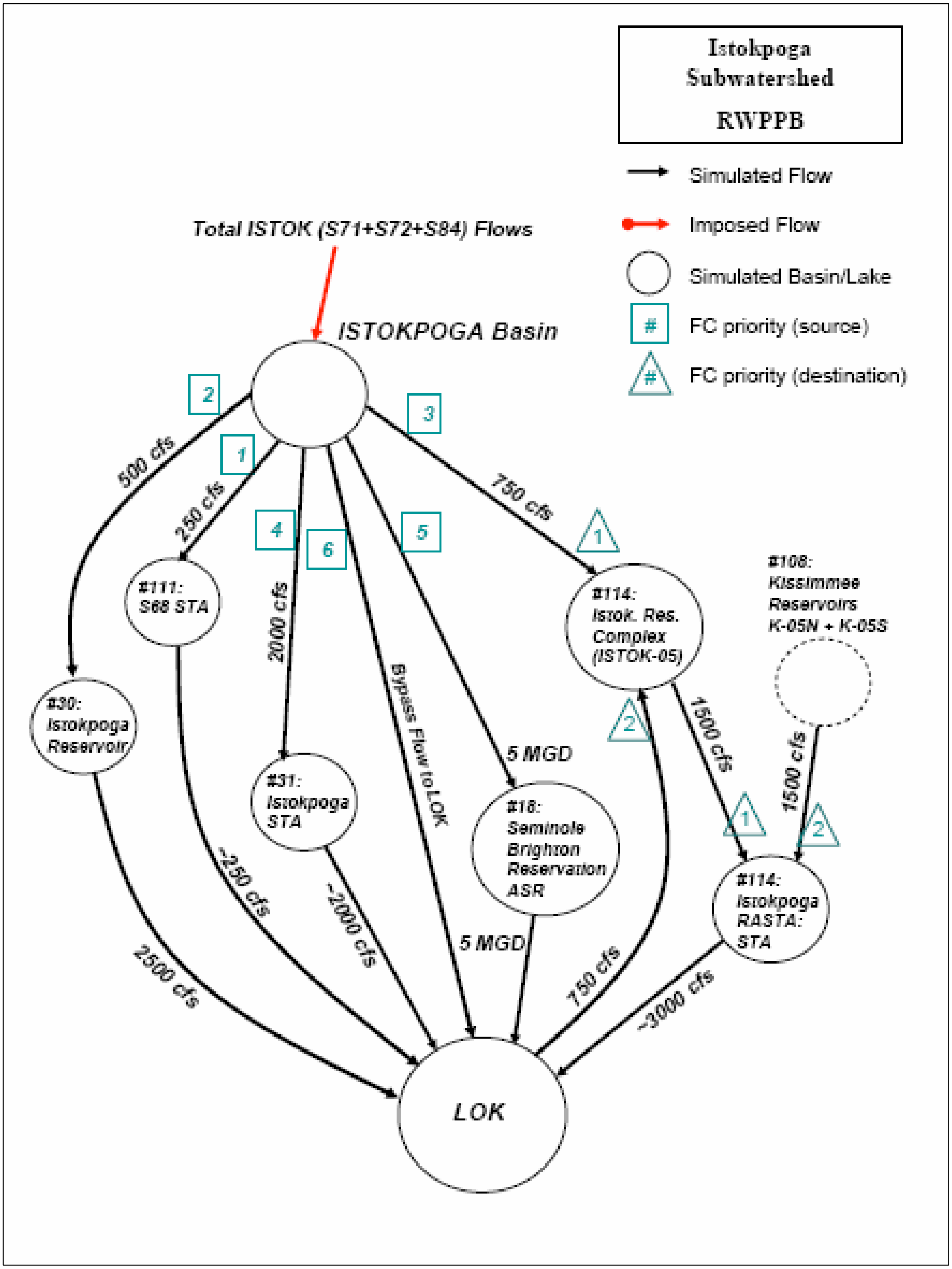


Figure C-10. Istokpoga Sub-watershed simulation configuration for RWPPB

C2.2.4 Fisheating Creek Sub-watershed

The Fisheating Creek (FEC) Sub-watershed has a total area of approximately 315,007 acres, with a substantial variation in elevation from upstream to downstream. Flows from the basin represent the "natural" inflow to Lake Okeechobee by gravity. The FEC Basin has not been greatly altered by water management projects, such as lake regulation schedules, channelization, and impoundments. The creek flows are extremely flashy in nature. The sub-watershed contains large areas of high quality habitat for fish and wildlife.

This basin is modeled as a flow pass through, which means the watershed outflow time series is imposed as the inflow boundary conditions. Since there are no flow-monitoring sites close to Lake Okeechobee, the inflow time series is developed based on historical data at the Palmdale station. This station is the most downstream "natural" station, which is located on the upper FEC Basin, several miles upstream of the confluence of the creek to Lake Okeechobee. The assumption is the Lake Okeechobee inflows downstream of Palmdale are included in the modified-delta-storage (MDS) term.

C2.2.4.1 Fisheating Creek Sub-watershed Configuration for RWPPB

Figure C-11 is a schematic showing how MMs in the FEC Sub-watershed were simulated in RWPPB. Descriptions are provided below of how FEC Basin flows and MMs are simulated in RWPPB:

#61: FEC RASTA I, #77: FEC RASTA II, Nicodemus Slough RASTA: Reservoirs

- Location: FEC Sub-watershed
- Storage capacity: 27,000 + 14,580 + 158,400 = 199,980 acre-feet
- Footprint: 3000 + 1350 + 11,000 =15,350 acres (90 percent of footprint =13,815 acres)
- Maximum depth: [10 feet (F-05); 12 feet (I-33); 16 feet [F-01]] , 199,980 / 13,815 = 14.5 feet; (Bottom Elevation + 14.5 feet) NGVD29
- Emergency discharge when depth reaches. Bottom Elevation + 14.5 + 0.5 feet NGVD29
- Inlets:
  450+200+1800 = 2450 cfs pump for first source: FEC Basin; and
  1,500 cfs pump from second source: Lake Okeechobee
- Outlet: capacity: 500+100+500 = 1100 cfs pump, destination: STA
- Operation:
  - When Lake Okeechobee is above high envelope stage, water is sent from FEC basin to the reservoir (subject to capacity and available storage below maximum depth), and any remaining excess will be sent to Lake Okeechobee through bypass – first priority
  - When Lake Okeechobee is above high envelope stage, water is sent from Lake Okeechobee to the reservoir (subject to capacity and available storage below maximum depth) – second priority
  - When Lake Okeechobee is below high envelope stage, water is sent directly from FEC basin to Lake Okeechobee through bypass.
  - When Lake Okeechobee is below the low envelope stage, water is sent from reservoir to the STA (subject to capacity and available storage below 2.5 feet maximum depth).

- Receives ET & rainfall representative of FEC Sub-watershed
- No seepage loss assumed

#61: FEC RASTA I, #77: FEC RASTA II, Nicodemus Slough RASTA: STAs

- Location: FEC Sub-watershed
- Storage capacity: 12,150+608+ 8,775 = 21,533 acre-feet
- Footprint: 9000+450 +6,500 = 15,950 acres (90 percent of footprint = 14,355 acres)
- Maximum depth: 21,533 / 14,355 = 1.5 feet;
- Inlet: capacity: 500+100+500 = 1100 cfs pump, (2.5 feet + Bottom Elevation NGVD) when reservoir stops releasing, source: FEC RASTA I, #77: FEC RASTA II, Nicodemus Slough RASTA Reservoir
- Outlet: crest length (calculated based on inflow and 1foot head difference), crest elevation at (1.5 feet + Bottom Elevation) NGVD29; destination: Lake Okeechobee; Outflow occurs when STA water level is above outlet weir elevation.
- Receives ET & rainfall representative of FEC Sub-watershed
- No seepage loss assumed

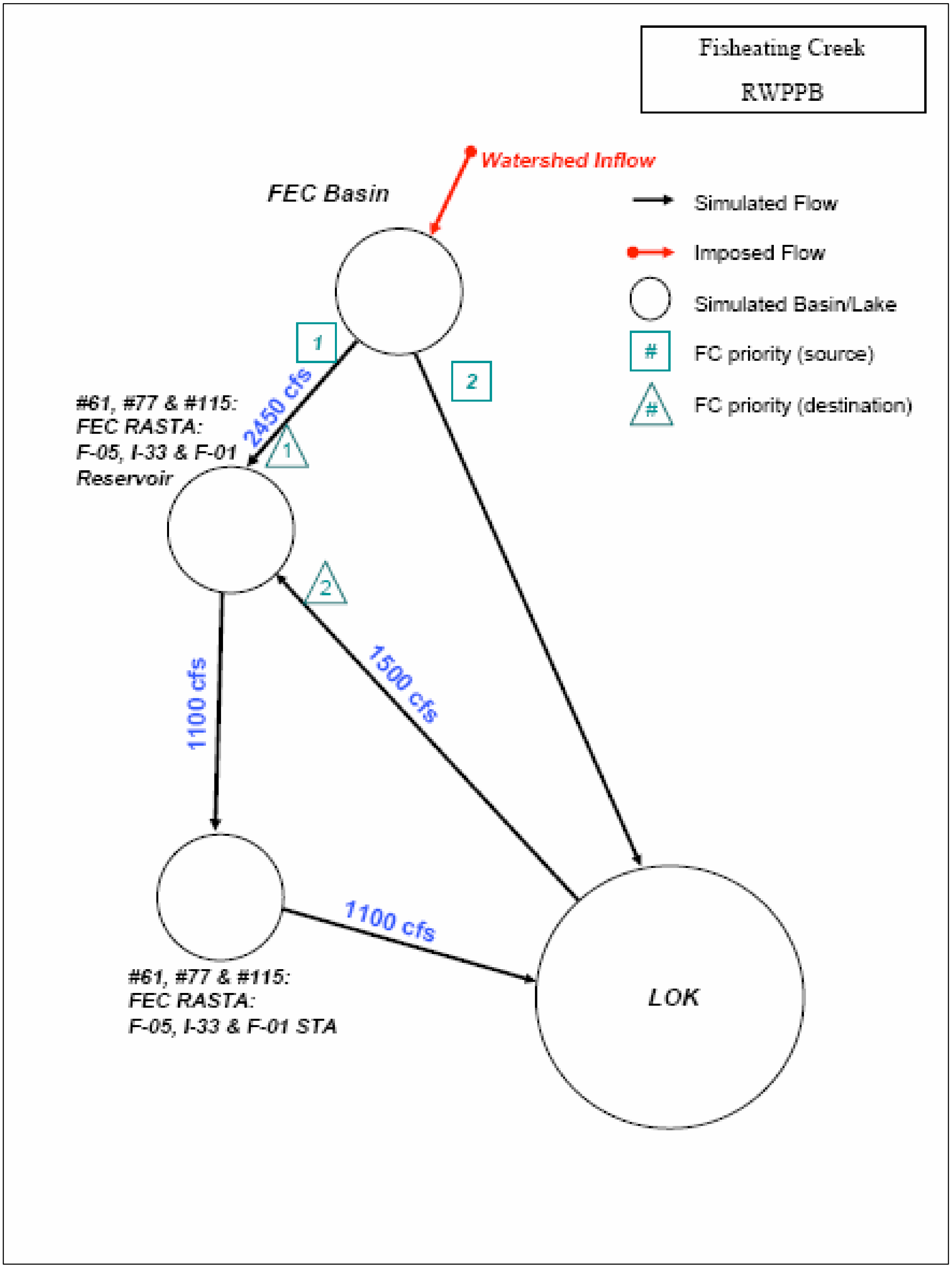


Figure C-11. Fisheating Creek Sub-watershed simulation configuration for RWPPB

C2.2.5 Caloosahatchee River Watershed

The Caloosahatchee River Watershed, as modeled in the NERSM, includes the non-tidal portion of the watershed that drains into the Caloosahatchee Estuary via S-79. The version of NERSM that was used in LOP2TP was based on a single node representation of all basins upstream of S-77. However, demand and runoff in the ECAL and WCAL basins can be very different in magnitude at times. Therefore, in order to better account for available water for capture by individual proposed water MMs in the RWPP these two sub-watersheds are modeled as separate nodes instead of a single node. In addition, the S-4 basin was included in the model domain in order to simulate direct interaction between S-4 Basin and East Caloosahatchee Basin, as well as S-4 Basin and Lake Okeechobee.

C2.2.5.1 River Watershed Protection Plan Base

The Caloosahatchee River Watershed is conceptualized as a series of interconnected nodes and links, as shown in **Figure C-12**. Model nodes represent water bodies such as basins, lakes, estuaries, reservoirs and STAs; while links represent water control structures (or components of structures) connecting model nodes. Water MMs, such as reservoirs and STAs, are simulated as storage nodes.

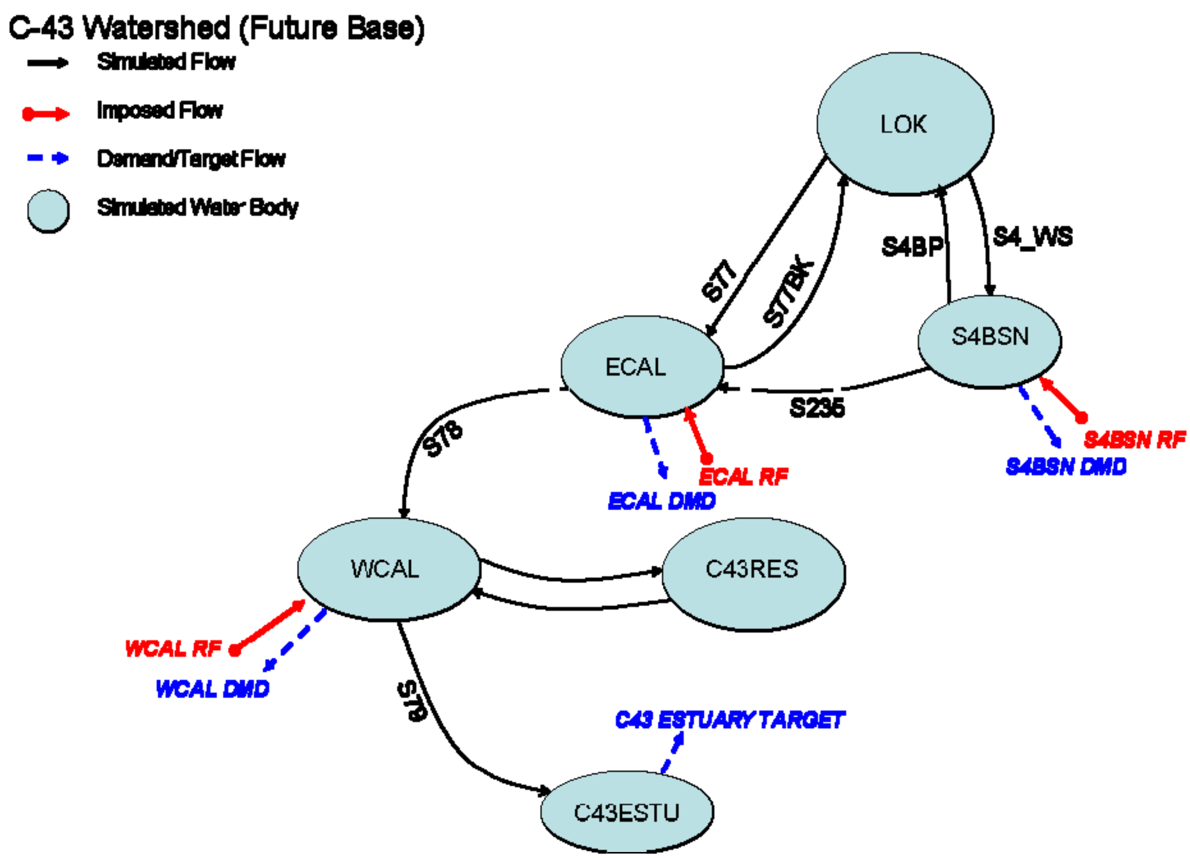


Figure C-12. Node-link diagram for the Caloosahatchee River Watershed as modeled in RWPP Future Base

Water control structure capacities are listed in **Table C-5**. Inflows into ECAL include the S-77 structure, which discharges from Lake Okeechobee for water supply, environmental, and regulatory purposes; and the S-235 structure, which discharges excess flows from the S-4 Basin. S-77 will also allow natural backflow into Lake Okeechobee when it is low (below 11.5 feet NGVD). This backflow component is modeled as a separate outflow structure from ECAL (S-77BK). ECAL and WCAL are connected through the S-78 structure, which discharges for water supply, environmental and flood control purposes. WCAL discharges to the C-43 Reservoir and into the Caloosahatchee Estuary through S-79 which handles both deliveries to meet estuary needs and upstream excess. The S-4 Basin gets its supplemental agricultural water supply from Lake Okeechobee (S-4WS) and can discharge to either the lake (S-4BP) or ECAL (S-235) for flood control.

Table C-5. Structure Capacities for the RWPPB Future Base Simulation

Structure	Capacity (cfs)
S-77	7800
S-77BK	7800
S-78	*
S-79	*
c43respumpin	1500
c43respumpout	1200
c43resoverflow	5000
S-4WS	*
S-4BP	2805
S-235	200

*Structure capacity is assumed to be limited only by available basin runoff.

Runoff generated on ECAL, WCAL and the S-4 Basin is applied directly to each corresponding basin node as a boundary condition. Runoff generated in the S-4 Basin is handled as follows: if the lake is below 13 feet NGVD, 100% of the excess in the S-4 Basin is sent to the lake; however, if the lake is above or equal to 13 feet NGVD, 83% of the excess is sent to ECAL through S-235, subject to capacity, and the remainder is sent to the lake.

Agricultural and public water supply demands in ECAL, WCAL, and the S-4 Basin, and environmental needs in the C-43 Estuary drive water supply and environmental deliveries in the model. Surface water demand (~10.2 MGD) from the Olga public water supply plant in Lee County is accounted for in the WCAL demand time series. Excess in upstream nodes is first used to meet water supply and environmental demands in downstream nodes before it is pushed or forced downstream. For example, ECAL excess and S-4 Basin discharges through S-235 are first used to meet downstream needs in the following order: (1) water supply needs in WCAL and (2) environmental needs in the C-43 Estuary. Excess in WCAL is first used to meet environmental needs in the C-43 Estuary. Any remaining water supply need in ECAL, WCAL and the S-4 Basin is to be met from Lake Okeechobee, subject to the Hybrid Lake Okeechobee Water Shortage Management (LOWSM) cutback scheme. It is assumed that basins farther downstream from the lake are cutback first, while delivering as much water supply as possible to those basins closer to the lake (i.e. WCAL is cutback before ECAL). Lake regulatory releases are not counted towards meeting water supply demands. Instead, the lake releases *additional* water beyond the regulatory release to meet water supply needs.

Starting from the RWPPB simulation, the C-43 Reservoir proposed as part of CERP is included in all alternatives. Stage-area and stage-volume relationships for the C-43 Reservoir are show in **Figure C-13**. The purpose of this reservoir is to store basin excess and Lake Okeechobee regulatory releases that exceed estuary demands, in order not to harm the estuary. Inflows into the reservoir are suspended when the reservoir reaches 41.7 feet NGVD. During times of low upstream excess and low lake regulatory releases, the C-43 Reservoir is used to meet estuary demands before any additional water is brought in from Lake Okeechobee for environmental purposes. This remaining environmental need may be met from Lake Okeechobee, as long as the lake stage is above 11.5 feet NGVD. The C-43 Reservoir may also overflow into WCAL for emergency purposes when its stage exceeds 41.8 feet NGVD.

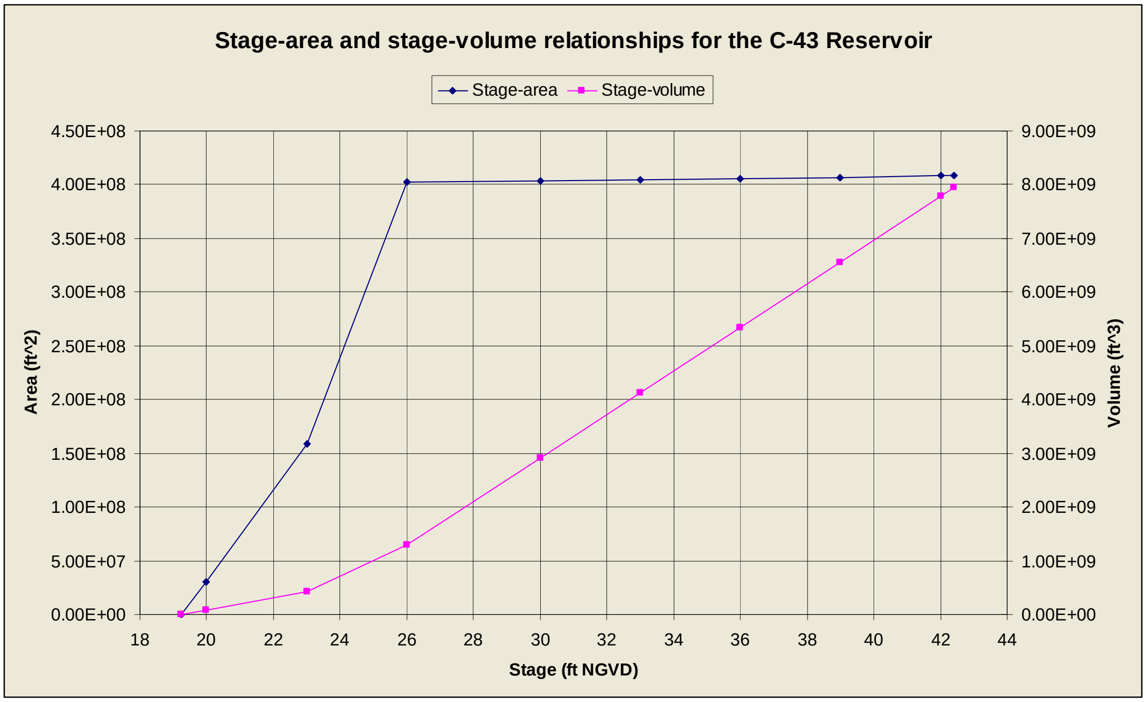


Figure C-13. Stage-area and stage-volume relationships for the C-43 Reservoir

C.2.2.5.2 Alternatives

All RWPP alternatives build upon the RWPPB simulation. Nodes are added to represent MMs and links represent structures linking the MMs to individual sub-watersheds or other MMs. Runoff time series applied to a sub-watershed are adjusted in each alternative in order to account for the footprint of proposed MMs (reservoirs and STAs) to be simulated as part of the alternative.

C.2.2.5.2.1 Caloosahatchee River Watershed Configuration for Alternative 1

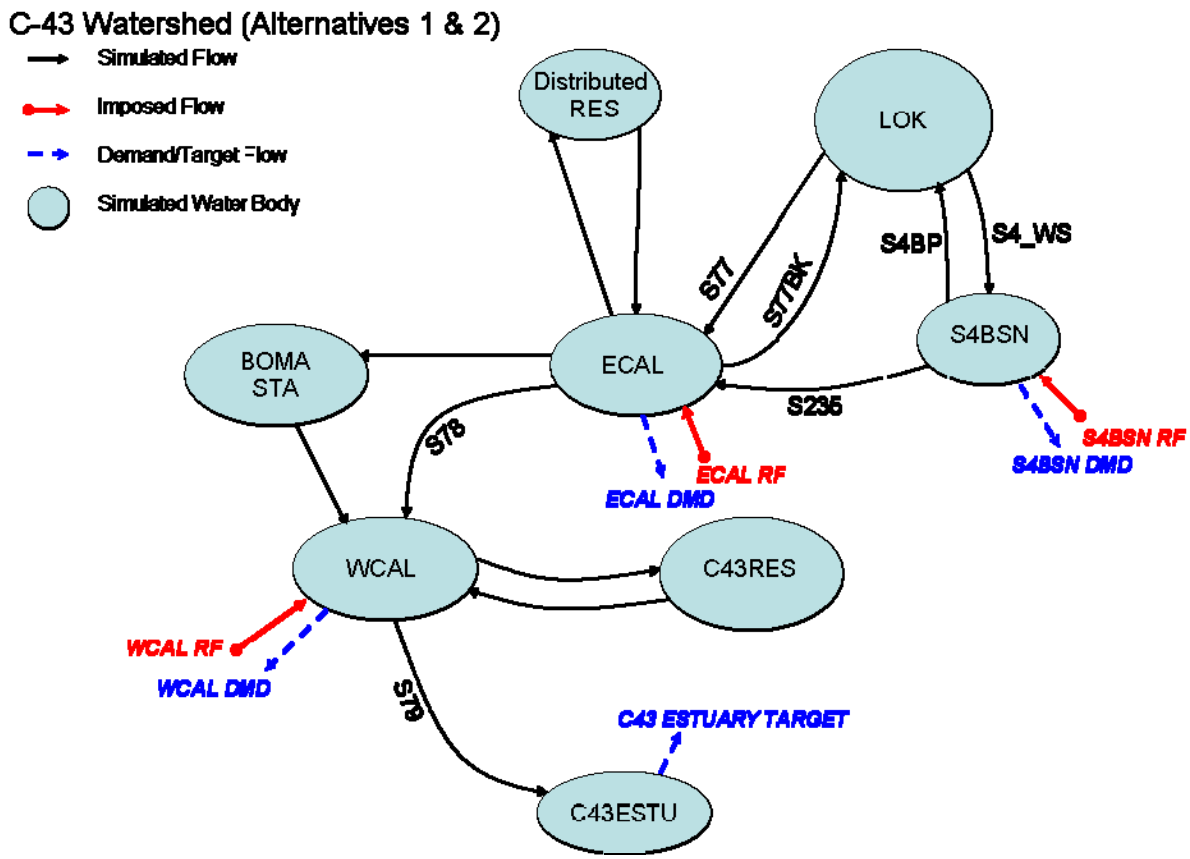


Figure C-14. Node-link diagram for the C-43 Watershed in RWPP Alternatives 1 & 2

Note: In Alternative 2, "Distributed RES" represents the combined storage of the C-43 Distributed Reservoirs, East Caloosahatchee Storage, and Lake Hicpochee MMs.

Figure C-14 shows the node-link representation of CRWPP for Alternative 1. The following are brief descriptions of the MMs included in this alternative:

- CRE-10: C-43 Water Quality Treatment and Demonstration Project (BOMA property)
  - Location: ECAL
  - Storage capacity: 4,500 acre-feet
  - Footprint: 1,335 acres
  - Effective storage area: 1,000 acres
  - Maximum depth: 4.5 feet (when outflow starts) = 4,500 acre-feet/1,000 acres
  - Inlet: capacity: 99 cfs, source: ECAL
  - Outlet: capacity: 99 cfs, destination: WCAL
  - Receives ET & rainfall representative of ECAL sub-watershed
  - No seepage loss assumed
- CRE-LO-41: C-43 Distributed Reservoirs
  - Location: ECAL
  - Storage capacity: 42,400 acre-feet

- Footprint: 6,600 acres
- Effective storage area: 5,280 acres
- Maximum depth allowed for inflow: 8.03 feet = 42,400 acre-feet/5,280 acres
- Emergency discharge when depth reaches: 8.53 feet
- Inlet: capacity: 500 cfs, source: ECAL
- Outlet: capacity: 500 cfs, destination: ECAL
- Overflow: capacity: 500 cfs, destination: ECAL
- Receives ET & rainfall representative of ECAL sub-watershed
- No seepage loss assumed

The general modeling approach used in Alternative 1 can be summarized as follows:

- As a general rule, any excess at a particular node is first used to meet demands (both water supply and environmental) immediately downstream of the node, and then demands farther downstream are met from upstream to downstream. Once excess has been used to meet all downstream demands, then it is forced downstream as flood control.
- Excess in ECAL and S-4 Basin, and storage in the C-43 Distributed Reservoirs are first used to meet downstream needs in the following order of priority: (1) water supply needs in ECAL, (2) water supply needs in WCAL, and (3) environmental demands in the C-43 Estuary.
- Excess in WCAL, plus other leftover excesses from upstream (i.e. excess after WCAL water supply needs are met), are first used to meet environmental demands in the C-43 Estuary.
- Water supply deliveries from Lake Okeechobee to ECAL, WCAL, and the S-4 Basin are subject to the Hybrid LOWSM cutback scheme. During times when the Hybrid LOWSM scheme calls for cutbacks, WCAL is cutback before ECAL.
- S-77 backflow to the lake is first priority for excess discharge when the lake stage < 11.5 feet NGVD.
- When the lake stage >= 11.5 feet NGVD, any leftover excess at the ECAL node (i.e. excess after downstream needs are met) is sent to the C-43 Distributed Reservoir and then to BOMA, before it is sent downstream through S-78 as flood control. The C-43 Distributed Reservoir will only capture leftover excess from the S-4 Basin and ECAL, not lake regulatory releases.
- Excess from the S-4 Basin is handled the same way as in the Future Base simulation:
  - If the lake stage < 13 feet NGVD, 100% of remaining excess is sent to Lake Okeechobee.
  - If the lake stage >= 13 feet NGVD, 83% of remaining excess is sent to S-235 (subject to capacity), while 17% is sent to Lake Okeechobee.
- C-43 Estuary demands are to be met first from lake regulatory releases and excess from the S-4 Basin, WCAL, ECAL, BOMA STA and C-43 Distributed Reservoir outflows; secondly from the C-43 Reservoir; and thirdly as an explicit environmental delivery from the lake. The lake can send additional environmental water to the C-43 Estuary only when the lake is above 11.5 feet NGVD.
- Uncontrolled outflow from BOMA STA is treated like any other upstream excess. It is first used to meet water supply needs in WCAL. The remainder (i.e. BOMA outflow beyond WCAL needs) will then be treated as WCAL excess.

C.2.2.5.2.2 Caloosahatchee River Watershed Configuration for Alternative 2

Figure C-14 shows the node-link representation of CRWPP for Alternative 2. The following are brief descriptions of the MMs included in this alternative:

- CRE-10: C-43 Water Quality Treatment and Demonstration Project (BOMA property)
  - Location: ECAL
  - Storage capacity: 4,500 acre-feet
  - Footprint: 1,335 acres
  - Effective storage area: 1,000 acres
  - Maximum depth: 4.5 feet (when outflow starts) = 4,500 acre-feet/1,000 acres
  - Inlet: capacity: 99 cfs, source: ECAL
  - Outlet: capacity: 99 cfs, destination: WCAL
  - Receives ET & rainfall representative of ECAL sub-watershed
  - No seepage loss assumed
- Simulated as a single reservoir: CRE-LO-41: C-43 Distributed Reservoirs; CRE-128: East Caloosahatchee Storage; CRE-LO-40: Lake Hicpochee
  - Location: ECAL
  - Storage capacity: 163,890 acre-feet
  - Footprint: 22,900 acres
  - Effective storage area: 18,320 acres
  - Maximum depth allowed for inflow: 8.95 feet = 163,890 acre-feet/18,320 acres
  - Emergency discharge when depth reaches: 9.45 feet
  - Inlet: capacity: 1,500 cfs, source: ECAL
  - Outlet: capacity: 1,500 cfs, destination: ECAL
  - Overflow: capacity: 1,500 cfs, destination: ECAL
  - Receives ET & rainfall representative of ECAL sub-watershed
  - No seepage loss assumed

The modeling approach is identical to that of Alternative 1, with the exception that the C-43 Distributed Reservoir + Caloosahatchee Storage + Lake Hicpochee will now capture lake regulatory releases, as well as leftover excess from the S-4 Basin and ECAL.

C.2.2.5.2.3 Caloosahatchee River Watershed Configuration for Alternative 3

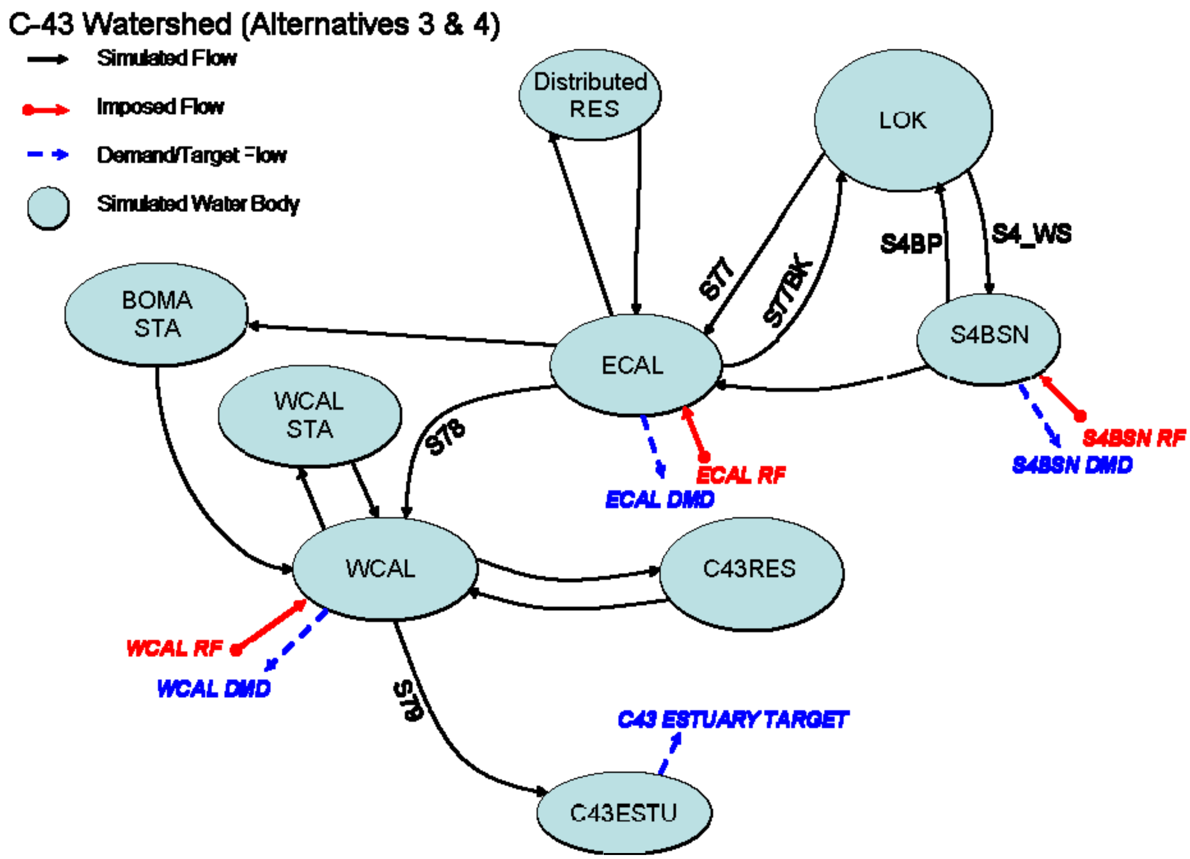


Figure C-15 - Node-link diagram for the C-43 Watershed in RWPP Alternatives 3 & 4

Notes: In Alternatives 3 & 4, "WCAL STA" represents the combined storage of Water Quality Treatment Areas Caloosahatchee Ecoscape and West Caloosahatchee. In Alternative 4, "Distributed RES" represents the combined storage of the C-43 Distributed Reservoirs, additional Caloosahatchee Storage, and Lake Hicpochee MMs.

Figure C-15 shows the node-link representation of CRWPP for Alternative 3. The following are brief descriptions of the MMs included in this alternative:

- CRE-04: Lake Hicpochee Restoration – Caloosa Lakes
  - Location: ECAL
  - Storage capacity: 10,600 acre-feet
  - Footprint: 5,300 acres
  - Maximum depth: N/A; this management measure was implemented by modifying the ECAL basin runoff/demand time series.
  - Inlet: 103 cfs
  - Outlet: 103 cfs
- CRE-10: C-43 Water Quality Treatment and Demonstration Project (BOMA property)
  - Location: ECAL
  - Storage capacity: 4,500 acre-feet
  - Footprint: 1,335 acres

  - Effective storage area: 1,000 acres
  - Maximum depth: 4.5 feet (when outflow starts) = 4,500 acre-feet/1,000 acres
  - Inlet: capacity: 99 cfs, source: ECAL
  - Outlet: capacity: 99 cfs, destination: WCAL
  - Receives ET & rainfall representative of ECAL sub-watershed
  - No seepage loss assumed
- CRE-LO-41: C-43 Distributed Reservoirs
  - Location: ECAL
  - Storage capacity: 42,400 acre-feet
  - Footprint: 6,600 acres
  - Effective storage area: 5,280 acres
  - Maximum depth allowed for inflow: 8.03 feet = 42,400 acre-feet/5,280 acres
  - Emergency discharge when depth reaches: 8.53 feet
  - Inlet: capacity: 500 cfs, source: ECAL
  - Outlet: capacity: 500 cfs, destination: ECAL
  - Overflow: capacity: 500 cfs, destination: ECAL
  - Receives ET & rainfall representative of ECAL sub-watershed
  - No seepage loss assumed
- Simulated as a single STA: CRE-11: Water Quality Treatment Area – Caloosahatchee Ecoscape; CRE-13: Water Quality Treatment Area – West Caloosahatchee
  - Location: WCAL
  - Storage capacity: 8,800 acre-feet
  - Footprint: 2,750 acres
  - Effective storage area: 2,200 acres
  - Maximum depth: 4.0 feet (when outflow starts) = 8,800 acre-feet/2,200 acres
  - Inlet: capacity: 198 cfs, source: WCAL
  - Outlet: capacity: 198 cfs, destination: WCAL
  - Receives ET & rainfall representative of WCAL sub-watershed
  - No seepage loss assumed

The modeling approach is identical to that of Alternative 1, with the exception that the Ecoscape and West Caloosahatchee Water Quality Treatment Areas now capture WCAL runoff as first priority before any other routing is performed in the model.

C.2.2.5.2.4 Caloosahatchee River Watershed Configuration for Alternative 4

Figure C-15 shows the node-link representation of CRWPP for Alternative 4. The following are brief descriptions of the MMs included in this alternative:

- CRE-04: Lake Hicpochee Restoration – Caloosa Lakes
  - Location: ECAL
  - Storage capacity: 10,600 acre-feet
  - Footprint: 5,300 acres
  - Maximum depth: N/A; this management measure was implemented by modifying the ECAL basin runoff/demand time series.
  - Inlet: 103 cfs

  - Outlet: 103 cfs
- CRE-10: C-43 Water Quality Treatment and Demonstration Project (BOMA property)
  - Location: ECAL
  - Storage capacity: 4,500 acre-feet
  - Footprint: 1,335 acres
  - Effective storage area: 1,000 acres
  - Maximum depth: 4.5 feet (when outflow starts) = 4,500 acre-feet/1,000 acres
  - Inlet: capacity: 99 cfs, source: ECAL
  - Outlet: capacity: 99 cfs, destination: WCAL
  - Receives ET & rainfall representative of ECAL sub-watershed
  - No seepage loss assumed
- Simulated as a single reservoir: CRE-LO-41: C-43 Distributed Reservoirs; CRE-128a: Caloosahatchee Storage – Additional; CRE-LO-40: Lake Hicpochee
  - Location: ECAL
  - Storage capacity: 213,890 acre-feet
  - Footprint: 25,819 acres
  - Effective storage area: 20,655 acres
  - Maximum depth allowed for inflow: 10.36 feet = 213,890 acre-feet/20,655 acres
  - Emergency discharge when depth reaches: 10.86 feet
  - Inlet: capacity: 1250 cfs, source: ECAL
  - Outlet: capacity: 1250 cfs, destination: ECAL
  - Overflow: capacity: 1250 cfs, destination: ECAL
  - Receives ET & rainfall representative of ECAL sub-watershed
  - No seepage loss assumed
- Simulated as a single STA: CRE-11: Water Quality Treatment Area – Caloosahatchee Ecoscape; CRE-13: Water Quality Treatment Area – West Caloosahatchee
  - Location: WCAL
  - Storage capacity: 8,800 acre-feet
  - Footprint: 2,750 acres
  - Effective storage area: 2,200 acres
  - Maximum depth: 4.0 feet (when outflow starts) = 8,800 acre-feet/2,200 acres
  - Inlet: capacity: 198 cfs, source: WCAL
  - Outlet: capacity: 198 cfs, destination: WCAL
  - Receives ET & rainfall representative of WCAL sub-watershed
  - No seepage loss assumed

The modeling approach is identical to that of Alternative 1, with the following exceptions:

- The Ecoscape and West Caloosahatchee Water Quality Treatment Areas now capture WCAL runoff as first priority before any other routing is performed in the model.
- The C-43 Distributed Reservoir + Additional Caloosahatchee Storage + Lake Hicpochee will now capture lake regulatory releases, as well as leftover excess from the S-4 Basin and ECAL.

C2.2.6 St. Lucie River Watershed

The St. Lucie River Watershed, as modeled in the NERSM, includes the portion of the Indian River Lagoon South that discharges excess runoff into the St. Lucie Estuary. The watershed is comprised of a number of basins that flow controlled (non-tidal) or uncontrolled (tidal) into the St. Lucie Estuary. The non-tidal basins C-23, C24, Ten-Mile Creek (TMC) and C-44 are controlled by S-48, S49, the TMC structure and S-80, respectively. A total of four nodes represent these non-tidal basins. The remainder of the watershed (portion of North Fork outside the Ten-Mile Creek Basin, South Fork, and Basins 4, 5 and 6) was lumped into a single-node representation.

The watershed is connected to Lake Okeechobee only via C-44 Basin. S-308 serves as conduit for Lake Okeechobee water to the basin (to meet supplemental irrigation needs) and to the estuary (via S80) to release regulatory discharge. The other basins in St. Lucie River Watershed are independent of Lake Okeechobee in terms of meeting their supplemental irrigation needs and, thus, are not part of the Lake Okeechobee Service Area.

The version of NERSM that was used in the LOP2TP conceptualized the St. Lucie River Watershed as two nodes: C-44 and non-C44. C-44 was provided runoff and demand time series obtained from an offline AFSIRS/WATBAL modeling effort (Wilcox et al., 2003). Non-C44, a lumped representation of C-23, C-24, North fork (including Ten-Mile Creek), South Fork, and Basins 4, 5 and 6, was considered to provide boundary flows to the estuary. The time series of such discharges were based on a previous WaSh modeling exercise (Wan et al, 2003).

The current version of NERSM, as used in the RWPP, treated the non-C44 basins separately, thus allowing for the inter-basin transfer to occur between C23 and C44 Reservoir/STA, C23/C24 STA and TMC Sub-watershed, C23 Basin and C23/24 reservoir, C24 Basin and C23/24 Reservoir, and C23/24 Reservoir and C23/24 STA, as specified in the IRL preferred alternative project. The St. Lucie Estuary target time series was defined for each of the five-node representation of the St. Lucie River Watershed discharging directly into the St. Lucie Estuary. The corresponding time series were obtained using OPTI-6, the hydrologic optimization model used in IRL project (Wan et al., 2006).

C2.2.6.1 St. Lucie River Watershed Configuration for River Watershed Protection Plan Base

Figure C-16 is a schematic showing how MMs in the St. Lucie River Watershed were simulated in RWPPB. Preferred priority is listed for releases from basins, reservoirs, and STAs, but can be changed from within the model. North Fork, South Fork, and B456 basins have been combined into one sub-watershed (NF-SF-B456) for RWPPB. A summary of the sub-watersheds and reservoir and STA features, as simulated in NERSM, are as follows.

C23, C24, and NF-SF-B456 Sub-watersheds

- Three outlet structures discharge from each of the basins into the St. Lucie Estuary. Structure capacity is assumed to be limited only by available basin runoff.
- Runoff from each basin is first used to meet St. Lucie Estuary demands.

- Demands in each basin represent supplemental irrigation needs from surface water sources only.

Ten Mile Creek Sub-Watershed

- One outlet structure discharges into the St. Lucie Estuary. Structure capacity is assumed to be limited only by available basin runoff. Basin runoff is first used to meet St. Lucie Estuary demands. If remaining runoff still exists, the remaining runoff is sent to the TMC Reservoir/STA.
- TMC Sub-watershed demands represent supplemental irrigation needs from surface water sources only. The TMC Reservoir/STA is the priority source for these needs.
- An emergency flood control pump of 200 cfs is added to discharge water from TMC Reservoir/STA to the TMC Sub-watershed to ensure that the reservoir does not exceed 11.29 feet (which corresponds to its maximum depth plus a buffer). Note that inflows to the TMC Reservoir/STA are cutoff once it reaches its maximum depth of 10.79 feet; however, rainfall may bring it above 10.79 feet.

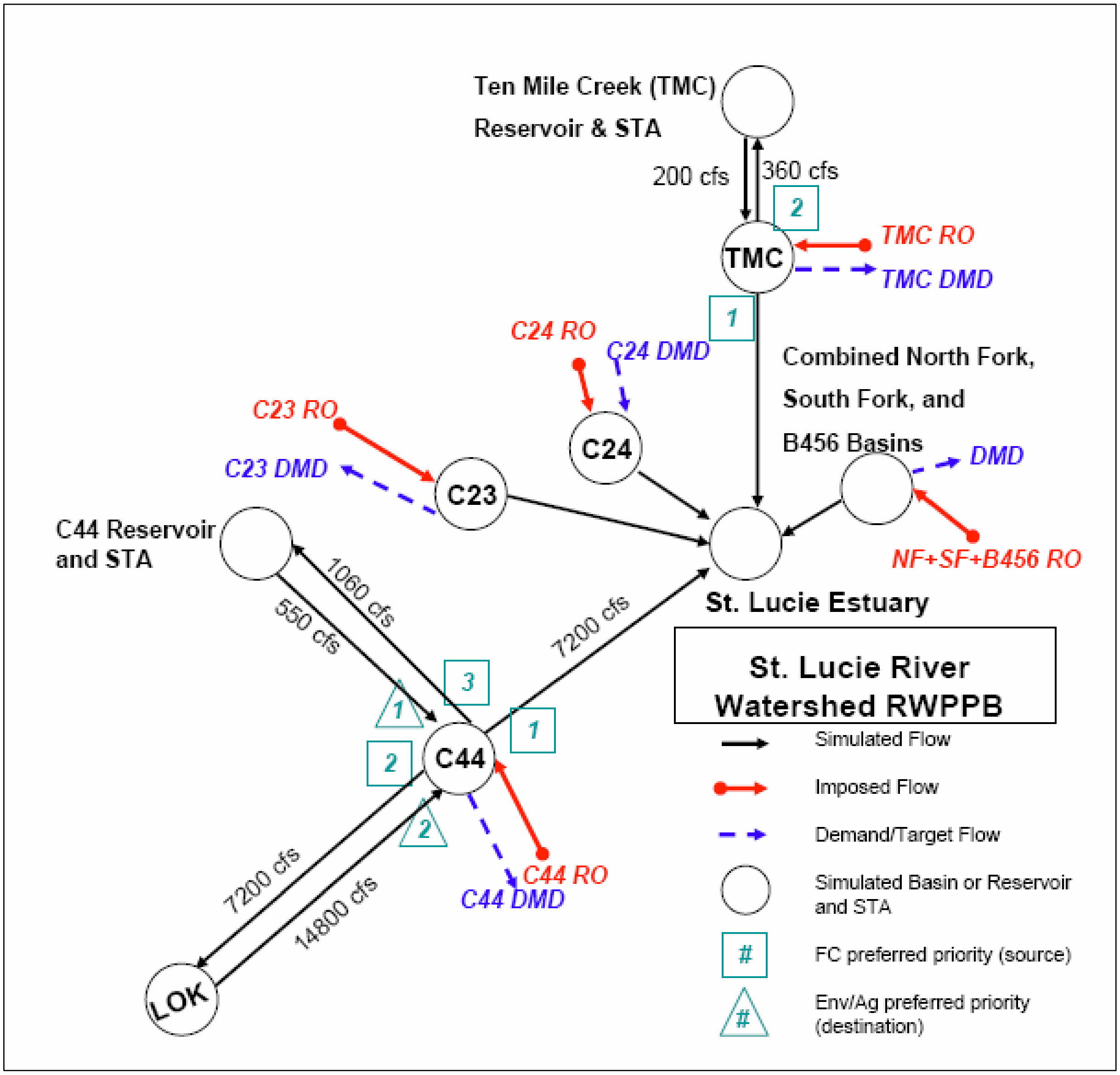


Figure C-16. St. Lucie River Watershed simulation configuration for RWPPB

Ten Mile Creek Reservoir and STA

- Location: TMC Sub-watershed
- Storage capacity: 656 acres * 10.79 feet = 7078 acre-feet
- Footprint: 820 acres (assumed 656 acres/80%)
- Effective storage area: 656 acres
- Approximate bottom elevation: 20.0 feet (assumed datum for depth calculations only)
- Maximum depth: 10.79 feet
- Emergency discharge when depth reaches: 11.29 feet
- Inlet: 360 cfs capacity, modeled as pump. Source: TMC Sub-watershed
- Outlet: 200 cfs capacity, modeled as pump. Destination: TMC Sub-watershed
- Will receive rainfall representative of North Fork basin.
- Will receive ET representative of St. Lucie basins (per input file)

- No seepage loss assumed

C44 Basin

- One outlet structure (S-80) discharges into the St. Estuary, with a capacity of 7200 cfs.
- Basin runoff is first used to meet St. Lucie Estuary demands. If remaining runoff still exists, then the remaining runoff is sent to the C44 Reservoir/STA.
- Runoff from C44 Basin flows into Lake Okeechobee when Lake Okeechobee stage is below 14.5 feet NGVD. This condition overrides previous statement that remaining runoff is diverted to the C44 Reservoir/STA.
- C44 Basin demands are met first by C44 Reservoir/STA, then by Lake Okeechobee.
- St Lucie Estuary at S80, demands to be met in this priority order: (1) C44 runoff, (2) C44 Reservoir & STA releases, and (3) Lake Okeechobee explicit delivery, if desired.
- An emergency flood control pump of 1063 cfs is added to discharge water from C44 Reservoir/STA to the C44 Basin to ensure that the reservoir does not exceed 5.68 feet (which corresponds to its maximum depth plus a buffer). Note that inflows to the C44 Reservoir/STA are cutoff once it reaches its maximum depth of 5.18 feet; however, rainfall may bring it above 5.18 feet.

C44 Reservoir and STA

- Location: C44 Basin
- Storage capacity: 9700 acres * 5.18 feet = 50,246 acre-feet
- Footprint: 12,125 acres (assumed 9700 acres/80%)
- Effective storage area: 9700 acres
- Approximate bottom elevation: 20.0 feet (assumed datum for depth calculations only)
- Maximum depth: 5.18 feet
- Emergency discharge when depth reaches: 5.68 feet
- Inlet: 1060 cfs capacity, modeled as pump source: C44 Basin
- Outlet: 550 cfs capacity, modeled as pump destination: C44 Basin
- Will receive ET and rainfall representative of C44 Basin.
- No seepage loss assumed.

C2.2.6.2 St. Lucie River Watershed Configuration for Alternative 1 (ALT1)

Figure C-17 shows how Alternative 1 was simulated in NERSM. The node representation of the basins in Alternative 1 is essentially the same as in RWPPB. The C-23/C-24 Reservoir and the C-23/C-24 STA are additional managements for Alternative 1.

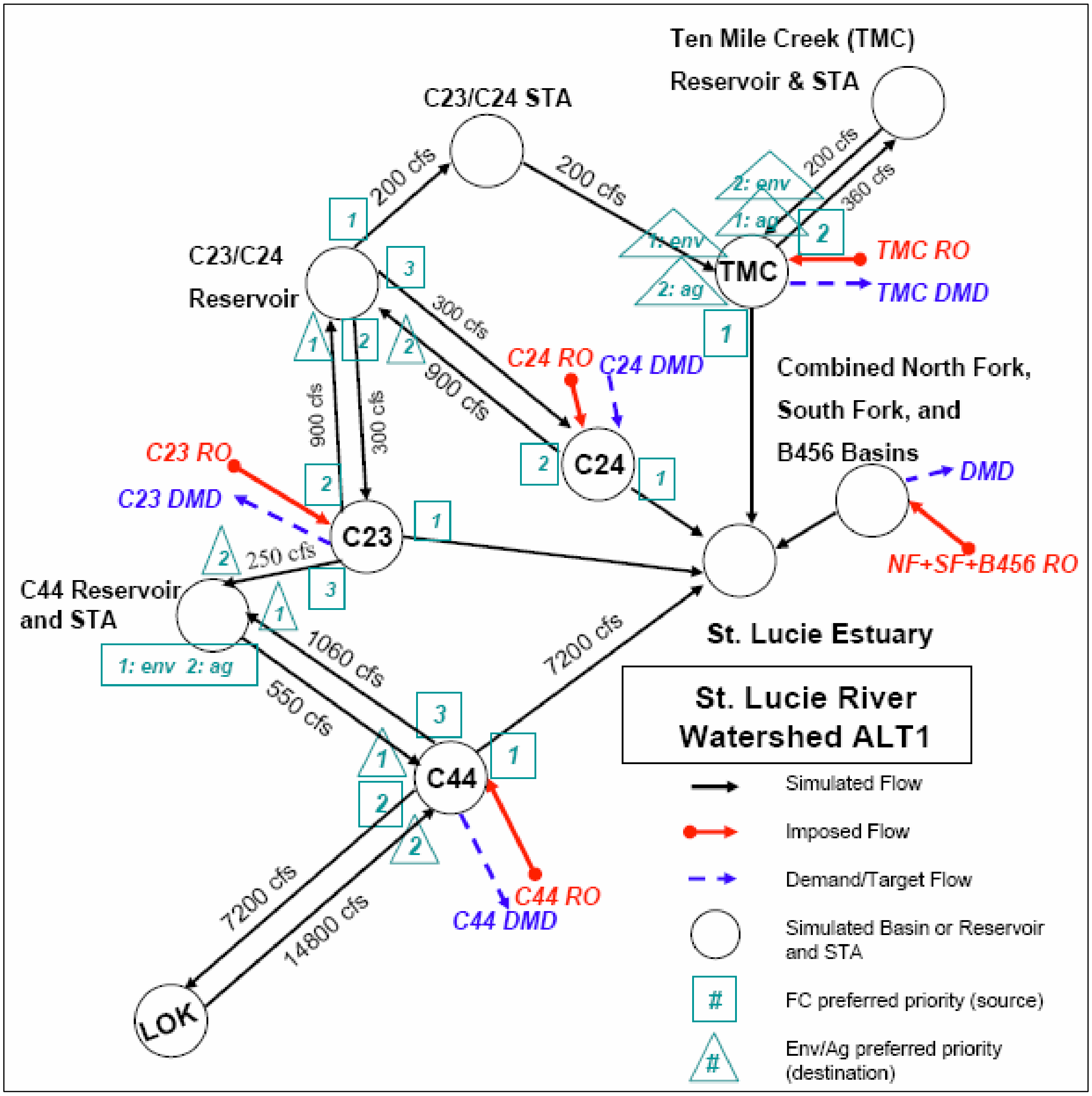


Figure C-17. St. Lucie River Watershed simulation configuration for Alternative 1

NF-SF-B456 Basins

- One outlet structure discharges into the St. Lucie Estuary.
- Basin runoff is first used to meet St. Lucie Estuary demands.
- Demands in each basin represent supplemental irrigation needs from surface water sources only.

C23 Basin

- One outlet structure discharges into the St. Lucie Estuary. Structure capacity is assumed to be limited only by available basin runoff. Basin runoff is first used to meet St. Lucie Estuary demands. If remaining runoff still exists, then the remaining runoff is sent in this priority order: (1) to the C23/C24 Reservoir and (2) to C44 Reservoir/STA to meet agricultural and environmental demands.

C24 Basin

- One outlet structure discharges into the St. Lucie Estuary. Structure capacity is assumed to be limited only by available basin runoff. Basin runoff is first used to meet St. Lucie Estuary demands. If remaining runoff still exists, then the remaining runoff is sent to the C23/C24 Reservoir.
- When water is available in the C23/C24 Reservoir, it will make releases to the basin to meet agricultural demands (third priority).

C23/C24 Reservoir and C23/C24 STA

- When water is available in the C23/C24 Reservoir, it will make 200 cfs release to the C23/24 STA when TMC estuary demand is greater than 200 cfs.
- When water is available in the C23/C24 Reservoir, it will make releases in this priority: (1) C23/C24 STA (above), (2) C23 Basin, and (3) C24 Basin.

C23/24 Reservoir

This reservoir is a combination of the C23 North Reservoir in C24 Basin and the C23/C24 South Reservoir in C23 and C24 basins.

- Location: C23 and C24 basins
- Storage capacity: 6940 acres * 13.27 feet = 92,094 acre-feet
- Footprint: 8675 acres (assumed 6940 acres/80 percent)
- Effective storage area: 6940 acres
- Approximate bottom elevation: 20.0 feet (assumed datum for depth calculations only)
- Maximum depth: 13.27 feet
- Emergency discharge when depth reaches: 13.77 feet
- Inlet: 900 cfs capacity, modeled as pump source: C23 Basin
- Inlet: 900 cfs capacity, modeled as pump source: C24 Basin
- Outlet: 300 cfs capacity, modeled as pump destination: C23 Basin
- Outlet: 300 cfs capacity, modeled as pump destination: C24 Basin
- Outlet: 200 cfs capacity, modeled as pump destination: C23/C24 STA
- Will receive rainfall representative of C24 Basin.
- Will receive ET and rainfall representative of St Lucie basins.
- No seepage loss assumed

C23/C24 STA Addition for ALT 1

This STA is physically located in TMC Sub-watershed.

- Location: C23 and C24 basins
- Storage capacity: 2568 acres * 1.5 feet = 3852 acre-feet
- Footprint: 3323 acres (assumed 2568 acres/ 80%)
- Effective storage area: 2568 acres
- Approximate bottom elevation: 20.0 feet (assumed datum for depth calculations only)

- Maximum depth: 1.5 feet
- Emergency discharge when depth reaches: 1.5 feet
- Inlet: 200 cfs capacity, modeled as pump   source: C23/C24 Reservoir
- Outlet: 200 cfs capacity, modeled as pump   destination: C23/C24 STA
- Will receive rainfall representative of North Folk Basin.
- Will receive ET and rainfall representative of St Lucie basins.
- No seepage loss assumed

Ten Mile Creek Basin

- One outlet structure discharges into the St. Lucie Estuary. Structure capacity is assumed to be limited only by available basin runoff. Basin runoff is first used to meet St. Lucie Estuary demands. If remaining runoff still exists, then the remaining runoff is sent to the TMC Reservoir/STA.
- TMC Sub-watershed demands are met first by the TMC Reservoir/STA, and then represent supplemental irrigation needs from surface water sources only.
- An emergency flood control pump of 200 cfs is added to discharge water from TMC Reservoir/STA to the TMC Sub-watershed to ensure that the reservoir does not exceed 11.29 feet (which corresponds to its maximum depth plus a buffer). Note that inflows to the TMC Reservoir/STA are cutoff once it reaches its maximum depth of 10.79 feet; however, rainfall may bring it above 10.79 feet.
- When St. Lucie Estuary demand at TMC is greater than 200 cfs, a 200 cfs release is made from the C23/24 STA to TMC Sub-watershed.

Ten Mile Creek Reservoir and STA

- Location: TMC Sub-watershed
- Storage capacity: 656 acres * 10.79 feet = 7078 acre-feet
- Footprint: 820 acres (assumed 656 acres/80 percent)
- Effective storage area: 656 acres
- Approximate bottom elevation: 20.0 feet (assumed datum for depth calculations only)
- Maximum depth: 10.79 feet
- Emergency discharge when depth reaches: 11.29 feet
- Inlet: 360 cfs capacity, modeled as pump source: TMC Sub-watershed
- Outlet: 200 cfs capacity, modeled as pump. TMC Sub-watershed
- Will receive rainfall representative of North Folk Basin.
- Will receive ET representative of St. Lucie basins (per input file).
- No seepage loss assumed

C44 Basin

- One outlet structure (S-80) discharges into the St. Estuary with a capacity of 7200 cfs.
- Basin runoff is first used to meet St. Lucie Estuary demands. If remaining runoff still exists, then the remaining runoff is sent to the C44 Reservoir/STA.
- Runoff from C44 Basin flows into Lake Okeechobee when Lake Okeechobee stage is below 14.5 feet NGVD. This condition overrides previous statement that states that remaining runoff is diverted to the C44 Reservoir/STA.
- C44 Basin demands are met first by C44 Reservoir & STA, then by Lake Okeechobee.

- St Lucie Estuary at S80, demands to be met in this priority order: (1) C44 runoff, (2) C44 Reservoir & STA releases, and (3) Lake Okeechobee explicit delivery, if desired.
- An emergency flood control pump of 1063 cfs is added to discharge water from C44 Reservoir/STA to the C44 Basin to ensure that the reservoir does not exceed 5.68 feet (which corresponds to its maximum depth plus a buffer). Note that inflows to the C44 Reservoir/STA are cutoff once it reaches its maximum depth of 5.18 feet; however, rainfall may bring it above 5.18 feet.
- C44 Reservoir/STA receives 250 cfs from the C23 basin to meet agricultural and estuary demands.

C44 Reservoir and STA

- Location: C44 Basin
- Storage capacity: 9700 acres * 5.18 feet = 50,246 acre-feet
- Footprint: 12,125 acres (assumed 9700 acres/80 percent)
- Effective storage area: 9700 acres
- Approximate bottom elevation: 20.0 feet (assumed datum for depth calculations only)
- Maximum depth: 5.18 feet
- Emergency discharge when depth reaches: 5.68 feet
- Inlet: 1060 cfs capacity, modeled as pump source: C44 Basin
- Inlet: 250 cfs capacity, modeled as pump source: C23 Basin
- Outlet: 550 cfs capacity, modeled as pump destination: C44 Basin
- Will receive ET and rainfall representative of C44 Basin.
- No seepage loss assumed

C2.2.7 Lake Okeechobee Sub-watershed

Several features from NERSM were developed or adopted from SFWMM in order to meet the modeling requirements established during the alternative formulation and analysis phase of the project. Primary components that comprise the Lake Okeechobee water balance and computational algorithms incorporated in the model are described briefly below.

Lake Okeechobee is modeled as a lake, using established stage-area and stage-volume relationships established in the SFWMM. Rainfall during the period 1970 to 2005 is used to calculate the volume of water that falls directly on the lake surface. ET is calculated using the same methodology as implemented in the SFWMM.

Historical flows are applied for the TCNS, LI, and FEC Sub-watersheds in all of the scenarios. Historical sub-watershed flows are adjusted in select alternative scenarios, as needed, to account for the “footprint” of MMs considered in a particular scenario. NERSM calculated flows from the LKB Sub-watershed are another tributary inflow to Lake Okeechobee.

Backflows coming from the Everglades Agricultural Area (EAA) in areas south of Lake Okeechobee as simulated in SFWMM are input as a boundary condition for the NERSM.

In the RWPPB and alternative scenarios, the C-43 Reservoir is modeled in the NERSM with the sole purpose of meeting the environmental needs of the Caloosahatchee Estuary. The performance of C-43 Reservoir and its ability to meet C-43 Estuary demands are affected by Lake Okeechobee stages and its interaction with other MMs during the RWPP alternatives formulation process. The footprint for the C-43 Reservoir was obtained from modeling in support of the Project Implementation Report (PIR) phase of CERP developed by Wilcox (email communications, 2007). Rainfall and reference ET datasets for the reservoir were also obtained from the PIR model. The storage area and volume relationships for the reservoir were developed by Stanley Consultants (email 2007).

The C-44 Reservoir/STA receives water only from local basin runoff. However, local basin demand can be met primarily from the reservoir and from Lake Okeechobee as a back-up source. Hence, it is not explicitly simulated in NERSM. The C44 Reservoir/STA is also used to treat runoff prior to discharge into the estuary.

C2.2.8 Lake Okeechobee Operations

The WSE Regulation Schedule is implemented in NERSM for Lake Okeechobee regulatory releases. The regulatory releases are based on lake stage (compared to calendar based trigger lines) and climatic influences (both local and global). Lake water levels are checked against operational zones A, B, C, D1, D2 and D3, and then additional criteria in a decision tree (Tributary Hydrologic Conditions and Climatic and Meteorological Outlooks) are checked to guide the amount of release. Similar to the SFWMM model, seasonal forecasts are assumed in place of short-term meteorological forecasts, due to difficulty in deriving these data.

Regulatory releases to the Caloosahatchee and St. Lucie estuaries are simulated in the Current Base scenario based on the WSE Regulation Schedule as implemented in the SFWMM 2005 base run. Releases for the same purpose are simulated in the Future Base and alternative scenarios based on the WSE Regulation Schedule as implemented in the SFWMM 2010A8 run.

Discharges to the Caloosahatchee River (C-43) through S-77 and discharges to the St Lucie Canal (C-44) through S-308 are simulated based on the WSE Regulation Schedule. Simulated discharges to conservation areas include Lake Okeechobee to WCA 1 (S-352 to West Palm Beach canal), to WCA 2A (S-351 to Hillsboro canal), and to WCA 3A (S-351 to North New River canal and S-354 to Miami Canal).

Instead of meeting local basin demand and estuarine demands, as in the PIR model, the C-43 Reservoir operating rule in NERSM is designed to meet only estuarine demands. This change in functionality is more in line with the original intent of the C-43 Reservoir. The C-43 Reservoir simulation is capable of simulating the following operations for multiple purposes:

- Flood Control: releases expected at S-79 from either the Caloosahatchee Basin runoff or Lake Okeechobee regulatory releases through S-77. A check is made of the S-79 Caloosahatchee Estuary targets. Flows in excess of this target should be directed to the C-43 Reservoir, provided there is capacity in the reservoir.
- Water Supply: If the Caloosahatchee Basin runoff and S-77 regulatory releases are less than the Caloosahatchee Estuary target, releases should be made from the C-43 Reservoir to meet the deficit, subject to the available reservoir capacity.

Explicit Lake Okeechobee discharges to meet minimum flow requirements in the St. Lucie Estuary are not simulated in RWPPB and the alternatives. However, NERSM-calculated Lake Okeechobee regulatory releases are combined with the C-44 Basin and Reservoir/STA releases to evaluate the total impact on St. Lucie Estuary.

In the Current Base scenario, regulatory releases through C-10A are simulated consistent with SWFMM 2005. In the RWPPB and alternative scenarios, regulatory releases south are zero, except through C-10A.

Non-regulatory releases are sent to areas of the system for a variety of purposes, including irrigation, saltwater intrusion control, domestic water supply and environmental enhancement.

In the NERSM, environmental releases to the estuaries and water supply releases to LOSA are the only simulated non-regulatory flows out of Lake Okeechobee. Individual LOSA demands are input as boundary conditions in NERSM for all simulation scenarios. EAA conveyance cutbacks are not simulated in any of the simulated scenarios, but instead are fixed based on appropriate SFWMM output. In the Future Base and Alternative Plans scenarios, the Hybrid LOWSM methodology described below is implemented in NERSM.

All other non-regulatory releases such as environmental water supply releases to the WCAs and Everglades National Park, urban water supply releases to the Lower East Coast and discharges to the EAA reservoir were obtained from the SFWMM and input as boundary condition flows. In future versions of NERSM, Lake Okeechobee discharges will be made to the proposed above-ground reservoirs to be constructed in the EAA, based on operating rules built into the model.

C2.2.9 MDS and LOWSM Algorithms

The MDS term represents the arithmetic sum of all lake historical water budget components that: (1) are not accounted for in another simulated term on Lake Okeechobee, and (2) are assumed not to change from what happened historically. The calculation begins with the historical water budget definition for the lake (excluding seepage and regional groundwater movement):

$$delS_{hist} = RF_{hist} + qin_{hist} - qout_{hist} - Et_{hist}$$

where:

q = total structural flow aggregated over the current time step

RF = rainfall volume over the current time step

delS = $S_{t+1} - S_t$ = change in storage from the current to the next time step

ET = evapotranspiration volume over the current time step

This is expanded to form the following equation, in which some components will not change for any anticipated management/operational scenario to be evaluated in the future (subscript *NC*), and some components will change given the same scenario (subscript *C*):

$$(delS_{hist})_C = [(qin_{hist})_{NC} + (qin_{hist})_C + (RF_{hist})_{NC}] - [(qout_{hist})_{NC} + (qout_{hist})_C + (Et_{hist})_C]$$

Rearranging this equation gives the MDS term to be used in the model simulations:

$$(delS_{hist} - qin_{hist} + qout_{hist} + ET_{hist})_C = (RF_{hist} + qin_{hist} - qout_{hist})_{NC}$$

Note that the equation above illustrates the ability to calculate the MDS term using an aggregation of historically observed lake storage change, structure flow for stations that will be simulated (subscript *C*) and historical ET measurement. All of these terms can be easily obtained or estimated.

LOWSM methodology is used for allocation of Lake Okeechobee water to agricultural users during drought conditions. The methodology incorporates calendar-based water shortage trigger lines in a phased-cutback approach along with a set of weekly LOSA demands to be met. The weekly demands, based on a one-in-ten-year drought condition, were obtained from SFWMM.

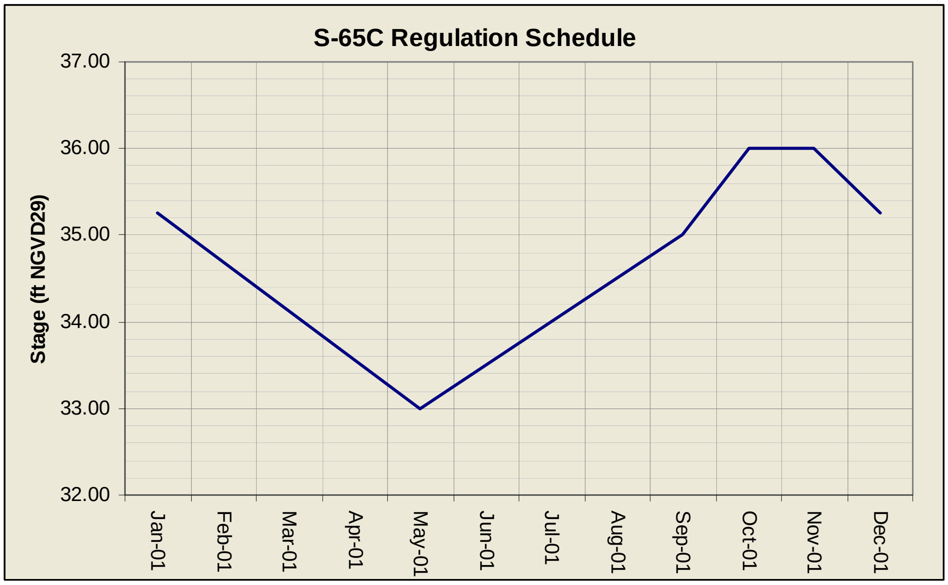
C2.3 Sub-watershed Specific Assumptions and Specifications

C2.3.1 Current Base (2005) Assumptions

Table C-6. Summary of Primary Characteristics of Current Base Condition Model

Feature	Entire Model Domain
General	• Model should reflect conditions around the year 2005, except when otherwise indicated. • Period of simulation is 1970 to 2005. • Model time step is daily. • All elevations are in feet, NGVD 29.
	Upper Kissimmee Sub-watershed (KUB)
General	• Model consists of nine interconnected lakes with flows imposed for the lakes with natural creeks. The outflows from the lakes are heavily regulated.
Climate	• Climate period of record is 1970-2005. Rainfall and ET data derived from the time series developed for the SFWMM, with open water evaporation assumed for the nine lakes.
Model Setup	• The Upper Kissimmee Sub-watershed model setup consists of nine lakes or Lake Management Areas (LMAs). The lakes are Alligator, Myrtle, Hart, Gentry, East Toho, Toho, Cypress, Hatchineha and Kissimmee. The lakes are interconnected with canals and water control structures which are tightly regulated.
Stage-Volume-Area Relationships	• Stage-volume and stage-area relationships for the nine lake management areas are those developed as part of the KBMOS effort.
Sub-watershed Inflows	• Sub-watershed flows developed as a part of the calibration of the UKISSWIN model (PBS&J, Christ et al. 2001) were imposed as flow boundary conditions for the nine lakes. Historical flows obtained from USGS for Shingle, Boggy, Reedy and Catfish creeks were also imposed as boundary conditions for Lakes Toho, East Toho, Cypress and Hatchineha. For Shingle Creek, the flow split was assumed to be 70 percent into Lake Hatchineha and 30 percent into Lake Cypress.
Structure Capacity	• The water control structures, which interconnect the lakes, include six spillways (S-60, S-62, S-59, S-61, S-63 and S-65), two culverts (S-57 and S-58) and two open channel connections (C36 and C37). The design capacities of the structures are given below: S-60 – 450 cfs S-62 – 500 cfs S-59 – 700 cfs S-61 – 2000 cfs S-63 – 700 cfs S-65 – 4000 cfs S-57 – 150 cfs S-58 – 130 cfs Locks used for navigation at the structures are not modeled.
Operations	The lakes and water control structures are regulated by rigid schedules, as defined in the Kissimmee Basin Water Supply Plan (SFWMD, 2000). An exception is Lake Kissimmee, which is simulated in the model using the Interim Regulation Schedule, as implemented in Phase I of the KRR Project. The flow through all structures in KUB were modeled using the daily headwater/tailwater and gate openings at the structure, as defined in the UKISS package in the SFWMD Technical Publication 86-5, and are similar to the SFWMD's Flow Program. The maximum allowable gate openings for a set of headwater/tailwater conditions at the spillway were computed using the "Riprap Control" criteria mentioned in the technical publication. The flow

Feature	Entire Model Domain
	through the open channel canals C-36 and C-37 connecting lakes Cypress and Hatchineha, and lakes Hatchineha and Kissimmee is modeled with a variation of the Manning's equation using stage and water surface slope as outlined in the technical publication.
	Lower Kissimmee Sub-watershed (LKB)
General	• Model reflects conditions post-Phase I of the KRR around the year 2005. • It is assumed that there is no connection between Lake Istokpoga and the Kissimmee River (i.e. G-85 is assumed closed).
Climate	• The climatic period of record is 1970 to 2005. • Rainfall time series were obtained from the 1914-2005 rainfall binary developed for the SFWMM. Rainfall values for the SFWMM grid cells fully contained within the LKB Sub-watershed were averaged to obtain the average rainfall time series for each pool or basin. • Reference grass evapotranspiration (RET) time series (by Penman-Monteith) were obtained from the 1948-2005 binary file developed for the SFWMM. RET values for the SFWMM grid cells fully contained within each LKB basin were averaged to obtain average RET time series for each basin. In the model it is assumed that open water evaporation from the four C-38/Kissimmee River reaches is 85 percent of RET for consistency with average annual open water ET rates in the UKISS model.
Model Setup	• The Lower Kissimmee Sub-watershed is comprised of four major basins reflecting partial (Phase I) KRR: S-65A, S-65BC, S-65D and S-65E. Only the C-38 canal, the Kissimmee River and floodplain portions of these basins are simulated as level pools: Pools A, BCD, and E.
Stage-Volume-Area Relationships	• Stage-volume and stage-area relationships used for the four level pools are those developed for the KBMOS project. For Pool BC, these relationships were later manipulated to obtain stage-volume and stage-area curves for representative level-pool head.
Sub-watershed Inflows	• To be consistent with the SFWMM methodology for translating S-65 into S-65E flows, sub-watershed inflows (runoff) were estimated based on historical flow data at LKB boundary structures (S-65E – S-65 flows). Runoff was prorated based on the relative area of each LKB basin and the resulting time series was imposed as boundary condition to each level pool.
Structure Capacity	• Only the major gated spillway structures in place post-Phase I of the KRR are included: S-65A, S-65C, S-65D, and S-65E. Culverts and overflow weirs next to these structures are not modeled. Broad-crested weirs on the tieback levee of S-65A are not modeled. Locks at these structures are also not modeled. • S-65B is not included in the simulation, as it was removed as part of Phase I of the KRR. • WEIRS 1, 2, 3, though still in place in 2005, are not modeled. • Rating curves developed by Ansar, et al. (2005) based on dimensionless analysis were used in simulating these gated spillways (**Table C-7)**. • Gates are assumed to always be at the maximum allowable gate opening (MAGO) for the set of headwater/tailwater stages. MAGO curves for these structures were obtained from the C&SF System Operating Manual (Draft-December 2005) and input as two-dimensional lookup tables. • Maximum historical discharges are used to limit flow through these structures: S-65A: 13,100 cfs S-65C: 19,300 cfs S-65D: 24,000 cfs S-65E: 27,900 cfs
Operations	• The four gated spillways are operated for flood control. The regulation schedule presented in Appendix C of the 2000 KB Water Supply Plan was only implemented in real-life for S-65B (D. Anderson, pers. comm.), which was removed as part of Phase I of KRR. Therefore, a single flood control trigger stage equal to the optimum headwater stage at each structure is used to operate the structures in the model. The exception is S-65C, where the schedule is used in the model as it captures the overall intent of post-Phase I operations (D. Anderson, pers. comm.). During a time step, a structure will try to remove any volume of water stored above this flood control trigger stage, plus any basin inflow subject to the structure capacity and limited to its maximum capacity.

Feature	Entire Model Domain
	Flood control trigger stage: S-65A: 46.3 ft S-65D: 26.8 ft S-65E: 21.0 ft 
Taylor Creek/Nubbin Slough Sub-watershed (TCNS)	
General	• A flow-pass-through method is implemented for this area. The historical flow from this area into Lake Okeechobee is imposed as flow boundary condition. Then the flow would pass through the sub-watershed and outlet directly into Lake Okeechobee.
Climate	• The climatic period of record is 1970 to 2005. • For flow pass-through method, RF and ET are not needed in the simulation.
Model Setup	• The whole sub-watershed is divided into three basins: TCNS (S191+S133), S154 (S154+S154C), and S135. Outflows from these basins into Lake Okeechobee are: TCNSQ (S191+S133), S154, and S135 respectively.
Stage-Volume-Area Relationships	• For flow pass-through method, stage-volume relationships will not be used.
Sub-watershed Inflows	• The sub-watershed inflows are assumed to produce historical outflows from the sub-watershed into Lake Okeechobee which are imposed as flow boundary conditions. These flows: TCNSQ, S-154 and S-135 are from DBHYDRO database.
Structure Capacity	• Design capacity: S-191 (7,440 cfs); S-133 (625 cfs); S-154 (1,000 cfs); S-135 (500 cfs). • Since flow pass-through method is implemented for this area, the design capacity does not impact the simulation.
Operations	• Historically, structure S-191 is operated on headwater elevation, and maximum gate opening. S-135 and S-133 are pump stations, operated according to headwater elevation. • For flow pass-through method, the structures are assumed to have been operated as was done historically.

Feature	Entire Model Domain
	Lake Istokpoga Sub-watershed
General	• A flow pass-through method is implemented for this area. The historical flow from this area into Lake Okeechobee is imposed as flow boundary condition. Then the flow would pass through the sub-watershed and outlet, directly into Lake Okeechobee. The sub-watershed is assumed to be cut off from Lower Kissimmee with the structure G-85 closed all the time.
Climate	• The climatic period of record is 1970 to 2005. • For flow pass-through method, RF and ET are not needed in the simulation.
Model Setup	• The Istokpoga model is set up such that historical outflows are assumed to pass through the sub-watershed. Outflows into Lake Okeechobee (through S-71, S-72, S-84, S-127, S-129 and S-131) are assumed to be lumped into a single quantity.
Stage-Volume-Area Relationships	• For flow pass-through method, stage-volume relationships will not be used.
Sub-watershed Inflows	• The sub-watershed inflows are assumed to produce historical outflows from the sub-watershed into Lake Okeechobee, which are imposed as flow boundary conditions.
Structure Capacity	• From the structure books, the major gated spillway structures design capacities are shown in parenthesis: S-68 (3,000 cfs), S-70 (5,000 cfs), S-71 (6,000 cfs), S-72 (3,000 cfs), S-84 (6,000 cfs), S-127 (625 cfs), S-129 (375 cfs) and S-131 (375 cfs). • Since flow pass-through method is implemented for this area, the design capacities do not impact the simulation.
Operations	• For flow pass-through method, the structures are assumed to have been operated as was done historically.
	Fisheating Creek Sub-watershed
General	• This sub-watershed is modeled as a flow pass-through. The historical outflow from Fisheating Creek into Lake Okeechobee is imposed as an inflow to the sub-watershed as a boundary condition and allowed to flow into Lake Okeechobee.
Climate	• The climatic period of record is 1970 to 2005. • For flow pass-through method, RF and ET are not needed in the simulation.
Model Setup	• The entire Fisheating Creek area is modeled as a single basin.
Stage-Volume-Area Relationships	• For flow pass-through method, stage-volume relationships are not used.
Sub-watershed Inflows	• Since this sub-watershed is modeled as a flow pass-through, sub-watershed outflow time series is imposed as inflow boundary conditions. • Since there are no flow-monitoring sites close to Lake Okeechobee, the inflow time series is developed based on historical data at the Palmdale station. Palmdale station is the most downstream "natural" station. It is located on Fisheating Creek, several miles upstream of its confluence with Lake Okeechobee. The assumption is that the runoff to Lake Okeechobee from the Fisheating Creek drainage area downstream of Palmdale is included in MDS term.
Structure Capacity	• No structures exist in this sub-watershed. Fisheating Creek has an open connection with Lake Okeechobee. A dummy structure is assumed with very high capacity to allow passing the sub-watershed inflow to Lake Okeechobee.
Operations	• For flow pass-through method, the structures are assumed to have been operated to pass historical outflow.

Feature	Entire Model Domain
Lake Okeechobee Sub-watershed	
General	• Current base simulation, as in SFWMM 2005 base run
Climate	• The climatic period of record is 1970 to 2005.
Model Setup	• Lake Okeechobee modeled as a "lake" in the Regional Simulation model with established stage-area and stage-volume relationships. Rainfall is part of the MDS term. ET simulated using the same methodology as in the SFWMM.
Stage-Volume-Area Relationships	• Same as in SFWMM
Sub-watershed Inflows	• Historical flows are applied for the Fisheating Creek, Lake Istokpoga and Taylor Creek/Nubbin Slough Sub-watersheds. Backflows coming from the east, west and south of Lake Okeechobee, as simulated in the SFWMM, will be input as boundary conditions in RSM. S-65E flows into Lake Okeechobee will be simulated.
Structure Capacity	• Same as in SFWMM
Operations	• Regulatory releases to the estuaries and to the WCAs are simulated based on the WSE Regulation Schedule. Based on the SFWMM equivalent run, regulatory releases through S-352 and S-351 (Hillsboro Canal) are zero. Regulatory releases through C-10A are also simulated. • Individual LOSA basin demands are boundary conditions. Water management cutback scheme is simulated based on hybrid LOWSM operations. EAA conveyance cutbacks are not currently simulated, but fixed based on SFWMM output. • NETP Sub-watersheds, which are simulated in the model, establish inflows into Lake Okeechobee. • All other inflows and outflows are fixed boundary conditions.

Table C-7. Spillway Equations Used in NERSM for All Modeling Scenarios

Flow Condition	Equation	Restriction	Remarks
Controlled Submerged (CS)	$Q = L\sqrt{gy_c{}^3}$ $y_c = aG_o\left(\frac{H-h}{G_o}\right)^b$ a = 1.04, b = 0.30	$\frac{h}{G_o} \geq 1.0$	Also known as submerged orifice
Controlled Free (CF)	$Q = L\sqrt{gy_c{}^3}$ $y_c = aG_o\left(\frac{H}{G_o}\right)^b$ a = 0.86, b = 0.35	$\frac{h}{G_o} < 1.0 \,\&\, \frac{H}{G_o} \geq \frac{1}{K}$ $K = 2/3$	Also known as free orifice
Uncontrolled Submerged (US)	$Q = L\sqrt{gy_c{}^3}$ $y_c = aH(1-\frac{h}{H})^b$ a = 0.838, b = 0.167	$\frac{h}{G_o} < 1.0, \frac{H}{G_o} < \frac{1}{K}, \& \frac{h}{H} \geq K$ $K = 2/3$	Also known as submerged weir
Uncontrolled Free (UF)	$Q = L\sqrt{gy_c{}^3}$ $y_c = aH$ a = 0.7	$\frac{h}{G_o} < 1.0, \frac{H}{G_o} < \frac{1}{K}, \& \frac{h}{H} < K$ $K = 2/3$	Also known as free weir
Transitional Flow	No transition region		

Source: "Dimensionless Flow Ratings at Kissimmee River Gated Spillways", December 2005, Tech Pub SHDM report, Operations and Hydro Data Management Division, SFWMD (M. Ansar, Z. Cheng, J. A. Gonzalez & M. J. Chen)]

In the table, the flow equation coefficients for the Kissimmee River spillways are shown.

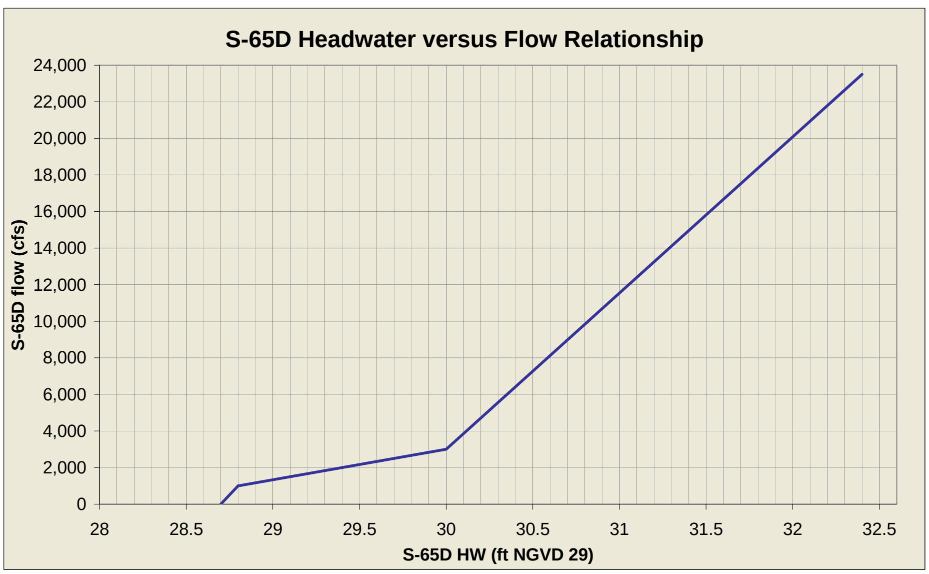
H: head water above CEL (feet) = HW-CEL;
h: tail water above CEL (feet) = TW-CEL;
g: gravitational acceleration, 32.2 ft/s^2;
G_o: gate opening (feet);
L: spillway width (feet);
y_c: critical depth (feet); and
Q: computed discharge (cfs).

Note: Coefficients a and b only apply to Kissimmee River gated spillways.

C2.3.2 Future Base (2015) Assumptions

Table C-8. Summary of Primary Characteristics of Future Base Condition

Feature	**Entire Model Domain**
General	• Model should reflect conditions around the year 2015, when all Acceler8 projects are in place. The future condition also assumes that the KRR and the Kissimmee River Headwaters Revitalization projects are in place. • Period of simulation is 1970 to 2005. • Model time step is daily. • All elevations are in feet NGVD 29.
	Upper Kissimmee Sub-watershed (KUB)
General	• Same as in Current Base.
Climate	• Same as in Current Base.
Model Setup	• Same as in Current Base.
Stage-Volume-Area Relationships	• Same as in Current Base.
Sub-watershed Inflows	• Same as in Current Base.
Structure Capacity	• Same as in Current Base.
Operations	• The lakes and water control structures are regulated by rigid schedules, as defined in the Kissimmee Basin Water Supply Plan (SFWMD, 2000). An exception is Lake Kissimmee, which is simulated in the model using the headwaters revitalization schedule.
	Lower Kissimmee Sub-watershed (LKB)
General	• Model reflects conditions after full KRR, around the year 2015. • It is assumed that there is no connection between Lake Istokpoga and the Kissimmee River (i.e. G-85 is assumed closed).
Climate	• Same as in Current Base.
Model Setup	• The Lower Kissimmee Sub-watershed is partitioned into three major basins reflecting full (Phases I-IV) KRR: S-65A, S-65BCD and S-65E. Only the C-38 Canal, the Kissimmee River, and floodplain portions of these basins are simulated as level pools: Pool A, BCD, D and E.
Stage-Volume-Area Relationships	• Stage-volume and stage-area relationships for the two channelized reaches are those developed as part of the KBMOS effort. Stage-volume and stage-area relationships have been recently developed for Pool BCD as part of this modeling effort.
Sub-watershed Inflows	• Same as in Current Base.
Structure Capacity	• Only the major gated spillway structures in place after full KRR are included: S-65A, S-65D, S-65E. Culverts and overflow weirs next to these structures are not modeled. Broad-crested weirs on the tieback levee of S-65A are not modeled. Locks at these structures are also not modeled. • S-65B, S-65C and WEIRS 1,2,3 are not included in the simulation as they were removed as part of KRR.

Feature	Entire Model Domain
	• U-shaped weir to be installed just upstream of S-65D, as part of the full KRR, is not modeled. • Rating curves developed by Ansar, et al. (2005) based on dimensionless analysis were used in simulating these gated spillways (**Table C-7**). • Gate openings are assumed to always be at the maximum allowable gate opening (MAGO) for the set of headwater/tail water stages. MAGO curves for these structures were obtained from the C&SF System Operating Manual (Draft-December 2005) and input as two-dimensional look-up tables. • Maximum historical discharges are used to limit flow through these structures, with the exception of S-65D, where limit reflects two additional gates that will be added as part of KRR: S-65A: 13,100 cfs S-65D: 28,000 cfs S-65E: 27,900 cfs
Operations	• S-65A and S-65E are operated for flood control based on a constant optimum headwater stage (flood control trigger level). S-65A: 46.3 ft S-65E: 21.0 ft • S-65D is operated for flood control based on the following headwater-flow relationship.  During a time step, a structure will try to remove any volume of water stored above this flood control trigger level, plus any basin inflows subject to the structure capacity and limited to its design capacity.
Taylor Creek/Nubbin Slough Sub-watershed (TCNS)	
General	• Same as in Current Base.
Climate	• Same as in Current Base.
Model Setup	• Same as in Current Base.
Stage-Volume-Area Relationships	• Same as in Current Base.

Feature	Entire Model Domain
Sub-watershed Inflows	• Same as in Current Base.
Structure Capacity	• Same as in Current Base.
Operations	• Same as in Current Base.
	Lake Istokpoga Sub-watershed
General	• Same as in Current Base.
Climate	• Same as in Current Base.
Model Setup	• Same as in Current Base.
Stage-Volume-Area Relationships	• Same as in Current Base.
Sub-watershed Inflows	• Same as in Current Base.
Structure Capacity	• Same as in Current Base.
Operations	• Same as in Current Base.
	Fisheating Creek Sub-watershed
General	• Same as in Current Base.
Climate	• Same as in Current Base.
Model Setup	• Same as in Current Base.
Stage-Volume-Area Relationships	• Same as in Current Base.
Sub-watershed Inflows	• Same as in Current Base.
Structure Capacity	• Same as in Current Base.
Operations	• Same as in Current Base.
	Lake Okeechobee Sub-watershed
General	• Future Base simulation based on SFWMM 2010A8 run
Climate	• Same as in Current Base.
Model Setup	• Lake Okeechobee modeled as a "lake" in the Regional Simulation model, with established stage-area and stage-volume relationships. Rainfall is part of the MDS term. ET simulated using the same methodology as in the SFWMM.
Stage-Volume-Area Relationships	• Same as in SFWMM
Sub-watershed Inflows	• Historical flows are applied for the Fisheating Creek, Lake Istokpoga and Taylor Creek/Nubbin Slough Sub-watersheds. Backflows coming from the east, west and south of Lake Okeechobee, as simulated in the SFWMM, will be input as boundary conditions in RSM. S-65E flows into Lake Okeechobee will be simulated.

Feature	Entire Model Domain
Structure Capacity	• Same as in SFWMM
Operations	• Regulatory releases to the estuaries are simulated based on the WSE Regulation Schedule. Based on the SFWMM equivalent run, regulatory releases south are zero. • Regulatory releases to the EAA reservoir will be fixed, based on the SFWMM simulation output. Likewise, EAA reservoir flows to meet EAA demand will also be fixed boundary conditions. • Lake Okeechobee serves as secondary source of irrigation water, subject to hybrid LOWSM for meeting C-43 Basin demand, as well as environmental deliveries to meet Caloosahatchee Estuary demands. In times of excess, lake regulatory discharges are also diverted into the C-43 Reservoir. • Lake Okeechobee serves as secondary source of irrigation water, subject to hybrid LOWSM for meeting C-44 Basin demand . Explicit Lake Okeechobee discharges to meet minimum flow requirements in the estuary are not simulated in all simulated scenarios for RWPP. However, lake regulatory discharges, as dictated by WSE Regulation Schedule, are still released into the St. Lucie Estuary. The C-44 Reservoir does not capture any Lake Okeechobee regulatory discharge. • Individual LOSA basin demands are boundary conditions. Water management cutback scheme is based on hybrid LOWSM operations. EAA conveyance cutbacks are not currently simulated but fixed, based on SFWMM output. • NETP Sub-watersheds: Same as in Current Base. • All other inflows and outflows are fixed boundary conditions.

C3.0 WATER BUDGET COMPONENTS

C3.1 Rainfall

South Florida is a sub-tropical region that is relatively wet, warm, and humid. On the average, the region receives about 53 inches of rain annually, 66 percent to 75 percent of which falls in the wet season (Shih, 1983). During the dry season, precipitation is governed by cold fronts that pass through the region approximately every seven days (Bradley, 1972). Rainfall from these fronts exhibit a more uniform distribution across the South Florida ecosystem compared to rainfall derived from the highly variable convection type thundershowers that occur during the wet season.

Rainfall distributions follow a bimodal pattern, with one peak in May or June and the other peak in September or October (Thomas, 1974). Annual rainfall over the past few decades has ranged from a low of 37 inches in 1961 to a high of 106 inches in 1947. Typically, annual values vary from 40 inches to 65 inches, with a mean annual rainfall over the Everglades of 51 inches (MacVicar and Lin, 1984).

Table C-9 shows average monthly and annual rainfall values for key individual sub-watersheds within the Lake Okeechobee Watershed. This data indicates that June and July are typically the wettest months and November, December, and January are the driest months. The Lake Okeechobee (Lake O) Sub-Watershed consists of lands that stretch from the west to the east coasts of Florida (Caloosahatchee, EAA, and St. Lucie drainage areas). Because of the extent of its geographic area, rainfall patterns in the sub-watershed are quite diverse. In **Table C-9**, rainfall values for the highest monthly and annual rainfalls (generally in the east coast portion of the sub-watershed (St Lucie drainage area)) and values for the smallest monthly and annual rainfalls (generally in the portion of the sub-watershed south of Lake Okeechobee (EAA drainage area)) are provided.

Table C-9. Average Monthly and Annual Rainfall Depths (inches) for Sub-watersheds as used in the NERSM (1970 – 2005)

Sub-Watershed	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Dec	Dec	An-nual
Upper Kiss	2.2	2.63	3.09	2.42	3.75	7.35	7.53	6.95	6.48	3.36	1.82	2.04	49.62
Lower Kiss	1.97	2.3	2.82	2.49	3.81	7.43	7.02	6.7	6.56	3.78	1.67	1.59	48.14
TCNS	1.85	2.07	2.67	2.48	4.04	7.86	7.16	6.99	6.8	3.74	1.72	1.55	48.93
Istokpoga	1.97	2.3	2.82	2.49	3.81	7.43	7.02	6.7	6.56	3.78	1.67	1.59	48.14
FEC	1.87	2.09	2.53	2.35	4.03	8.46	7.71	7.53	7.13	3.69	1.58	1.55	50.52
Lake O	1.89	1.86	2.99	1.99	3.53	6.14	5.45	5.82	5.71	3.00	2.06	1.48	41.98
SLRW†	2.26	2.43	3.47	2.58	4.13	7.01	6.41	7.02	7.25	4.66	3.10	1.94	52.32
CRW‡	2.18	2.05	3.26	2.20	4.15	8.93	7.80	7.76	6.68	3.25	2.13	1.66	52.12

† Saint Lucie River Watershed
‡ Caloosahatchee River Watershed

C3.2 C3.2 Evapotranspiration

Evapotranspiration (ET) is the total evaporation plus transpiration by vegetation. Potential evapotranspiration (PET) is the water loss that would occur if soil moisture was always available, and all wetlands, streams, and lakes and impoundments always had standing water. If a marsh is only inundated for a portion of the year, actual ET will be less than PET.

District-wide average annual ET is estimated to be 51.2 inches (130.1 cm) although there is geographic variation. Temporal variation in annual PET in most of south Florida is small compared to annual variation in rainfall, which can be 50 percent less than, or greater than the average (Visher and Hughes, 1969). Greatest ET rates occur from April through August and the lowest rates occur in November, December, and January.

Average annual ET for Lake Okeechobee for the period of record from 1970 through 2005 was 55.36 inches. **Figure C-18** shows the variation in average monthly PET values for Lake Okeechobee.

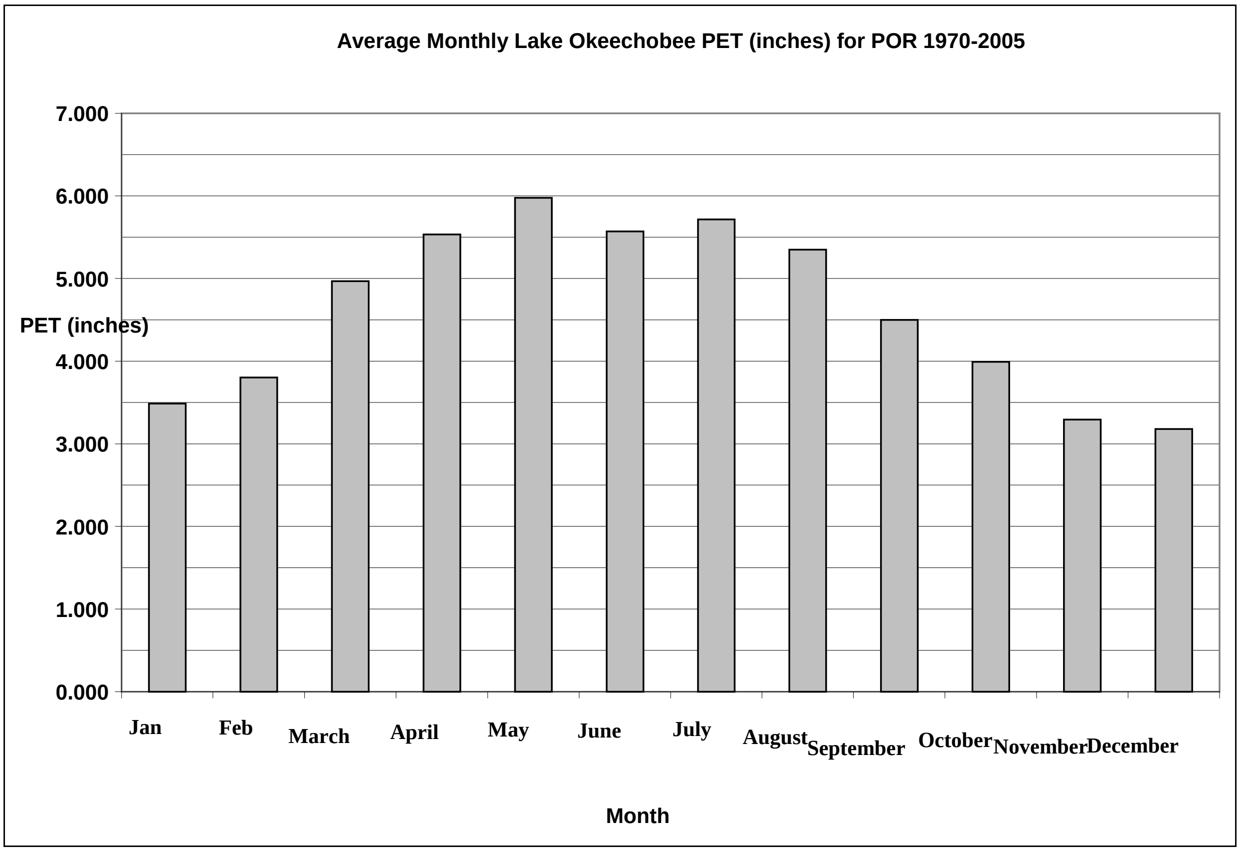


Figure C-18. Average monthly potential evapotranspiration rates at Lake Okeechobee as used in the NERSM (1970 through 2005)

C3.3 Flows

Flow characteristics, such as magnitude and timing of peak flows, seasonal variations in flows, and base flow conditions, are important considerations in the formulation, evaluation and comparison of alternative plans. Flow characteristics within the Lake Okeechobee Watershed vary considerably between sub-watersheds. In natural, unmanaged areas such as Fisheating Creek, flows are typically directly related to meteorological conditions. In heavily managed areas such as Taylor Creek/Nubbin Slough, magnitude and duration of peak flows is primarily controlled based on pre-determined water management objectives. Appendix B in the LOP2TP report describes the existing and Future Base flow conditions for the different sub-watersheds in the study area.

C4.0 ANNUAL AND SEASONAL SUB-WATERSHEDS WATER BUDGETS

During the course of creating the various models representing Current, Future Base and alternative scenarios, a simple graphic was developed to facilitate evaluating the reasonableness of model results. The graphic depicts the primary components of the hydrologic water budget calculated by NERSM for each sub-watershed for the period of simulation. The simulation-period average volumes of water associated with rainfall, ET, model-calculated flows, imposed flows (i.e. historical sub-watershed runoff, regulatory and non-regulatory releases, and change in Lake Okeechobee storage) are indicated on the graphics. Graphics were prepared for each modeling scenario, on an annual basis, for a wet season representing the period from June through October, and a dry season representing the period from November through May.

C4.1 Annual Sub-watershed Water Budget Components

Average annual volumes for primary sub-watershed water budget components are illustrated in **Figures C-19** through **C-24** for the six simulation scenarios. The net change in Lake Okeechobee storage in all scenarios is less than one percent of the total inflows or outflows from the lake. This important check of model integrity indicates that the various sinks and sources of water to Lake Okeechobee are being properly accounted for.

C4.2 Dry Season Sub-watershed Water Budget Components

Average dry season volumes for the primary sub-watershed water budget components are illustrated in **Figures B-25** through **B-30**. The negative value for Lake Okeechobee storage change indicates a net loss of water from storage in Lake Okeechobee during the seven-month dry period. A negative change in storage is associated with falling lake levels. The effects of MMs associated with the additional storage capacity considered in RWPPB and used in all alternatives are indicated by the arrows labeled "LOK withdrawals" that originate from Lake Okeechobee and go into the LI, TCNS and FEC sub-watersheds.

C4.3 Wet Season Sub-watershed Water Budget Components

Average wet season volumes for the primary sub-watershed water budget components are illustrated in **Figures B-31** through **B-36**. The positive value for Lake Okeechobee storage change indicates a net gain of water in Lake Okeechobee storage during the five- month wet period. A positive change in storage is associated with rising lake levels. Compared to the simulated volumes withdrawn during the dry season, the average volumes withdrawn from Lake Okeechobee for discharge in upland storage facilities is greater during the wet season.

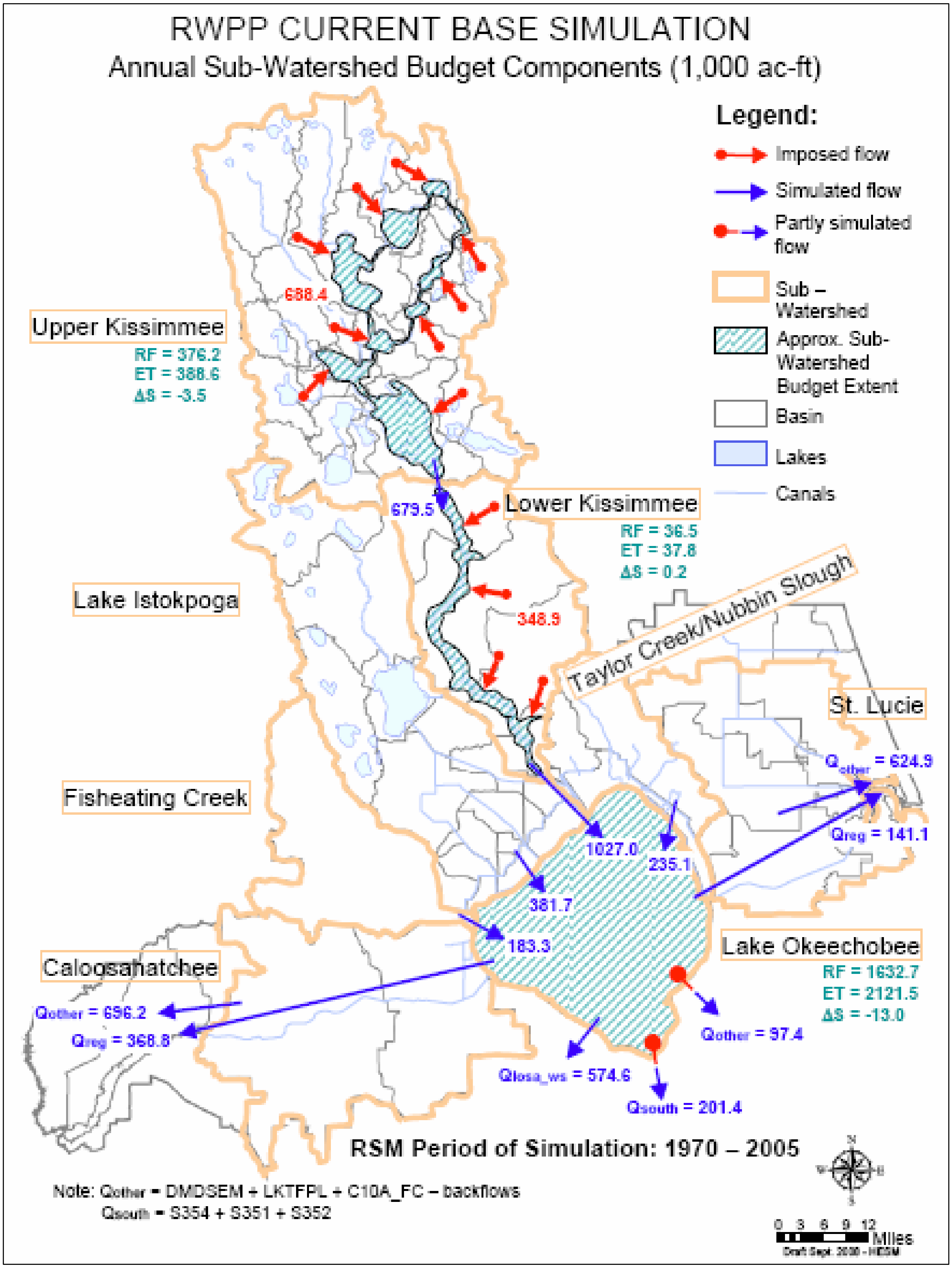


Figure C-19. NERSM calculated annual sub-watershed water budget components for Current Base

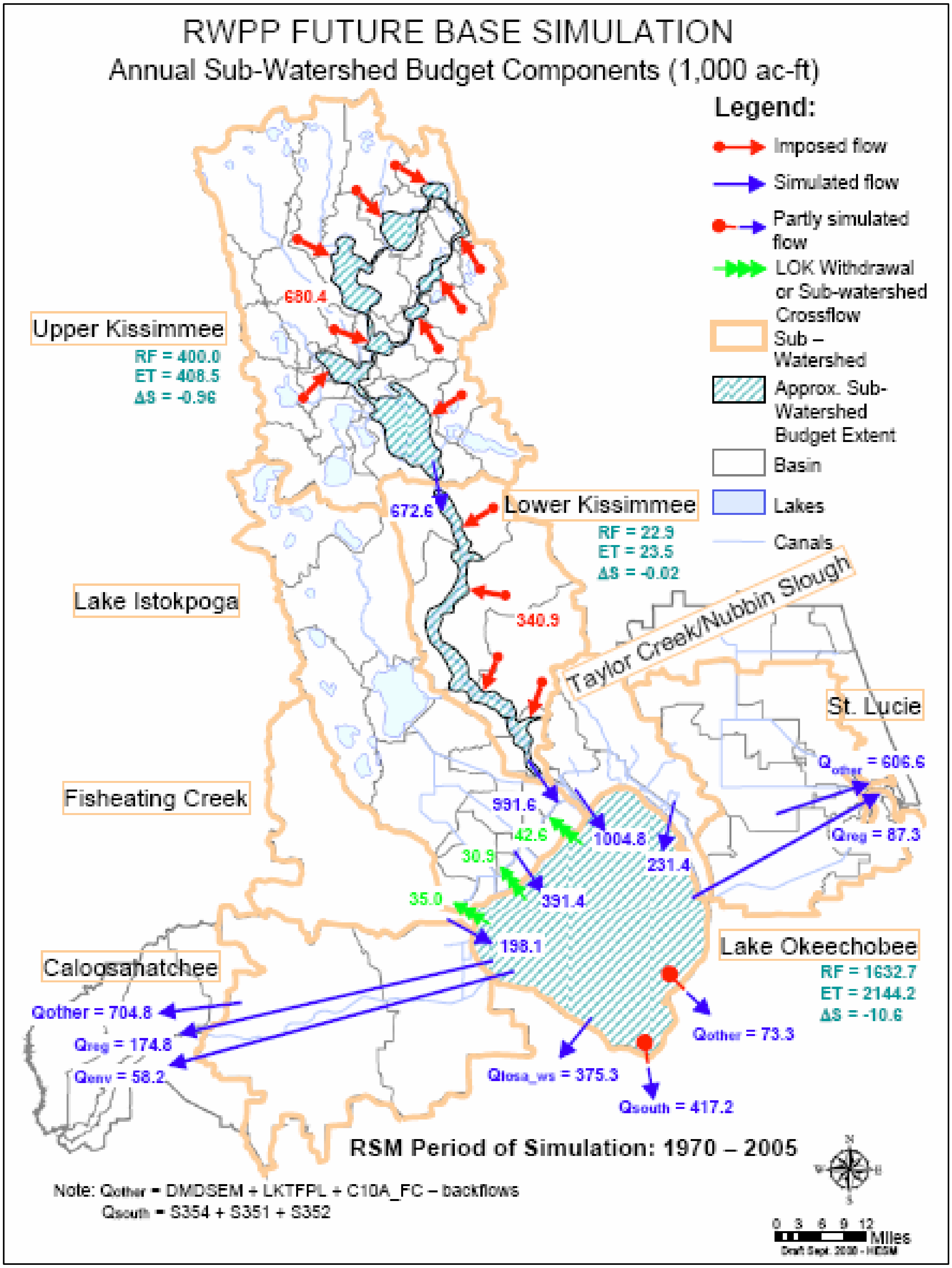


Figure C-20. NERSM calculated annual sub-watershed water budget components for RWPPB

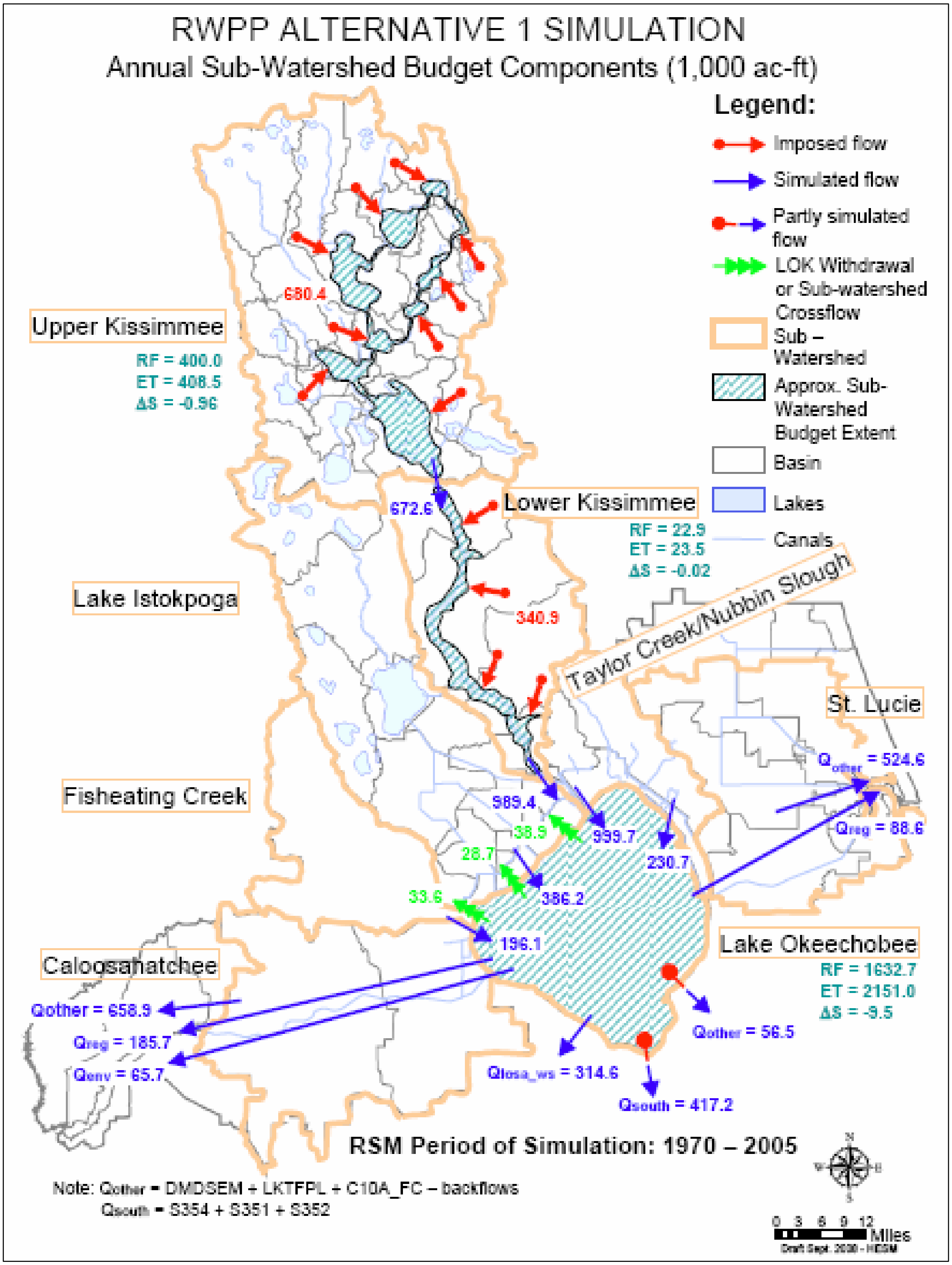


Figure C-21. NERSM calculated annual sub-watershed water budget components for Alternative 1

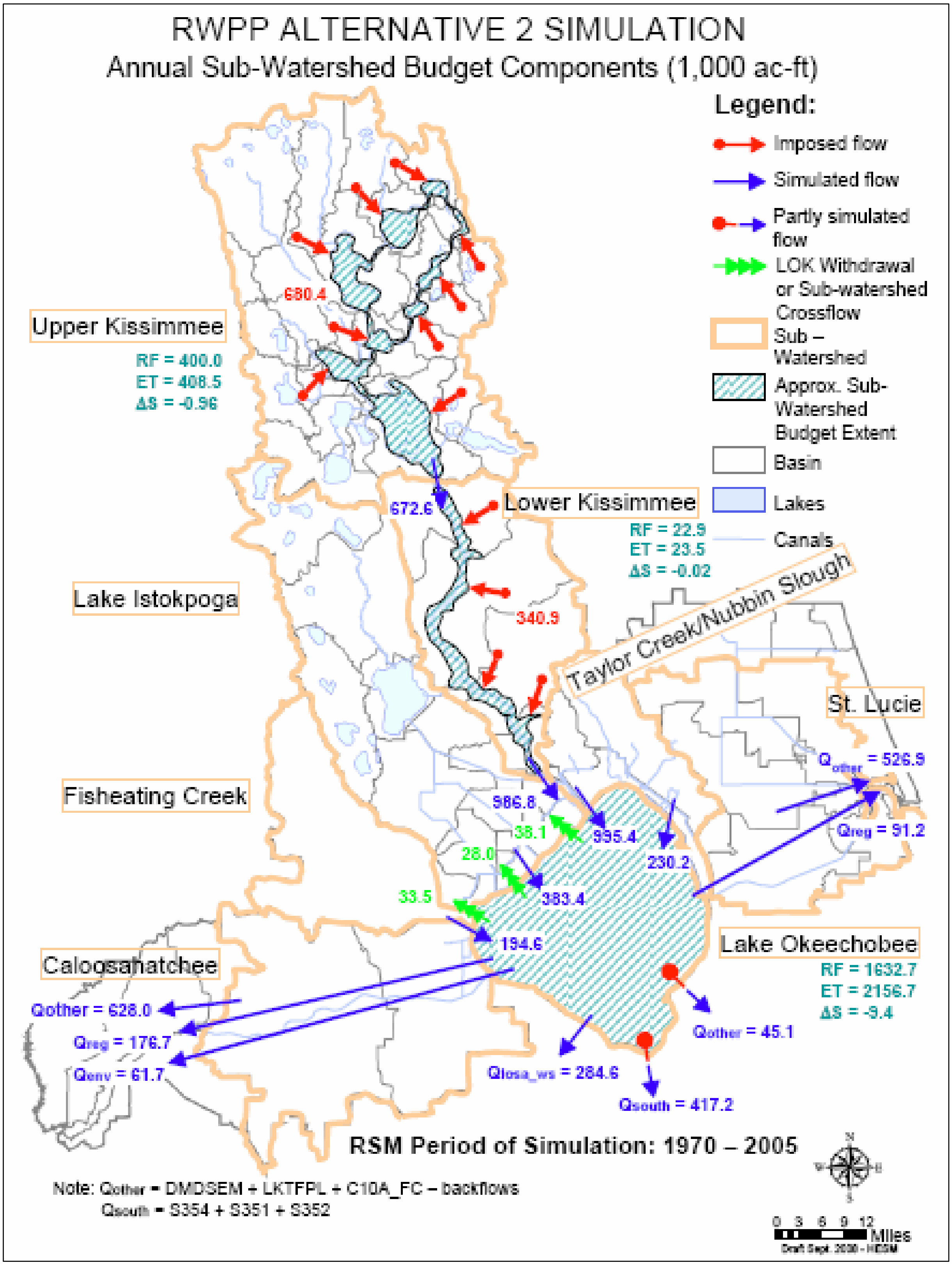


Figure C-22. NERSM calculated annual sub-watershed water budget components for Alternative 2

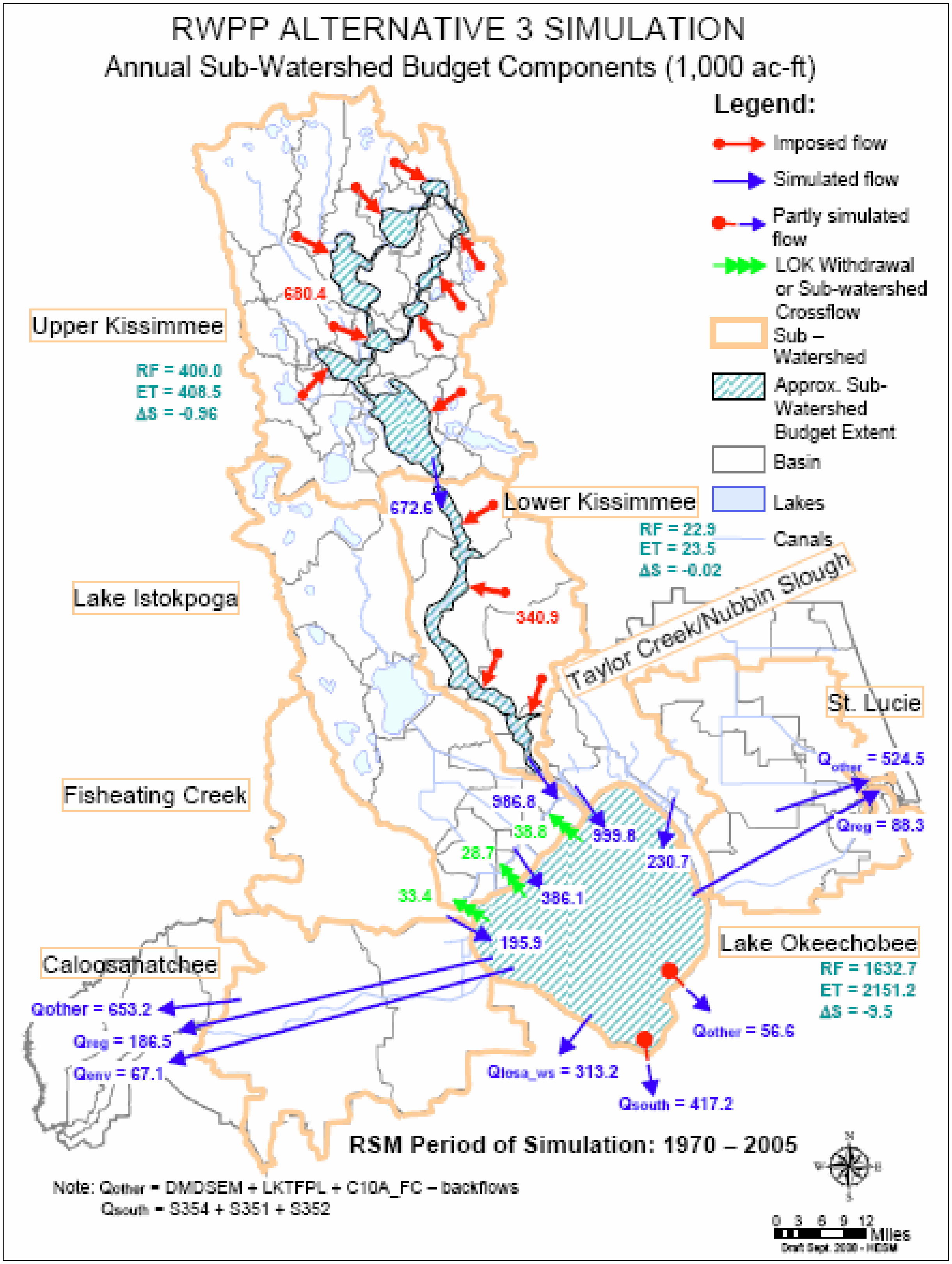


Figure C-23. NERSM calculated annual sub-watershed water budget components for Alternative 3

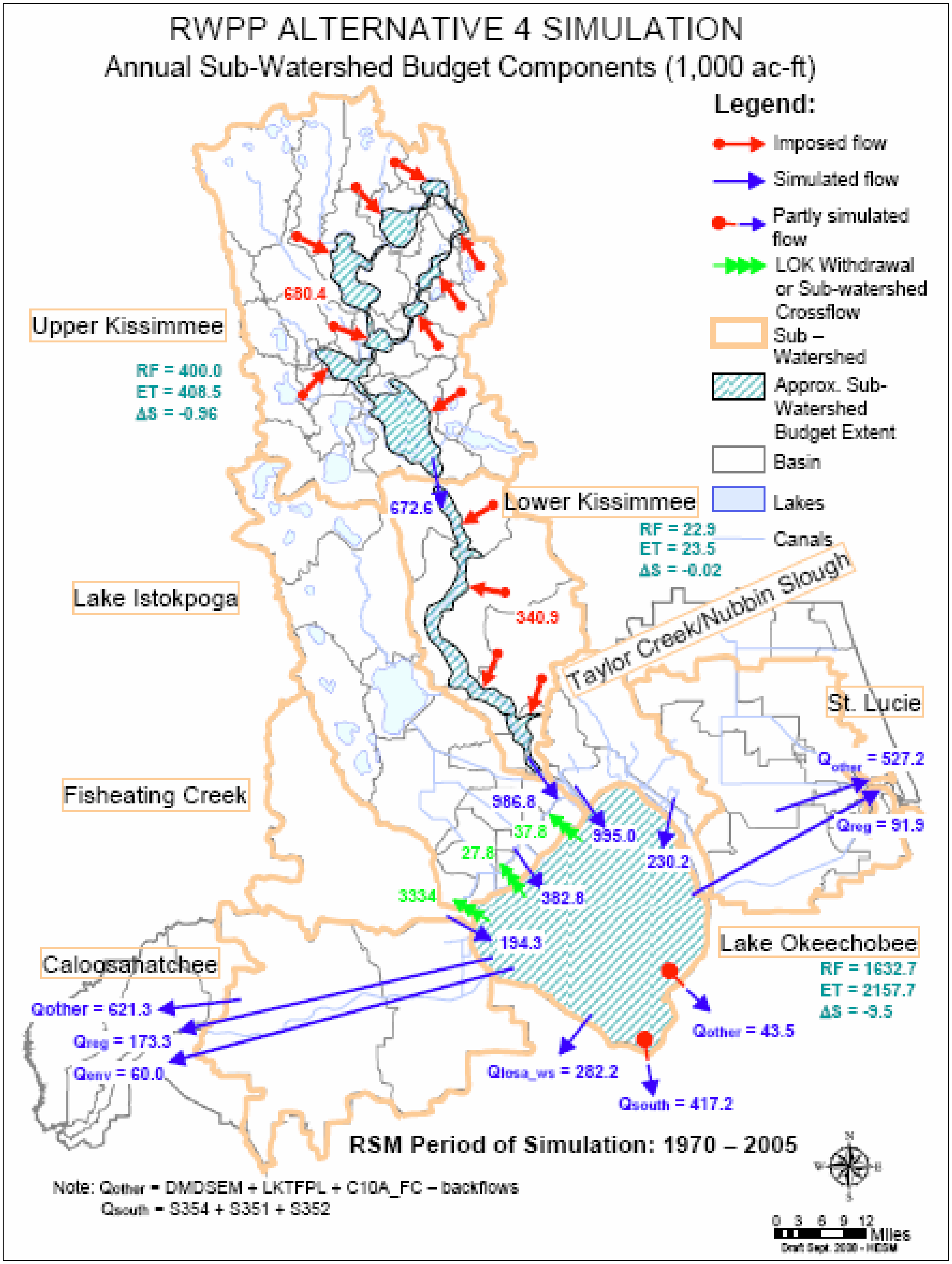


Figure C-24. NERSM calculated annual sub-watershed water budget components for Alternative 4

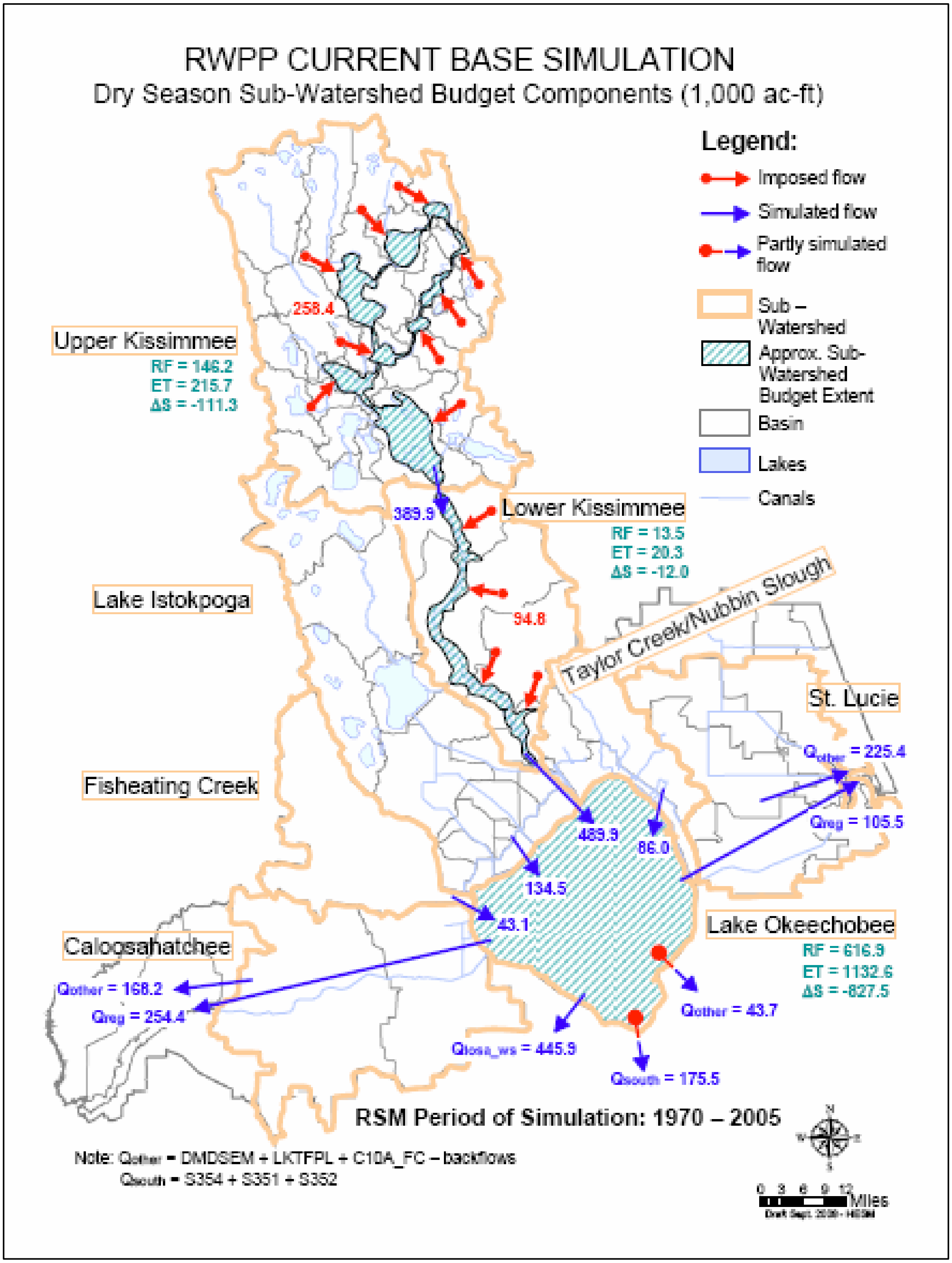


Figure C-25. NERSM calculated dry season sub-watershed water budget components for Current Base

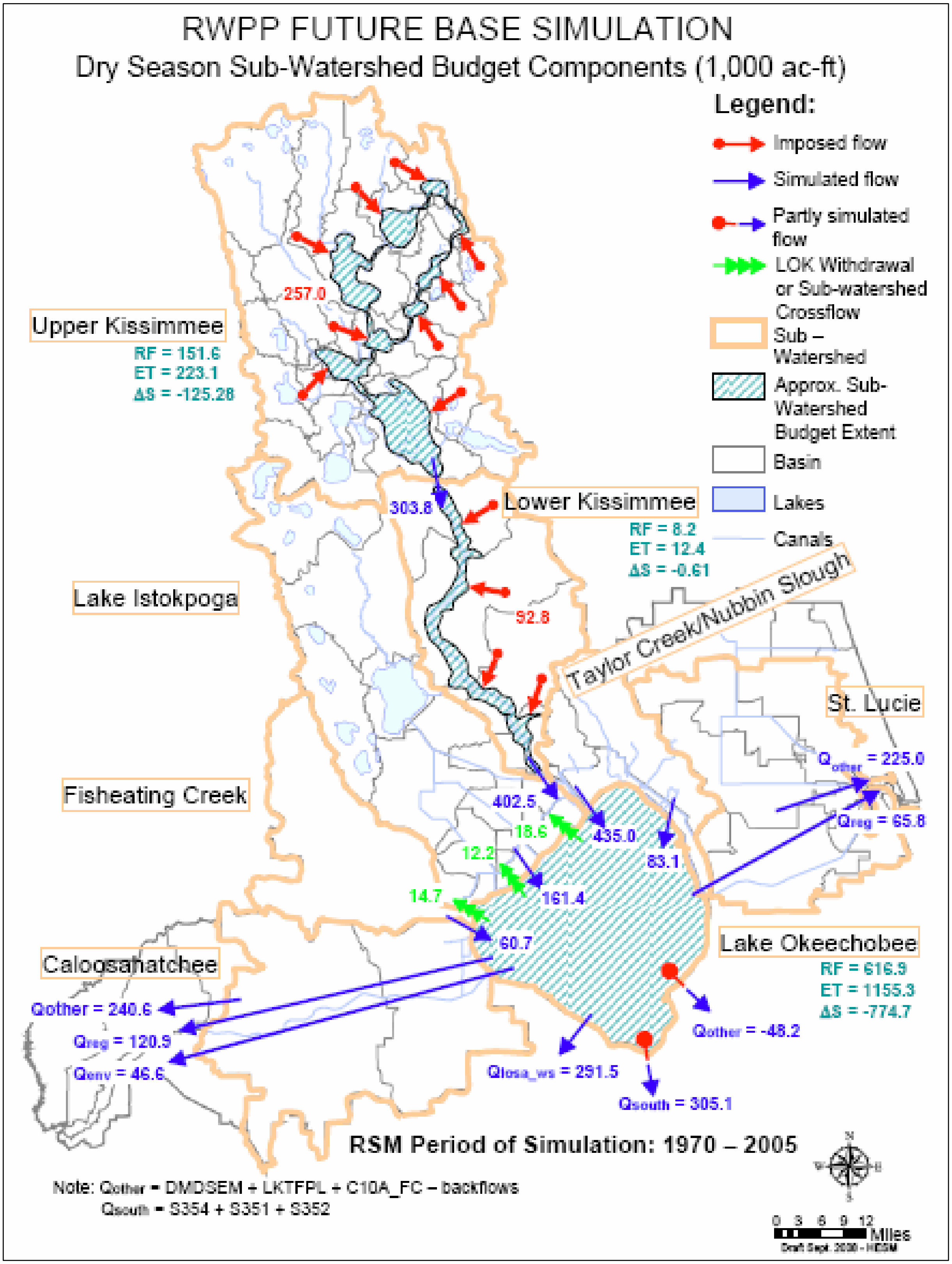


Figure C-26. NERSM calculated dry season sub-watershed water budget components for RWPPB

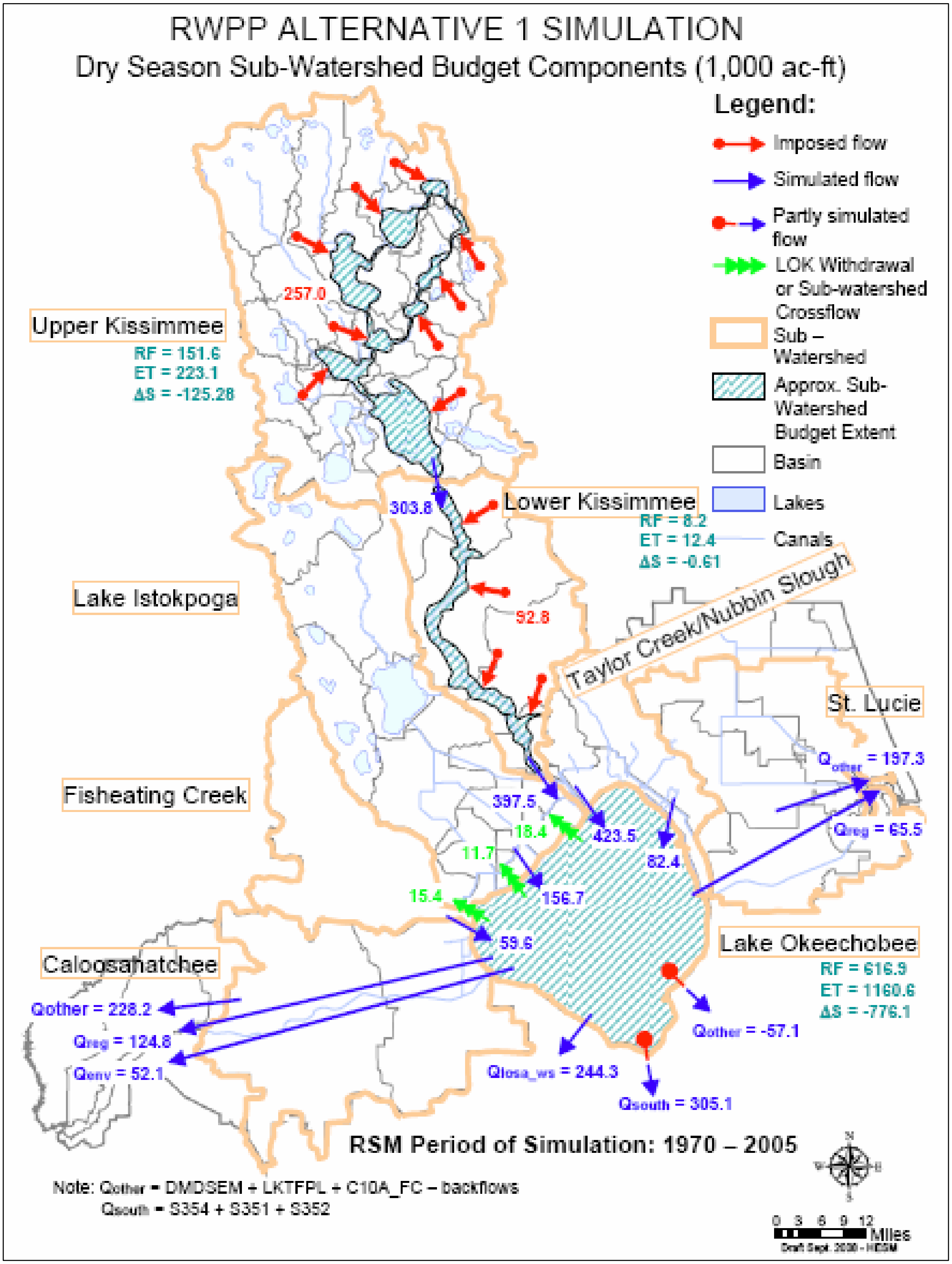


Figure C-27. NERSM calculated dry season sub-watershed water budget components for Alternative 1

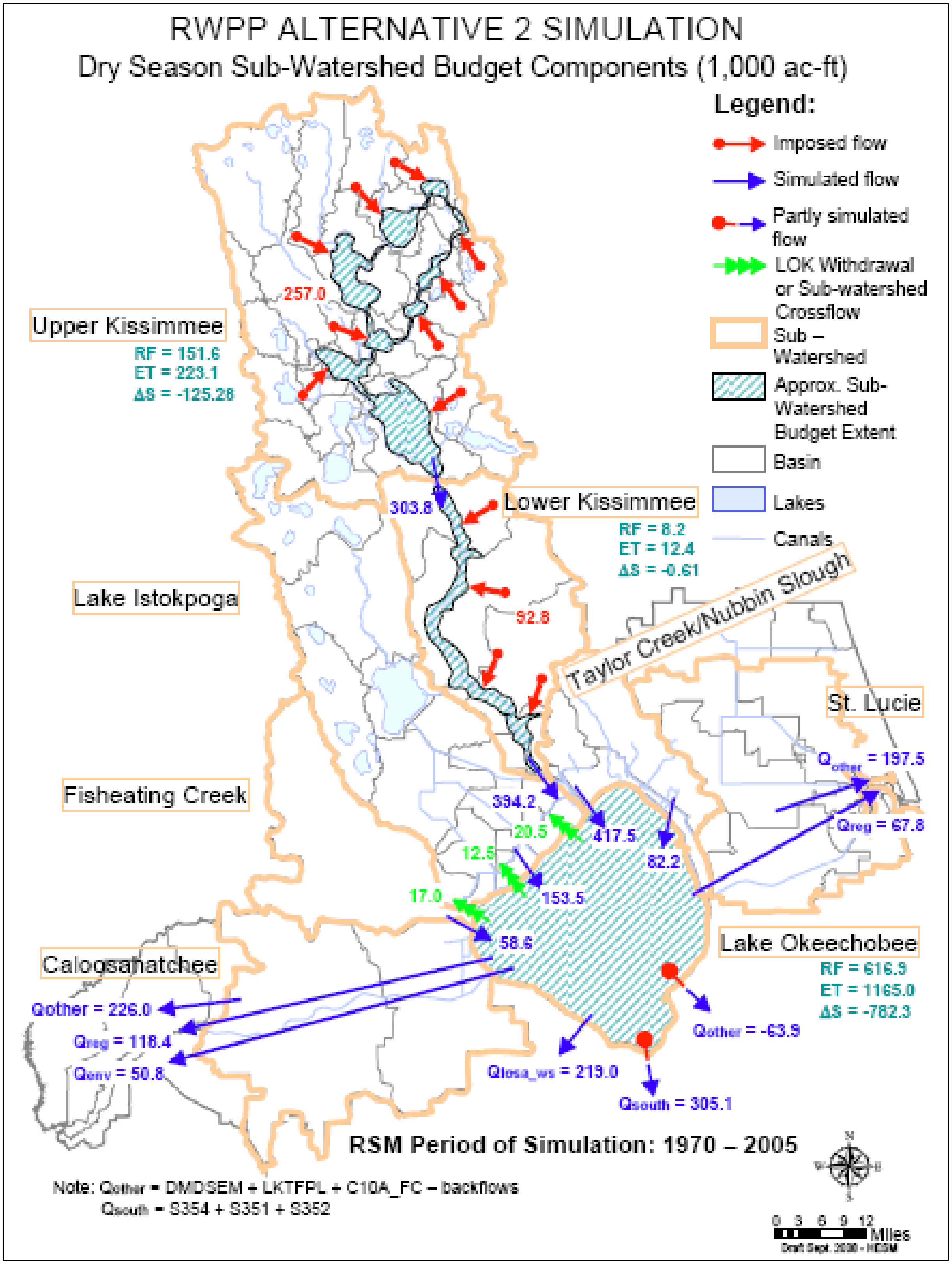


Figure C-28. NERSM calculated dry season sub-watershed water budget components for Alternative 2

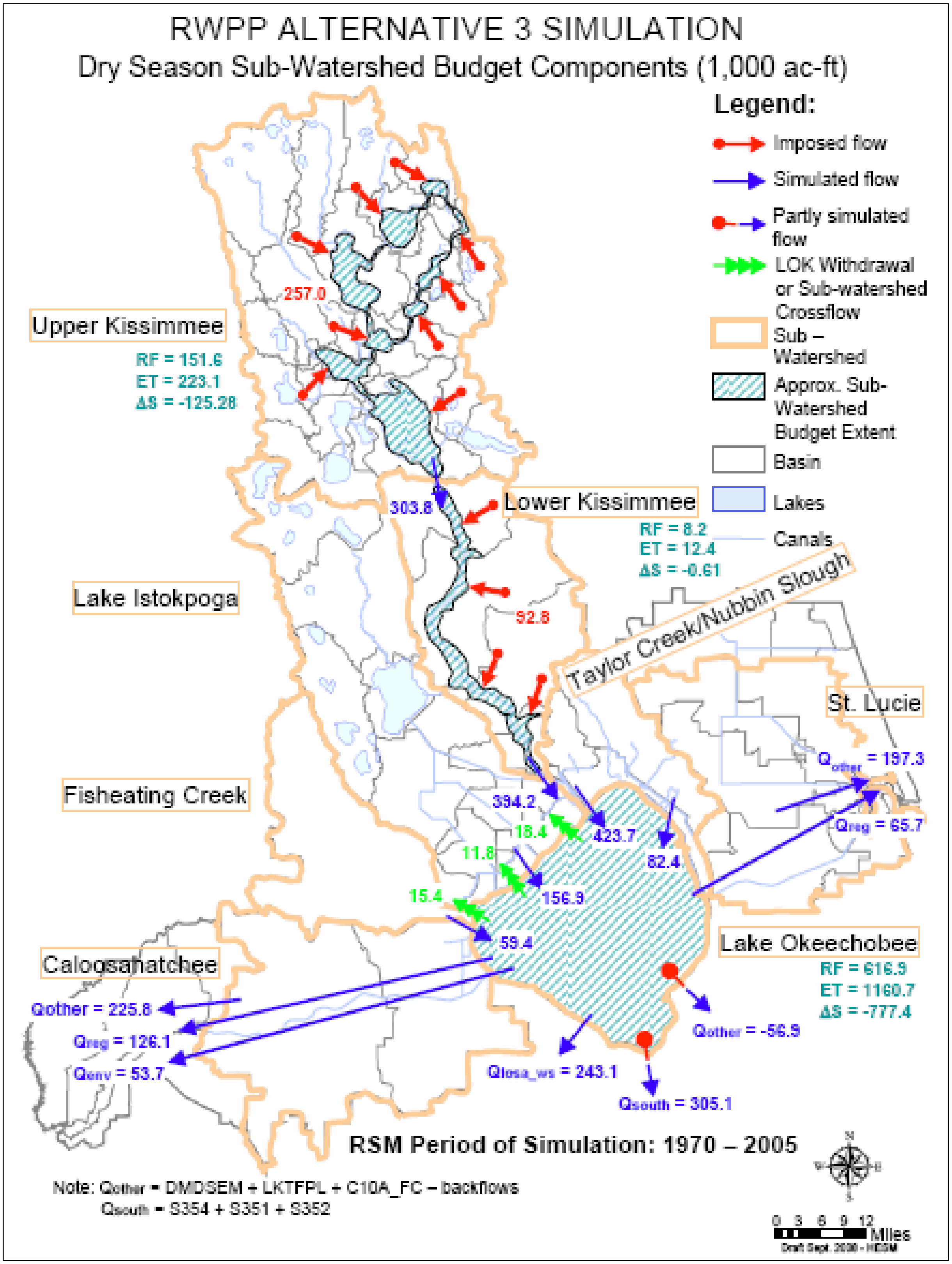


Figure C-29. NERSM calculated dry season sub-watershed water budget components for Alternative 3

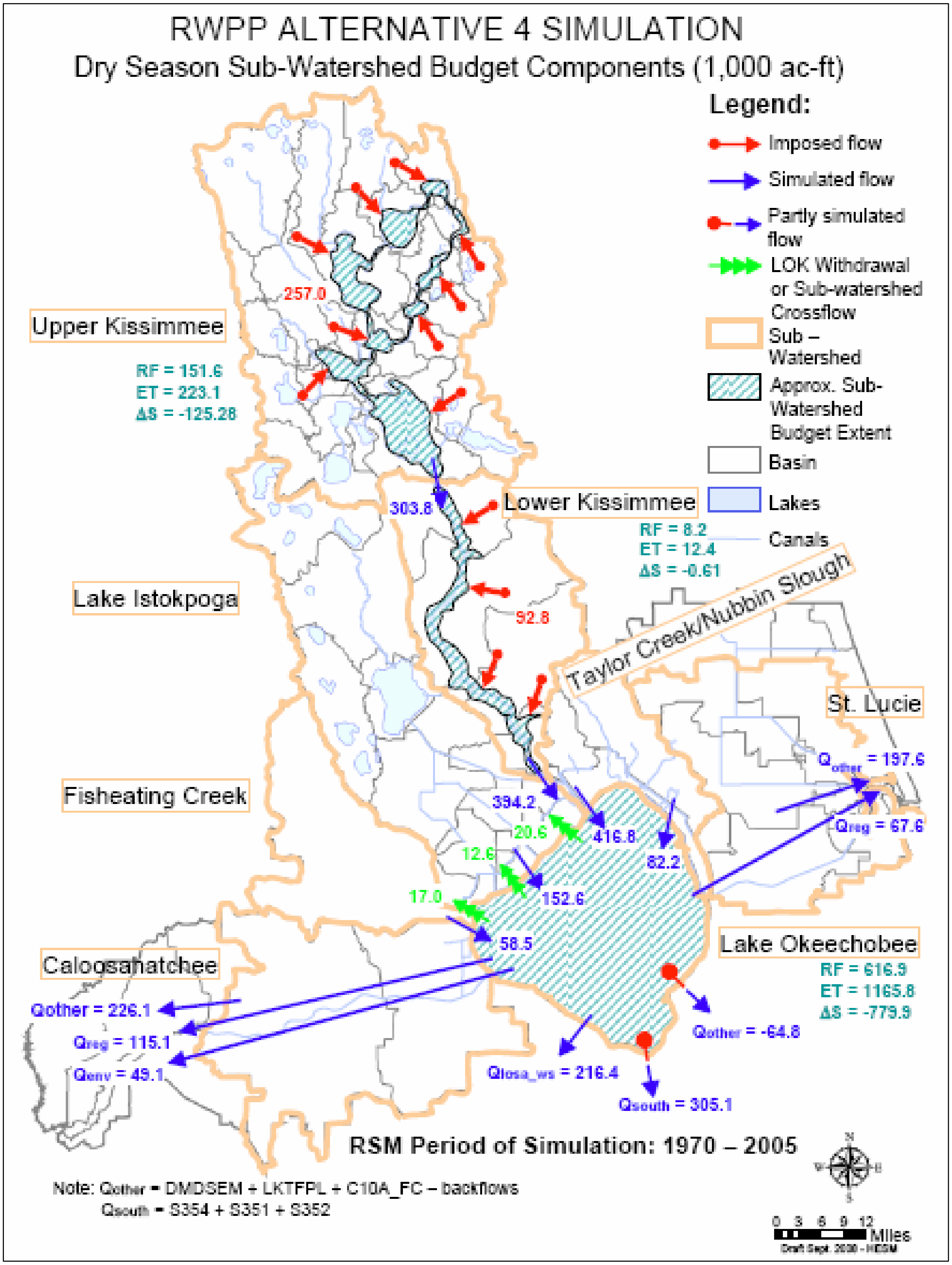


Figure C-30. NERSM calculated dry season sub-watershed water budget components for Alternative 4

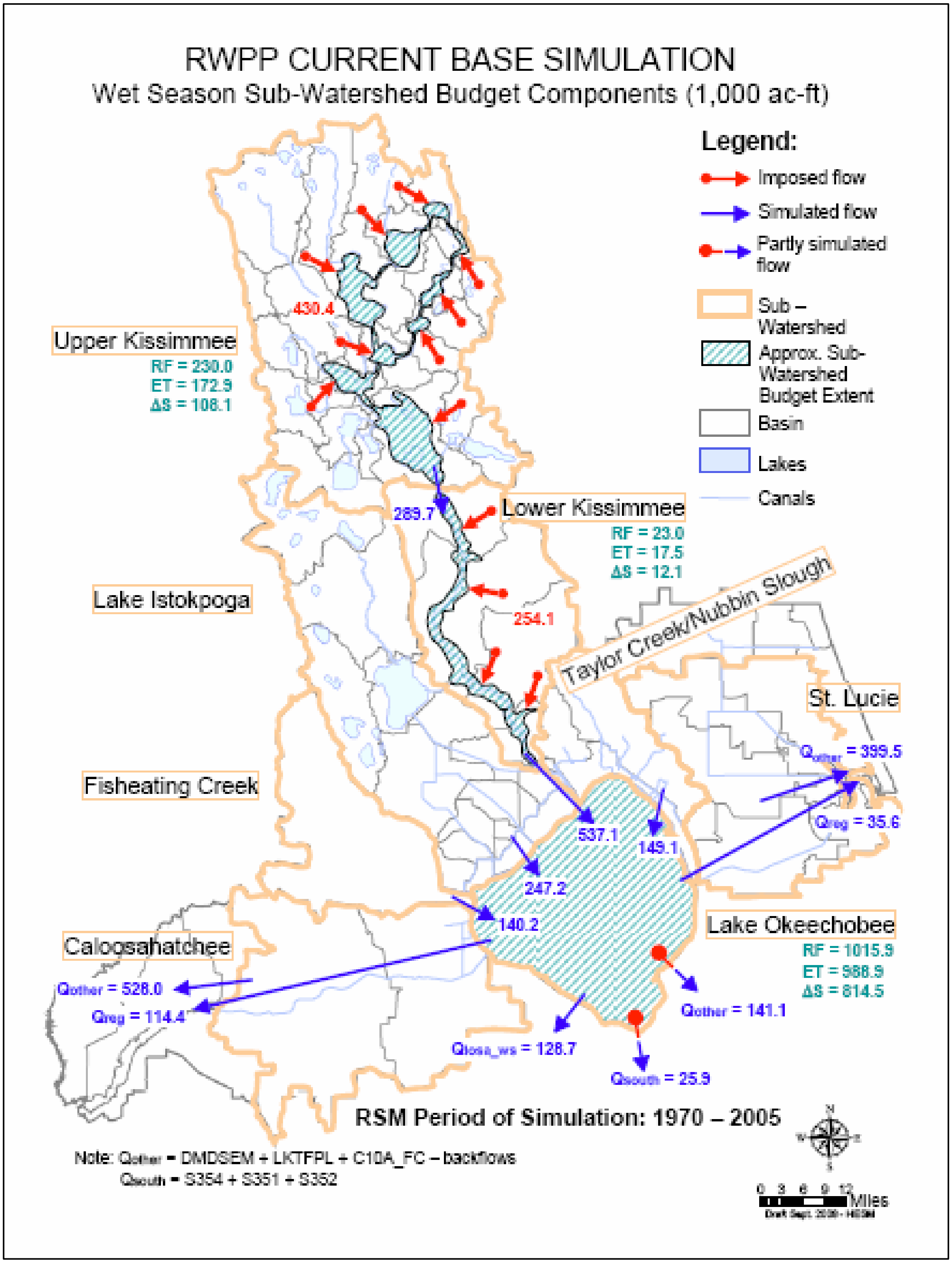


Figure C-31. NERSM calculated wet season sub-watershed water budget components for Current Base

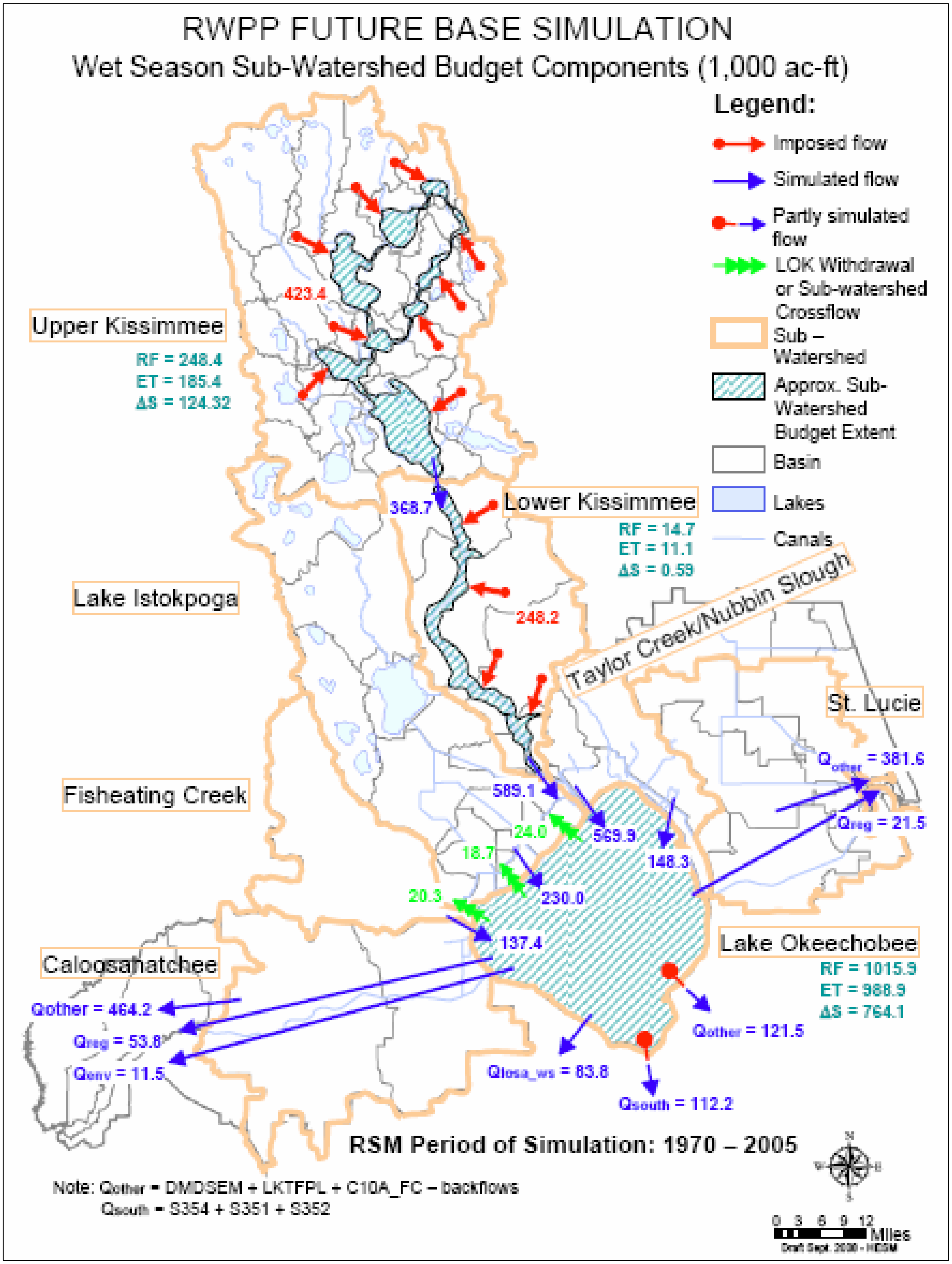


Figure C-32. NERSM calculated wet season sub-watershed water budget components for RWPPB

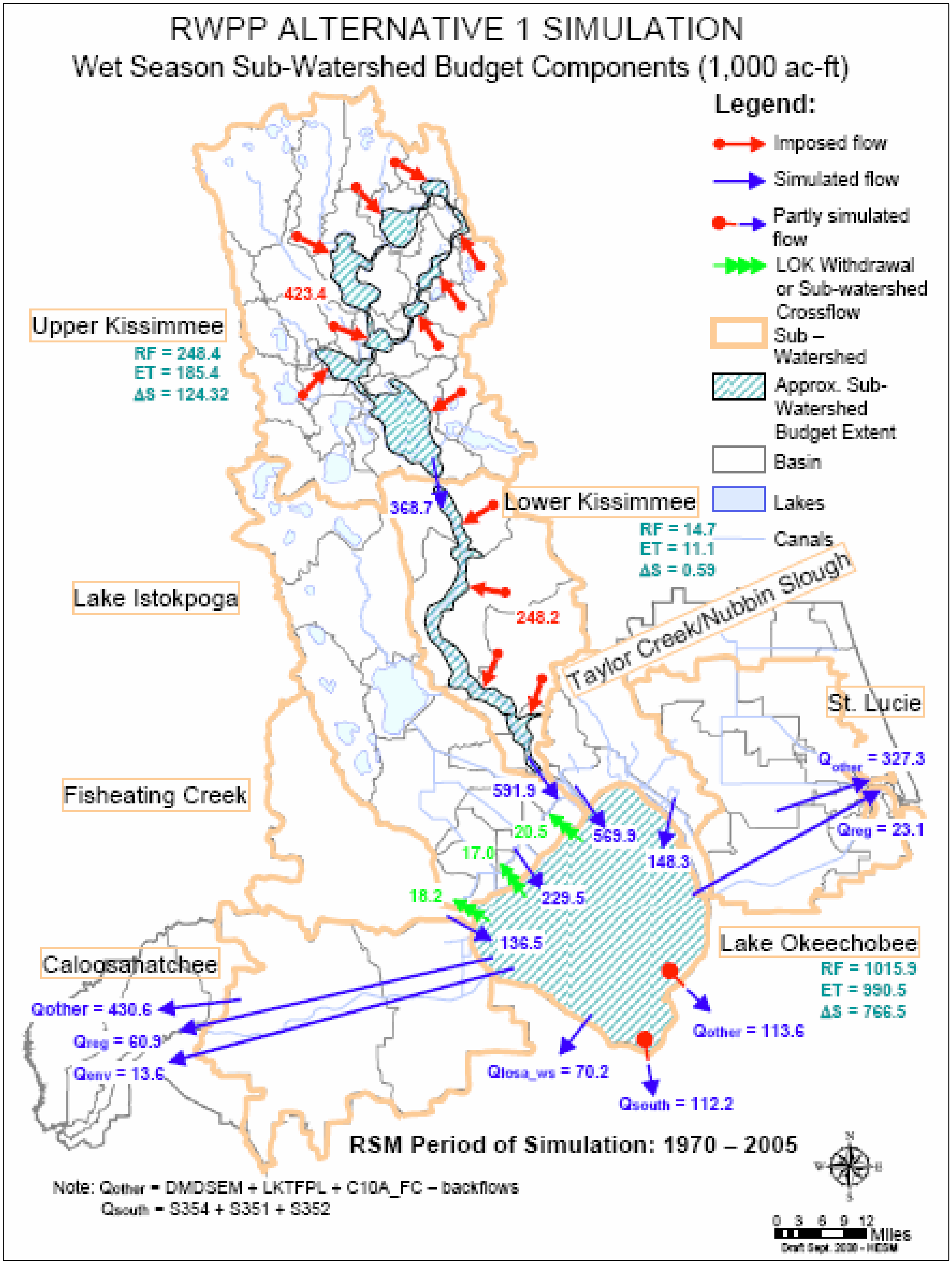


Figure C-33. NERSM calculated wet season sub-watershed water budget components for Alternative 1

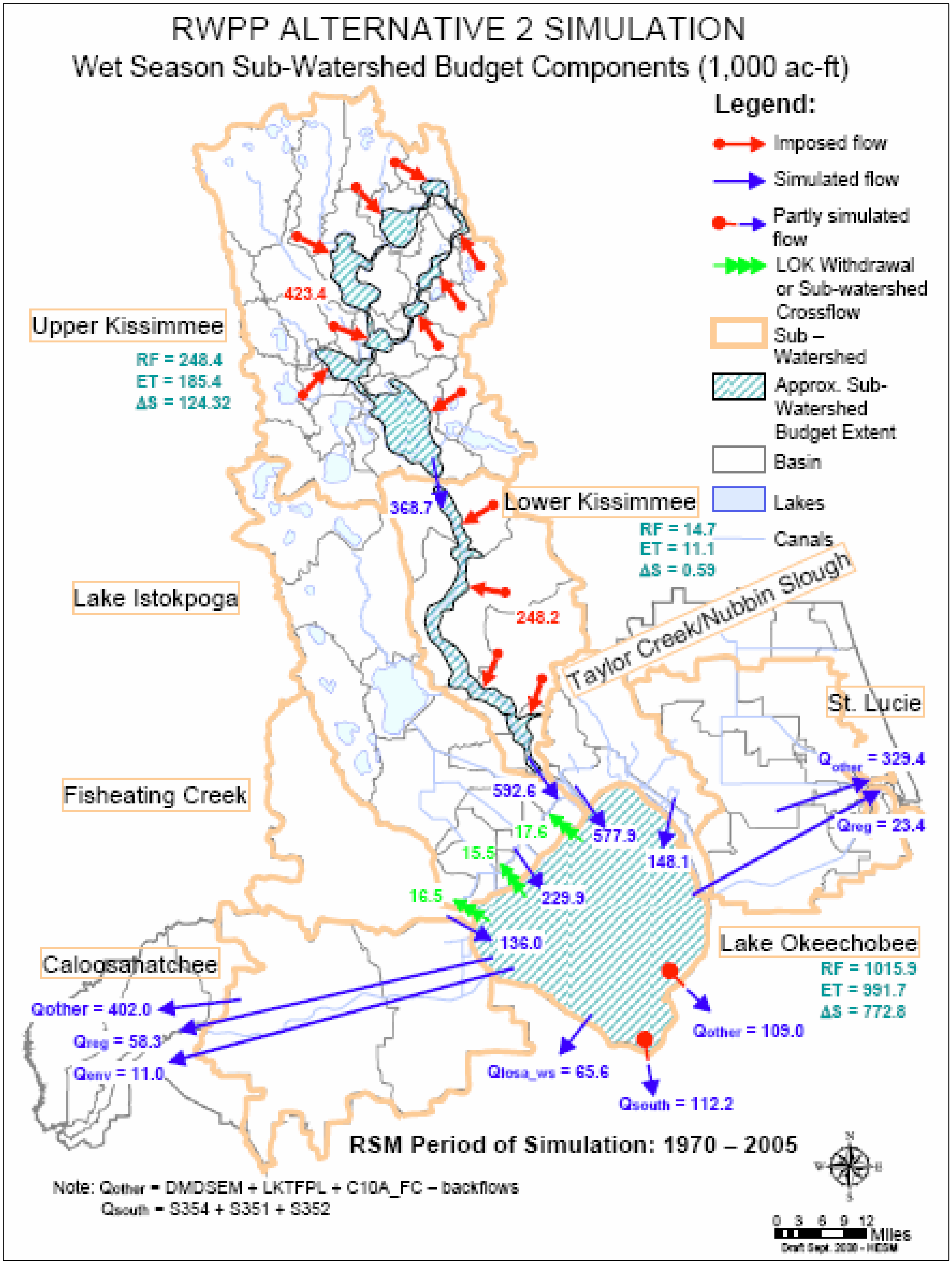


Figure C-34. NERSM calculated wet season sub-watershed water budget components for Alternative 2

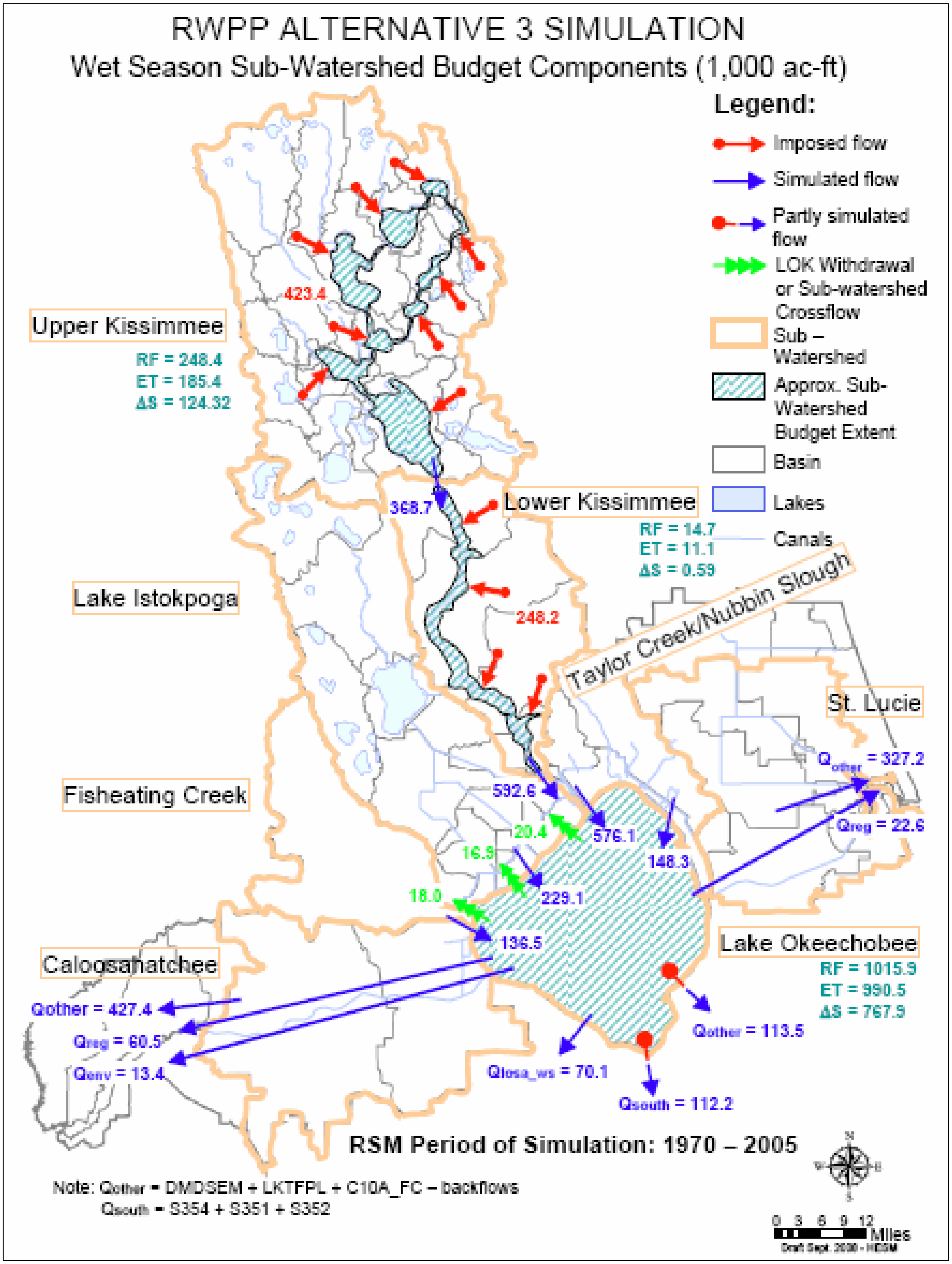


Figure C-35. NERSM calculated wet season sub-watershed water budget components for Alternative 3

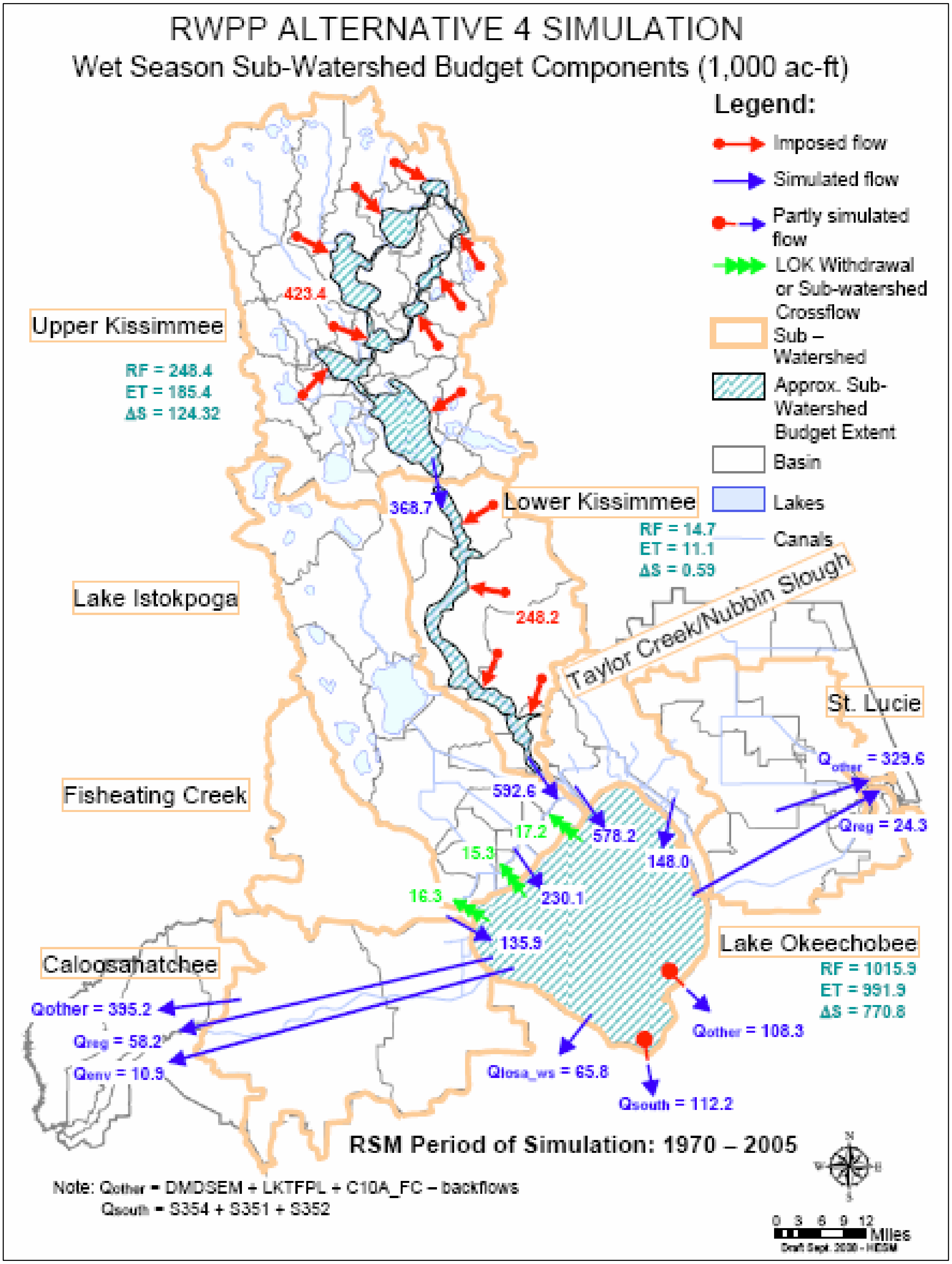


Figure C-36. NERSM calculated wet season sub-watershed water budget components for Alternative 4

C5.0 DETAILED WATER BUDGETS FOR THE CALOOSAHATCHEE AND ST. LUCIE RIVER WATERSHEDS

C5.1 Introduction

Additional annual water budget maps were developed for Caloosahatchee and St. Lucie River Watersheds and their interaction with Lake Okeechobee based on the Future Base conditions and alternative scenarios. Regional water budgets at this level of detail provide a useful means of comparing results from different model simulations and also to perform a quality check on the validity of the simulations.

Figure C-37 is a reference map showing the types of flows from sources to destinations to be summarized in this section. The accompanying **Table C-10** provides a description of all flow types as depicted in the selected water budget components maps corresponding to the modeling scenarios being compared. The number next to each description refers to the numbered arrow on the primary water budget component key.

Water budget maps (**Figures C-38** through **C-42**) are shown for the RWPP Future Base (RWPPB), Alternative 1 (ALT1), Alternative 2 (ALT2), Alternative 3 (ALT3) and Alternative 4 (ALT4). The key reflects the flow arrow on the water budget map, while each individual map reflects only those arrows relative to that particular simulation. The period of simulation is 1970-2005 and the flows shown are annual averages in 1000 acre-feet. In order to simplify the maps, flows are often lumped and represented by a single arrow. In the following discussion, the term "units" refers to 1000 acre-feet.

Table C-10. Description of Flow Types in the Selected Water Budget Components for RWPP

Key	Description
1.	Portion of S77 release from LOK to meet agricultural demands in CRW.
2.	LOK regulatory flow through S77.
3.	LOK environmental flows through S77 (can include LOK regulatory flows).
4.	Backflow to LOK from CRW.
5.	Agricultural water supply from C43 distributed reservoir.
6.	Portion of LOK regulatory release that goes to C43 reservoir.
7.	Portion of LOK regulatory release that goes to C43 distributed reservoir.
8.	Portion of LOK regulatory release that ends up in C43 estuary.
9.	Portion of LOK regulatory release that goes to BOMA.
10.	Flood control release from BOMA to C43 estuary.
11.	Environmental release from BOMA to C43 estuary.
12.	Environmental release from C43 distributed reservoir to C43 estuary.
13.	Portion of C43 runoff that bypasses WCAL Water Quality STA.
14.	Portion of C43 runoff that goes through WCAL Water Quality STA.
15.	Portion of C43 runoff that is treated through WCAL Water Quality STA.
16.	Portion of C43 runoff that goes to C43 distributed reservoir.
17.	Portion of C43 runoff that goes to BOMA.
18.	Portion of C43 runoff that ends up in C43 estuary.
19.	Portion of C43 runoff that is used for C43 estuary environmental demands.
20.	Environmental water supply from C43 reservoir.
21.	C43 runoff that ends up in C43 reservoir.
22.	C43 basin runoff.

Key	Description
23.	Runoff from EAA to LOK
24.	Agricultural water supply to EAA from LOK.
25.	Regulatory releases from LOK to EAA storage reservoir compartment 2.
26.	Backflows from C44 basin to LOK through S308.
27.	Agricultural water supply to C44 basin from LOK through S308.
28.	Regulatory releases from LOK to C44 estuary.
29.	Excess in C44 basin that goes to C44 estuary.
30.	Portion of excess runoff in C44 basin that meets environmental needs of St. Lucie estuary.
31.	Runoff from C44 basin that goes to C44 reservoir.
32.	Agricultural water supply to C44 basin from C44 reservoir.
33.	Environmental water supply to C44 estuary from C44 reservoir.
34.	Excess from non-C44 basins that goes to C44 estuary.
35.	Runoff from non-C44 basins that goes to C44 estuary.
36.	Environmental water supply from LOK to C44 estuary (already included in 27).
37.	C44 basin runoff.
38.	Actual environmental deliveries to C43 estuary from LOK and CRW.
39.	C43 estuary target flow.
40.	Actual environmental deliveries to C44 estuary from LOK and SLRW.
41.	C44 estuary target flow.

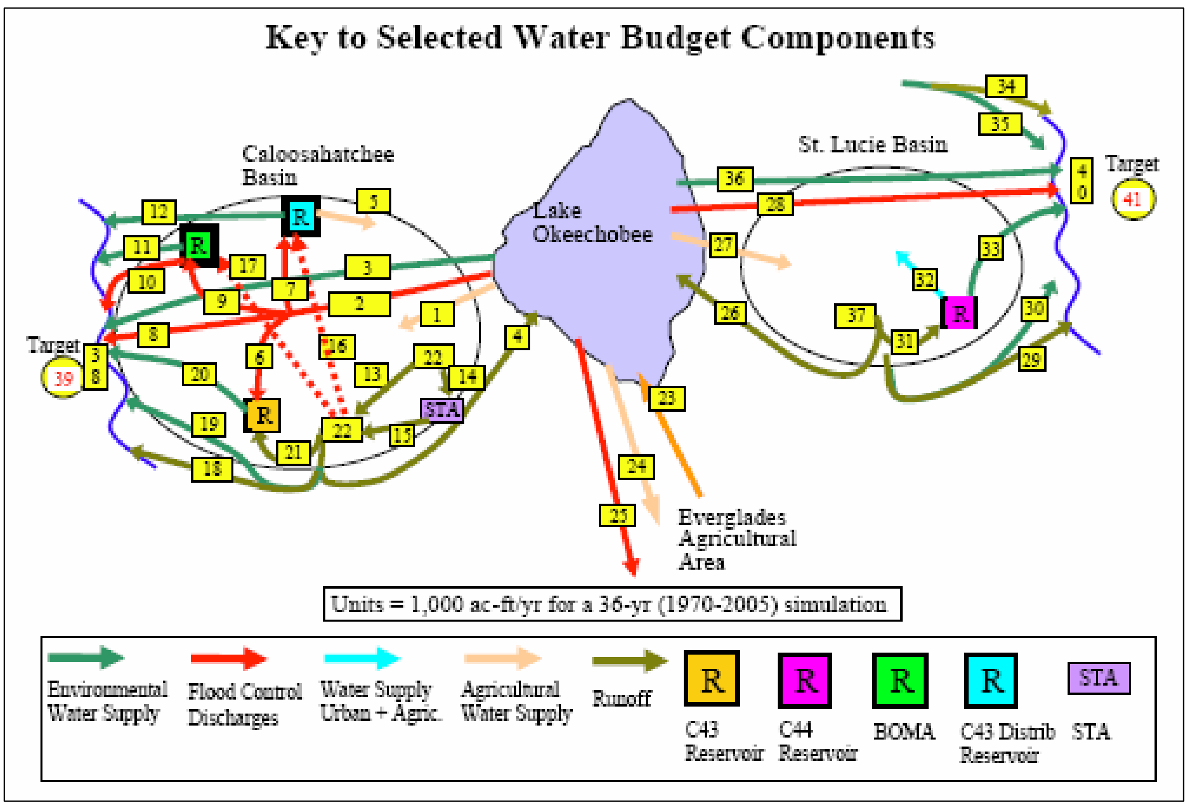


Figure C-37. Key to the selected water budget components for RWPP

C5.2 Annual Water Budget Components for River Watershed Protection Plan Base

Figure C-38 shows the annual average flows (1000 acre-feet) for the RWPP Future Base. For both Caloosahatchee River Watershed (CRW) and St. Lucie River Watershed (SLRW), the actual environmental deliveries to the estuary (530 and 460 units for CRW and SLRW, respectively) are close to the target (537 and 500 units for CRW and SLRW, respectively). The C43 Reservoir provides 31 percent of the environmental deliveries in CRW while the C44 Reservoir provides 3.5 percent of the environmental deliveries in SLRW. Non-C44 basins provide a major portion (82 percent) of the environmental deliveries to the estuary in SLRW. Backflow from the basin to the lake is a larger component in SLRW (53 units) than in CRW (6 units). Agricultural supply from the Lake Okeechobee to the basin is more in CRW (141 units) than in SLRW (21 units) due to higher agricultural demands.

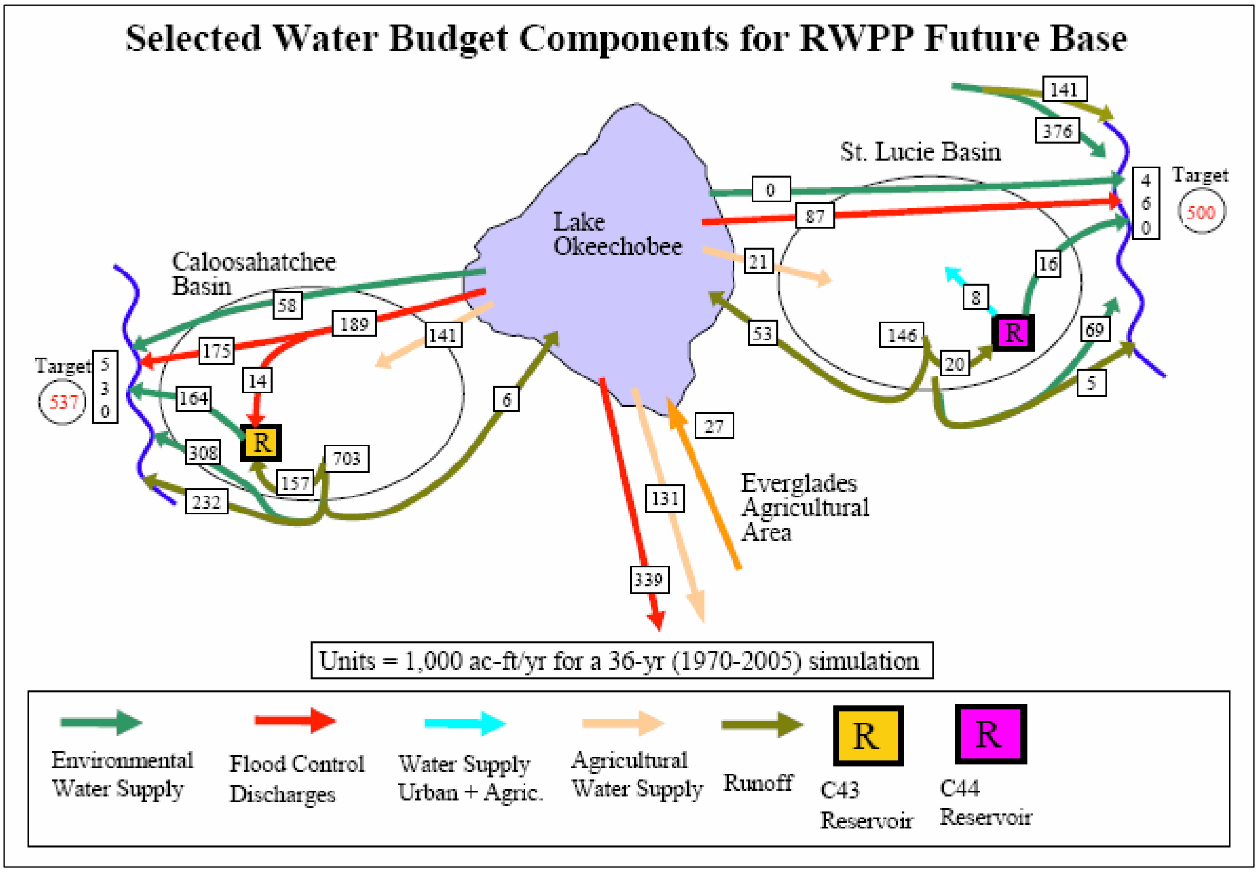


Figure C-38. Selected water budget components for RWPP Future Base

C5.3 Annual Water Budget Components for Alternative 1

Figure C-39 shows the annual average flows (1000 acre-feet) for Alternative 1. There is no new feature for SLRW and the only feature changes are in CRW. Alternative 1 includes the BOMA Reservoir and the C43 Distributed Reservoir in CRW. These two reservoirs aid in storing C43 Basin runoff (54 units in C43 Distributed Reservoir and 15 units in BOMA). The C43 Distributed Reservoir also helps in meeting CRW agricultural demands (54 units), which results in less demands on Lake Okeechobee (a reduction of 38 percent from the Future Base). Changes in SLRW are insignificant from the Future Base.

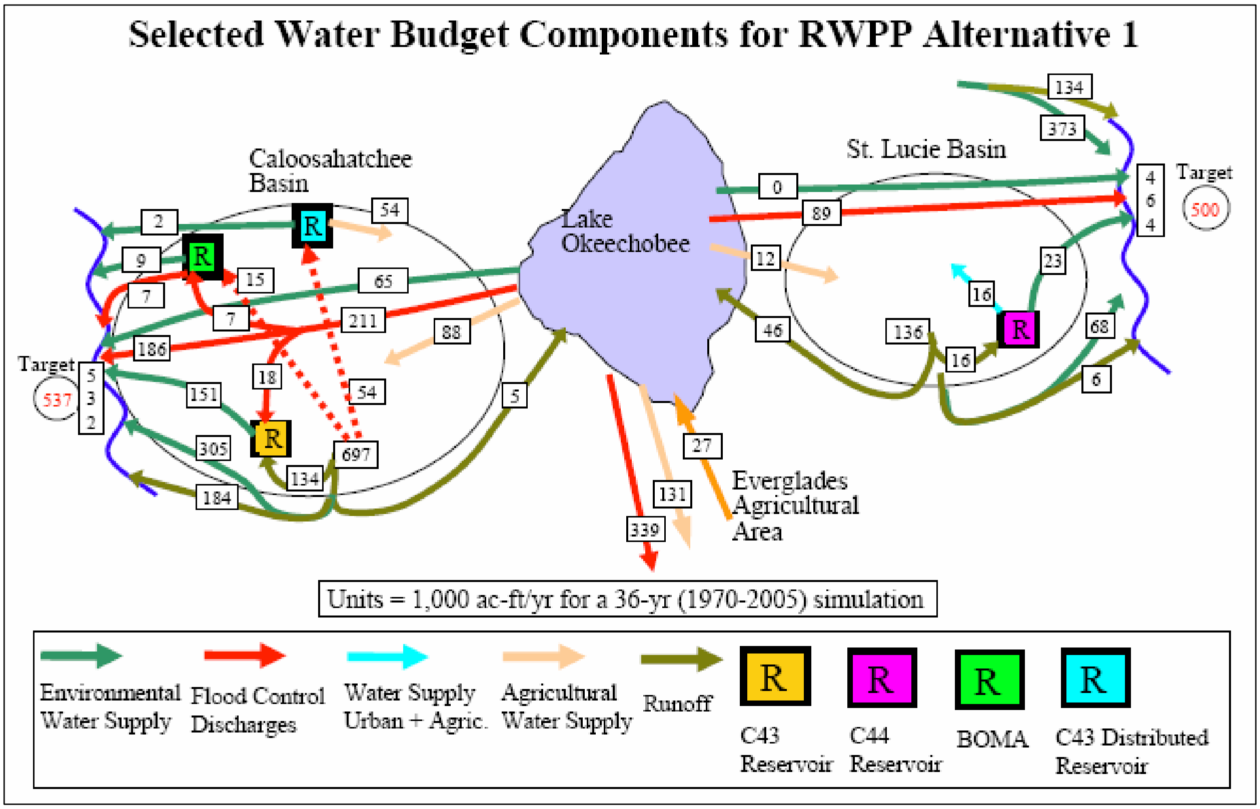


Figure C-39. Selected water budget components for RWPP Alternative 1

C5.4 Annual Water Budget Components for Alternative 2

Figure C-40 shows the annual average flows (1000 acre-feet) for management Alternative 2. There are no new features for SLRW. Additional storage due to East Caloosahatchee Storage and West Lake Hicpochee Project are combined with the C43 Distributed Reservoir to form a single storage node in NERSM for this alternative (designated as "C43 Distributed Reservoir"). Lake Okeechobee regulatory water is allowed to go to C43 Distributed Reservoir (15 units). Due to the increased size of the C43 Distributed Reservoir, it gets more water (114 units) than in ALT1 (54 units). As a result, the C43 Distributed Reservoir supplies more water for agricultural needs (85 units; an increase of 57 percent over alternative 1) and therefore there is less demand on Lake Okeechobee to provide for C43 Basin agricultural water needs (35 percent reduction over alternative 1).

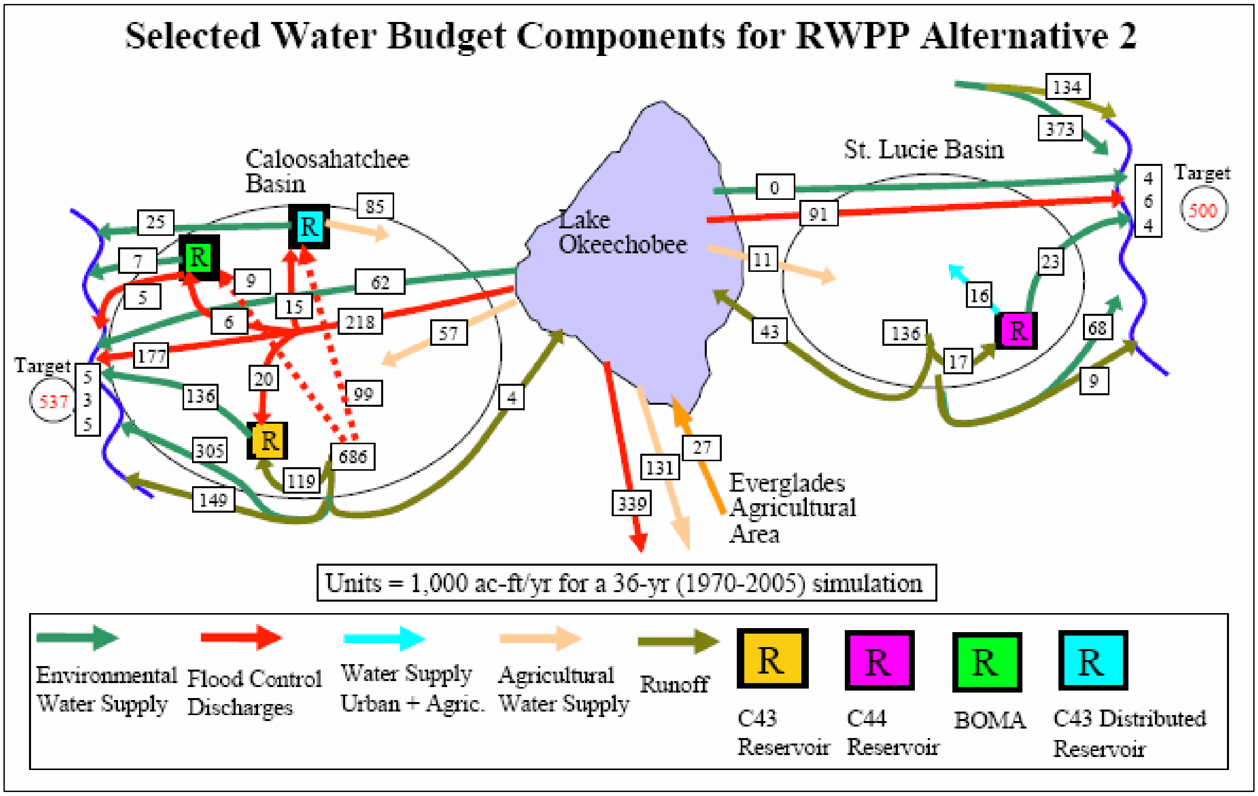


Figure C-40. Selected water budget components for RWPP Alternative 2

C5.5 Annual Water Budget Components for Alternative 3

Figure C-41 shows the annual average flows (1000 acre-feet) for Alternative 3. This management alternative includes a water quality storage node (designated as an STA) that represents the combination of Caloosahatchee Ecoscape Water Quality Treatment Area and the West Caloosahatchee Water Quality Treatment Area. The operation and size of the C43 Distributed Reservoir is the same as in Alternative 1. This management alternative performs very close to Alternative 1, except 10 percent of C43 Basin runoff (71 units out of 692 units) is treated through the water quality STA. Note that the total basin runoff is reduced in proportion to the STA footprint taken up by the management measure in consideration, e.g. 697 units in ALT1 and 692 units in ALT2.

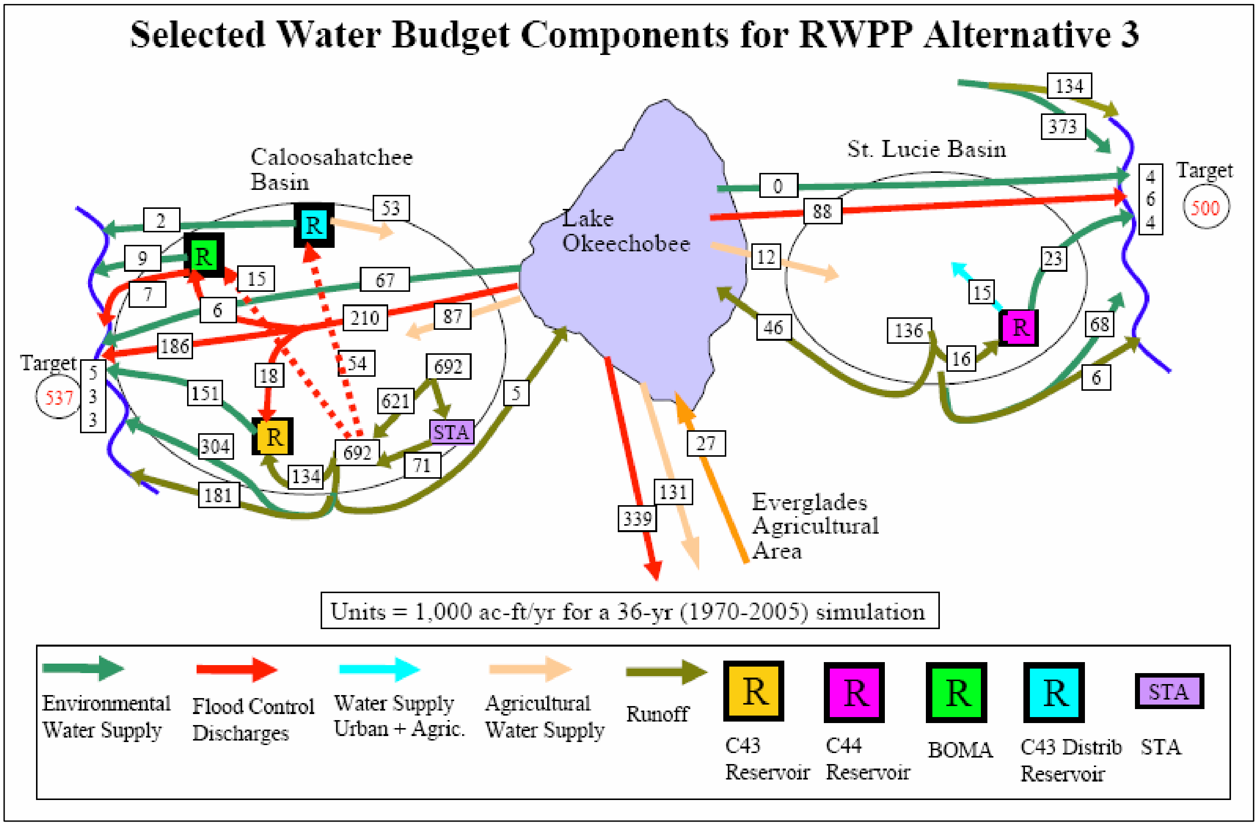


Figure C-41. Selected water budget components for RWPP Alternative 3

C5.6 Annual Water Budget Components for Alternative 4

Figure C-42 shows the annual average flows (1000 acre-feet) for Alternative 4. This management alternative combines the water quality MMs from Alternative 3 and the operation and increased storage facilities based on scenario runs built off of Alternative 2 (Section C6.0). This management alternative performs similar to Alternative 2, in terms of the standard set of performance measure graphics. In addition, 10 percent of C43 Basin runoff (71 units out of 695 units) is treated through the water quality MMs as in Alternative 3.

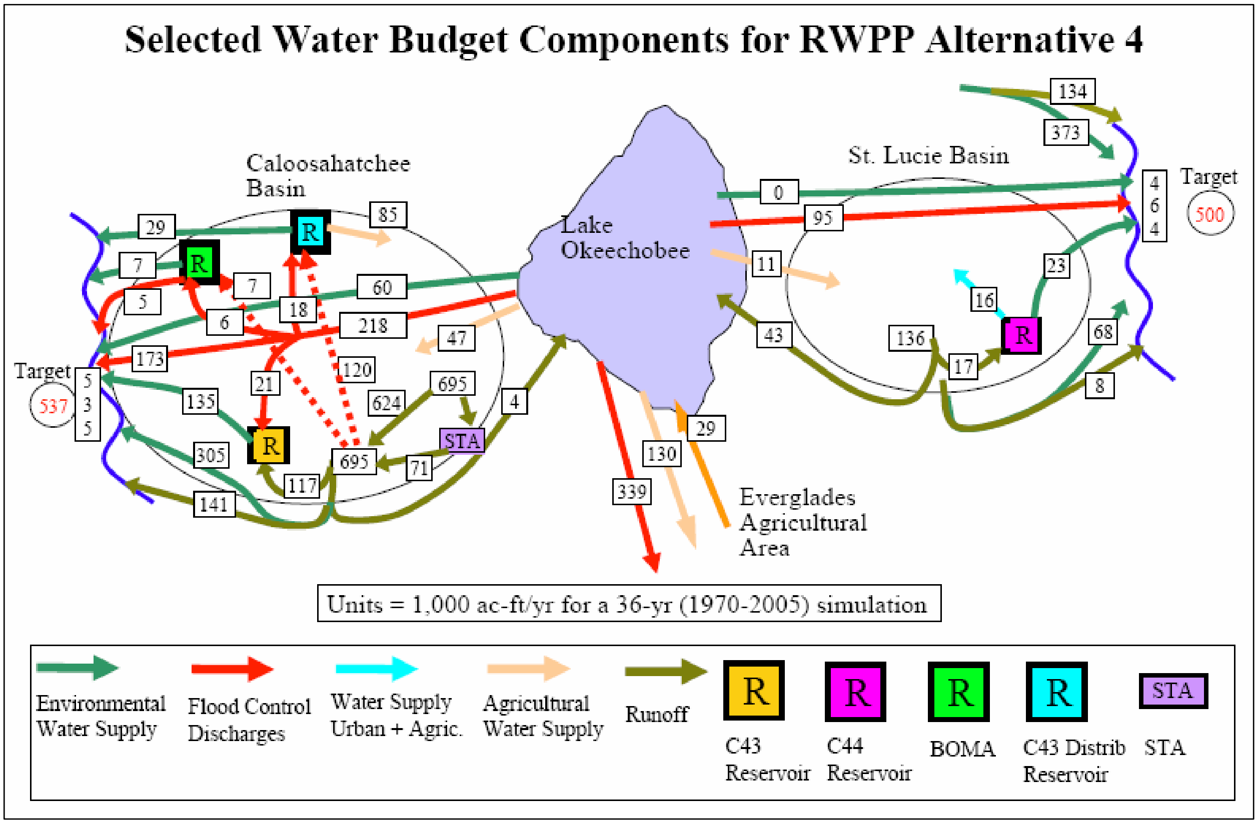


Figure C-42. Selected water budget components for RWPP Alternative 4

C6.0 SENSITIVITY ANALYSES FOR STORAGE CAPACITY SCENARIOS IN THE CALOOSAHATCHE RIVER WATERSHED

C6.1 Methodology

A sensitivity analysis on the impact of storage capacity in the Caloosahatchee Basin was conducted on Alternative 2, to evaluate the potential benefits from incrementally larger storage capacities. The added storage capacities located in the East Caloosahatchee Basin, ranging from 163,890 acre-feet for ALT2 to 563,890 acre-feet for ALT2D. The analyses are focused on the performance of Lake Okeechobee, the estuaries, and water supply. Implementation issues such as cost, real estate availability, etc. were not considered.

C6.2 Scenario Runs: Alternatives 2, 2A, 2B, 2C and 2D

Four scenario runs were performed by increasing the total storage capacity (including C43 Reservoir in the West Caloosahatchee Basin) in Alternative 2, as shown in **Table C-11**.

Table C-11. Storage Capacities (in acre-feet) of Alternative 2 Scenario Simulations in Caloosahatchee River Watershed

Scenario Run	ALT2	ALT2A	ALT2B	ALT2C	ALT2D
Storage Capacity (ac-ft)	342,490	392,490	492,490	642,490	742,490

C6.3 Performance Measures

The storage capacity scenarios were simulated over a 36-yr period of record from 1970 to 2005. Performances of each scenario were evaluated using the same set of RECOVER performance measures that were used in the evaluation of the RWPP Future Base and the original set of alternatives (Section 6.5).

C6.3.1 Lake Okeechobee

As can be seen in the Lake Okeechobee stage duration curve (**Figure C-43**), the change of storage capacity in Caloosahatchee has very small impact on lake stage.

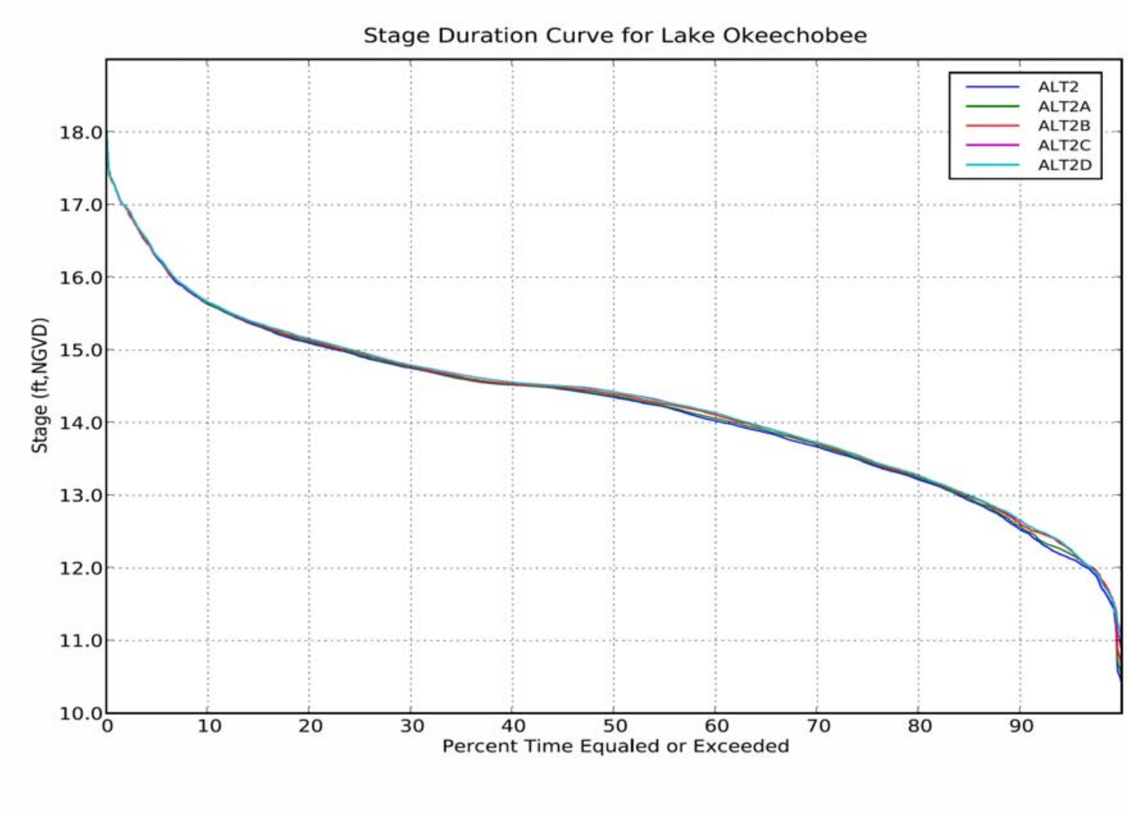


Figure C-43. Lake Okeechobee stage exceedance curves for scenario runs

C6.3.2 Estuaries

As shown in **Figure C-44**, the number of times that mean monthly estuary flow is greater than 2,800 cfs decreases with increases in storage capacity: from 47 times in ALT 2 to 38 times in ALT 2D. The number of times that mean monthly flow is over 4,500 cfs also dropped from 17 times in ALT 2 to 14 times in ALT 2D. The increase of storage capacity benefits the high estuary flow criteria to a limited extent. From **Figure C-45**, there is no significant change in the number of low flow occurrences (mean monthly flow less than 450 cfs), except from ALT2 to ALT2A when it decreased by 50 percent: from six to three occurrences.

Since the storage capacity changes were made in the Caloosahatchee Basin only, the performance of St. Lucie Estuary was only slightly affected. **Figure C-46** shows that the number of times mean monthly estuary flow is between 2,000 cfs and 3,000 cfs increases from 24 to 26 times from ALT2 to ALT2A; and stays the same (26) for the remaining scenario runs. In general, the performance of the scenario runs moved further away from the target (21). **Figure C-47** shows that the influence of storage capacity changes in the Caloosahatchee Basin has very little impact on the St. Lucie Estuary salinity envelope criteria, if at all.

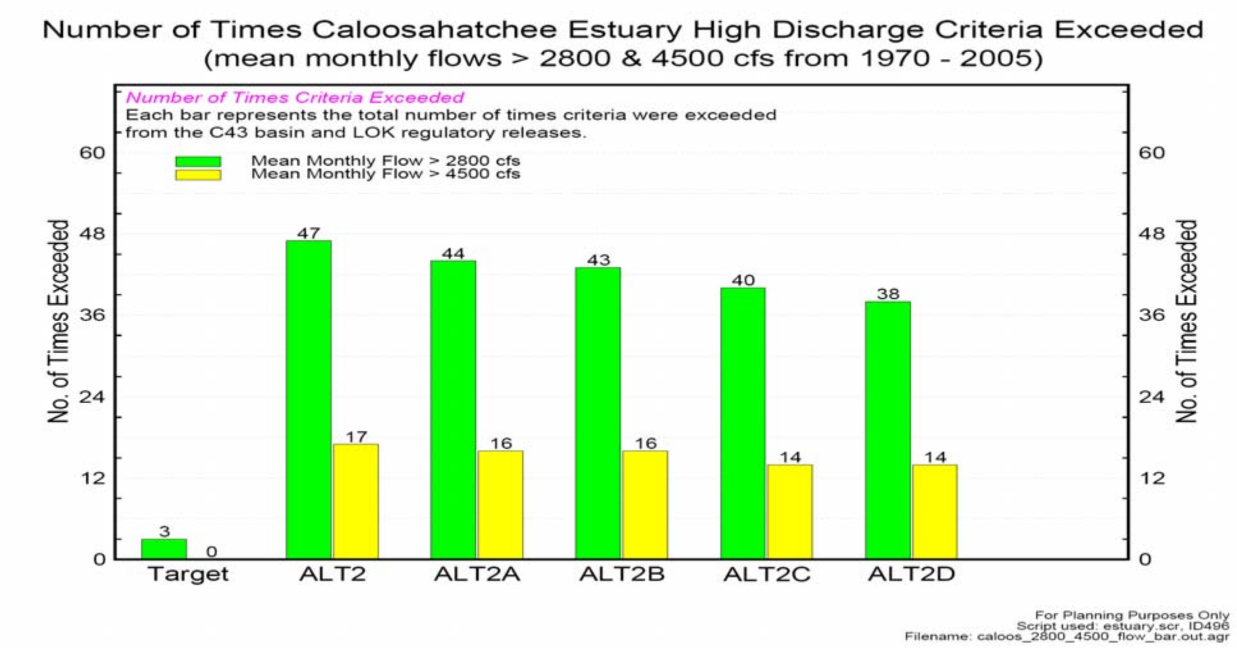


Figure C-44. Number of times Caloosahatchee Estuary high discharge criteria exceeded

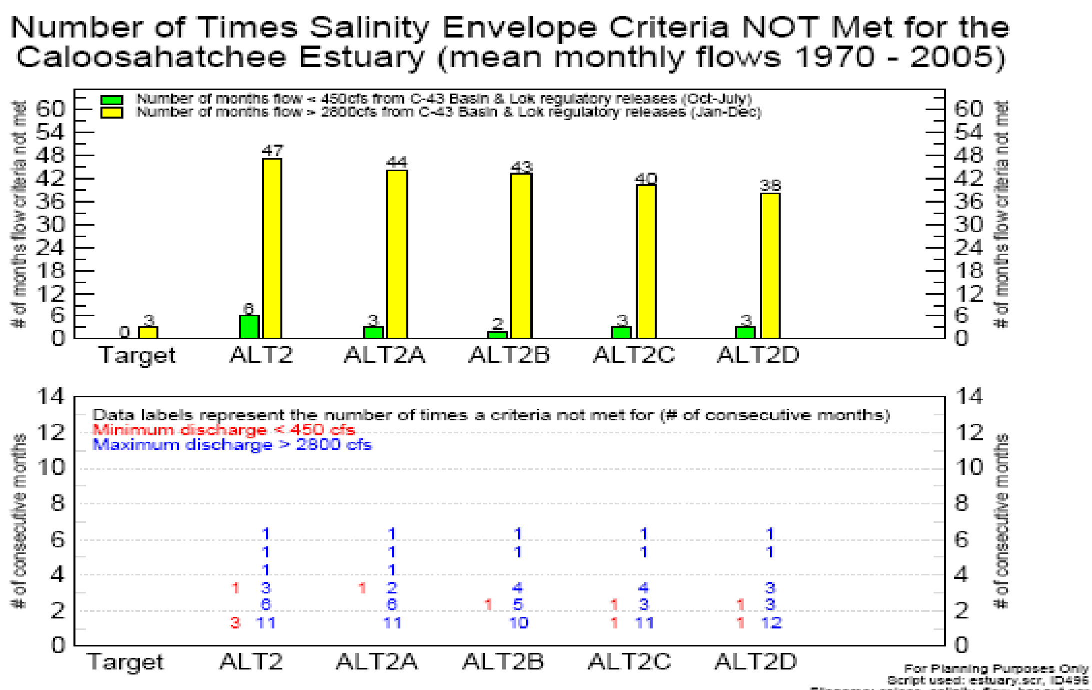


Figure C-45. Number of times salinity envelope criteria not met for the Caloosahatchee Estuary

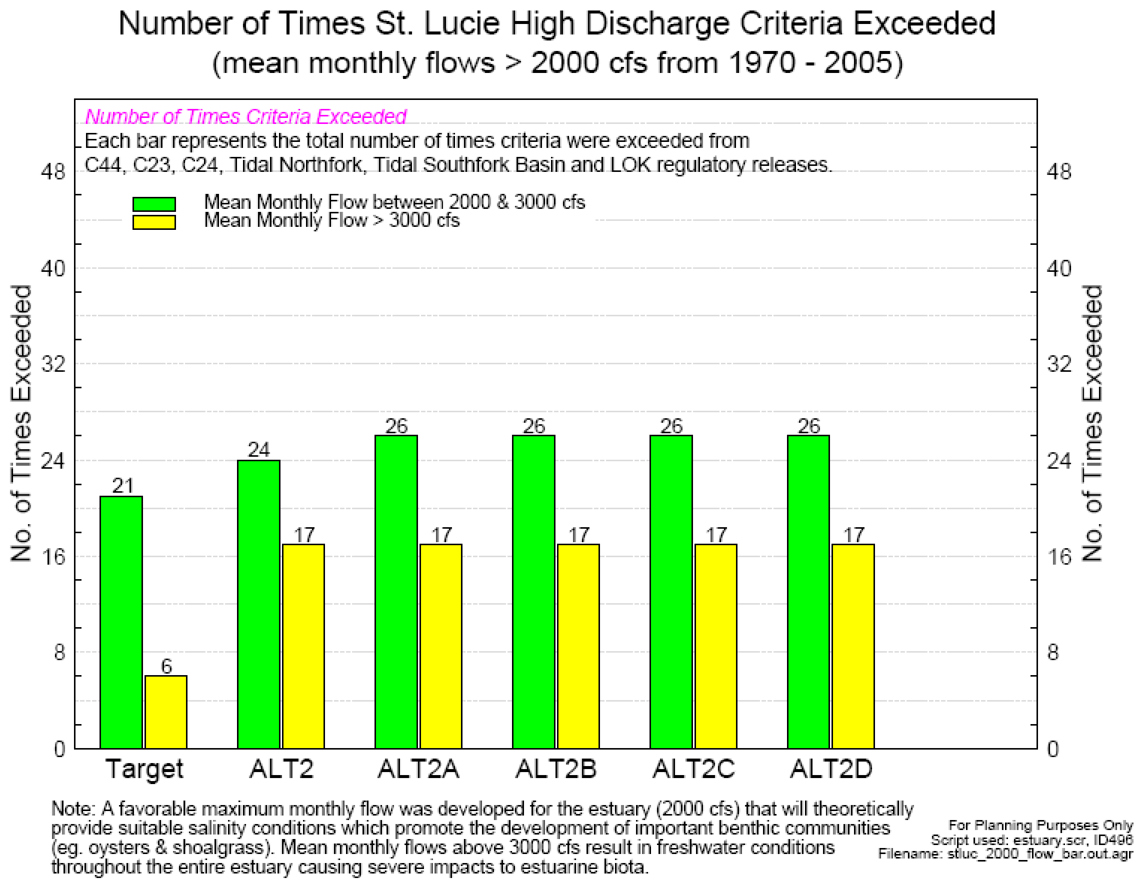


Figure C-46. Number of times St. Lucie Estuary high discharge criteria exceeded

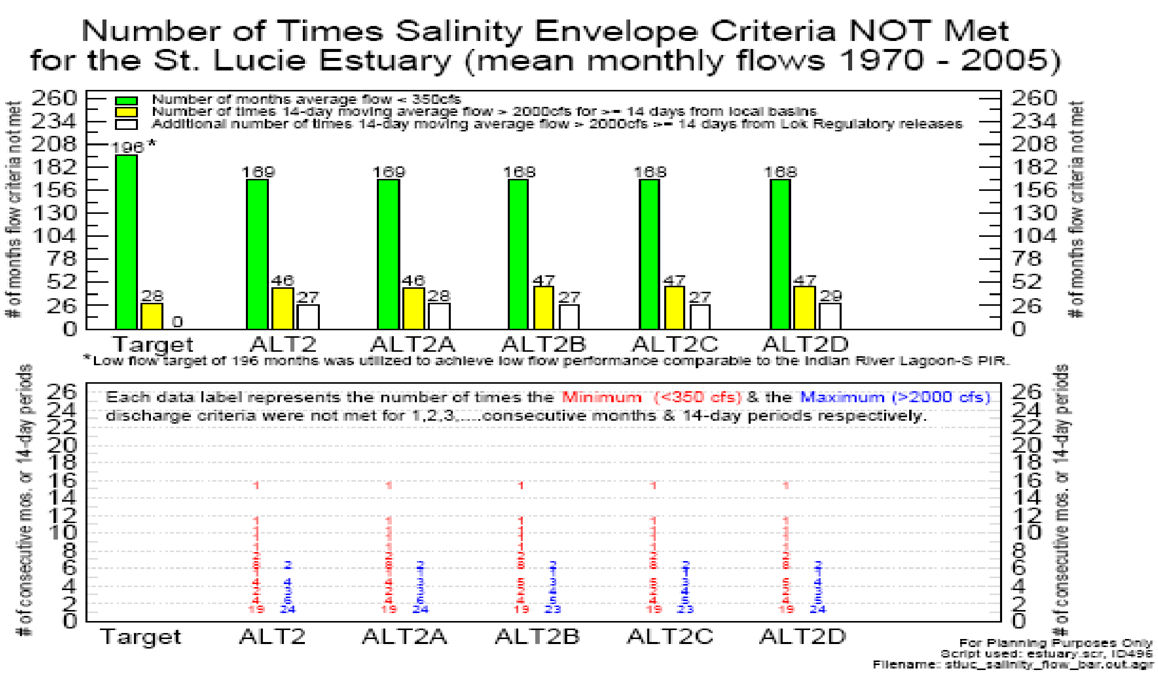


Figure C-47. Number of times salinity envelope criteria not met for the St. Lucie Estuary

C6.3.3 Lake Okeechobee Service Area

Figure C-48 shows the demand cutback volumes for the seven years within the simulation period with the largest cutbacks. The figure shows that LOSA demand cutback volumes decrease with increasing storage capacity, with the maximum reduction in 2001.

The annual EAA/LOSA supplemental irrigation plots (**Figure C-49**) show no significant difference among different storage capacity runs.

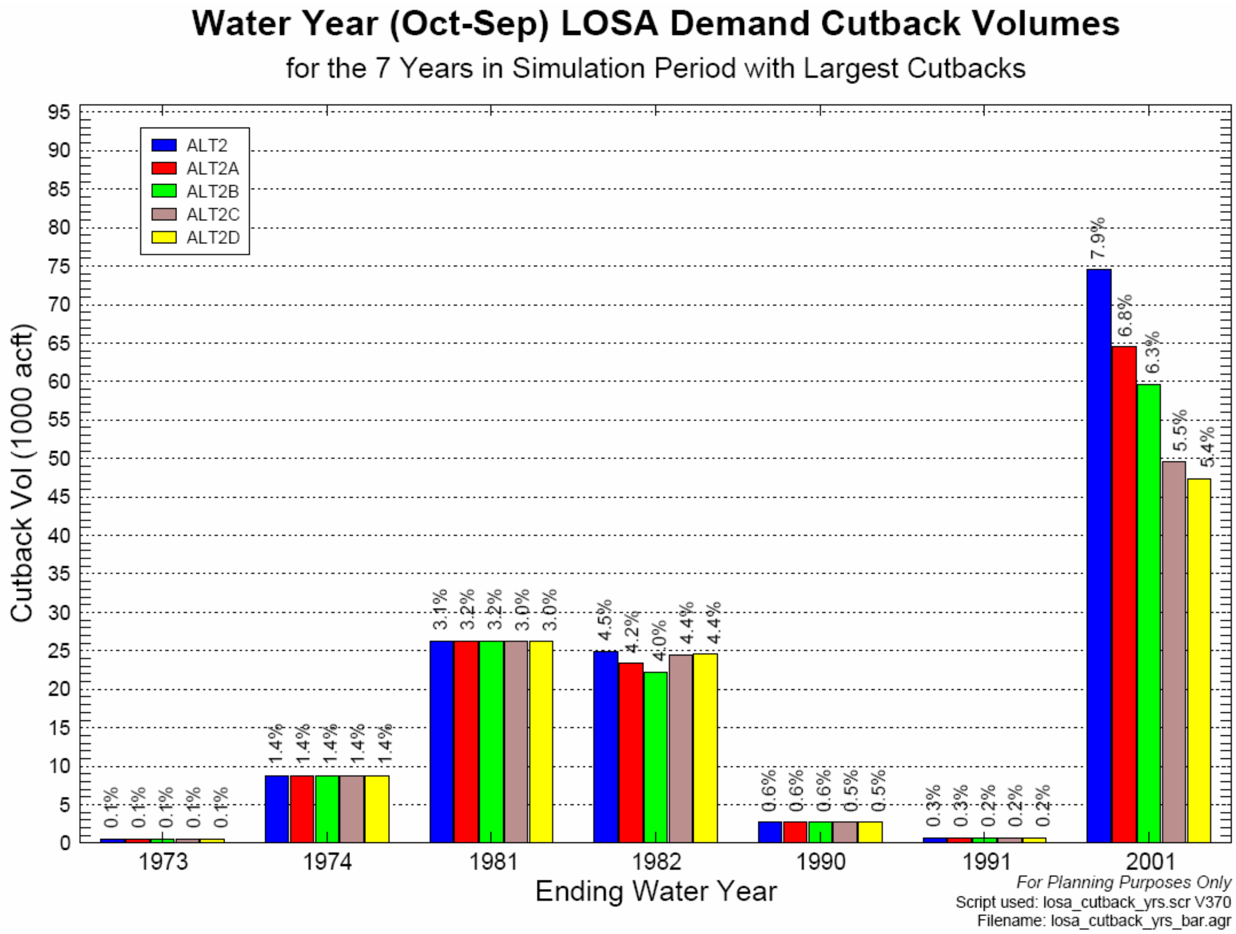


Figure C-48. Water year LOSA demand cutback volumes

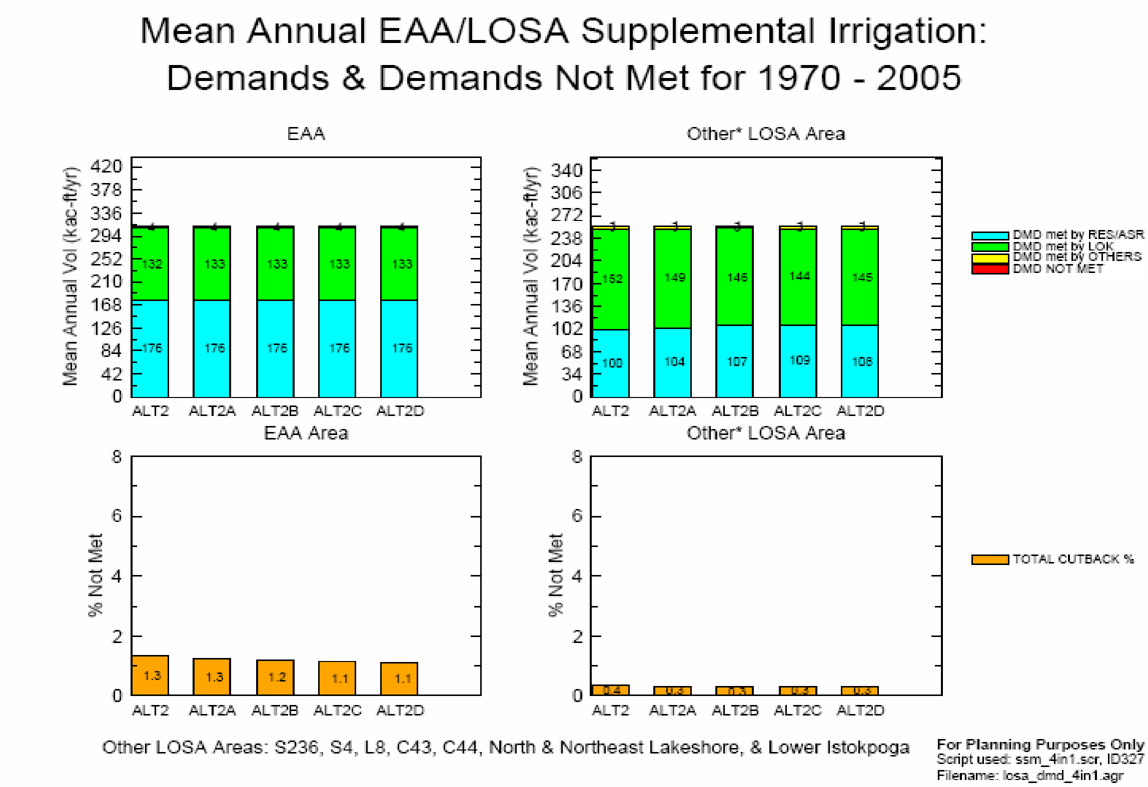


Figure C-49. Mean annual EAA/LOSA supplemental irrigation

C6.4 Conclusion

Based on a comparison of scenario runs with increasing storage capacities in the Caloosahatchee Basin, the follow conclusions could be drawn:

- Lake Okeechobee: Increase in storage capacity in Caloosahatchee Basin from 342,490 acre-feet to 742,490 acre-feet showed no significant impact on the Lake Okeechobee stage.
- Estuary: The Caloosahatchee Estuary high discharge performance measure showed limited improvement, with an increase in storage capacity. The impact on the estuary low flow was generally minimal, although a significant improvement can be demonstrated going from ALT2 to ALT2A. The storage capacity changes in Caloosahatchee Basin had a slight impact on St. Lucie Estuary performance.
- Water Supply: LOSA cutback volumes decreased the most (in terms of volume and percentage volume) in the worst year (water year 2001). EAA/LOSA water irrigation is not impacted.

Therefore, increases in storage capacities in the Caloosahatchee Basin would benefit the Caloosahatchee Estuary performance, both in the high discharge criteria (greater than 2,000 cfs) and low flow criteria (less than 450 cfs). The improvement was most pronounced from ALT2 to ALT2A. Likewise, the LOSA water supply performance, in terms of reduction in cutback and demand-not-met, would also improve. The benefits are quite limited because relatively large amounts of storage capacity increases beyond ALT2A did not show improvements in the other LOSA areas.

C7.0 REFERENCES

Abtew, W., J. Obeysekera, M. Irizarry-Ortiz, D. Lyons and A. Reardon. 2003. "Evapotranspiration Estimation for South Florida." P. Bizier and P. DeBarry (ed.), Proceedings of the World Water and Environmental Resources Congress 2003, ASCE (CD)

Ali, A. and W. Abtew. 1999. "Regional Rainfall Frequency Analysis for Central and South Florida." Technical Publication, WRE #380, South Florida Water Management District, West Palm Beach, FL.

Ansar, M., Z. Cheng, J.A. Gonzalez and M.J. Chen. December 2005. Dimensionless Flow Ratings at Kissimmee River Gated Spillways." Technical Publication, SHDM Report, Operations and Hydro Data Management Division, South Florida Water Management District, West Palm Beach, FL.

Camp Dresser and McKee. 2007. "Lake Okeechobee Basis of Design Report." Contract Report Prepared for South Florida Water Management District, West Palm Beach, FL.

Christ, T., G. Thompson, and S. Lin. 2001. "Upper Kissimmee Chain of Lakes Routing Model – Technical Memorandum." SFWMD Contract No. 11665 Report Prepared for South Florida Water Management District, West Palm Beach, FL.

Earth Tech. 2007. "Kissimmee Basin Modeling and Operations Study Base Condition Summary Report – Final Draft." Contract No. CN040920-W002 Report Prepared for South Florida Water Management District, West Palm Beach, FL.

Fan, A. 1986. "A routing model for the Upper Kissimmee Chain of Lakes." Technical Publications 86-5. Water Resources Division. South Florida Water Management District.

Smajstrla, A. G. 1990. Agricultural Field-Scale Irrigation Requirements Simulation (AFSIRS) Model, ver. 5.5 Technical Manual, University of Florida, Gainesville, FL.

South Florida Water Management District (SFWMD). 2004. Appendix B. "Final Integrated Project Implementation Report, Environmental Impact Statement," C&SF Project- Indian River Lagoon – South. SFWMD, West Palm Beach, FL.

South Florida Water Management District (SFWMD). 2005a. "Regional Simulation Model (RSM) Hydrologic Simulation Engine (HSE) User's Manual RSM Version 2.2.9." South Florida Water Management District, West Palm Beach, FL.

South Florida Water Management District (SFWMD). 2005b. "Regional Simulation Model (RSM) Theory Manual RSM." SFWMD, West Palm Beach, FL.

Visher, F.N. and G.H. Hughes. 1969. "The difference between rainfall and potential evaporation in Florida." Journal of American Water Resources Association, 34(1), 149-157.

Wan, Y., C. Reed and E. Roaza. 2003. Modeling watersheds with high groundwater tables and dense drainage canals. *Proceedings of 2003 AWRA International Congress: Watershed Management for Water Supply*. New York, p. 10.

Wan, Y., J.W. Labadie, K.D. Konyha, and T. Conboy. 2006. “Optimization of Frequency Distribution of Storm-Water Discharges for Coastal Ecosystem Restoration.” Journal of Water Resources Planning and Management, 320pp.

Wilcox, W.M. and K.G. Konyha. 2003. “Calibration of the Caloosahatchee (C43) Basin AFSIRS/WATBAL Model for Use in Modeling Selected Lake Okeechobee Service Area Basins in ver. 5.0 of the South Florida Water Management Model.” Internal Memorandum, South Florida Water Management District, West Palm Beach, FL.

APPENDIX D

Nutrient Loading Rates, Reduction Factors and Implementation Costs Associated with BMPs and Technologies

Final Report

Tasks 1, 2, and 3

For Project Entitled

Nutrient Loading Rates, Reduction Factors and Implementation Costs Associated with BMPs and Technologies

Prepared for

South Florida Water Management District

by

Soil and Water Engineering Technology, Inc.

July 14, 2008

INTRODUCTION

The South Florida Water Management District (SFWMD), in cooperation with the Florida Department of Environmental Protection (FDEP) and the Florida Department of Agriculture and Consumer Services (FDACS), is developing the protection plans for both Caloosahatchee River and St. Lucie River watersheds as required by the Northern Everglades and Estuaries Protection Program (Section 373.4595, F.S). The plans will be developed partially based on a nutrient reduction spreadsheet approach detailing how nitrogen (N) and phosphorus (P) reductions will be achieved. The spreadsheet provides load reduction estimates resulting from Best Management Practices (BMPs), as well as local and regional projects. The letter report titled "Phosphorus Reduction Performance and Implementation Costs under BMPs and Technologies in the Lake Okeechobee Protection Plan Area" provides only part of the input data needed for the BMP spreadsheet for these additional watersheds. Therefore, the overall objectives of this project are to: 1) develop nutrient (nitrogen and phosphorus) loading rates, BMP reduction factors and implementation costs for both watersheds; and 2) conduct a detailed literature review and data analysis to quantify the BMP effectiveness for each commodity and soil type statewide.

METHODOLOGY AND RESULTS

The approach taken for developing the nutrient reduction spreadsheets for Caloosahatchee River and St. Lucie River watersheds was to update the previously developed spreadsheets for the Lake Okeechobee watershed using the additional literature data, land use data, observed flow and nutrient load data, and information from the watershed modeling project for the two watersheds. The SFWMD provided the land use breakdown for the two watersheds for twenty major land use categories, which included the six new land use categories (low density residential, medium density residential, high density residential, horse farms, transportation, and utilities). The following section describes how these data were used to develop the final unit nutrient load and BMP reduction spreadsheets. Though the methodology was very similar for both the Caloosahatchee and the St. Lucie watersheds, they are both included in order to highlight data sources and verification differences.

St. Lucie River Watershed

Figure 1 shows the basins within the St. Lucie River watershed. The 2004 land use distribution for this watershed was provided by SFWMD and is presented in Table 1. As can be seen, the table provides additional land use breakdowns beyond the twenty primary land use categories required for the project. These additional data were used during the development of the unit loads, but were integrated within the twenty categories for the final tables to prevent confusion. Measured data were provided by the SFWMD as presented in Table 2, which compared to data obtained from the Comprehensive Everglades Restoration Plan (CERP) System-wide Performance Measure Documentation Sheet (April 5, 2007).

The initial estimates of the unit nutrient loads were developed from the Lake Okeechobee Basin data provided in the BMP Letter Report (SWET, 2006b), general Florida estimates by Harper and Baker (2003 and 2007), and data collected within the basin by Graves, et al (2004). The final N and P unit loads for the watershed presented in Table 3 were developed as an iterative process starting with the initial unit loads estimates linked to a basin spreadsheet where the accumulative N and P loads from each basin could be calculated by multiplying the land use acreage by the unit loads. The net N and P loads were then compared to the measured basin and basin loads to verify if the net loads were at least in the ballpark and how the calculated and measured N and P loads for each of the basins compared. It was clear that the dominant land uses in the western basins were improved pasture and citrus while the eastern basins were much more residential and urban. Using this cross information, it was possible to estimate the relative importance of the various land uses and adjustments were made accordingly to obtain a reasonable agreement of runoff and nutrient loads and concentrations for each of the basins. However, it was observed that there was a potential problem using the measured flow data for net load estimates because of the high runoff variability between basins as seen in Table 2 for the annual runoff in terms of inches per year. Therefore, the cross basin comparisons focused more on matching the concentrations because they would be less influenced by any flow errors that might be the result of unmeasured inter-basin transfers. Since the unit loads are a function of both concentration and flow, it was first necessary to establish reasonable runoff coefficients for the various land uses (Harper and Baker, 2007). The resulting annual average runoff for the various land uses are provided in Table 3. Table 3 also provides the resulting N and P unit loads and concentrations from the iterative process of adjusting individual land use unit loads, which multiplied by the acreage of each land use within the basins (Table 4) to obtain reasonable basin runoff (Table 5), P loads (Table 6), and N loads (Table 7) comparison to observed data. The P unit load factors were adjusted individually. The N unit loads were also initially adjusted individually, but then a global multiplier factor was used to obtain reasonable matches to observed data. The verification for the N and P concentrations is also provided in Tables 6 and 7, respectively at the bottom of the tables. Note that the net calculated loads are slightly higher than observed data because these represent net source loads which do not reflect the additional assimilation that is expected in the stream and canals before reaching the basin outlets. Stream assimilation rates have been evaluated and new algorithms developed and upgraded by SWET (2001 and 2006a), where they found that P assimilation (20% to 50%) occurs mostly in the upland overland flow and small streams. Major sloughs/wetland systems were also found to have P assimilation rates in a similar range, while P assimilation rates in the canals and larger stream conveyances had much lower rates of 2% to 20%. Since the predominant flow features, below where the unit P source loads are, being estimated are canals and larger stream, the additional P assimilation was estimated to be in the order of 10%. Due to denitrification processes, N assimilation was estimated to be 50% larger than P, but very little data are available to verify the N values.

The next step was to establish BMP N and P reduction estimates for the St. Lucie watershed. This task was done by starting with the BMP reduction spreadsheets developed by SWET (2006b). These spreadsheets were expanded to include six additional land use categories and N responses. The BMP effectiveness values are based on the review and the author's involvement in numerous studies and modeling projects around Florida. Typically, the studies provided more information on crop responses to water and fertility management than water quality responses. Where water quality responses were available, they were limited to specific crop management and soil conditions. There are no specific reports that provided BMP effectiveness values for the basin; therefore, the values for the St. Lucie watershed had to be estimated based on best professional judgment utilizing models that simulate the primary processes within the soil-plant environment based on results from numerous field and laboratory studies.

A complete description of the BMP information used in developing the BMP effectiveness values will be provided in the Task 4 report of this project, and therefore will only be briefly summarized here. The primary sources of agricultural BMP information were research and extension reports completed by Institute of Food and Agriculture Sciences, University of Florida (IFAS, UF) in association with various state agencies and grower groups, while urban BMP information was primarily from summary reports by Environmental Research and Design, Inc. and University of Central Florida. For citrus, the studies by Brian Bowman and David Calvert at the Indian River Research and Education Center and Ashok Alva and S. Paramasivam at the Citrus Research and Education Center were primarily used, while the best source of cow-calf production studies came from the Cattle Research Station at Ona and the Buck Island Ranch studies. Vegetable production BMPs were reviewed from research studies across the state, but focused mostly on work out of IFAS' Gulf Coast (Immokalee) and the old Bradenton Research and Education Centers. Though many of the research studies focused more on crop production responses to management practices as opposed to water quality responses, their results were very useful in bracketing the economical feasibility limits for BMPs. To further access the actual water quality responses, both field studies and hydrologic transport modeling were evaluated. The Watershed Assessment Model (WAM) model was used extensively in the Okeechobee and Caloosahatchee basins and provided BMP responses beyond the specific conditions covered by field studies.

A report developed by Dr. Harvey Harper (2003) for the northern Lake Okeechobee watershed was primarily used for the urban BMPs responses for P. Nitrogen responses were taken from reports developed by Harper and Baker (2003, 2007). The N reduction estimates were adjusted based on WAM modeling experience because the reductions reported by Harper and Baker were only associated with surface water reductions and therefore any loses to groundwater that might re-emerge elsewhere were not being accounted for. In particular, N in percolated stormwater can easily enter groundwater and eventually re-emerge downstream. This effect is most prominent in dry detention systems.

BMP implementation costs were typically not provided with the research studies and therefore had to be developed by SWET, Inc. Cost estimates tried to take into account the following factors: saved fertilizer, equipment and construction, operation and maintenance, energy/fuel, crop yield reduction, crop displacement, and land purchases. In agriculture when a BMP requires additional land for BMPs, such as for retention/detention systems, the area is typically carved out of existing land holdings, so the costs are associated with lost crop production (displacement), where as in urban settings, new land will typically need to be purchased for such systems. High land costs in urban settings will therefore make urban projects, particularly stormwater retrofit projects, very expensive.

The resulting BMP reduction estimates and costs for P and N are presented in Appendix A. These tables reflect the updated unit loads provided in Table 3. Table 8 provides a summary of the P unit loads and estimated BMP reduction factors for the three categories of owner implemented BMPs, cost share BMPs, and alternative practices. Owner implemented BMPs reflect those that would likely be implemented by land owners without incentives, while the cost share BMPs are those that a reasonably funded cost share program or modest regulatory approach would obtain implementation. The alternative practices are those that are more expensive but would be needed if additional nutrient reductions are needed beyond what the first two levels could obtain. The P reduction values provided in Table 8 are taken directly from Appendix A where the existing level of BMPs implemented has been taken into account in the "typical" value. The "typical" value was selected within the presented range of reduction responses that reflect existing conditions with no BMPs to those with high levels of BMPs implemented. These ranges also reflect natural variations due to soils and farm layouts, but the level of BMP implementation is the dominant factor. Therefore, assumptions had to be made as to the current level of BMPs for each land use.

Table 9 provides the same information as Table 8 except for N instead of P. This table provides a summary of the N unit loads and estimated BMP reduction factors for the three categories of owner implemented BMPs, cost share BMPs, and alternative practices.

Caloosahatchee River Watershed

Figure 2 shows the basins within the Caloosahatchee watershed. The 2004 land use distribution for the Caloosahatchee watershed was provided by SFWMD and is presented in Table 10. As can be seen, the table provides additional land use breakdowns beyond the twenty primary land use categories required for the project. These additional data were used during the development of the unit loads, but were integrated within the twenty categories for the final tables to prevent confusion. Measured data for the major structures on the C-43 canal were provided by the SFWMD and are presented in Table 11. Because of the influence of the Lake Okeechobee releases, only the basin (Freshwater West) between the S-78 and S-79 structures was considered reliable enough for comparisons to actual land source area discharges. Unmonitored flow releases from the Lake Okeechobee, Nicodemus Slough, and the S-4 basin into the Freshwater East basin were considered more problematic than potential bypass water around S-78 as documented by the WAM model results (SWET, 2008). Therefore, the loads differences between these two structures shown in Table 11 were used for verification of the land use unit loads. The high measured discharge rates are a concern and are discussed further below.

The initial estimates of the unit nutrient loads were developed from the Okeechobee Basin data provided in the BMP Letter Report (SWET, 2006b), general Florida estimates by Harper and Baker (2003 and 2007), WMM EMC estimates developed by CDM (2007), and the WAM modeling results for the USACE (SWET, 2008). The final N and P unit loads for the C-43 basin presented in Table 12 were developed as an iterative process starting with the initial unit loads estimates linked to a basin spreadsheet where the accumulative N and P loads from each basin could be calculated by multiplying the land use acreage by the unit loads. The net N and P loads were then compared to the measured basin and basin loads to verify if the net loads were at least in the ballpark and how the calculated and measured N and P loads for each of the basins compared. It was clear that the dominant land uses in the western basins were improved pasture and citrus with limited urban around the Le Belle area. The more highly developed area is located in the western (tidal and north coastal) basins. Using just the Freshwater West basin, however, it was possible to estimate the relative importance of the various land uses and adjustments were made accordingly to obtain a reasonable agreement of runoff and nutrient loads and concentrations for each of the basins. However, it was observed that measured runoff for the Freshwater West basin seems high at 22 inches per year as seen in Table 14, which makes the unit loads higher than expected. Therefore, the basin comparisons focused more on matching the concentrations because they would be less influenced by any flow errors that might be the result of unmeasured inter-basin transfers. Since the unit loads are a function of both concentration and flow, it was first necessary to establish reasonable runoff coefficients for the various land uses (Harper and Baker, 2007). The resulting annual average runoff for the various land uses are provided in Table 12. Table 12 also provides the resulting N and P unit loads and concentrations from the iterative process of adjusting individual land use unit loads which multiplied by the acreage of each land use within the basins (Table 13) to obtain reasonable basin runoff (Table 14), P loads (Table 15), and N loads (Table 16) comparison to observed data. The P unit load factors were adjusted individually. The N unit loads were also initially adjusted individually, but then a global multiplier factor was used to obtain reasonable matches to observed data at the basin level. The verification for the N and P loads and concentrations is also provided in Tables 15 and 16, respectively at the bottom of the tables. Note that the net calculated loads and concentrations are slightly higher than observed data because these represent net source loads which do not reflect the additional assimilation that is expected in the streams and canals before reaching the basin outlets. In-stream assimilation rates have been evaluated and new algorithms developed and upgraded by SWET (2001 and 2006a), where they found that P assimilation (20% to 50%) occurs mostly in the upland overland flow and small streams. Major sloughs/wetland systems were also found to have P assimilation rates in a similar range, while P assimilation rates in the canals and larger stream conveyances had much lower rates of 2% to 20%. Since the predominant flow features below where the unit P source loads are being estimated are canals and larger stream, the additional P assimilation was estimated to be in the order of 10%. Due to denitrification processes, N assimilation was estimated to be 50% larger than P, but very little data are available to verify the N values.

The next step was to establish BMP N and P reduction estimates for the Caloosahatchee watershed. This task was done by starting with the BMP reduction spreadsheets developed by SWET (2006b). These spreadsheets were expanded to include six additional land use categories and N responses. The BMP effectiveness values are based on the review and personal involvement in numerous studies and modeling projects around Florida. Typically, the studies provided more information on crop responses to water and fertility management than water quality responses. Where water quality responses were available they were limited to specific crop management and soil conditions. There are no specific reports that provided BMP effectiveness values for the basin and therefore the values for the C-43 had to be estimated based on best professional judgment utilizing models that simulate the primary processes within the soil-plant environment based on results from numerous field and laboratory studies.

A complete description of the BMP information used in developed the BMP effectiveness values will be provided in the Task 4 report of this project, and therefore will only be briefly summarized here. The primary sources of agricultural BMP information were research and extension reports completed by IFAS in association with various state agencies and grower groups, while urban BMP information were primarily from summary reports by Environmental Research and Design, Inc. and University of Central Florida. For all of the crops growth on the muck soils in the eastern part of the basin, particularly sugarcane and vegetable, studies done by the Everglades Research and Education Center were used. For citrus the studies by Brian Bowman and David Calvert at the Indian River Research and Education Center and Ashok Alva and S. Paramasivam at the Citrus Research and Education Center were primarily used, while the best source of cow-calf production studies came from the Cattle Research Station at Ona and the Buck Island Ranch studies. Vegetable production BMPs were reviewed from research studies across the state, but focused mostly on work out of IFAS' Gulf Coast (Immokalee) and the old Bradenton Research and Education Centers. Though many of the research studies focused more on crop production responses to management practices as opposed to water quality responses, their results were very useful in bracketing the economical feasibility limits for BMPs. To further access the actual water quality responses both field studies and hydrologic transport modeling was evaluated. The WAM model was used extensively in the Okeechobee and Caloosahatchee basins and provided BMP responses beyond the specific conditions covered by field studies.

A report developed by Dr. Harvey Harper (2003) for the northern Lake Okeechobee watershed was primarily used for the urban BMPs responses for P. Nitrogen responses were taken from reports developed by Harper and Baker (2003, 2007). The N reduction estimates were adjusted based on WAM modeling experience because the reductions reported by Harper and Baker were only associated with surface water reductions and therefore any loses to groundwater that might re-emerge elsewhere were not being accounted for. In particular, nitrogen in percolated stormwater can easily enter groundwater and eventually re-emerge downstream. This effect is most prominent in dry detention systems.

BMP implementation costs were typically not provided with the research studies and therefore had to be developed by SWET, Inc. Cost estimates tried to take into account the following factors: saved fertilizer, equipment and construction, operation and maintenance, energy/fuel, crop yield reduction, crop displacement, and land purchases. In agriculture when a BMP requires additional land for BMPs, such as for retention/detention systems, the area is typically carved out of existing land holdings so the costs are associated with lost crop production (displacement), where as in urban settings, new land will typically need to be purchased for such systems. High land costs in urban settings will therefore make urban projects, particularly stormwater retrofit projects, very expensive.

The resulting BMP reduction estimates and costs for P and N are presented in Appendix B. These tables reflect the updated unit loads provided in Table 12. Table 17 provides a summary of the P unit loads and estimated BMP reduction factors for the three categories of owner implemented BMPs, cost share BMPs, and alternative practices. Owner implemented BMPs reflect those that would likely be implemented by land owners without incentives, while the cost share BMPs are those that a reasonably funded cost share program or modest regulatory approach would obtain implementation. The alternative practices are those that are more expensive but would be needed if additional nutrient reductions are needed beyond what the first two levels could obtain. The nutrient reduction values provided in Table 17 are taken directly from Appendix B where the existing level of BMPs implemented has been taken into account in the "typical" value. The "typical" value was selected within the presented range of reduction responses that reflect existing conditions with no BMPs to those with high levels of BMPs implemented. These ranges also reflect natural variations due to soils and farm layouts, but the level of BMP implementation is the dominant factor. Therefore, assumptions had to be made as to the current level of BMPs for each land use.

Table 18 provides the same information as Table 17 except for N. This table provides a summary of the N unit loads and estimated BMP reduction factors for the three categories of owner implemented BMPs, cost share BMPs, and alternative practices.

REFERENCES

CDM. 2007. Nutrient Load Assessment Estero Bay and Caloosahatchee Watershed. Final Report to South Florida Water Management District. West Palm Beach, FL.

Graves, G.A., Y. Wan, and D.L. Fike. 2004. Water Quality Characteristics of Storm Water From Major Land Uses in South Florida. J. American Water Resources Association. 1405:1419

Harper, H.H. 2003. Evaluation of Runoff Load Reductions from Urban Land Uses. Submitted to South Florida Water Management District as Attachment 2 to the SWET's Letter Report (SWET, 2003).

Harper, H.H. and D.M. Baker. 2003. Evaluation of Alternative Stormwater Regulations for Southwest Florida. Final Report prepared by Environmental Research and Design for the Florida Department of Environmental Protection, Tallahassee, FL.

Harper, H.H. and D.M. Baker. 2007. Evaluation of Current Stormwater Design Criteria within the State of Florida. Final Report prepared by Environmental Research and Design for the Florida Department of Environmental Protection, Tallahassee, FL.

SWET. 2001. Development of Phosphorus Retention/Assimilation Algorithm for the Lake Okeechobee Watershed. Final Report to South Florida Water Management District.

SWET. 2003. Estimation of Best management Practices and Technologies Phosphorus Reduction Performance and Implementation Costs in the Northern Lake Okeechobee Watershed. Final Letter Report to the South Florida Water Management District.

SWET. 2006a. Data Review and Evaluation for Upgrading the Phosphorus Assimilation Algorithm. Final Report to South Florida Water Management District.

SWET. 2006b. Phosphorus Reduction Performance and Implementation Costs under BMPs and Technologies in the Lake Okeechobee Protection Plan Area. Letter Report to Joyce Zhang, South Florida Water Management District.

SWET. 2008. Assessment of the Caloosahatchee River (C-43) Basin Using the WAM Model. Final Report to the US Army Corps of Engineers. Jacksonville, FL.

Figure 1. Basin Layout for the St. Lucie River Watershed

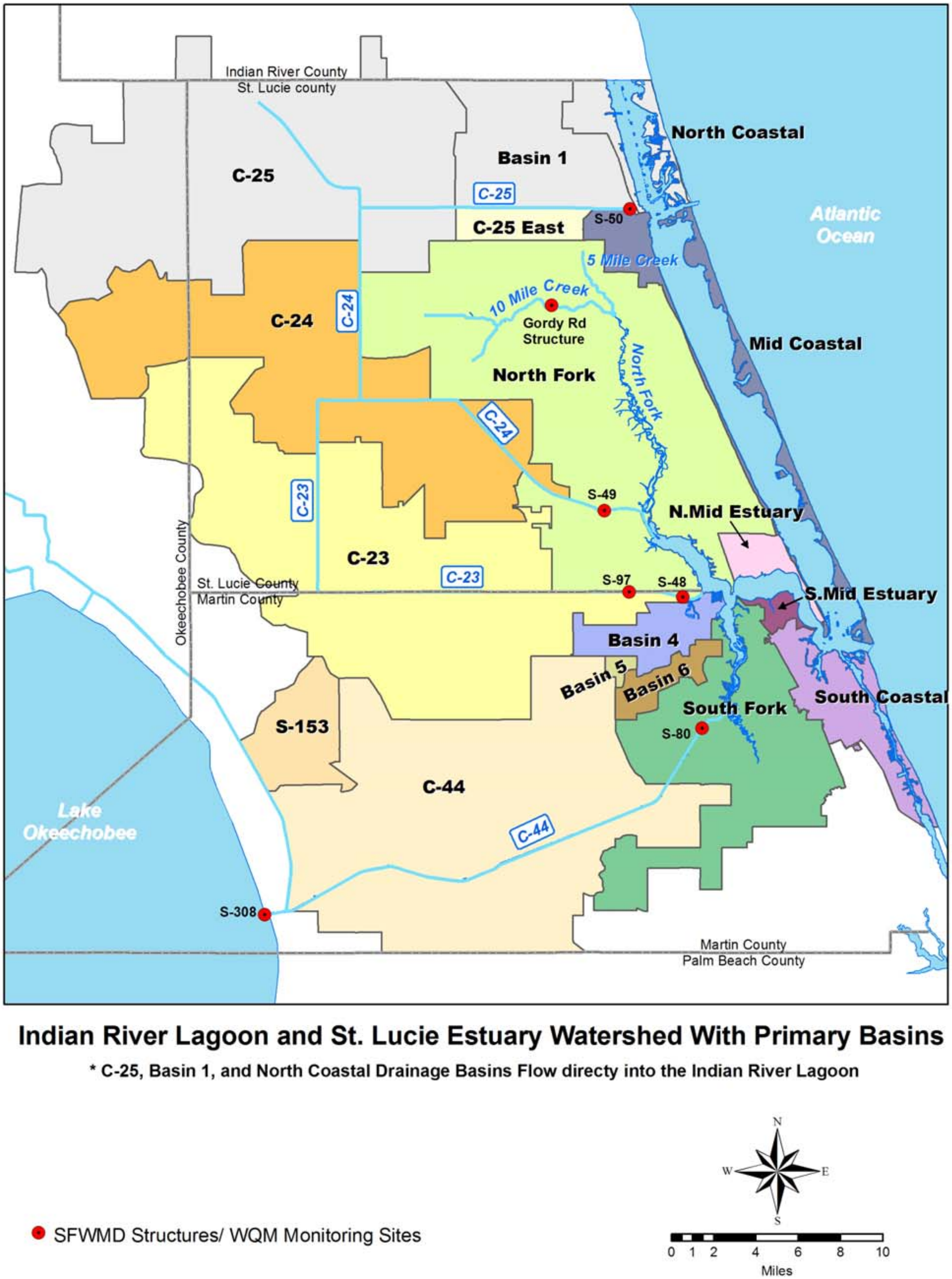


Figure 2. Basin Layout for the Caloosahatchee River Watershed

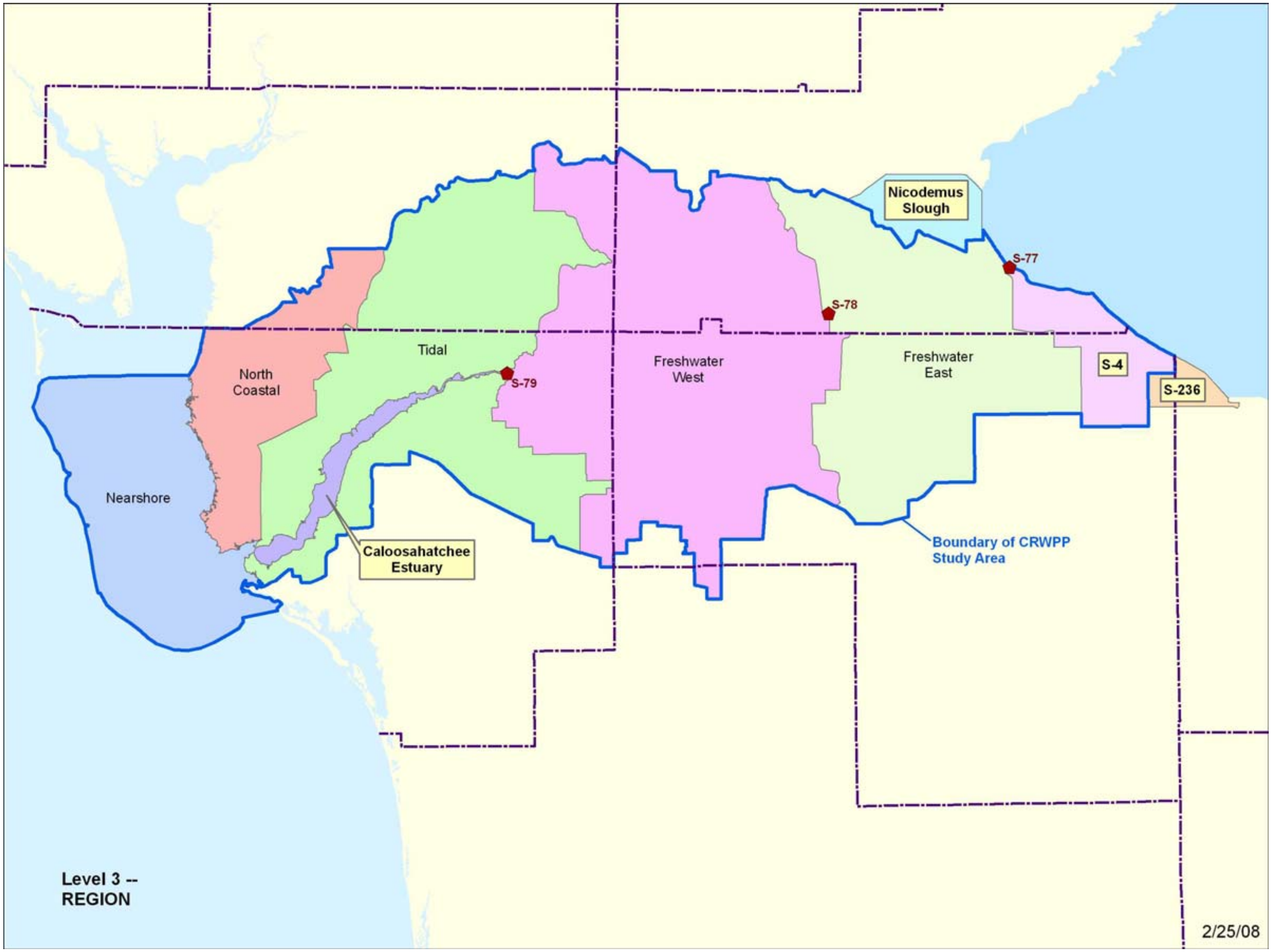


Table 1. Land Use Distribution in the St. Lucie Watershed

Land Use Category	Land Use Description	FLUCCS	Area (ac)	Percent	Sum_Area (ac)	Percent
Residential Low Density	Residential Low Density	1100	22,050	4.29%	22,050	4.30%
Residential Medium Density	Residential Medium Density	1200	38,206	7.43%	38,206	7.40%
Residential High Density	Residential High Density	1300	7,698	1.50%	7,698	1.50%
Other Urban	Commercial and Services	1400	5,090	0.99%	15,907	3.10%
	Industrial	1500	2,034	0.40%		
	Extractive	1600	640	0.12%		
	Institutional	1700	2,977	0.58%		
	Recreational	1800	5,167	1.00%		
Improved Pastures	Improved Pastures	2110	106,321	20.67%	106,321	20.70%
Unimproved Pastures	Unimproved Pastures	2120	15,033	2.92%	15,033	2.90%
Woodland Pastures/Rangeland	Woodland Pastures	2130	25,205	4.90%	39,351	7.70%
	Rangeland	3000	14,147	2.75%		
Row Crops	Row Crops	2140	7,881	1.53%	7,881	1.50%
Sugar Cane	Sugar Cane	2156	5,562	1.08%	5,562	1.10%
Citrus	Citrus	2210	116,442	22.64%	116,442	22.60%
Sod Farms	Sod Farms	2420	294	0.06%	294	0.10%
Ornamentals	Ornamentals	2430	1,246	0.24%	1,246	0.20%
Horse Farms	Horse Farms	2510	784	0.15%	784	0.20%
Dairies	Dairies	2520	419	0.08%	419	0.10%
Other Areas	Field Crops	2150	2,800	0.54%	4,108	0.80%
	Other Groves	2230	48	0.01%		
	Cattle Feeding Operations	2310	105	0.02%		
	Poultry Feeding Operations	2320	107	0.02%		
	Tree Nurseries	2410	463	0.09%		
	Specialty Farms	2500	133	0.03%		
	Aquaculture	2540	204	0.04%		
	Fallow Crop Land	2610	248	0.05%		
Tree Plantations	Tree Plantations	4400	0	0.00%	0	0.00%
Water	Water	5000	11,411	2.22%	11,411	2.20%
Natural Areas	Upland Forests	4000	37,608	7.31%	105,380	20.50%
	Wetlands	6000	61,052	11.87%		
	Barren Land	7000	2,613	0.51%		
	Open Land	1900	4,108	0.80%		
Transportation	Transportation	8100	5,665	1.10%	5,665	1.10%
Communication/Utilities	Communication	8200	91	0.02%	10,529	2.00%
	Utilities	8300	10,438	2.03%		
Total			**514,287**	**100.00%**	**514,287**	**100.00%**

Table 2 Summary of Measured Nitrogen and Phosphorus Load to SLE

Sub-watershed	Area (acres)	Average Annual Discharge(1) (1995-2005) (Acre-ft)	Calculated Runoff (in)	Average Annual TN Load(2) (1995-2005) (MTons)	Average Annual TN Conc. (Calculated) (1995-2005) (ppb)	Average Annual TP Load(2) (1995-2005) (MTons)	Average Annual TP Conc. (Calculated) (1995-2005) (ppb)
Basins 4 5 6	15055	23620	18.8	34	1182	6	218.96
C-23	112675	152789	16.3	330	1750	91	480.55
C-24	87706	178853	24.5	355	1609	76	343.25
C-44&S-153	129719	158194	14.6	300	1540	40	203.38
North Fork*	119168	126152	12.7	185	1191	43	278
Tidal St. Lucie**	49965	59408	14.3	91	1244	21	285.16
Lake Okeechobee	-	414754		922	1802	96	188.14
Total	514287	1113771		2218	1615	373	271.33

*North Fork basin includes North Fork and N. Mid. Estuary

**Tidal St. Lucie basin includes South Fork and S. Mid. Estuary

(1) Measured data are used for flow from C-23 basin, C-24 basin, C-44&S-153 basin, and Lake Okeechobee. WaSh Model output data are used for flow from North Fork basin, South Fork basin, and Basin 4 5 6.

(2) Measured data are used for TN and TP concentrations for C-23 basin, C-24 basin, C-44&S-153 basin, and Lake Okeechobee. WaSh Model output data are used for TN and TP concentrations for North Fork basin, South Fork basin, and Basin 4 5 6.

Table 3. Estimated Runoff, Unit N and P Loads and Concentration for 2004 Land Uses in the St. Lucie Watershed

Land Use Category	Land Use Description	FLUCCS	Runoff (in/yr)	Unit N Load)	N Conc. (mg/l)	Unit P Load (lbs/acre/yr)	P Conc. (mg/l)
Residential Low Density	Residential Low Density[1]	1100	17.57	4.95	1.25	0.49	0.12
Residential Medium Density	Residential Medium Density[2]	1200	20.76	7.20	1.53	1.40	0.30
Residential High Density	Residential High Density[2]	1300	23.96	10.80	1.99	3.00	0.55
Other Urban	Commercial and Services[2]	1400	25.55	9.90	1.71	1.40	0.24
	Industrial[2]	1500	27.15	9.00	1.47	2.40	0.39
	Extractive[2]	1600	23.96	6.30	1.16	0.66	0.12
	Institutional[2]	1700	23.96	6.30	1.16	2.40	0.44
	Recreational[2]	1800	17.57	6.30	1.59	0.96	0.24
Improved Pastures	Improved Pastures	2110	19.16	9.99	2.30	1.90	0.44
Unimproved Pastures	Unimproved Pastures	2120	15.97	4.95	1.37	0.92	0.25
Woodland Pastures/Rangeland	Woodland Pastures	2130	15.97	3.69	1.02	0.88	0.24
	Rangeland	3000	15.97	3.69	1.02	0.28	0.08
Row Crops	Row Crops	2140	22.36	13.50	2.67	4.50	0.89
Sugar Cane	Sugar Cane	2156	19.16	7.20	1.66	0.63	0.15
Citrus	Citrus	2210	19.16	7.65	1.76	1.80	0.42
Sod Farms	Sod Farms	2420	19.16	8.10	1.87	2.52	0.58
Ornamentals	Ornamentals	2430	19.16	10.80	2.49	2.90	0.67
Horse Farms	Horse Farms	2510	15.97	14.40	3.99	1.82	0.50
Dairies	Dairies	2520	15.97	18.00	4.98	9.38	2.60
Other Areas	Field Crops	2150	15.97	5.96	1.65	2.96	0.82
	Mixed Crops	2160	19.16	9.90	2.28	3.50	0.81
	Fruit Orchards	2220	19.16	8.10	1.87	2.30	0.53
	Other Groves	2230	19.16	8.10	1.87	2.30	0.53
	Cattle Feeding Operations	2310	19.16	48.65	11.22	8.96	2.07
	Poultry Feeding Operations	2320	19.16	9.00	2.08	1.50	0.35
	Tree Nurseries	2410	15.97	10.80	2.99	2.90	0.80
	Specialty Farms	2500	15.97	7.20	1.99	1.82	0.50
	Aquaculture	2540	7.99	9.00	4.98	0.70	0.39
	Fallow Crop Land	2610	19.16	6.30	1.45	0.70	0.16
Tree Plantations	Tree Plantations	4400	15.97	2.79	0.77	0.18	0.05
Water	Water	5000	3.19	0.81	1.12	0.05	0.07
Natural Areas	Upland Forests (not including 4400's)	4000	14.37	2.25	0.69	0.28	0.09
	Wetlands	6000	1.60	1.35	3.74	0.01	0.03
	Barren Land	7000	23.96	6.30	1.16	0.75	0.14
	Open Land	1900	15.97	3.60	1.00	0.28	0.08
Transportation	Transportation	8100	27.15	8.28	1.35	1.65	0.27
Communication/Utilities	Communications	8200	15.97	5.40	1.49	0.48	0.13
	Utilities	8300	15.97	5.40	1.49	0.48	0.13

1 Assumed on Septic
2 Assumed Discharge from WWT outside basin

Table 4. Acreage of Land Uses within the St. Lucie Watershed

FLUCCS	Basins 4 5 6	C-23	C-24	C-44&S-153	North Fork*	Tidal St. Lucie**	Grand Total
1100	4315.6	1909.4	1236.1	1813.7	9445	3329.8	22049.7
1200	1236.1	303.7	2505.9	314.9	30453.4	3392.3	38206.3
1300	702.6		295	185.7	4784.2	1730.3	7697.8
1400	222.9	9	39.8	204.4	3453.9	1159.8	5089.8
1500	133.2	48.3	55.5	76.7	1552.3	167.8	2033.7
1600	0.8	411.5			92.3	135.2	639.8
1700	110.3	661.7	21.7	97.7	1567.1	518.3	2976.7
1800	683.8	254.8	665.6	209.5	2308.4	1045.2	5167.3
1900	110.8	9.8	74.7	148.7	3291.5	472.2	4107.5
2110	1006.7	33628	33949.7	23185	4998.8	9552.4	106320.6
2120	86.4	5062	6064.3	2167.9	558.4	1094.1	15033.1
2130	374.6	8697.3	6890.3	6457.9	1071.8	1712.9	25204.8
2140	156.1	1696.2	1550.3	852.5	1166.2	2459.9	7881.1
2150		1574.6	834.7	390.9			2800.2
2156				5240.1		321.7	5561.8
2210	30.2	32466.1	17487.8	42754.5	20678.2	3025.4	116442.2
2220							0
2230	5	17.1			26.2		48.3
2310		104.7					104.7
2320			44.3	62.5			106.8
2410	100.2	153.8	55.5	85.3	68.3	0.1	463.1
2420				294.1			294.1
2430	211		25.1	267.6	237.9	504.4	1246
2500				28.7	23.9	79.9	132.6
2510	53.7	54	14.1	591.6		71.1	784.4
2520		419.1					419.1
2540	60.1	70.4	23.3		9.5	40.8	204.2
2610		216.7			31.3		247.9
3000	394.5	1603.5	220.1	6383.5	3494	2051	14146.6
4000	2679	2723.8	1264.5	11535.9	12030.8	7373.6	37607.6
5000	382.5	1810.5	1218.4	1890.7	4317.3	1791.3	11410.7
6000	1262.5	16278.9	12248.2	15114.6	9485.1	6662.2	61051.5
7000		1108.1	297.8	939	235.2	33.2	2613.4
8100	297.6	455.4	521.1	611.2	2623.4	1156.6	5665.3
8200	10.9	10.2		5.6	64.3		91
8300	428.3	916.1	102.4	7808.5	1099.2	83.1	10437.6
Grand Total	15055.4	112674.5	87705.8	129718.9	119167.9	49964.7	514287.2

*North Fork basin includes North Fork and N.Mid.Estuary

**Tidal St. Lucie basin includes South Fork and S.Mid.Estuary

Table 5. Runoff in Acre-ft/yr to Stream within the St. Lucie Watershed by Land Use

FLUCCS	Basins 4 5 6	C-23	C-24	C-44&S-153	North Fork*	Tidal St. Lucie**	Grand Total
1100	6318	2795	1810	2655	13827	4875	32280
1200	2139	525	4336	545	52689	5869	66102
1300	1403	0	589	371	9551	3454	15367
1400	475	19	85	435	7355	2470	10838
1500	301	109	126	174	3512	380	4601
1600	2	821	0	0	184	270	1277
1700	220	1321	43	195	3128	1035	5942
1800	1001	373	974	307	3379	1530	7565
1900	147	13	99	198	4381	628	5467
2110	1608	53706	54219	37028	7983	15256	169799
2120	115	6737	8071	2885	743	1456	20007
2130	499	11575	9170	8595	1426	2280	33544
2140	291	3160	2889	1588	2173	4583	14684
2150	0	2096	1111	520	0	0	3727
2156	0	0	0	8369	0	514	8882
2210	48	51850	27929	68281	33024	4832	185964
2220	0	0	0	0	0	0	0
2230	8	27	0	0	42	0	77
2310	0	167	0	0	0	0	167
2320	0	0	71	100	0	0	171
2410	133	205	74	114	91	0	616
2420	0	0	0	470	0	0	470
2430	337	0	40	427	380	806	1990
2500	0	0	0	38	32	106	176
2510	71	72	19	787	0	95	1044
2520	0	558	0	0	0	0	558
2540	40	47	16	0	6	27	136
2610	0	346	0	0	50	0	396
3000	525	2134	293	8496	4650	2730	18827
4000	3209	3263	1515	13818	14410	8832	45046
5000	102	482	324	503	1149	477	3037
6000	168	2167	1630	2012	1262	887	8125
7000	0	2212	595	1875	470	66	5217
8100	673	1030	1179	1383	5935	2617	12818
8200	15	14	0	7	86	0	121
8300	570	1219	136	10392	1463	111	13891
Grand Total	**20417**	**149043**	**117341**	**172566**	**173382**	**66183**	**698,932**
(in/yr)	**16**	**16**	**16**	**16**	**17**	**16**	**16**

*North Fork basin includes North Fork and N.Mid.Estuary

**Tidal St. Lucie basin includes South Fork and S.Mid.Estuary

Verification

Lake Okee			414,754
	Calculated	Total	1,113,686
	Measured		1,113,771

Table 6. Net P Loads in Pounds/year to Stream within the St. Lucie Watershed by Land Use

FLUCCS	Basins 4 5 6	C-23	C-24	C-44&S-153	North Fork*	Tidal St. Lucie**	Grand Total
1100	2115	936	606	889	4628	1632	10804
1200	1731	425	3508	441	42635	4749	53489
1300	2108	0	885	557	14353	5191	23093
1400	312	13	56	286	4835	1624	7126
1500	320	116	133	184	3726	403	4881
1600	1	272	0	0	61	89	422
1700	265	1588	52	234	3761	1244	7144
1800	656	245	639	201	2216	1003	4961
1900	31	3	21	42	922	132	1150
2110	1913	63893	64504	44052	9498	18150	202009
2120	79	4657	5579	1994	514	1007	13830
2130	330	7654	6063	5683	943	1507	22180
2140	702	7633	6976	3836	5248	11070	35465
2150	0	4668	2475	1159	0	0	8301
2156	0	0	0	3301	0	203	3504
2210	54	58439	31478	76958	37221	5446	209596
2220	0	0	0	0	0	0	0
2230	12	39	0	0	60	0	111
2310	0	938	0	0	0	0	938
2320	0	0	66	94	0	0	160
2410	291	446	161	247	198	0	1343
2420	0	0	0	741	0	0	741
2430	612	0	73	776	690	1463	3613
2500	0	0	0	52	43	145	241
2510	98	98	26	1077	0	129	1428
2520	0	3931	0	0	0	0	3931
2540	42	49	16	0	7	29	143
2610	0	152	0	0	22	0	174
3000	110	449	62	1787	978	574	3961
4000	750	763	354	3230	3369	2065	10530
5000	19	91	61	95	216	90	571
6000	13	163	122	151	95	67	611
7000	0	831	223	704	176	25	1960
8100	491	751	860	1008	4329	1908	9348
8200	5	5	0	3	31	0	44
8300	206	440	49	3748	528	40	5010
Grand Total	**13264**	**159686**	**125049**	**153531**	**141301**	**59983**	**652814**
Conc.(ppbl)	**233**	**384**	**382**	**319**	**292**	**325**	**335**
Meas.Conc.(ppb)	**219**	**481**	**343**	**203**	**278**	**285**	
Lake Okee (lbs)							**211200**
Calc. (Mt/yr)	**6**	**73**	**57**	**70**	**64**	**27**	**393**
Measured (Mt/yr)	**6**	**91**	**76**	**40**	**43**	**21**	**373**

*North Fork basin includes North Fork and N.Mid.Estuary

**Tidal St. Lucie basin includes South Fork and S.Mid.Estuary

Table 7. Net N Loads in Pounds/year to Stream within the St. Lucie Watershed by Land Use

FLUCCS	Basins 4 5 6	C-23	C-24	C-44&S-153	North Fork*	Tidal St. Lucie**	Grand Total
1100	21362	9452	6119	8978	46753	16483	109146
1200	8900	2187	18042	2267	219264	24425	275085
1300	7588	0	3186	2006	51669	18687	83136
1400	2207	89	394	2024	34194	11482	50389
1500	1199	435	500	690	13971	1510	18303
1600	5	2592	0	0	581	852	4031
1700	695	4169	137	616	9873	3265	18753
1800	4308	1605	4193	1320	14543	6585	32554
1900	399	35	269	535	11849	1700	14787
2110	10057	335944	339158	231618	49938	95428	1062143
2120	428	25057	30018	10731	2764	5416	74414
2130	1382	32093	25425	23830	3955	6321	93006
2140	2107	22899	20929	11509	15744	33209	106395
2150	0	9384	4975	2330	0	0	16689
2156	0	0	0	37729	0	2316	40045
2210	231	248366	133782	327072	158188	23144	890783
2220	0	0	0	0	0	0	0
2230	41	139	0	0	212	0	391
2310	0	5094	0	0	0	0	5094
2320	0	0	399	563	0	0	961
2410	1082	1661	599	921	738	1	5001
2420	0	0	0	2382	0	0	2382
2430	2279	0	271	2890	2569	5448	13457
2500	0	0	0	207	172	575	955
2510	773	778	203	8519	0	1024	11295
2520	0	7544	0	0	0	0	7544
2540	541	634	210	0	86	367	1838
2610	0	1365	0	0	197	0	1562
3000	1456	5917	812	23555	12893	7568	52201
4000	6028	6129	2845	25956	27069	16591	84617
5000	310	1467	987	1531	3497	1451	9243
6000	1704	21977	16535	20405	12805	8994	82420
7000	0	6981	1876	5916	1482	209	16464
8100	2464	3771	4315	5061	21722	9577	46909
8200	59	55	0	30	347	0	491
8300	2313	4947	553	42166	5936	449	56363
Grand Total	**79917**	**762762**	**616731**	**803355**	**723011**	**303076**	**3288847**
Conc.(ppb)	**1404**	**1836**	**1885**	**1670**	**1496**	**1643**	**1688**
Meas.Conc.(ppb)	**1182**	**1750**	**1609**	**1540**	**1191**	**1244**	
Lake Okee (lbs)							**2028400**
Calc. (Mt/yr)	**36**	**347**	**280**	**365**	**329**	**138**	**2417**
Measured (Mt/yr)	**34**	**330**	**355**	**300**	**185**	**91**	**2217**

*North Fork basin includes North Fork and N.Mid.Estuary

**Tidal St. Lucie basin includes South Fork and S.Mid.Estuary

Table 8. Land Use Categories, Unit Load Factors, and P Reduction Factors for the St. Lucie Watershed

Land Use Category	Land Use Description	FLUCCS	Unit P Load (lbs/acre/yr)	Estimated Phosphorus Reduction		
				Owner Implemented BMPs	Cost Share BMPs	Alternative Practices
Residential Low Density	Residential Low Density[1]	1100	0.49	5%	5%	70%
Residential Medium Density	Residential Medium Density[2]	1200	1.40	5%	5%	70%
Residential High Density	Residential High Density[2]	1300	3.00	5%	5%	70%
Other Urban	Commercial/Industrial[2]	1400-1800	1.54	5%	5%	70%
Improved Pastures	Improved Pastures	2110	1.90	11%	19%	49%
Unimproved Pastures	Unimproved Pastures	2120	0.92	7%	13%	44%
Woodland Pastures/Rangeland	Woodland/Range Pastures	2130/3000	0.66	4%	6%	35%
Row Crops	Row Crops	2140	4.50	30%	30%	50%
Sugar Cane	Sugar Cane	2156	0.63	10%	23%	52%
Citrus	Citrus	2210	1.80	12%	5%	52%
Sod Farms	Sod Farms	2420	2.52	20%	27%	50%
Ornamentals	Ornamentals	2430	2.90	32%	35%	50%
Horse Farms	Horse Farms	2510	1.82	20%	22%	49%
Dairies	Dairies	2520	9.38	9%	28%	48%
Other Areas	Other Areas	2150-2610	2.78	15%	25%	36%
Tree Plantations	Tree Plantations	4400	0.18	1%	10%	50%
Water	Water	5000	0.05	0%	0%	0%
Natural Areas	Forrests/wetlands/Open	4000/6000	0.14	0%	0%	0%
Transportation	Transportation	8100	1.65	10%	23%	52%
Communication/Utilities	Communication/Utilities	8200/8300	0.48	5%	5%	50%

1 Assumed on Septic

2 Assumed all of Discharge from WWT outside basin

Table 9. Land Use Categories, Unit Load Factors, and N Reduction Factors for the St. Lucie Watershed

Land Use Category	Land Use Description	FLUCCS	Unit N Load (lbs/acre/yr)	Estimated Nitrogen Reduction		
				Owner Implemented BMPs	Cost Share BMPs	Alternative Practices
Residential Low Density	Residential Low Density[1]	1100	4.95	15%	15%	15%
Residential Medium Density	Residential Medium Density[2]	1200	7.20	25%	25%	15%
Residential High Density	Residential High Density[2]	1300	10.80	30%	25%	15%
Other Urban	Commercial/Industrial[2]	1400-1800	7.80	25%	25%	15%
Improved Pastures	Improved Pastures	2110	9.99	17%	10%	30%
Unimproved Pastures	Unimproved Pastures	2120	4.95	11%	8%	30%
Woodland Pastures/Rangeland	Woodland/Range Pastures	2130/3000	3.69	4%	6%	20%
Row Crops	Row Crops	2140	13.50	30%	30%	50%
Sugar Cane	Sugar Cane	2156	7.20	10%	23%	52%
Citrus	Citrus	2210	7.65	10%	5%	52%
Sod Farms	Sod Farms	2420	8.10	20%	27%	50%
Ornamentals	Ornamentals	2430	10.80	25%	25%	25%
Horse Farms	Horse Farms	2510	14.40	30%	22%	30%
Dairies	Dairies	2520	18.00	20%	40%	48%
Other Areas	Other Areas	2150-2610	7.91	15%	25%	36%
Tree Plantations	Tree Plantations	4400	2.79	5%	10%	25%
Water	Water	5000	0.81	0%	0%	0%
Natural Areas	Forrests/wetlands/Open	4000/6000	1.88	0%	0%	0%
Transportation	Transportation	8100	8.28	20%	23%	25%
Communication/Utilities	Communication/Utilities	8200/8300	5.40	5%	5%	50%

1 Assumed on Septic

2 Assumed all of Discharge from WWT outside basin

Table 10. Land Use Distribution for the Caloosahatchee Watershed

Land Use Category	Land Use Description	FLUCCS	Area (ac)	Percent	Area (ac)	Percent
Residential Low Density	Residential Low Density	1100	76,863	7.12%	76,863	7.10%
Residential Medium Density	Residential Medium Density	1200	33,396	3.09%	33,396	3.10%
Residential High Density	Residential High Density	1300	11,453	1.06%	11,453	1.10%
	Commercial and Services	1400	8,906	0.82%		
	Industrial	1500	2,648	0.25%		
	Extractive	1600	2,278	0.21%		
	Institutional	1700	3,675	0.34%		
Other Urban	Recreational	1800	6,062	0.56%	23,568	2.20%
Improved Pastures	Improved Pastures	2110	117,152	10.85%	117,152	10.80%
Unimproved Pastures	Unimproved Pastures	2120	23,827	2.21%	23,827	2.20%
	Woodland Pastures	2130	20,280	1.88%		
Woodland Pastures/Rangeland	Rangeland	3000	57,850	5.36%	78,130	7.20%
Row Crops	Row Crops	2140	9,656	0.89%	9,656	0.90%
Sugar Cane	Sugar Cane	2156	87,741	8.13%	87,741	8.10%
Citrus	Citrus	2210	96,684	8.95%	96,684	9.00%
Sod Farms	Sod Farms	2420	5,070	0.47%	5,070	0.50%
Ornamentals	Ornamentals	2430	861	0.08%	861	0.10%
Horse Farms	Horse Farms	2510	202	0.02%	202	0.00%
Dairies	Dairies	2520	56	0.01%	56	0.00%
	Field Crops	2150	5,326	0.49%		
	Mixed Crops	2160	17	0.00%		
	Fruit Orchards	2220	12	0.00%		
	Other Groves	2230	1,995	0.18%		
	Tree Nurseries	2410	971	0.09%		
	Specialty Farms	2500	165	0.02%		
	Aquaculture	2540	215	0.02%		
Other Areas	Fallow Crop Land	2610	2,209	0.20%	10,909	1.00%
Tree Plantations	Tree Plantations	4400	42,498	3.94%	42,498	3.90%
Water	Water	5000	130,368	12.07%	130,368	12.10%
	Upland Forests (not including 4400's)	4000	84,379	7.81%		
	Wetlands	6000	184,666	17.10%		
	Barren Land	7000	5,866	0.54%		
Natural Areas	Open Land	1900	49,378	4.57%	324,289	30.00%
Transportation	Transportation	8100	4,915	0.46%	4,915	0.50%
	Communications	8200	96	0.01%		
Communication/Utilities	Utilities	8300	2,063	0.19%	2,159	0.20%
Total			**1,079,796**	**100.00%**	**1,079,796**	**100.00%**

Table 11. Summary of Annual Flow and Loads for TP and TN along the main stem of the Caloosahatchee River (C-43 Canal)

Calendar Year	S-77 (02292000)					S-78 (02292480)					S-79 (02292900)					Basin Between S78 and S79				
	Flow	TP Load	TP Conc.	TN Load	TN Conc.	Flow	TP Load	TP Conc.	TN Load	TN Conc.	Flow	TP Load	TP Conc.	TN Load	TN Conc.	Flow	TP Load	TP Conc.	TN Load	TN Conc.
	acre-feet	mtons	ug/L	mtons	mg/L	acre-feet	mtons	ug/L	mtons	mg/L	acre-feet	mtons	ug/L	mtons	mg/L	acre-feet	mtons	ug/L	mtons	mg/L
1990	120,575	14.0	94	237.6	1.60	174,966	33.0	153	322.4	1.49	423,951	101.0	193	936.9	1.79	248,986	68	222	614	2.00
1991	63,594	7.3	93	136.2	1.74	288,783	72.1	202	670.0	1.88	922,265	193.2	170	1,890.5	1.66	633,481	121	155	1,221	1.56
1992	193,275	22.9	96	344.7	1.45	437,933	93.2	172	756.4	1.40	943,491	406.5	349	2,198.8	1.89	505,559	313	502	1,442	2.31
1993	500,243	30.7	50	1,382.3	2.24	645,118	68.2	86	972.4	1.22	1,230,588	182.0	120	2,334.1	1.54	585,470	114	158	1,362	1.89
1994	770,253	50.7	53	1,345.0	1.42	1,044,125	119.2	93	2,201.9	1.71	1,633,414	216.6	108	3,380.2	1.68	589,289	97	134	1,178	1.62
1995	2,110,116	113.5	44	4,311.3	1.66	2,381,744	186.4	63	3,244.1	1.10	3,379,883	314.1	75	5,482.4	1.32	998,139	128	104	2,238	1.82
1996	474,489	47.0	80	797.6	1.36	568,330	58.2	83	853.6	1.22	941,009	129.5	112	1,647.2	1.42	372,680	71	155	794	1.73
1997	158,049	16.2	83	393.5	2.02	290,448	36.2	101	661.3	1.85	756,311	114.8	123	1,413.3	1.51	465,864	79	137	752	1.31
1998	1,618,473	135.5	68	2,988.8	1.50	1,831,790	204.9	91	3,216.9	1.42	2,613,724	296.8	92	4,309.0	1.34	781,933	92	95	1,092	1.13
1999	564,104	52.4	75	945.3	1.36	848,093	123.6	118	1,602.2	1.53	1,578,821	324.1	166	3,041.8	1.56	730,729	201	222	1,440	1.60
2000	477,520	104.7	178	1,683.5	2.86	409,244	47.1	93	687.8	1.36	619,878	118.6	155	1,061.9	1.39	210,634	71	275	374	1.44
2001	72,771	9.0	101	172.2	1.92	176,661	66.0	303	462.5	2.12	835,815	232.8	226	1,694.6	1.64	659,154	167	205	1,232	1.52
2002	466,052	57.4	100	969.6	1.69	888,496	154.4	141	1,774.4	1.62	1,491,120	318.2	173	3,166.7	1.72	602,624	164	220	1,392	1.87
2003	1,396,713	101.5	59	2,454.0	1.42	1,745,887	209.3	97	3,239.4	1.50	2,589,761	335.0	105	4,529.1	1.42	843,874	126	121	1,290	1.24
2004	1,120,739	127.3	92	2,146.6	1.55	1,247,980	128.0	83	1,996.4	1.30	1,853,038	230.2	101	2,815.2	1.23	605,058	102	137	819	1.10
2005	2,266,435	384.6	138	4,597.7	1.64	2,898,397	476.4	133	5,821.6	1.63	3,734,684	577.7	125	6,740.1	1.46	836,287	101	98	918	0.89
2006	353,758	65.1	149	732.9	1.68	463,033	88.2	154	856.5	1.50	920,989	193.0	170	1,689.2	1.49	457,956	105	186	833	1.47
1990-2006	**748,656**	**78.8**	**85**	**1,508.2**	**1.63**	**961,237**	**127.3**	**107**	**1,725.9**	**1.46**	**1,556,985**	**252.0**	**131**	**2,843.0**	**1.48**	**595,748**	**125**	**170**	**1,117**	**1.52**
1995-2005	**975,042**	**104.5**	**87**	**1,950.9**	**1.62**	**1,207,915**	**153.7**	**103**	**2,141.8**	**1.44**	**1,854,004**	**272.0**	**119**	**3,263.7**	**1.43**	**646,089**	**118**	**148**	**1,122**	**1.41**

Table 12. Estimated Runoff, Unit N and P Loads and Concentration for 2004 Land Uses in the Caloosahatchee Watershed

Land Use Category	Land Use Description	FLUCCS	Runoff (in/yr)	Unit N Load (lbs/acre/yr)	N Conc. (mg/l)	Unit P Load (lbs/acre/yr)	P Conc. (mg/l)
Residential Low Density	Residential Low Density[1]	1100	27.43	7.26	1.17	0.68	0.11
Residential Medium Density	Residential Medium Density[2]	1200	32.42	10.56	1.44	1.93	0.26
Residential High Density	Residential High Density[2]	1300	39.90	15.84	1.75	4.14	0.46
	Commercial and Services[2]	1400	39.90	14.52	1.61	1.93	0.21
	Industrial[2]	1500	42.39	13.20	1.38	3.31	0.35
	Extractive[2]	1600	37.41	9.24	1.09	0.91	0.11
	Institutional[2]	1700	37.41	9.24	1.09	3.31	0.39
Other Urban	Recreational[2]	1800	27.43	9.24	1.49	1.32	0.21
Improved Pastures	Improved Pastures	2110	29.93	14.65	2.16	1.93	0.29
Unimproved Pastures	Unimproved Pastures	2120	24.94	7.26	1.29	0.99	0.18
	Woodland Pastures	2130	24.94	5.41	0.96	0.83	0.15
Woodland Pastures/Rangeland	Rangeland	3000	19.95	5.41	1.20	0.25	0.06
Row Crops	Row Crops	2140	34.91	19.80	2.51	3.45	0.44
Sugar Cane	Sugar Cane	2156	29.93	10.56	1.56	0.55	0.08
Citrus	Citrus	2210	29.93	11.22	1.66	0.90	0.13
Sod Farms	Sod Farms	2420	29.93	11.88	1.75	2.79	0.41
Ornamentals	Ornamentals	2430	29.93	15.84	2.34	4.00	0.59
Horse Farms	Horse Farms	2510	24.94	21.12	3.74	2.51	0.45
Dairies	Dairies	2520	24.94	26.40	4.68	12.94	2.29
	Field Crops	2150	24.94	8.74	1.55	4.09	0.73
	Mixed Crops	2160	29.93	14.52	2.14	4.83	0.71
	Fruit Orchards	2220	29.93	11.88	1.75	3.17	0.47
	Other Groves	2230	29.93	11.88	1.75	3.17	0.47
	Cattle Feeding Operations	2310	29.93	71.35	10.54	12.37	1.83
	Poultry Feeding Operations	2320	29.93	13.20	1.95	2.07	0.31
	Tree Nurseries	2410	24.94	15.84	2.81	4.00	0.71
	Specialty Farms	2500	24.94	10.56	1.87	2.51	0.45
	Aquaculture	2540	12.47	13.20	4.68	0.97	0.34
Other Areas	Fallow Crop Land	2610	29.93	9.24	1.36	0.97	0.14
Tree Plantations	Tree Plantations	4400	14.96	4.09	1.21	0.21	0.06
Water	Water	5000	4.99	1.19	1.05	0.07	0.06
	Upland Forests (not including 4400's)	4000	14.96	3.30	0.97	0.10	0.03
	Wetlands	6000	7.48	1.98	1.17	0.01	0.01
	Barren Land	7000	37.41	9.24	1.09	1.04	0.12
Natural Areas	Open Land	1900	24.94	5.28	0.94	0.39	0.07
Transportation	Transportation	8100	49.88	12.14	1.08	2.28	0.20
	Communications	8200	27.43	7.92	1.28	0.66	0.11
Communication/Utilities	Utilities	8300	24.94	7.92	1.40	0.66	0.12

1 Assumed on Septic
2 Assumed about 70% of Discharge from WWT outside basin

Table 13. Acreage of Land Uses within the Caloosahatchee Watershed

FLUCCS	Caloosahatchee Estuary	Freshwater East	Freshwater West	Nearshore	North Coastal	S-4	Tidal	Grand Total
1100	19	3,015	14,869	4236	24,084	548	30,092	76,863
1200	65	383	1,758	1741	1,825	1,506	26,118	33,396
1300	15	59	398	983	1,434	77	8,486	11,453
1400	8	191	688	421	384	428	6,787	8,906
1500		236	445	6	23	1,264	673	2,648
1600		553	22	3	340	68	1,292	2,278
1700	0	105	245	91	475	213	2,545	3,675
1800	11	76	472	1193	1,039	257	3,014	6,062
1900	1	2,437	25,047	522	6,947	204	14,220	49,378
2110	1	36,795	55,555	231	2,381	797	21,392	117,152
2120		5,752	12,736	30	436		4,873	23,827
2130	3	5,924	10,033	67	83		4,171	20,280
2140		1,080	6,354	363	228		1,632	9,656
2150		422	1,269	8	56	38	3,533	5,326
2156		52,751	2,058			32,932		87,741
2160			17					17
2210		26,593	69,008	193		66	824	96,684
2220							12	12
2230			53	1793	6		143	1,995
2410		174	111	185		270	230	971
2420		289	2,947				1,833	5,070
2430		16	369	160	15		300	861
2500			79			17	68	165
2510		140	38				24	202
2520		18					38	56
2540		27	91				97	215
2610		133	1,124	80	68		803	2,209
3000	50	4,966	21,510	3087	8,929	278	19,030	57,850
4000	51	7,791	23,793	3396	10,881	359	38,108	84,379
4400		12,923	28,403		69		1,103	42,498
5000	15780	2,061	3,639	94206	6,848	717	7,117	130,368
6000	275	30,329	63,513	24493	21,682	1,193	43,181	184,666
7000		1,910	2,244	67	456	675	514	5,866
8100	6	741	645	36	488	330	2,668	4,915
8200		20	24		10		42	96
8300	1	388	171	62	395	268	777	2,063
Grand Tota	16,285	198,299	349,734	137653	89,583	42,504	245,738	1,079,796

Table 14. Runoff in Acre-ft/year to Streams within the Caloosahatchee Watershed by Land Use

FLUCCS	Caloosahatchee Estuary	Freshwater East	Freshwater West	Nearshore	North Coastal	S-4	Tidal	Grand Total
1100	43	6892	33990	9683	55055	1253	68788	175704
1200	176	1035	4749	4703	4930	4069	70559	90221
1300	50	196	1323	3268	4768	256	28216	38081
1400	27	635	2288	1400	1277	1423	22567	29612
1500	0	834	1572	21	81	4465	2378	9355
1600	0	1724	69	9	1060	212	4027	7101
1700	0	327	764	284	1481	664	7933	11456
1800	25	174	1079	2727	2375	587	6890	13857
1900	2	5064	52051	1085	14437	424	29551	102614
2110	2	91758	138540	576	5938	1988	53346	292148
2120	0	11953	26467	62	906	0	10127	49515
2130	6	12311	20850	139	172	0	8668	42144
2140	0	3142	18486	1056	663	0	4748	28093
2150	0	877	2637	17	116	79	7342	11068
2156	0	131548	5132	0	0	82124	0	218804
2160	0	0	42	0	0	0	0	42
2210	0	66316	172089	481	0	165	2055	241106
2220	0	0	0	0	0	0	30	30
2230	0	0	132	4471	15	0	357	4975
2410	0	362	231	384	0	561	478	2018
2420	0	721	7349	0	0	0	4571	12643
2430	0	40	920	399	37	0	748	2147
2500	0	0	164	0	0	35	141	343
2510	0	291	79	0	0	0	50	420
2520	0	37	0	0	0	0	79	116
2540	0	28	95	0	0	0	101	223
2610	0	332	2803	200	170	0	2002	5509
3000	83	8256	35760	5132	14844	462	31637	96176
4000	64	9714	29667	4234	13567	448	47516	105210
4400	0	16113	35415	0	86	0	1375	52990
5000	6559	857	1512	39154	2846	298	2958	54184
6000	171	18908	39596	15270	13517	744	26921	115128
7000	0	5954	6995	209	1421	2104	1602	18285
8100	25	3080	2681	150	2028	1372	11089	20428
8200	0	46	55	0	23	0	96	219
8300	2	806	355	129	821	557	1615	4287
Grand Total	7,235	400,330	645,938	95,245	142,636	104,289	460,562	1,856,254

Verification

Calculated Runoff	645,938
Measured Runoff	646,089
(inches)	22.17

Table 15. Net P Loads in Pounds/year to Stream within the Caloosahatchee Watershed by Land Use

FLUCCS	Caloosahatchee Estuary	Freshwater East	Freshwater West	Nearshore	North Coastal	S-4	Tidal	Grand Total
1100	13	2,039	10,054	2,864	16,286	371	20,348	51,975
1200	126	740	3,396	3,364	3,526	2,910	50,460	64,521
1300	62	244	1,648	4,070	5,937	319	35,132	47,415
1400	15	369	1,329	813	742	827	13,112	17,206
1500	-	782	1,474	20	76	4,186	2,229	8,770
1600	-	504	20	3	310	62	1,177	2,075
1700	-	348	811	301	1,573	705	8,429	12,172
1800	15	101	625	1,580	1,376	340	3,993	8,031
1900	0	942	9,678	202	2,684	79	5,495	19,080
2110	2	71,088	107,332	446	4,600	1,540	41,329	226,338
2120	-	5,715	12,654	30	433	-	4,842	23,675
2130	2	4,905	8,307	55	69	-	3,454	16,792
2140	-	3,726	21,921	1,252	787	-	5,630	33,313
2150	-	1,726	5,192	33	229	155	14,454	21,789
2156	-	29,119	1,136	-	-	18,178	-	48,433
2160	-	-	82	-	-	-	-	82
2210	-	23,854	61,900	173	-	59	739	86,726
2220	-	-	-	-	-	-	38	38
2230	-	-	168	5,691	19	-	454	6,332
2410	-	696	444	740	-	1,081	920	3,886
2420	-	806	8,215	-	-	-	5,110	14,133
2430	-	64	1,477	640	60	-	1,201	3,446
2500	-	-	198	-	-	43	171	414
2510	-	352	95	-	-	-	60	507
2520	-	233	-	-	-	-	492	725
2540	-	26	88	-	-	-	94	208
2610	-	128	1,086	77	66	-	776	2,134
3000	12	1,234	5,343	767	2,218	69	4,727	14,370
4000	5	753	2,298	328	1,051	35	3,681	8,151
4400	-	2,675	5,879	-	14	-	228	8,797
5000	1,089	142	251	6,500	473	49	491	8,995
6000	4	419	876	338	299	16	596	2,548
7000	-	1,977	2,323	69	472	699	532	6,071
8100	14	1,687	1,469	82	1,111	751	6,075	11,191
8200	-	13	16	-	7	-	28	64
8300	1	257	113	41	262	178	515	1,367
Grand Total	1,360	157,662	277,903	30,481	44,679	32,652	237,011	781,770

Verification Data for Freshwater West

Calculated	277,903	lbs/year
	0.158	mg/l
Measured	260,240	lbs/year
	0.148	mg/l

Table 16. Net N Loads in Pounds/year to Stream within the Caloosahatchee Watershed by Land Use

FLUCCS	Caloosahatchee Estuary	Freshwater East	Freshwater West	Nearshore	North Coastal	S-4	Tidal	Grand Total
1100	138	21,889	107,949	30,753	174,850	3,978	218,468	558,025
1200	686	4,044	18,564	18,385	19,272	15,903	275,806	352,662
1300	238	935	6,304	15,571	22,715	1,220	134,418	181,416
1400	116	2,773	9,990	6,113	5,576	6,215	98,547	129,315
1500	-	3,115	5,874	79	304	16,685	8,884	34,954
1600	-	5,110	203	28	3,142	628	11,938	21,049
1700	-	970	2,264	841	4,389	1,968	23,516	33,957
1800	102	702	4,361	11,023	9,600	2,375	27,849	56,013
1900	5	12,867	132,248	2,756	36,680	1,077	75,082	260,716
2110	15	539,120	813,992	3,385	34,886	11,678	313,436	1,716,511
2120	-	41,760	92,463	218	3,165	-	35,378	172,984
2130	16	32,061	54,299	363	449	-	22,573	109,755
2140	-	21,384	125,809	7,187	4,514	-	32,314	191,189
2150	-	3,689	11,093	70	490	332	30,883	46,556
2156	-	557,051	21,732	-	-	347,762	-	926,545
2160	-	-	247	-	-	-	-	247
2210	-	298,373	774,270	2,165	-	741	9,245	1,084,794
2220	-	-	-	-	-	-	143	143
2230	-	-	630	21,301	71	-	1,699	23,701
2410	-	2,756	1,758	2,930	-	4,277	3,643	15,381
2420	-	3,433	35,010	-	-	-	21,776	60,232
2430	-	253	5,845	2,534	238	-	4,752	13,638
2500	-	-	834	-	-	180	718	1,742
2510	-	2,957	803	-	-	-	507	4,266
2520	-	475	-	-	-	-	1,003	1,478
2540	-	356	1,201	-	-	-	1,280	2,838
2610	-	1,229	10,386	739	628	-	7,420	20,411
3000	271	26,876	116,412	16,707	48,324	1,505	102,990	313,084
4000	168	25,710	78,517	11,207	35,907	1,185	125,756	278,451
4400	-	52,881	116,225	-	282	-	4,513	173,902
5000	18,747	2,448	4,323	111,917	8,135	852	8,455	154,877
6000	545	60,051	125,756	48,496	42,930	2,362	85,498	365,639
7000	-	17,648	20,735	619	4,213	6,237	4,749	54,202
8100	73	8,999	7,833	437	5,926	4,008	32,400	59,688
8200	-	158	190	-	79	-	333	760
8300	8	3,073	1,354	491	3,128	2,123	6,154	16,339
Grand Tota	21,127	1,755,149	2,709,474	316,316	469,895	433,288	1,732,127	7,437,458

Verification

Calculated	2,709,474	lbs/year
	1.543	mg/l
Measured	2,468,224	lbs/year
	1.405	mg/l

Table 17. Land Use Categories, Unit Load Factors, and P Reduction Factors for the Caloosahatchee Watershed

Land Use Category	Land Use Description	FLUCCS	Unit P Load (lbs/acre/yr)	Estimated Phosphorus Reduction		
				Owner Implemented BMPs	Cost Share BMPs	Alternative Practices
Residential Low Density	Residential Low Density[1]	1100	0.68	5%	5%	70%
Residential Medium Density	Residential Medium Density[2]	1200	1.93	5%	5%	70%
Residential High Density	Residential High Density[2]	1300	4.14	5%	5%	70%
Other Urban	Commercial/Industrial[2]	1400-1800	2.05	5%	5%	70%
Improved Pastures	Improved Pastures	2110	1.93	11%	19%	49%
Unimproved Pastures	Unimproved Pastures	2120	0.99	7%	13%	44%
Woodland Pastures/Rangeland	Woodland/Range Pastures	2130/3000	0.40	4%	6%	35%
Row Crops	Row Crops	2140	3.45	30%	30%	50%
Sugar Cane	Sugar Cane	2156	0.55	10%	23%	52%
Citrus	Citrus	2210	0.90	12%	20%	42%
Sod Farms	Sod Farms	2420	2.79	20%	27%	50%
Ornamentals	Ornamentals	2430	4.00	32%	35%	50%
Horse Farms	Horse Farms	2510	2.51	20%	22%	49%
Dairies	Dairies	2520	12.94	9%	28%	48%
Other Areas	Other Areas	2150-2610	3.20	15%	25%	36%
Tree Plantations	Tree Plantations	4400	0.21	1%	10%	50%
Water	Water	5000	0.07	0%	0%	0%
Natural Areas	Forrests/wetlands/Open	4000/6000	0.11	0%	0%	0%
Transportation	Transportation	8100	2.28	10%	23%	52%
Communication/Utilities	Communication/Utilities	8200/8300	0.66	5%	5%	50%

1 Assumed on Septic

2 Assumed about 70% of Discharge from WWT outside basin

Table 18. Land Use Categories, Unit Load Factors, and N Reduction Factors for Caloosahatchee Watershed

Land Use Category	Land Use Description	FLUCCS	Unit N Load (lbs/acre/yr)	Estimated Nitrogen Reduction		
				Owner Implemented BMPs	Cost Share BMPs	Alternative Practices
Residential Low Density	Residential Low Density[1]	1100	7.26	15%	15%	15%
Residential Medium Density	Residential Medium Density[2]	1200	10.56	25%	25%	15%
Residential High Density	Residential High Density[2]	1300	15.84	30%	25%	15%
Other Urban	Commercial/Industrial[2]	1400-1800	11.68	25%	25%	15%
Improved Pastures	Improved Pastures	2110	14.65	17%	10%	30%
Unimproved Pastures	Unimproved Pastures	2120	7.26	11%	8%	30%
Woodland Pastures/Rangeland	Woodland/Range Pastures	2130/3000	5.41	4%	6%	20%
Row Crops	Row Crops	2140	19.80	30%	30%	50%
Sugar Cane	Sugar Cane	2156	10.56	10%	23%	52%
Citrus	Citrus	2210	11.22	10%	20%	42%
Sod Farms	Sod Farms	2420	11.88	20%	27%	50%
Ornamentals	Ornamentals	2430	15.84	25%	25%	25%
Horse Farms	Horse Farms	2510	21.12	30%	22%	30%
Dairies	Dairies	2520	26.40	20%	40%	48%
Other Areas	Other Areas	2150-2610	10.18	15%	25%	36%
Tree Plantations	Tree Plantations	4400	4.09	5%	10%	25%
Water	Water	5000	1.19	0%	0%	0%
Natural Areas	Forrests/wetlands/Open	4000/6000	2.96	0%	0%	0%
Transportation	Transportation	8100	12.14	20%	23%	25%
Communication/Utilities	Communication/Utilities	8200/8300	7.92	5%	5%	50%

1 Assumed on Septic

2 Assumed about 70% of Discharge from WWT outside basin

Appendix A
Current condition assumptions, existing loads, potential load reductions, and costs of implementation for the primary land uses in the St. Lucie River watershed

Table of Contents for BMP Assessment Tables

BMPs for Low Density Residential

Assume for Typical Condition

Low Density Residential		
Assumed average development size of 200 ac		
Moderately Managed Lawns		
Limited Pond retention		
Limited Lawn Irrigation		
Existing P Load	0.49	lbs-P/ac/yr
Existing P Concentration	0.12	mg/l
Average Annual Runoff	17.57	in/yr

BMPs	Type	P Reduction[1]		Initial Cost	Annual Cost[3]		Quickness
		Range	Typical	of BMP[2]	per acre	P Removed	of
		%	%	($/ac)	($/ac/yr)	($/lb/ac/yr)	Response
Fertility							
Reduced P Fertilization (testing, placement, and type)	Owner	0 to10	5	0	0	0	Slow
Dry Retention/Swales 0.25"	Cost share	20 to 80	50	6400	2048	8359	Fast
Wet Detention - 0.25"	Cost share	30 to 90	80	8000	2560	6531	Fast
Street Sweeping	Cost share	0 to 25	15	20	6.4	87	Fast
Sediment/Baffle Boxes	Cost share	10 to 60	20	440	140.8	1437	Fast
Dry Detention - Regional	Alternative	15 to 35	25	3200	1024	8359	Fast
Wet Detention - Regional	Alternative	40 to 80	65	4000	1280	4019	Fast
Stormwater R/D and Chemical Treatment[4]	Alternative	20 to 90	70	3200	1024	2985	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMPs

2 Costs presented on per acre of entire development basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.

3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.

4 High O&M Costs

Program	Range %	Typical %	Initial Cost ($/ac)	per acre ($/ac/yr)	P Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced P Fertilization, Swales, and limited Dry Retention/Sweeping	0 to 20	10	6400	2048	41796	Moderate
Owner BMP Program Reduced P Fertilization	0 to 10	5	0	0	0	Slow
Cost Share BMP Program Limited Dry Retention, Street Sweeping, Sediment R/D and Wetland Restoration	5 to 50	5	6400	2048	83592	Fast
Alternative BMP Program Stormwater R/D with Chemical Treatment	20 to 90	70	3200	1024	2985	Fast

BMPs for Medium Density Residential

Assume for Typical Condition

Medium Density Residential		
Assumed average development size of 200 ac		
Moderately Managed Lawns		
Limited Pond retention		
Limited Lawn Irrigation		
Existing P Load	1.40	lbs-P/ac/yr
Existing P Concentration	0.30	mg/l
Average Annual Runoff	20.76	in/yr

BMPs	**Type**	**P Reduction[1]** Range %	Typical %	**Initial Cost of BMP[2]** ($/ac)	**Annual Cost[3]** **per acre** ($/ac/yr)	**P Removed** ($/lb/ac/yr)	**Quickness of Response**
Fertility							
Reduced P Fertilization (testing, placement, and type)	Owner	0 to10	5	0	0	0	Slow
Dry Retention/Swales 0.25"	Cost share	20 to 80	50	6400	2048	2926	Fast
Wet Detention - 0.25"	Cost share	30 to 90	80	8000	2560	2286	Fast
Street Sweeping	Cost share	0 to 25	15	20	6.4	30	Fast
Sediment/Baffle Boxes	Cost share	10 to 60	20	440	140.8	503	Fast
Dry Detention - Regional	Alternative	15 to 35	25	3200	1024	2926	Fast
Wet Detention - Regional	Alternative	40 to 80	65	4000	1280	1407	Fast
Stormwater R/D and Chemical Treatment[4]	Alternative	20 to 90	70	3200	1024	1045	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMPs
2 Costs presented on per acre of entire development basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

	Range %	Typical %	Initial Cost ($/ac)	per acre ($/ac/yr)	P Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced P Fertilization, Swales, and limited Dry Retention/Sweeping	0 to 20	10	6400	2048	14629	Moderate
Owner BMP Program Reduced P Fertilization	0 to 10	5	0	0	0	Slow
Cost Share BMP Program Limited Dry Retention, Street Sweeping, Sediment R/D and Wetland Restoration	5 to 50	5	6400	2048	29257	Fast
Alternative BMP Program Stormwater R/D with Chemical Treatment	20 to 90	70	3200	1024	1045	Fast

BMPs for High Density Residential

Assume for Typical Condition

High Density Residential		
Assumed average development size of 200 ac		
Moderately Managed Lawns		
Limited Pond retention		
Limited Lawn Irrigation		
Existing P Load	3.00	lbs-P/ac/yr
Existing P Concentration	0.55	mg/l
Average Annual Runoff	23.96	in/yr

BMPs	Type	P Reduction[1]		Initial Cost of BMP[2]	Annual Cost[3]		Quickness of Response
		Range %	Typical %	($/ac)	per acre ($/ac/yr)	P Removed ($/lb/ac/yr)	
Fertility							
Reduced P Fertilization (testing, placement, and type)	Owner	0 to10	5	0	0	0	Slow
Dry Retention/Swales 0.25"	Cost share	20 to 80	50	6400	2048	1365	Fast
Wet Detention - 0.25"	Cost share	30 to 90	80	8000	2560	1067	Fast
Street Sweeping	Cost share	0 to 25	15	20	6.4	14	Fast
Sediment/Baffle Boxes	Cost share	10 to 60	20	440	140.8	235	Fast
Dry Detention - Regional	Alternative	15 to 35	25	3200	1024	1365	Fast
Wet Detention - Regional	Alternative	40 to 80	65	4000	1280	656	Fast
Stormwater R/D and Chemical Treatment[4]	Alternative	20 to 90	70	3200	1024	488	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMPs
2 Costs presented on per acre of entire development basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Owner/Cost Share BMP Program Reduced P Fertilization, Swales, and limited Dry Retention/Sweeping	0 to 20	10	6400	2048	6827	Moderate
Owner BMP Program Reduced P Fertilization	0 to 10	5	0	0	0	Slow
Cost Share BMP Program Limited Dry Retention, Street Sweeping, Sediment R/D and Wetland Restoration	5 to 50	5	6400	2048	13653	Fast
Alternative BMP Program Stormwater R/D with Chemical Treatment	20 to 90	70	3200	1024	488	Fast

BMPs for Other Urban

Assume for Typical Condition

Medium Density Residential with Mixed Commercial
Assumed average development size of 200 ac
Moderately Managed Lawns
Limited Pond retention
Limited Lawn Irrigation

Existing P Load	1.54	lbs-P/ac/yr
Existing P Concentration	0.30	mg/l
Average Annual Runoff	22.80	in/yr

BMPs	**Type**	**P Reduction**[1]		**Initial Cost of BMP**[2]	**Annual Cost**[3]		**Quickness of Response**
		Range %	Typical %	($/ac)	**per acre** ($/ac/yr)	**P Removed** ($/lb/ac/yr)	
Fertility							
Reduced P Fertilization (testing, placement, and type)	Owner	0 to10	5	0	0	0	Slow
Dry Retention/Swales 0.25"	Cost share	20 to 80	50	6400	2048	2656	Fast
Wet Detention - 0.25"	Cost share	30 to 90	80	8000	2560	2075	Fast
Street Sweeping	Cost share	0 to 25	15	20	6.4	28	Fast
Sediment/Baffle Boxes	Cost share	10 to 60	20	440	140.8	456	Fast
Dry Detention - Regional	Alternative	15 to 35	25	3200	1024	2656	Fast
Wet Detention - Regional	Alternative	40 to 80	65	4000	1280	1277	Fast
Stormwater R/D and Chemical Treatment[4]	Alternative	20 to 90	70	3200	1024	949	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMPs
2 Costs presented on per acre of entire development basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

	Range %	Typical %	Initial Cost ($/ac)	per acre ($/ac/yr)	P Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced P Fertilization, Swales, and limited Dry Retention/Sweeping	0 to 20	10	6400	2048	13279	Moderate
Owner BMP Program Reduced P Fertilization	0 to 10	5	0	0	0	Slow
Cost Share BMP Program Limited Dry Retention, Street Sweeping, Sediment R/D and Wetland Restoration	5 to 50	5	6400	2048	26558	Fast
Alternative BMP Program Stormwater R/D with Chemical Treatment	20 to 90	70	3200	1024	949	Fast

BMPs for Cow Calf Production

Improved Pastures

Assume for Typical Condition

- 3 ac / cow
- Assumed average farm size of 500 ac
- Existing P fertilization of 3 lbs P/ac
- No retention or wetland restoration
- Bahia grass
- Animals have access to streams

Existing P Load	1.90	lbs-P/ac/yr
Existing P Concentration	0.44	mg/l
Average Annual Runoff	19.16	in/yr

BMPs	**Type**	**P Reduction[1]**		**Initial Cost**	**Annual Cost[3]**		**Quickness**
		Range	Typical	**of BMP[2]**	**per acre**	**P Removed**	**of**
		%	%	($/ac)	($/ac/yr)	($/lb/ac/yr)	**Response**
Fertility							
Reduced P Fertilization (testing, split, placement, and type)	Owner	0 to 30	10	2.2	2.2	12	Slow
Better N and Micros Fertilization	Owner	0 to 20	3	5.5	5.5	96	Slow
Grass Management (variety, mowing, burning, irrigation, etc.)	Owner	0 to 20	2	5.5	1.76	46	Slow
Improved Grazing Management							
Rotational Grazing	Cost share	0 to 30	3	5.5	1.76	31	Moderate
Reduced Stocking Rate[4] (4ac /cow)	Owner	0 to 10	3	165	52.8	926	Slow
HIA and Direct Water Access Prevention							
Improved Watering Facilities to move cattle from streams	Cost share	0 to 20	10	11	3.52	19	Fast
Provide Alternative Shade to move cattle from streams	Alternative	0 to 10	2	16.5	5.28	139	Fast
Feeder/Minerals and Water Placement	Owner	0 to 30	3	2.2	0.704	12	Fast
Critical Area Fencing	Cost share	2 to 20	5	44	14.08	148	Fast
Retention Basin by Working Pens	Cost share	2 to 10	5	3.3	1.056	11	Fast
Buffer Strips	Cost share	0 to 10	5	44	14.08	148	Fast
Stormwater R/D	Cost share	5 to 40	15	44	14.08	49	Fast
Wetland Restoration	Cost share	2 to 15	5	11	3.52	37	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[5]	Alternative	20 to 90	70	220	70.4	53	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 This practice would typically be unacceptable to most farmers, but if significant feed is being purchased then it should be considered
5 High O&M Costs

	Range %	Typical %	Initial Cost ($/ac)	Annual Cost per acre ($/ac/yr)	P Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program P reduced to zero, Better N Management, Rotational Grazing, New Water Facilities, Retention Basin by Working Pens, Improved Grass Management, Feed Placement, Critical Area Fencing, and Moderate Wetland Restoration/Retention	10 to 50	30	49.5	15.84	28	Moderate
Owner BMP Program P Reduced to zero, Better N Management, Grass Management, and Feeder/Minerals and Water Placement	0 to 25	11	11	4	17	Slow
Cost Share BMP Program Rotational Grazing, New Water Facilities, Retention Basin by Working Pens, Critical Area Fencing, and Moderate Wetland Restoration/Retention	10 to 50	19	38.5	12	34	Moderate
Alternative BMP Program Provide Alternative Shade to move cattle from streams and Edge-of-farm Stormwater R/D and Chemical Treatment	20 to 90	49	110	35	38	Fast

BMPs for Cow Calf Production

Unimproved Pasture

Assume for Typical Condition

8 ac per cow		
Assumed average farm size of 500 ac		
Existing P fertilization of 1 lbs P/ac		
No retention or wetland restoration		
Bahia grass / native		
Animals have access to streams		
Existing P Load	0.92	lbs-P/ac/yr
Existing P Concentration	0.25	mg/l
Average Annual Runoff	15.97	in/yr

BMPs	**Type**	**P Reduction**[1]		**Initial Cost of BMP**[2] ($/ac)	**Annual Cost**[3]		**Quickness of Response**
		Range %	Typical %		**per acre** ($/ac/yr)	**P Removed** ($/lb/ac/yr)	
Fertility							
Better N and Micros Fertilization - No P added	Owner	0 to 10	1	2.2	2.2	239	Slow
Grass Management (chopping, mowing, burning, etc.)	Owner	0 to 10	2	2.2	0.704	38	Slow
Improved Grazing Management							
Rotational Grazing (limited)	Cost share	0 to 5	3	5.5	1.76	64	Moderate
HIA and Direct Water Access Prevention							
Improved Watering Facilities to move cattle from streams	Owner	0 to 10	5	5.5	1.76	38	Fast
Feeder/Minerals and Water Placement	Owner	0 to 10	3	2.2	0.704	26	Fast
Critical Area Fencing	Alternative	2 to 10	3	11	3.52	128	Fast
Retention Basin by Working Pens	Cost share	2 to 10	3	3.3	1.056	38	Fast
Stormwater R/D	Cost share	2 to 15	7	22	7.04	109	Fast
Wetland Restoration	Cost share	2 to 10	4	11	3.52	96	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	20 to 70	50	110	35.2	77	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP

2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.

3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.

4 High O&M Costs

Owner/Cost Share BMP Program Some rotational grazing, new water facilities, retention basin basin by working pens, improved grass management, feed placement, and moderate wetland restoration/retention	5 to 30	20	13.2	4.224	23	Moderate
Owner BMP Program Improved Grass Management, Watering Facilities, and Feed Placement	0 to 20	7	2.2	1	11	Slow
Cost Share BMP Program Some Rotational Grazing, retention basin basin by working pens, and moderate wetland restoration/retention	5 to 25	13	11	4	29	Moderate
Alternative BMP Program Critical Area Fencing and Edge-of-farm Stormwater R/D and Chemical Treatment	20 to 70	44	55	18	43	Fast

BMPs for Cow Calf Production

Rangeland and Wooded Pasture

Assume for Typical Condition

16ac per cow		
Assumed average farm size of 500 ac		
Existing P fertilization of 0 lbs P/ac		
No retention or wetland restoration		
Bahia grass / native		
Animals have access to streams		
Existing P Load	0.66	lbs-P/ac/yr
Existing P Concentration	0.18	mg/l
Average Annual Runoff	15.97	in/yr

BMPs	Type	P Reduction[1]		Initial Cost of BMP[2]	Annual Cost[3]		Quickness of Response
		Range %	Typical %	($/ac)	per acre ($/ac/yr)	P Removed ($/lb/ac/yr)	
Fertility							
Better N and Micros Fertilization - No P added	Owner	0 to 10	1	2.2	2.2	331	Slow
Grass Management (chopping, mowing, burning, etc.)	Owner	0 to 10	2	2.2	0.704	53	Slow
Improved Grazing Management							
Rotational Grazing (limited)	Cost share	0 to 5	3	5.5	1.76	88	Moderate
HIA and Direct Water Access Prevention							
Improved Watering Facilities to move cattle from streams	Owner	0 to 10	5	5.5	1.76	53	Fast
Feeder/Minerals and Water Placement	Owner	0 to 10	3	2.2	0.704	35	Fast
Critical Area Fencing	Alternative	2 to 10	3	11	3.52	177	Fast
Retention Basin by Working Pens	Cost share	2 to 10	3	3.3	1.056	53	Fast
Stormwater R/D	Cost share	2 to 20	10	22	7.04	106	Fast
Wetland Restoration	Cost share	2 to 10	4	11	3.52	132	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	20 to 70	40	110	35.2	132	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Program	Range %	Typical %	Initial Cost ($/ac)	per acre ($/ac/yr)	P Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Some rotational grazing, new water facilities, retention basin basin by working pens, improved grass management, feed placement, and moderate wetland restoration/retention	5 to 30	10	13.2	4.224	64	Moderate
Owner BMP Program Improved Grass Management, Watering Facilities, and Feed Placement	0 to 20	4	2.2	1	26	Slow
Cost Share BMP Program Some Rotational Grazing, retention basin basin by working pens, and moderate wetland restoration/retention	5 to 25	6	11	4	88	Moderate
Alternative BMP Program Critical Area Fencing and Edge-of-farm Stormwater R/D and Chemical Treatment	20 to 70	35	55	18	76	Fast

BMPs for Row Crop

Assume for Typical Condition

Potatoes Spring Crop
Assumed average farm size of 100 ac
Existing P fertilization of 100 lbs P/ac
No retention or wetland restoration
Seepage Irrigation with 60' furrows

Existing P Load	4.50	lbs-P/ac/yr
Existing P Concentration	0.89	mg/l
Average Annual Runoff	22.36	in/yr

BMPs	**Type**	**P Reduction[1]**		**Initial Cost of BMP[2]**	**Annual Cost[3]**		**Quickness of Response**
		Range %	Typical %	($/ac)	**per acre** ($/ac/yr)	**P Removed** ($/lb/ac/yr)	
Fertility							
Reduced P Fertilization (testing, split, placement, and type)	Owner	20 to 70	30	11	11	8	Slow
Water Management (irrigation and drainage, riser board control)	Cost share	0 to 40	10	11	3.52	8	Fast
Water Reuse from Retention/Detention Ponds	Alternative	0 to 20	10	33	10.56	23	Fast
Erosion Control (sediment trap in front of risers)	Alternative	0 to 5	2	11	3.52	39	Fast
Off Season In-Field Retention	Cost share	0 to 15	5	11	3.52	16	Fast
Off Season Cover Crop	Cost share	0 to 10	4	55	17.6	98	Fast
Stormwater R/D	Cost share	10 to 55	25	220	70.4	63	Fast
Wetland Restoration	Cost share	5 to 20	10	11	3.52	8	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	20 to 90	50	550	176	78	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

	Range %	Typical %	Initial Cost ($/ac)	per acre ($/ac/yr)	P Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced P Fertilization, Water Management, additional Stormwater Retention, Cover Crop, and limited Wetland Restoration/Retention	10 to 80	60	220	70.4	26	Moderate
Owner BMP Program Reduced P Fertilization	20 to 70	30	11	3.52	3	Slow
Cost Share BMP Program Water Management, additional Stormwater Retention, Cover Crop, and limited Wetland Restoration/Retention	10 to 50	30	209	66.88	50	Fast
Alternative BMP Program Water Reuse from Retention/Detention Ponds, Erosion Control, and Edge-of-farm stormwater R/D and Chemical Treatment	20 to 90	50	440	140.8	63	Fast

BMPs for Sugarcane

Assume for Typical Condition

3 year ratoon
Assumed average farm size of 400 ac
Existing P fertilization of 30 lbs P/ac
Limited retention or wetland restoration
Seepage Irrigation with 330' furrows

Existing P Load	0.63	lbs-P/ac/yr
Existing P Concentration	0.15	mg/l
Average Annual Runoff	19.16	in/yr

BMPs	**Type**	**P Reduction[1]**		**Initial Cost of BMP[2]**	**Annual Cost[3]**		**Quickness of Response**
		Range %	Typical %	($/ac)	**per acre** ($/ac/yr)	**P Removed** ($/lb/ac/yr)	
Fertility pH management		0 to 20	10	0	0	0	Fast
Reduced P Fertilization (testing, split, placement, and type)	Owner	10 to 50	20	0	0	0	Slow
Water Management (irrigation and drainage, in-field retention)	Cost share	0 to 20	10	11	3.52	56	Fast
Water Reuse from Retention/Detention Ponds	Alternative	0 to 20	10	33	10.56	168	Fast
Stormwater R/D	Cost share	5 to 45	15	110	35.2	372	Fast
Wetland Restoration	Cost share	2 to 15	7	11	3.52	80	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	20 to 90	70	220	70.4	160	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Program	Range %	Typical %	Initial Cost of BMP ($/ac)	Annual Cost per acre ($/ac/yr)	Annual Cost P Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced P fertilization, water management, and limited wetland restoration/retention	10 to 70	33	110	35	169	Moderate
Owner BMP Program Reduced P Fertilization	10 to 50	10	2.2	0	0	Slow
Cost Share BMP Program Water Management and limited Wetland Restoration/Retention	10 to 60	23	107.8	34	238	Fast
Alternative BMP Program Water Reuse from Retention/Detention Ponds and Edge-of-farm stormwater R/D and Chemical Treatment	20 to 90	52	275	88	269	Fast

BMPs for Citrus

Assume for Typical Condition		
Two row crown bedded		
Assumed average farm size of 200 ac		
Grass Management between Trees		
Pond retention with limited wetland restoration		
Micro jet irrigation and fertigation of young stock		
Existing P Load	1.80	lbs-P/ac/yr
Existing P Concentration	0.41	mg/l
Average Annual Runoff	19.16	in/yr

BMPs	Type	P Reduction[1]		Initial Cost	Annual Cost[3]		Quickness
		Range	Typical	of BMP[2]	per acre	P Removed	of
		%	%	($/ac)	($/ac/yr)	($/lb/ac/yr)	Response
Fertility							
Reduced P Fertilization (testing, placement, and type)	Owner	0 to 25	10	0	0	0	Slow
Better N and Micros Fertilization	Owner	0 to 5	2	0	0	0	Slow
Water Management (irrigation and drainage)	Cost share	0 to 20	5	0	0	0	Fast
Water Reuse from Retention/Detention Ponds[4]	Alternative	0 to 50	10	33	10.56	59	Fast
Grass Management between Trees	Owner	0 to 5	2	22	7.04	196	Moderate
Grassed Waterways	Alternative	0 to 15	5	110	35.2	391	Fast
Stormwater R/D[5]	Alternative	10 to 60	40	440	140.8	196	Fast
Wetland Restoration	Alternative	5 to 20	10	44	14.08	78	Fast
Edge-of-farm Stormwater R/D and Chemical Treatment[6]	Alternative	20 to 90	70	220	70.4	56	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 Values shown are for using existing ponds for water reuse, if new facilities are needed then cost would increase significantly.
5 Average of pre/post 1984 stormwater management requirements, i.e. P > .6ppm if developed prior to 1984 and less if developed after 1984.
Groves developed after 1984 would probably have stormwater R/D systems, so little addition benefit would be expected for newer groves.
6 High O&M Costs

Program	Range %	Typical %	Initial Cost ($/ac)	Annual Cost per acre ($/ac/yr)	P Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced P Fertilization, Better N Management, Grass Management between Trees, additional Stormwater Retention, and limited Wetland Restoration/Retention	10 to 50	17	75	24	245	Moderate
Owner BMP Program Reduced P Fertilization, Better N Management, and Grass Management between Trees	0 to 25	12	5.5	0	0	Slow
Cost Share BMP Program Water Management (irrigation and drainage)	0 to 20	5	77	24.64	274	Fast
Alternative BMP Program Fertigation, Grassed Waterways, and Edge-of-farm Stormwater R/D with Chemical Treatment	20 to 90	52	242	77	83	Fast

BMPs for Sod / Turf Grass

Assume for Typical Condition

Bermudagrass		
Assumed average farm size of 100 ac		
Existing P fertilization of 70 lbs P/ac		
No retention or wetland restoration		
Seepage Irrigation with 100' furrows		
Existing P Load	2.52	lbs-P/ac/yr
Existing P Concentration	0.58	mg/l
Average Annual Runoff	19.16	in/yr

BMPs	**Type**	**P Reduction[1]**		**Initial Cost of BMP[2]**	**Annual Cost[3]**		**Quickness of Response**
		Range %	Typical %	($/ac)	**per acre** ($/ac/yr)	**P Removed** ($/lb/ac/yr)	
Fertility							
Reduced P Fertilization (testing, split, placement, and type)	Owner	10 to 50	20	2.2	2.2	4	Slow
Water Management (irrigation and drainage, riser board control)	Cost Share	0 to 20	10	11	3.52	14	Fast
Erosion Control (Buffer Strips and sediment traps)	Alternative	0 to 15	5	55	17.6	140	Fast
Stormwater R/D	Cost Share	5 to 40	25	110	35.2	56	Fast
Wetland Restoration	Cost Share	2 to 15	8	11	3.52	17	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	20 to 90	50	330	105.6	84	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
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3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Owner/Cost Share BMP Program Reduced P fertilization, water management, additional stormwater retention, and limited wetland restoration	10 to 70	47	110	35.2	30	Moderate
Owner BMP Program Reduced P Fertilization	10 to 50	20	2.2	2.2	4	Slow
Cost Share BMP Program Water Management, additional Stormwater Retention, Cover Crop, and limited Wetland Restoration/Retention	10 to 50	27	107.8	34	51	Fast
Alternative BMP Program Erosion Control, and Edge-of-farm stormwater R/D and Chemical Treatment	20 to 70	50	330	105.6	84	Fast

BMPs for Ornamentals

Assume for Typical Condition

Ornamental Nursery
Assumed average farm size of 10 ac
Existing P fertilization of 160 lbs P/ac
No retention or wetland restoration
Overhead Irrigation

Existing P Load	2.90	lbs-P/ac/yr
Existing P Concentration	0.67	mg/l
Average Annual Runoff	19.16	in/yr

BMPs	Type	P Reduction[1]		Initial Cost of BMP[2]	Annual Cost[3]		Quickness of Response
		Range %	Typical %	($/ac)	per acre ($/ac/yr)	P Removed ($/lb/ac/yr)	
Fertility							
Reduced P Fertilization (testing, split, placement, and type)	Owner	20 to 70	30	11	11	13	Slow
Water Management (irrigation and drainage, riser board control)	Cost share	0 to 40	10	11	4	12	Fast
Water Reuse from Retention/Detention Ponds	Alternative	0 to 20	10	33	11	36	Fast
Erosion Control (sediment trap in front of risers)	Alternative	0 to 5	2	11	4	61	Fast
Off Season In-Field Retention	Cost share	0 to 15	5	11	4	24	Fast
Off Season Cover Crop	Cost share	0 to 10	4	55	18	152	Fast
Stormwater R/D	Cost share	10 to 65	40	220	70	61	Fast
Wetland Restoration	Cost share	0 to 10	4	11	4	30	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	20 to 90	50	550	176	121	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
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3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

BMP Program	Range %	Typical %	Initial Cost ($/ac)	per acre ($/ac/yr)	P Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced P Fertilization, Water Management, additional Stormwater Retention, Cover Crop, and limited Wetland Restoration/Retention	10 to 80	67	220	70	36	Moderate
Owner BMP Program Reduced P Fertilization	20 to 70	32	11	4	4	Slow
Cost Share BMP Program Water Management, additional Stormwater Retention, Cover Crop, and limited Wetland Restoration/Retention	10 to 50	35	209	67	66	Fast
Alternative BMP Program Water Reuse from Retention/Detention Ponds, Erosion Control, and Edge-of-farm stormwater R/D and Chemical Treatment	20 to 90	50	440	141	97	Fast

BMPs for Horse Farms

Assume for Typical Condition

1 ac / horse		
Assumed average farm size of 10 ac		
Existing P fertilization of 5 lbs P/ac		
No retention or wetland restoration		
Bahia grass		
Existing P Load	1.82	lbs-P/ac/yr
Existing P Concentration	0.50	mg/l
Average Annual Runoff	15.97	in/yr

BMPs	**Type**	**P Reduction**[1]		**Initial Cost of BMP**[2]	**Annual Cost**[3]		**Quickness of Response**
		Range %	Typical %	($/ac)	**per acre** ($/ac/yr)	**P Removed** ($/lb/ac/yr)	
Fertility							
Reduced P Fertilization (testing, split, placement, and type)	Owner	0 to 30	15	2.2	2.2	8	Slow
Better N and Micros Fertilization	Owner	0 to 20	10	5.5	5.5	30	Slow
Grass Management (variety, mowing, burning, irrigation, etc.)	Owner	0 to 20	2	5.5	1.76	48	Slow
Improved Grazing Management							
Rotational Grazing	Cost share	0 to 30	3	5.5	1.76	32	Moderate
Reduced Stocking Rate[4] (2ac /horse)	Owner	0 to 10	20	165	52.8	145	Slow
HIA and Direct Water Access Prevention							
Improved Watering Facilities to move animals from streams	Cost share	0 to 20	5	11	3.52	39	Fast
Provide Alternative Shade to move animals from streams	Alternative	0 to 10	1	16.5	5.28	290	Fast
Feeder/Minerals and Water Placement	Owner	0 to 30	3	2.2	0.704	13	Fast
Critical Area Fencing	Cost share	2 to 20	2	44	14.08	387	Fast
Buffer Strips	Cost share	0 to 10	5	44	14.08	155	Fast
Stormwater R/D	Cost share	5 to 40	15	44	14.08	52	Fast
Wetland Restoration	Cost share	2 to 15	5	11	3.52	39	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[5]	Alternative	20 to 90	70	220	70.4	55	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
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3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 This practice would typically be unacceptable to most farmers, but if significant feed is being purchased then it should be considered
5 High O&M Costs

Program	Range %	Typical %	Initial Cost ($/ac)	per acre ($/ac/yr)	P Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program P reduced to zero, Better N Management, Rotational Grazing, New Water Facilities, Retention Basin by Working Pens, Improved Grass Management, Feed Placement, Critical Area Fencing, and Moderate Wetland Restoration/Retention	10 to 50	42	49.5	15.84	21	Moderate
Owner BMP Program P Reduced to zero, Better N Management, Grass Management, and Feeder/Minerals and Water Placement	0 to 25	20	11	4	10	Slow
Cost Share BMP Program Rotational Grazing, New Water Facilities, Retention Basin by Working Pens, Critical Area Fencing, and Moderate Wetland Restoration/Retention	10 to 50	22	38.5	12	31	Moderate
Alternative BMP Program Provide Alternative Shade to move cattle from streams and Edge-of-farm Stormwater R/D and Chemical Treatment	20 to 90	49	110	35	39	Fast

BMPs for Dairies

Assume for Typical Condition

- 1000 head Dairy, dry cows pastured on site, 400 heifer/springers on site
- Assumed average farm size of 700 ac
- Existing P fertilization of 0 lbs P/ac
- No existing retention or wetland restoration
- Stargrass Pastures
- Animals are fenced from streams

Existing P Load	9.38	lbs-P/ac/yr
Existing P Concentration	2.59	mg/l
Average Annual Runoff	15.97	in/yr

BMPs	Type	P Reduction[1] Range %	Typical %	Initial Cost of BMP[2] ($/ac)	Annual Cost[3] per acre ($/ac/yr)	P Removed ($/lb/ac/yr)	Quickness of Response
Barn Waste							
Feed Ration Management	Owner	0 to 25	8	2.2	2.2	3	Slow
Solids Separation for Off Site Disposal	Alternative	0 to 10	3	5.5	1.76	6	Slow
Expanded Waste Storage Ponds	Alternative	----	----	----	----	----	----
Expanded Sprayfields	Alternative	----	----	----	----	----	----
Improved Pasture Management (See Cow-Calf Imp.. Pasture)	Owner	10 to 40	20	16.5	5.28	3	Moderate
Improved Forage/Sprayfield Management - P balanced, new crops	Owner	0 to 15	5	0	0	0	Slow
HIA Management							
Add Housing to Move Animals off Fields[4]	Alternative	30 to 70	50	3,929	1257	268	Slow
Stormwater Retention / Expanded Sprayfield	Alternative	20 to 70	40	440	140.8	38	Moderate
Edge-of-field Chemical Treatment[5]	Alternative	50 to 90	70	550	176	27	Fast
Buffer Strips	Alternative	0 to 10	5	44	14.08	30	Moderate
Stormwater R/D	Cost Share	15 to 50	30	1100	352	125	Fast
Wetland Restoration	Cost Share	5 to 20	10	11	3.52	4	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[5]	Alternative	50 to 90	70	550	176	27	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Value only include implementation cost, i.e. doesn't include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 Includes associated waste pond and sprayfield expansions
5 High O&M Costs

Program	Range %	Typical %	Initial Cost ($/ac)	per acre ($/ac/yr)	P Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program	20 to 65	37	1045	334.4	301	Moderate
Stormwater R/D and Wetland Restoration						
Feed Management						
Owner BMP Program	0 to 25	9	2.2	2	7	Slow
Feed Ration Management						
Cost Share BMP Program	20 to 60	28	1042.8	333.696	316	Fast
Stormwater R/D and Wetland Restoration						
Alternative BMP Program	20 to 90	48	550	176	39	Fast
Barn Waste						
Solids Separation for Off Site Disposal	0 to 10	3	6	1.76	6	Slow
Expanded Waste Storage Ponds[4]	----	----	----	----	----	----
Expanded Sprayfields[4]	----	----	----	----	----	----
HIA Management						
Add Housing to Move Animals off Fields[4]	30 to 70	50	3929	1257	268	Slow
Stormwater Retention / Expanded Sprayfield	20 to 70	40	440	141	38	Moderate
Edge-of-field Chemical Treatment[5]	50 to 90	70	550	176	27	Fast
Buffer Strips	0 to 10	5	44	14	30	Moderate
Edge-of-farm stormwater R/D and Chemical Treatment[5]	50 to 90	70	550	176	27	Fast

BMPs for Field Crop (Hayland) Production

Assume for Typical Condition

Assumed average farm size of 500 ac		
Existing P fertilization of 60 lbs P/ac		
No retention or wetland restoration		
Various Land Uses including hay, orchards, poultry, etc.		
Existing P Load	2.78	lbs-P/ac/yr
Existing P Concentration	0.77	mg/l
Average Annual Acres	15.97	in/yr

BMPs	**Type**	**P Reduction[1]**		**Initial Cost of BMP[2]**	**Annual Cost[3]**		**Quickness of Response**
		Range %	Typical %	($/ac)	**per acre** ($/ac/yr)	**P Removed** ($/lb/ac/yr)	
Fertility							
Reduced P Fertilization (testing, split, placement, and type)	Owner	0 to 50	15	2.2	2.2	5	Slow
Better N and Micros Fertilization	Owner	0 to 20	3	5.5	5.5	66	Slow
Grass Management (variety, mowing, burning, irrigation, etc.)	Owner	0 to 20	2	5.5	1.76	32	Slow
Buffer Strips	Cost share	0 to 10	5	44	14.08	101	Fast
Stormwater R/D	Cost share	10 to 40	20	55	17.6	32	Fast
Wetland Restoration	Cost share	5 to 20	10	11	3.52	13	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	20 to 90	36	220	70.4	70	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Owner/Cost Share BMP Program P reduced to zero, Better N Management, Rotational Grazing, New Water Facilities, Retention Basin by Working Pens, Improved Grass Management, Feed Placement, Critical Area Fencing, and Moderate Wetland Restoration/Retention	10 to 60	40	50	15.84	14	Moderate
Owner BMP Program P Reduced to zero, Better N Management, Grass Management, and Feeder/Minerals and Water Placement	0 to 25	15	11	4	8	Slow
Cost Share BMP Program Rotational Grazing, New Water Facilities, Retention Basin by Working Pens, Critical Area Fencing, and Moderate Wetland Restoration/Retention	10 to 50	25	39	12	18	Moderate
Alternative BMP Program Provide Alternative Shade to move cattle from streams and Edge-of-farm Stormwater R/D and Chemical Treatment	20 to 90	36	110	35	35	Fast

BMPs for Pine Plantation

Assume for Typical Condition

Planted Pine Plantation (20 yr rotation)		
Assumed average farm size of 200 ac		
Existing P fertilization of 5 lbs P/ac		
No retention or wetland restoration		
Existing P Load	0.18	lbs-P/ac/yr
Existing P Concentration	0.05	mg/l
Average Annual Runoff	15.97	in/yr

BMPs	**Type**	**P Reduction[1]**		**Initial Cost of BMP[2]**	**Annual Cost[3]**		**Quickness of Response**
		Range %	Typical %	($/ac)	**per acre** ($/ac/yr)	**P Removed** ($/lb/ac/yr)	
Reduced P Fertilization (testing, placement, and type)	Owner	0 to 10	1	0	0	0	Slow
Stormwater R/D	Cost share	2 to 15	8	22	22	1528	Fast
Wetland Restoration	Cost share	1 to 5	2	11	3.52	978	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	20 to 70	50	110	35.2	391	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP

2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.

3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.

4 High O&M Costs

Owner/Cost Share BMP Program Reduced P Fertilization, Stormwater R/D, and limited Wetland Restoration	2 to 25	11	22	22	1111	Moderate
Owner BMP Program Reduced P Fertilization	0 to 25	1	0	0	0	Slow
Cost Share BMP Program Stormwater R/D and limited Wetland Restoration	10 to 50	10	22	20	1111	Fast
Alternative BMP Program Edge-of-farm Stormwater R/D and Chemical Treatment	20 to 70	50	100	32	355	Fast

BMPs for Transportation Corridors

Assume for Typical Condition

- 50% Paved Surface
- Bahia Grass Shoulders
- Existing P fertilization of 15 lbs P/ac
- Limited retention or wetland restoration

Existing P Load	1.65	lbs-P/ac/yr
Existing P Concentration	0.27	mg/l
Average Annual Runoff	27.15	in/yr

BMPs	**Type**	**P Reduction**[1] Range %	**P Reduction**[1] Typical %	**Initial Cost of BMP**[2] ($/ac)	**Annual Cost**[3] **per acre** ($/ac/yr)	**Annual Cost**[3] **P Removed** ($/lb/ac/yr)	**Quickness of Response**
Fertility pH management		0 to 20	10	0	0	0	Fast
Reduced P Fertilization (testing, split, placement, and type)	Owner	10 to 50	20	0	0	0	Slow
Stormwater R/D	Cost share	5 to 45	15	110	35.2	142	Fast
Wetland Restoration	Cost share	2 to 15	7	11	3.52	30	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	20 to 90	70	220	70.4	61	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Program	P Reduction Range %	P Reduction Typical %	Initial Cost of BMP ($/ac)	Annual Cost per acre ($/ac/yr)	Annual Cost P Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced P fertilization, water management, and limited wetland restoration/retention	10 to 70	33	110	35	65	Moderate
Owner BMP Program Reduced P Fertilization	10 to 50	10	2.2	0	0	Slow
Cost Share BMP Program Water Management and limited Wetland Restoration/Retention	10 to 60	23	107.8	34	91	Fast
Alternative BMP Program Water Reuse from Retention/Detention Ponds and Edge-of-System stormwater R/D and Chemical Treatment	20 to 90	52	275	88	103	Fast

BMPs for Communications and Utilities

Assume for Typical Condition		
Marginally Maintained Bahia Grass		
No Pond retention		
Existing P Load	0.48	lbs-P/ac/yr
Existing P Concentration	0.13	mg/l
Average Annual Runoff	15.97	in/yr

BMPs	Type	P Reduction[1]		Initial Cost	Annual Cost[3]		Quickness
		Range %	Typical %	of BMP[2] ($/ac)	per acre ($/ac/yr)	P Removed ($/lb/ac/yr)	of Response
Fertility							
Reduced P Fertilization (testing, placement, and type)	Owner	0 to10	5	0	0	0	Slow
Dry/Wet Retention 0.25"	Cost share	0 to 20	2	1280	409.6	42667	Fast
Wet Restoration	Cost share	0 to 20	3	1600	512	35556	Fast
Dry Detention - Regional	Alternative	15 to 35	25	3200	1024	8533	Fast
Wet Detention - Regional	Alternative	40 to 80	65	4000	1280	4103	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMPs
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3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Owner/Cost Share BMP Program Reduced P Fertilization,limited dry/wet retention, and wetland restoration	0 to 20	10	6400	2048	42667	Moderate
Owner BMP Program Reduced P Fertilization	0 to 10	5	0	0	0	Slow
Cost Share BMP Program Selective limited dry/wet retention and Wetland Restoration	5 to 50	5	6400	2048	85333	Fast
Alternative BMP Program Stormwater R/D with Chemical Treatment	15 to 80	50	3200	1024	4267	Fast

BMPs for Low Density Residential

Assume for Typical Condition

Low Density Residential
Assumed average development size of 200 ac
Moderately Managed Lawns Mid-IFAS 1.5 lb-N/1000ft2
Limited Pond retention
Limited Lawn Irrigation

Existing N Load	4.95	lbs-P/ac/yr
Existing N Concentration	1.24	mg/l
Average Annual Runoff	17.57	in/yr

BMPs	**Type**	**N Reduction**[1]		**Initial Cost**	**Annual Cost**[3]		**Quickness**
		Range	Typical	**of BMP**[2]	**per acre**	**N Removed**	**of**
		%	%	($/ac)	($/ac/yr)	($/lb/ac/yr)	**Response**
Fertility							
Reduced N Fertilization (IFAS low, placement, and type)	Owner	0 to 30	15	11	3.52	5	Fast
Dry Retention/Swales[4] 0.25"	Cost share	10 to 40	15	6400	2048	2758	Fast
Wet Detention - 0.25"	Cost share	10 to 40	20	8000	2560	2586	Fast
Street Sweeping	Cost share	0 to 10	2	20	6.4	65	Fast
Sediment/Baffle Boxes	Cost share	2 to 30	15	440	140.8	190	Fast
Dry Detention - Regional	Alternative	5 to 35	15	3200	1024	1379	Fast
Wet Detention - Regional	Alternative	5 to 30	15	4000	1280	1724	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMPs
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3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 Adjusted down to correct for reported Dry Detention reductions not including ground water re-emergent N loads.

Owner/Cost Share BMP Program Reduced N Fertilization, Swales, and limited Dry Retention/Sweeping	0 to 50	30	6411	2051.52	1381	Fast
Owner BMP Program Reduced N Fertilization	0 to 30	15	11	3.52	5	Fast
Cost Share BMP Program Limited Dry Retention, Street Sweeping, Sediment R/D and Wetland Restoration	10 to 40	15	6400	2048	2758	Fast
Alternative BMP Program Stormwater R/D with Chemical Treatment	5 to 35	15	3200	1024	1379	Fast

BMPs for Medium Density Residential

Assume for Typical Condition

Medium Density Residential		
Assumed average development size of 200 ac		
Moderately Managed Lawns Mid-IFAS 3.5 lb-N/1000ft2		
Limited Pond retention		
Limited Lawn Irrigation		
Existing N Load	7.20	lbs-N/ac/yr
Existing N Concentration	1.53	mg/l
Average Annual Runoff	20.76	in/yr

BMPs	**Type**	**N Reduction[1]** Range %	Typical %	**Initial Cost of BMP[2]** ($/ac)	**Annual Cost[3]** **per acre** ($/ac/yr)	**N Removed** ($/lb/ac/yr)	**Quickness of Response**
Fertility							
Reduced N Fertilization (IFAS low, placement, and type)	Owner	0 to 50	25	15	4.8	3	Fast
Dry Retention/Swales[4] 0.25"	Cost share	10 to 50	25	6400	2048	1138	Fast
Wet Detention - 0.25"	Cost share	10 to 40	20	8000	2560	1778	Fast
Street Sweeping	Cost share	0 to 10	2	20	6.4	44	Fast
Sediment/Baffle Boxes	Cost share	2 to 30	15	440	140.8	130	Fast
Dry Detention - Regional	Alternative	5 to 35	15	3200	1024	948	Fast
Wet Detention - Regional	Alternative	5 to 30	15	4000	1280	1185	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMPs
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3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 Adjusted down to correct for reported Dry Detention reductions not including ground water re-emergent N loads.

Program	Range %	Typical %	Initial Cost ($/ac)	per acre ($/ac/yr)	N Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced N Fertilization, Swales, and limited Dry Retention/Sweeping	0 to 70	50	6415	2052.8	570	Fast
Owner BMP Program Reduced N Fertilization	0 to 60	25	15	4.8	3	Fast
Cost Share BMP Program Limited Dry Retention, Street Sweeping, Sediment R/D and Wetland Restoration	5 to 50	25	6400	2048	1138	Fast
Alternative BMP Program Stormwater R/D with Chemical Treatment	5 to 35	15	3200	1024	948	Fast

BMPs for High Density Residential

Assume for Typical Condition

High Density Residential
Assumed average development size of 200 ac
Moderately Managed Lawns Mid-IFAS 3.5 lb-N/1000ft2
Limited Pond retention
Limited Lawn Irrigation

Existing N Load	10.80	lbs-N/ac/yr
Existing N Concentration	1.99	mg/l
Average Annual Runoff	23.96	in/yr

BMPs	**Type**	**N Reduction[1]**		**Initial Cost of BMP[2]**	**Annual Cost[3]**		**Quickness of Response**
		Range %	Typical %	($/ac)	**per acre** ($/ac/yr)	**N Removed** ($/lb/ac/yr)	
Fertility							
Reduced N Fertilization (IFAS low, placement, and type)	Owner	0 to 60	30	15	4.8	1	Fast
Dry Retention/Swales[4] 0.25"	Cost share	10 to 50	25	6400	2048	759	Fast
Wet Detention - 0.25"	Cost share	10 to 40	20	8000	2560	1185	Fast
Street Sweeping	Cost share	0 to 10	2	20	6.4	30	Fast
Sediment/Baffle Boxes	Cost share	2 to 30	15	440	140.8	87	Fast
Dry Detention - Regional	Alternative	5 to 35	15	3200	1024	632	Fast
Wet Detention - Regional	Alternative	5 to 30	15	4000	1280	790	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMPs
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3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 Adjusted down to correct for reported Dry Detention reductions not including ground water re-emergent N loads.

Program	Range %	Typical %	Initial Cost ($/ac)	Annual Cost per acre ($/ac/yr)	N Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced N Fertilization, Swales, and limited Dry Retention/Sweeping	0 to 70	55	6415	2052.8	346	Fast
Owner BMP Program Reduced N Fertilization	0 to 60	30	15	4.8	1	Fast
Cost Share BMP Program Limited Dry Retention, Street Sweeping, Sediment R/D and Wetland Restoration	5 to 50	25	6400	2048	759	Fast
Alternative BMP Program Stormwater R/D with Chemical Treatment	5 to 35	15	3200	1024	632	Fast

BMPs for Other Urban

Assume for Typical Condition

Mixed Commercial, Industrial, institutional, recreation
Assumed average development size of 200 ac
Moderately Managed Lawns Mid-IFAS 3.5 lb-N/1000ft2
Limited Pond retention
Limited Lawn Irrigation

Existing N Load	7.80	lbs-N/ac/yr
Existing N Concentration	1.51	mg/l
Average Annual Runoff	22.80	in/yr

BMPs	**Type**	**N Reduction[1]**		**Initial Cost**	**Annual Cost[3]**		**Quickness**
		Range %	Typical %	**of BMP[2]** ($/ac)	**per acre** ($/ac/yr)	**N Removed** ($/lb/ac/yr)	**of Response**
Fertility							
Reduced N Fertilization (IFAS low, placement, and type)	Owner	0 to 50	25	15	4.8	2	Fast
Dry Retention/Swales[4] 0.25"	Cost share	10 to 50	25	6400	2048	1051	Fast
Wet Detention - 0.25"	Cost share	10 to 40	20	8000	2560	1642	Fast
Street Sweeping	Cost share	0 to 10	2	20	6.4	41	Fast
Sediment/Baffle Boxes	Cost share	2 to 30	15	440	140.8	120	Fast
Dry Detention - Regional	Alternative	5 to 35	15	3200	1024	876	Fast
Wet Detention - Regional	Alternative	5 to 30	15	4000	1280	1094	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMPs
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3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 Adjusted down to correct for reported Dry Detention reductions not including ground water re-emergent N loads.

Program	Range %	Typical %	Initial Cost ($/ac)	per acre ($/ac/yr)	N Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced N Fertilization, Swales, and limited Dry Retention/Sweeping	0 to 70	50	6415	2052.8	527	Fast
Owner BMP Program Reduced N Fertilization	0 to 50	25	15	4.8	2	Fast
Cost Share BMP Program Limited Dry Retention, Street Sweeping, Sediment R/D and Wetland Restoration	10 to 50	25	6400	2048	1051	Fast
Alternative BMP Program Stormwater R/D with Chemical Treatment	5 to 35	15	3200	1024	876	Fast

BMPs for Cow Calf Production

Improved Pastures

Assume for Typical Condition

- 3 ac / cow
- Assumed average farm size of 500 ac
- Existing N fertilization of 120 lbs N/ac
- No retention or wetland restoration
- Bahia grass
- Animals have access to streams

Existing N Load	9.99	lbs-N/ac/yr
Existing N Concentration	2.30	mg/l
Average Annual Runoff	19.16	in/yr

BMPs	Type	N Reduction[1]		Initial Cost of BMP[2]	Annual Cost[3]		Quickness of Response
		Range %	Typical %	($/ac)	per acre ($/ac/yr)	N Removed ($/lb/ac/yr)	
Fertility							
Reduced N Fertilization (IFAS, placement, and type)	Owner	0 to 30	15	2.2	2.2	1	Fast
Better Micros Fertilization	Owner	0 to 20	3	5.5	5.5	18	Fast
Grass Management (variety, mowing, burning, irrigation, etc.)	Owner	0 to 20	2	5.5	1.76	9	Fast
Improved Grazing Management							
Rotational Grazing	Cost share	0 to 30	3	5.5	1.76	6	Fast
Reduced Stocking Rate[4] (4ac /cow)	Owner	0 to 10	5	165	52.8	106	Fast
HIA and Direct Water Access Prevention							
Improved Watering Facilities to move cattle from streams	Cost share	0 to 20	10	11	3.52	4	Fast
Provide Alternative Shade to move cattle from streams	Alternative	0 to 10	2	16.5	5.28	26	Fast
Feeder/Minerals and Water Placement	Owner	0 to 30	3	2.2	0.704	2	Fast
Critical Area Fencing	Cost share	2 to 20	5	44	14.08	28	Fast
Retention Basin by Working Pens	Cost share	2 to 10	5	3.3	1.056	2	Fast
Buffer Strips	Cost share	0 to 10	5	44	14.08	28	Fast
Stormwater R/D	Cost share	5 to 40	15	44	14.08	9	Fast
Wetland Restoration	Cost share	2 to 15	5	11	3.52	7	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[5]	Alternative	5 to 70	50	220	70.4	14	Fast
Owner/Cost Share BMP Program P reduced to zero, Better N Management, Rotational Grazing, New Water Facilities, Retention Basin by Working Pens, Improved Grass Management, Feed Placement, Critical Area Fencing, and Moderate Wetland Restoration/Retention		10 to 50	27	49.5	15.84	6	Fast
Owner BMP Program Reduced N Fertilization (IFAS, placement, and type) Grass Management, and Feeder/Minerals and Water Placement		0 to 25	17	11	4	2	Fast
Cost Share BMP Program Rotational Grazing, New Water Facilities, Retention Basin by Working Pens, Critical Area Fencing, and Moderate Wetland Restoration/Retention		10 to 50	10	38.5	12	12	Fast
Alternative BMP Program Provide Alternative Shade to move cattle from streams and Edge-of-farm Stormwater R/D and Chemical Treatment		5 to 60	30	110	35	12	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
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3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 This practice would typically be unacceptable to most farmers, but if significant feed is being purchased then it should be considered
5 High O&M Costs

BMPs for Cow Calf Production

Unimproved Pasture

Assume for Typical Condition

8 ac per cow		
Assumed average farm size of 500 ac		
Existing N fertilization of 60 lbs N/ac		
No retention or wetland restoration		
Bahia grass / native		
Animals have access to streams		
Existing N Load	4.95	lbs-N/ac/yr
Existing N Concentration	1.37	mg/l
Average Annual Runoff	15.97	in/yr

BMPs	**Type**	**N Reduction**[1]		**Initial Cost of BMP**[2]	**Annual Cost**[3]		**Quickness of Response**
		Range %	Typical %	($/ac)	**per acre** ($/ac/yr)	**N Removed** ($/lb/ac/yr)	
Fertility							
Reduced N Fertilization (IFAS, placement, and type)	Owner	0 to 20	9	1.2	1.2	3	Fast
Grass Management (chopping, mowing, burning, etc.)	Owner	0 to 10	2	2.2	0.704	7	Fast
Improved Grazing Management							
Rotational Grazing (limited)	Cost share	0 to 5	3	5.5	1.76	12	Fast
HIA and Direct Water Access Prevention							
Improved Watering Facilities to move cattle from streams	Owner	0 to 10	5	5.5	1.76	7	Fast
Feeder/Minerals and Water Placement	Owner	0 to 10	3	2.2	0.704	5	Fast
Critical Area Fencing	Alternative	2 to 10	3	11	3.52	24	Fast
Retention Basin by Working Pens	Cost share	2 to 10	3	3.3	1.056	7	Fast
Stormwater R/D	Cost share	2 to 15	7	22	7.04	20	Fast
Wetland Restoration	Cost share	2 to 10	4	11	3.52	18	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	5 to 50	25	110	35.2	28	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
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3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Program	Range %	Typical %	Initial Cost ($/ac)	per acre ($/ac/yr)	N Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Some rotational grazing, new water facilities, retention basin basin by working pens, improved grass management, feed placement, and moderate wetland restoration/retention	5 to 30	19	13.2	4.224	4	Fast
Owner BMP Program Improved Grass Management, Watering Facilities, and Feed Placement	0 to 20	11	2.2	1	1	Fast
Cost Share BMP Program Some Rotational Grazing, retention basin basin by working pens, and moderate wetland restoration/retention	5 to 30	8	11	4	9	Fast
Alternative BMP Program Critical Area Fencing and Edge-of-farm Stormwater R/D and Chemical Treatment	5 to 60	30	55	18	12	Fast

BMPs for Cow Calf Production

Rangeland and Wooded Pasture

Assume for Typical Condition		
16ac per cow		
Assumed average farm size of 500 ac		
Existing N fertilization of 10 lbs N/ac		
No retention or wetland restoration		
Bahia grass / native		
Animals have access to streams		
Existing N Load	3.69	lbs-N/ac/yr
Existing N Concentration	1.02	mg/l
Average Annual Runoff	15.97	in/yr

BMPs	Type	N Reduction[1]		Initial Cost of BMP[2]	Annual Cost[3]		Quickness of Response
		Range %	Typical %	($/ac)	per acre ($/ac/yr)	N Removed ($/lb/ac/yr)	
Fertility							
Better N and Micros Fertilization - No P added	Owner	0 to 10	1	2.2	1	27	Fast
Grass Management (chopping, mowing, burning, etc.)	Owner	0 to 10	2	2.2	0.704	10	Fast
Improved Grazing Management							
Rotational Grazing (limited)	Cost share	0 to 5	3	5.5	1.76	16	Fast
HIA and Direct Water Access Prevention							
Improved Watering Facilities to move cattle from streams	Owner	0 to 10	5	5.5	1.76	10	Fast
Feeder/Minerals and Water Placement	Owner	0 to 10	3	2.2	0.704	6	Fast
Critical Area Fencing	Alternative	2 to 10	3	11	3.52	32	Fast
Retention Basin by Working Pens	Cost share	2 to 10	3	3.3	1.056	10	Fast
Stormwater R/D	Cost share	2 to 20	10	22	7.04	19	Fast
Wetland Restoration	Cost share	2 to 10	4	11	3.52	24	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	5 to 50	25	110	35.2	38	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP

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3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.

4 High O&M Costs

Owner/Cost Share BMP Program Some rotational grazing, new water facilities, retention basin basin by working pens, improved grass management, feed placement, and moderate wetland restoration/retention	5 to 30	10	13.2	4.224	11	Fast
Owner BMP Program Improved Grass Management, Watering Facilities, and Feed Placement	0 to 20	4	2.2	1	5	Fast
Cost Share BMP Program Some Rotational Grazing, retention basin basin by working pens, and moderate wetland restoration/retention	5 to 25	6	11	4	16	Fast
Alternative BMP Program Critical Area Fencing and Edge-of-farm Stormwater R/D and Chemical Treatment	5 to 50	20	55	18	24	Fast

BMPs for Row Crop

Assume for Typical Condition

Potatoes Spring Crop
Assumed average farm size of 100 ac
Existing N fertilization of 225 lbs N/ac
No retention or wetland restoration
Seepage Irrigation with 60' furrows

Existing N Load	13.50	lbs-N/ac/yr
Existing N Concentration	2.67	mg/l
Average Annual Runoff	22.36	in/yr

BMPs	**Type**	**N Reduction[1]** Range %	Typical %	**Initial Cost of BMP[2]** ($/ac)	**Annual Cost[3] per acre** ($/ac/yr)	**Annual Cost[3] N Removed** ($/lb/ac/yr)	**Quickness of Response**
Fertility							
Reduced N Fertilization (testing, split, placement, and type)	Owner	20 to 70	30	18	18	4	Fast
Water Management (irrigation and drainage, riser board control)	Cost share	0 to 40	10	11	3.52	3	Fast
Water Reuse from Retention/Detention Ponds	Alternative	0 to 20	10	33	10.56	8	Fast
Erosion Control (sediment trap in front of risers)	Alternative	0 to 5	2	11	3.52	13	Fast
Off Season In-Field Retention	Cost share	0 to 15	5	11	3.52	5	Fast
Off Season Cover Crop	Cost share	0 to 10	4	55	17.6	33	Fast
Stormwater R/D	Cost share	10 to 55	25	220	70.4	21	Fast
Wetland Restoration	Cost share	5 to 20	10	11	3.52	3	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	5 to 70	50	550	176	26	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Program	Range %	Typical %	Initial Cost ($/ac)	per acre ($/ac/yr)	N Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced N Fertilization, Water Management, additional Stormwater Retention, Cover Crop, and limited Wetland Restoration/Retention	10 to 80	60	220	70.4	9	Fast
Owner BMP Program Reduced N Fertilization	20 to 70	30	11	3.52	1	Fast
Cost Share BMP Program Water Management, additional Stormwater Retention, Cover Crop, and limited Wetland Restoration/Retention	10 to 50	30	209	66.88	17	Fast
Alternative BMP Program Water Reuse from Retention/Detention Ponds, Erosion Control, and Edge-of-farm stormwater R/D and Chemical Treatment	5 to 70	50	440	140.8	21	Fast

BMPs for Sugarcane

Assume for Typical Condition

3 year ratoon on organic soils
Assumed average farm size of 400 ac
Existing N fertilization of 30 lbs N/ac
Limited retention or wetland restoration
Seepage Irrigation with 330' furrows

Existing N Load	7.20	lbs-N/ac/yr
Existing N Concentration	1.66	mg/l
Average Annual Runoff	19.16	in/yr

BMPs		**Type**	**N Reduction2**		**Initial Cost**	**Annual Cost**[3]		**Quickness**
			Range %	Typical %	**of BMP**[2] ($/ac)	**per acre** ($/ac/yr)	**N Removed** ($/lb/ac/yr)	**of Response**
Fertility	pH management		0 to 20	10	1	1	1	Fast
	Reduced N Fertilization (testing, split, placement, and type)	Owner	10 to 50	20	2	2	1	Fast
Water Management (irrigation and drainage, in-field retention)		Cost share	0 to 20	10	11	3.52	5	Fast
Water Reuse from Retention/Detention Ponds		Alternative	0 to 20	10	33	10.56	15	Fast
Stormwater R/D		Cost share	5 to 45	15	110	35.2	33	Fast
Wetland Restoration		Cost share	2 to 15	7	11	3.52	7	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]		Alternative	5 to 70	50	220	70.4	20	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

	Range %	Typical %	Initial Cost ($/ac)	Annual Cost per acre ($/ac/yr)	N Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced N fertilization, water management, and limited wetland restoration/retention	10 to 70	33	110.8	35	15	Fast
Owner BMP Program Reduced N Fertilization	10 to 50	10	3	1	1	Fast
Cost Share BMP Program Water Management and limited Wetland Restoration/Retention	10 to 60	23	107.8	34	21	Fast
Alternative BMP Program Water Reuse from Retention/Detention Ponds and Edge-of-farm stormwater R/D and Chemical Treatment	5 to 70	52	275	88	24	Fast

BMPs for Citrus

Assume for Typical Condition

Two row crown bedded
Assumed average farm size of 200 ac
Grass Management between Trees
Pond retention with limited wetland restoration
Micro jet irrigation and fertigation of young stock

Existing N Load at 160 lb-N/ac/yr fertilizer	7.65	lbs-N/ac/yr
Existing N Concentration	1.76	mg/l
Average Annual Runoff	19.16	in/yr

BMPs	**Type**	**N Reduction[1]**		**Initial Cost of BMP[2]**	**Annual Cost[3]**		**Quickness of Response**
		Range %	Typical %	($/ac)	**per acre** ($/ac/yr)	**N Removed** ($/lb/ac/yr)	
Fertility							
Reduced N Fertilization (IFAS, placement, and type)	Owner	0 to 25	10	20	6.4	8	Fast
Better Micros Fertilization	Owner	0 to 5	2	0	0	0	Fast
Water Management (irrigation and drainage)	Cost share	0 to 20	5	0	0	0	Fast
Water Reuse from Retention/Detention Ponds[4]	Alternative	0 to 50	10	33	10.56	14	Fast
Grass Management between Trees	Owner	0 to 5	2	22	7.04	46	Fast
Grassed Waterways	Alternative	0 to 15	5	110	35.2	92	Fast
Stormwater R/D[5]	Alternative	10 to 60	40	440	140.8	46	Fast
Wetland Restoration	Alternative	5 to 20	10	44	14.08	18	Fast
Edge-of-farm Stormwater R/D and Chemical Treatment[6]	Alternative	5 to 70	50	220	70.4	18	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 Values shown are for using existing ponds for water reuse, if new facilities are needed then cost would increase significantly.
5 Average of pre/post 1984 stormwater management requirements, i.e. P > .6ppm if developed prior to 1984 and less if developed after 1984.
Groves developed after 1984 would probably have stormwater R/D systems, so little addition benefit would be expected for newer groves.
6 High O&M Costs

	Range %	Typical %	Initial Cost ($/ac)	per acre ($/ac/yr)	N Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced P Fertilization, Better N Management, Grass Management between Trees, additional Stormwater Retention, and limited Wetland Restoration/Retention	10 to 50	15	490	156.8	137	Fast
Owner BMP Program Reduced N Fertilization (IFAS, placement, and type) Better Micros Fertilization	0 to 25	10	20	6.4	8	Fast
Cost Share BMP Program Water Management (irrigation and drainage)	0 to 20	5	470	150.4	393	Fast
Alternative BMP Program Fertigation, Grassed Waterways, and Edge-of-farm Stormwater R/D with Chemical Treatment	5 to 70	52	242	77	19	Fast

BMPs for Sod / Turf Grass

Assume for Typical Condition

Bermudagrass
Assumed average farm size of 100 ac
Existing N fertilization of 190 lbs N/ac
No retention or wetland restoration
Seepage Irrigation with 100' furrows

Existing N Load	8.10	lbs-N/ac/yr
Existing N Concentration	1.87	mg/l
Average Annual Runoff	19.16	in/yr

BMPs	Type	N Reduction[1]		Initial Cost of BMP[2]	Annual Cost[3]		Quickness of Response
		Range %	Typical %	($/ac)	per acre ($/ac/yr)	N Removed ($/lb/ac/yr)	
Fertility							
Reduced N Fertilization (testing, split, placement, and type)	Owner	10 to 50	20	2.2	2.2	1	Fast
Water Management (irrigation and drainage, riser board control)	Cost share	0 to 20	10	11	3.52	4	Fast
Erosion Control (Buffer Strips and sediment traps)	Alternative	0 to 15	5	55	17.6	43	Fast
Stormwater R/D	Cost share	5 to 40	25	110	35.2	17	Fast
Wetland Restoration	Cost share	2 to 15	8	11	3.52	5	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	20 to 70	50	330	105.6	26	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Program	Range %	Typical %	Initial Cost ($/ac)	per acre ($/ac/yr)	N Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced N fertilization, water management, additional stormwater retention, and limited wetland restoration	10 to 70	47	110	35.2	9	Fast
Owner BMP Program Reduced N Fertilization	10 to 50	20	2.2	2.2	1	Fast
Cost Share BMP Program Water Management, additional Stormwater Retention, Cover Crop, and limited Wetland Restoration/Retention	10 to 50	27	107.8	34	16	Fast
Alternative BMP Program Erosion Control, and Edge-of-farm stormwater R/D and Chemical Treatment	20 to 70	50	330	105.6	26	Fast

BMPs for Ornamentals

Assume for Typical Condition

Ornamental Nursery
Assumed average farm size of 10 ac
Existing N fertilization of 160 lbs N/ac
No retention or wetland restoration
Overhead Irrigation

Existing N Load	10.80	lbs-N/ac/yr
Existing N Concentration	2.49	mg/l
Average Annual Runoff	19.16	in/yr

BMPs	Type	N Reduction[1]		Initial Cost	Annual Cost[3]		Quickness
		Range	Typical	of BMP[2]	per acre	N Removed	of
		%	%	($/ac)	($/ac/yr)	($/lb/ac/yr)	Response
Fertility							
Reduced N Fertilization (testing, split, placement, and type)	Owner	10 to 50	25	11	11	4	Fast
Water Management (irrigation and drainage, riser board control)	Cost share	0 to 40	10	11	4	3	Fast
Water Reuse from Retention/Detention Ponds	Alternative	0 to 20	10	33	11	10	Fast
Erosion Control (sediment trap in front of risers)	Alternative	0 to 5	2	11	4	16	Fast
Off Season In-Field Retention	Cost share	0 to 15	5	11	4	7	Fast
Off Season Cover Crop	Cost share	0 to 30	15	55	18	11	Fast
Stormwater R/D	Cost share	10 to 65	40	220	70	16	Fast
Wetland Restoration	Cost share	0 to 10	4	11	4	8	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	5 to 70	50	550	176	33	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Program	Range %	Typical %	Initial Cost ($/ac)	Annual Cost per acre ($/ac/yr)	N Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced N Fertilization, Water Management, additional Stormwater Retention, Cover Crop, and limited Wetland Restoration/Retention	10 to 80	50	220	70	13	Fast
Owner BMP Program Reduced N Fertilization	10 to 50	25	11	4	1	Fast
Cost Share BMP Program Water Management, additional Stormwater Retention, Cover Crop, and limited Wetland Restoration/Retention	10 to 50	25	209	67	25	Fast
Alternative BMP Program Water Reuse from Retention/Detention Ponds, Erosion Control, and Edge-of-farm stormwater R/D and Chemical Treatment	10 to 50	25	440	141	52	Fast

BMPs for Horse Farms

Assume for Typical Condition

1 ac / horse
Assumed average farm size of 10 ac
Existing N fertilization of 180 lbs N/ac
No retention or wetland restoration
Bahia grass

Existing N Load	14.40	lbs-N/ac/yr
Existing N Concentration	3.98	mg/l
Average Annual Runoff	15.97	in/yr

BMPs	Type	N Reduction[1] Range %	N Reduction[1] Typical %	Initial Cost of BMP[2] ($/ac)	Annual Cost[3] per acre ($/ac/yr)	Annual Cost[3] N Removed ($/lb/ac/yr)	Quickness of Response
Fertility							
Reduced N Fertilization (IFAS, placement, and type)	Owner	0 to 60	30	4.2	4.2	1	Fast
Better Micros Fertilization	Owner	0 to 20	3	5.5	5.5	13	Fast
Grass Management (variety, mowing, burning, irrigation, etc.)	Owner	0 to 20	2	5.5	1.76	6	Fast
Improved Grazing Management							
Rotational Grazing	Cost share	0 to 30	3	5.5	1.76	4	Fast
Reduced Stocking Rate[4] (2ac /horse)	Owner	0 to 20	10	165	52.8	37	Fast
HIA and Direct Water Access Prevention							
Improved Watering Facilities to move animals from streams	Cost share	0 to 20	5	11	3.52	5	Fast
Provide Alternative Shade to move animals from streams	Alternative	0 to 10	1	16.5	5.28	37	Fast
Feeder/Minerals and Water Placement	Owner	0 to 30	3	2.2	0.704	2	Fast
Critical Area Fencing	Cost share	2 to 20	2	44	14.08	49	Fast
Buffer Strips	Cost share	0 to 10	5	44	14.08	20	Fast
Stormwater R/D	Cost share	5 to 40	15	44	14.08	7	Fast
Wetland Restoration	Cost share	2 to 15	5	11	3.52	5	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[5]	Alternative	5 to 70	50	220	70.4	10	Fast
Owner/Cost Share BMP Program P reduced to zero, Better N Management, Rotational Grazing, New Water Facilities, Retention Basin by Working Pens, Improved Grass Management, Feed Placement, Critical Area Fencing, and Moderate Wetland Restoration/Retention		10 to 70	52	49.5	15.84	2	Fast
Owner BMP Program Reduced N Fertilization (IFAS, placement, and type) Grass Management, and Feeder/Minerals and Water Placement		0 to 60	30	11	4	1	Fast
Cost Share BMP Program Rotational Grazing, New Water Facilities, Retention Basin by Working Pens, Critical Area Fencing, and Moderate Wetland Restoration/Retention		10 to 50	22	38.5	12	4	Fast
Alternative BMP Program Provide Alternative Shade to move cattle from streams and Edge-of-farm Stormwater R/D and Chemical Treatment		5 to 60	30	110	35	8	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 This practice would typically be unacceptable to most farmers, but if significant feed is being purchased then it should be considered
5 High O&M Costs

BMPs for Dairies

Assume for Typical Condition

1000 head Dairy, dry cows pastured on site, 400 heifer/springers on site
Assumed average farm size of 700 ac
Existing N fertilization of 100 lbs N/ac
No existing retention or wetland restoration
Stargrass Pastures
Animals are fenced from streams

Existing N Load	18.00	lbs-N/ac/yr
Existing N Concentration	4.98	mg/l
Average Annual Runoff	15.97	in/yr

BMPs	**Type**	**N Reduction[1]**		**Initial Cost**	**Annual Cost[3]**		**Quickness**
		Range	Typical	**of BMP[2]**	**per acre**	**N Removed**	**of**
		%	%	($/ac)	($/ac/yr)	($/lb/ac/yr)	**Response**
Barn Waste							
Feed Ration Management	Owner	0 to 25	1	2.2	2.2	12	Fast
Solids Separation for Off Site Disposal	Alternative	0 to 10	1	5.5	1.76	10	Fast
Expanded Waste Storage Ponds	Alternative	----	----	----	----	----	----
Expanded Sprayfields	Alternative	----	----	----	----	----	----
Improved Pasture Management (See Cow-Calf Imp.. Pasture)	Owner	10 to 40	20	16.5	5.28	1	Fast
Improved Forage/Sprayfield Management - N/P balanced, new crops	Owner	0 to 15	5	0	0	0	Fast
HIA Management							
Add Housing to Move Animals off Fields[4]	Alternative	30 to 70	50	3,929	1257	140	Fast
Stormwater Retention / Expanded Sprayfield	Alternative	20 to 70	40	440	140.8	20	Fast
Edge-of-field Chemical Treatment[5]	Alternative	5 to 30	15	550	176	65	Fast
Buffer Strips	Alternative	0 to 10	5	44	14.08	16	Fast
Stormwater R/D	Cost share	15 to 50	30	1100	352	65	Fast
Wetland Restoration	Cost share	5 to 20	10	11	3.52	2	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[5]	Alternative	5 to 70	50	550	176	20	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
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4 Includes associated waste pond and sprayfield expansions
5 High O&M Costs

Owner/Cost Share BMP Program	20 to 65	60	1045	334.4	97	Fast
Stormwater R/D and Wetland Restoration						
N Fertilizer Reduction						
Owner BMP Program	10 to 40	20	2.2	0.704	0	Fast
N Fertilzer Management						
Cost Share BMP Program	20 to 60	40	1042.8	333.696	46	Fast
Stormwater R/D and Wetland Restoration						
Alternative BMP Program	20 to 90	48	750	240	28	Fast
Barn Waste						
Solids Separation for Off Site Disposal	0 to 10	1	6	1.76	10	Fast
Expanded Waste Storage Ponds[4]	----	----	----	----	----	----
Expanded Sprayfields[4]	----	----	----	----	----	----
HIA Management						
Add Housing to Move Animals off Fields[4]	30 to 70	50	3929	1257	140	Fast
Stormwater Retention / Expanded Sprayfield	20 to 70	40	440	141	20	Fast
Edge-of-field Chemical Treatment[5]	5 to 30	15	550	176	65	Fast
Buffer Strips	0 to 10	5	44	14	16	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[5]	5 to 70	50	550	176	20	Fast

BMPs for Field Crop (Hayland) Production

Assume for Typical Condition		
Assumed average farm size of 500 ac		
Existing N fertilization of 180 lbs N/ac		
No retention or wetland restoration		
Various Land Uses including hay, orchards, poultry, etc.		
Existing N Load	7.91	lbs-N/ac/yr
Existing N Concentration	2.19	mg/l
Average Annual Acres	15.97	in/yr

BMPs	Type	N Reduction[1] Range %	N Reduction[1] Typical %	Initial Cost of BMP[2] ($/ac)	Annual Cost[3] per acre ($/ac/yr)	Annual Cost[3] N Removed ($/lb/ac/yr)	Quickness of Response
Fertility							
Reduced N Fertilization (IFAS, placement, and type)	Owner	0 to 50	15	2.2	2.2	2	Fast
Better Micros Fertilization	Owner	0 to 20	3	5.5	5.5	23	Fast
Grass Management (variety, mowing, burning, irrigation, etc.)	Owner	0 to 20	2	5.5	1.76	11	Fast
Buffer Strips	Cost share	0 to 10	5	44	14.08	36	Fast
Stormwater R/D	Cost share	10 to 40	20	55	17.6	11	Fast
Wetland Restoration	Cost share	5 to 20	10	11	3.52	4	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	5 to 70	50	220	70.4	18	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Program	Range %	Typical %	Initial Cost ($/ac)	Annual Cost per acre ($/ac/yr)	N Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program P reduced to zero, Better N Management, Rotational Grazing, New Water Facilities, Retention Basin by Working Pens, Improved Grass Management, Feed Placement, Critical Area Fencing, and Moderate Wetland Restoration/Retention	10 to 60	40	58	18.56	6	Fast
Owner BMP Program Reduced N Fertilization (IFAS, placement, and type) Grass Management, and Feeder/Minerals and Water Placement	0 to 25	15	11	4	3	Fast
Cost Share BMP Program Rotational Grazing, New Water Facilities, Retention Basin by Working Pens, Critical Area Fencing, and Moderate Wetland Restoration/Retention	10 to 50	25	47	15	8	Fast
Alternative BMP Program Provide Alternative Shade to move cattle from streams and Edge-of-farm Stormwater R/D and Chemical Treatment	5 to 70	36	110	35	12	Fast

BMPs for Pine Plantation

Assume for Typical Condition

Planted Pine Plantation (20 yr rotation)
Assumed average farm size of 200 ac
Existing N fertilization of 5 lbs N/ac
No retention or wetland restoration

Existing N Load	2.79	lbs-N/ac/yr
Existing N Concentration	0.77	mg/l
Average Annual Runoff	15.97	in/yr

BMPs	**Type**	**N Reduction[1]**		**Initial Cost of BMP[2]**	**Annual Cost[3]**		**Quickness of Response**
		Range %	Typical %	($/ac)	**per acre** ($/ac/yr)	**N Removed** ($/lb/ac/yr)	
Reduced N Fertilization (testing, placement, and type)	Owner	0 to 15	5	3	3	22	Fast
Stormwater R/D	Cost share	2 to 15	8	22	22	99	Fast
Wetland Restoration	Cost share	1 to 5	2	11	3.52	63	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	5 to 50	25	110	35.2	50	Fast

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3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Owner/Cost Share BMP Program Reduced N Fertilization, Stormwater R/D, and limited Wetland Restoration	2 to 25	15	22	22	53	Fast
Owner BMP Program Reduced N Fertilization	0 to 15	5	3	0	0	Fast
Cost Share BMP Program Stormwater R/D and limited Wetland Restoration	3 to 20	10	16.5	12.76	46	Fast
Alternative BMP Program Edge-of-farm Stormwater R/D and Chemical Treatment	5 to 50	25	110	35.2	50	Fast

BMPs for Transportation Corridors

Assume for Typical Condition

- 50% Paved Surface
- Bahia Grass Shoulders
- Existing N fertilization of 35 lbs N/ac
- Limited retention or wetland restoration

Existing N Load	8.28	lbs-N/ac/yr
Existing N Concentration	1.35	mg/l
Average Annual Runoff	27.15	in/yr

BMPs		Type	N Reduction1		Initial Cost of BMP[2]	Annual Cost[3]		Quickness of Response
			Range %	Typical %	($/ac)	per acre ($/ac/yr)	N Removed ($/lb/ac/yr)	
Fertility	pH management		0 to 20	3	2	2	8	Fast
	Reduced N Fertilization (testing, split, placement, and type)	Owner	10 to 50	20	2	2	1	Fast
Stormwater R/D		Cost share	5 to 45	15	110	35.2	28	Fast
Wetland Restoration		Cost share	2 to 15	7	11	3.52	6	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]		Alternative	5 to 50	25	220	70.4	34	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Program	N Reduction Range %	Typical %	Initial Cost of BMP ($/ac)	Annual Cost per acre ($/ac/yr)	N Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced N fertilization, water management, and limited wetland restoration/retention	10 to 70	43	111.8	36	10	Fast
Owner BMP Program Reduced N Fertilization	10 to 50	20	4	1	5	Fast
Cost Share BMP Program Water Management and limited Wetland Restoration/Retention	10 to 60	23	107.8	34	18	Fast
Alternative BMP Program Water Reuse from Retention/Detention Ponds and Edge-of-System stormwater R/D and Chemical Treatment	5 to 50	25	220	70	34	Fast

BMPs for Communications and Utilities

Assume for Typical Condition

Marginally Maintained Bahia Grass		
No Pond retention		
Existing N Load	5.40	lbs-N/ac/yr
Existing N Concentration	1.49	mg/l
Average Annual Runoff	15.97	in/yr

BMPs	**Type**	**N Reduction[1]**		**Initial Cost of BMP[2]**	**Annual Cost[3]**		**Quickness of Response**
		Range %	Typical %	($/ac)	**per acre** ($/ac/yr)	**N Removed** ($/lb/ac/yr)	
Fertility							
Reduced P Fertilization (testing, placement, and type)	Owner	0 to10	5	0	0	0	Fast
Dry/Wet Retention 0.25"	Cost share	0 to 20	2	1280	409.6	3793	Fast
Wet Restoration	Cost share	0 to 20	3	1600	512	3160	Fast
Dry Detention - Regional	Alternative	15 to 35	25	3200	1024	759	Fast
Wet Detention - Regional	Alternative	40 to 80	65	4000	1280	365	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMPs
2 Costs presented on per acre of entire development basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Program	Range %	Typical %	Initial Cost ($/ac)	per acre ($/ac/yr)	N Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced N Fertilization,limited dry/wet retention, and wetland restoration	0 to 20	10	6400	2048	3793	Moderate
Owner BMP Program Reduced N Fertilization	0 to 10	5	0	0	0	Fast
Cost Share BMP Program Selective limited dry/wet retention and Wetland Restoration	5 to 50	5	6400	2048	7585	Fast
Alternative BMP Program Stormwater R/D with Chemical Treatment	15 to 80	50	3200	1024	379	Fast

Appendix B
Current condition assumptions, existing loads, potential load reductions, and costs of implementation for the primary land uses in the Caloosahatchee River watershed

Table of Contents for BMP Assessment Tables

BMPs for Low Density Residential

Assume for Typical Condition

Low Density Residential		
Assumed average development size of 200 ac		
Moderately Managed Lawns		
Limited Pond retention		
Limited Lawn Irrigation		
Existing P Load	0.68	lbs-P/ac/yr
Existing P Concentration	0.11	mg/l
Average Annual Runoff	27.43	in/yr

BMPs	**Type**	**P Reduction[1]**		**Initial Cost**	**Annual Cost[3]**		**Quickness**
		Range %	Typical %	**of BMP[2]** ($/ac)	**per acre** ($/ac/yr)	**P Removed** ($/lb/ac/yr)	**of Response**
Fertility							
Reduced P Fertilization (testing, placement, and type)	Owner	0 to10	5	0	0	0	Slow
Dry Retention/Swales 0.25"	Cost share	20 to 80	50	6400	2048	6057	Fast
Wet Detention - 0.25"	Cost share	30 to 90	80	8000	2560	4732	Fast
Street Sweeping	Cost share	0 to 25	15	20	6.4	63	Fast
Sediment/Baffle Boxes	Cost share	10 to 60	20	440	140.8	1041	Fast
Dry Detention - Regional	Alternative	15 to 35	25	3200	1024	6057	Fast
Wet Detention - Regional	Alternative	40 to 80	65	4000	1280	2912	Fast
Stormwater R/D and Chemical Treatment[4]	Alternative	20 to 90	70	3200	1024	2163	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMPs
2 Costs presented on per acre of entire development basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Owner/Cost Share BMP Program Reduced P Fertilization, Swales, and limited Dry Retention/Sweeping	0 to 20	10	6400	2048	30287	Moderate
Owner BMP Program Reduced P Fertilization	0 to 10	5	0	0	0	Slow
Cost Share BMP Program Limited Dry Retention, Street Sweeping, Sediment R/D and Wetland Restoration	5 to 50	5	6400	2048	60574	Fast
Alternative BMP Program Stormwater R/D with Chemical Treatment	20 to 90	70	3200	1024	2163	Fast

BMPs for Medium Density Residential

Assume for Typical Condition

Medium Density Residential		
Assumed average development size of 200 ac		
Moderately Managed Lawns		
Limited Pond retention		
Limited Lawn Irrigation		
Existing P Load	1.93	lbs-P/ac/yr
Existing P Concentration	0.26	mg/l
Average Annual Runoff	32.42	in/yr

BMPs	**Type**	**P Reduction[1]**		**Initial Cost**	**Annual Cost[3]**		**Quickness**
		Range %	Typical %	**of BMP[2]** ($/ac)	**per acre** ($/ac/yr)	**P Removed** ($/lb/ac/yr)	**of Response**
Fertility							
Reduced P Fertilization (testing, placement, and type)	Owner	0 to10	5	0	0	0	Slow
Dry Retention/Swales 0.25"	Cost share	20 to 80	50	6400	2048	2120	Fast
Wet Detention - 0.25"	Cost share	30 to 90	80	8000	2560	1656	Fast
Street Sweeping	Cost share	0 to 25	15	20	6.4	22	Fast
Sediment/Baffle Boxes	Cost share	10 to 60	20	440	140.8	364	Fast
Dry Detention - Regional	Alternative	15 to 35	25	3200	1024	2120	Fast
Wet Detention - Regional	Alternative	40 to 80	65	4000	1280	1019	Fast
Stormwater R/D and Chemical Treatment[4]	Alternative	20 to 90	70	3200	1024	757	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMPs
2 Costs presented on per acre of entire development basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Owner/Cost Share BMP Program Reduced P Fertilization, Swales, and limited Dry Retention/Sweeping	0 to 20	10	6400	2048	10600	Moderate
Owner BMP Program Reduced P Fertilization	0 to 10	5	0	0	0	Slow
Cost Share BMP Program Limited Dry Retention, Street Sweeping, Sediment R/D and Wetland Restoration	5 to 50	5	6400	2048	21201	Fast
Alternative BMP Program Stormwater R/D with Chemical Treatment	20 to 90	70	3200	1024	757	Fast

BMPs for High Density Residential

Assume for Typical Condition

High Density Residential		
Assumed average development size of 200 ac		
Moderately Managed Lawns		
Limited Pond retention		
Limited Lawn Irrigation		
Existing P Load	4.14	lbs-P/ac/yr
Existing P Concentration	0.46	mg/l
Average Annual Runoff	39.90	in/yr

BMPs	**Type**	**P Reduction[1]**		**Initial Cost of BMP[2]**	**Annual Cost[3]**		**Quickness of Response**
		Range %	Typical %	($/ac)	**per acre** ($/ac/yr)	**P Removed** ($/lb/ac/yr)	
Fertility							
Reduced P Fertilization (testing, placement, and type)	Owner	0 to10	5	0	0	0	Slow
Dry Retention/Swales 0.25"	Cost share	20 to 80	50	6400	2048	989	Fast
Wet Detention - 0.25"	Cost share	30 to 90	80	8000	2560	773	Fast
Street Sweeping	Cost share	0 to 25	15	20	6.4	10	Fast
Sediment/Baffle Boxes	Cost share	10 to 60	20	440	140.8	170	Fast
Dry Detention - Regional	Alternative	15 to 35	25	3200	1024	989	Fast
Wet Detention - Regional	Alternative	40 to 80	65	4000	1280	476	Fast
Stormwater R/D and Chemical Treatment[4]	Alternative	20 to 90	70	3200	1024	353	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMPs
2 Costs presented on per acre of entire development basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Owner/Cost Share BMP Program Reduced P Fertilization, Swales, and limited Dry Retention/Sweeping	0 to 20	10	6400	2048	4947	Moderate
Owner BMP Program Reduced P Fertilization	0 to 10	5	0	0	0	Slow
Cost Share BMP Program Limited Dry Retention, Street Sweeping, Sediment R/D and Wetland Restoration	5 to 50	5	6400	2048	9894	Fast
Alternative BMP Program Stormwater R/D with Chemical Treatment	20 to 90	70	3200	1024	353	Fast

BMPs for Other Urban

Assume for Typical Condition

Medium Density Residential with Mixed Commercial
Assumed average development size of 200 ac
Moderately Managed Lawns
Limited Pond retention
Limited Lawn Irrigation

Existing P Load	2.05	lbs-P/ac/yr
Existing P Concentration	0.25	mg/l
Average Annual Runoff	36.34	in/yr

BMPs	Type	P Reduction[1]		Initial Cost of BMP[2]	Annual Cost[3]		Quickness of Response
		Range %	Typical %	($/ac)	per acre ($/ac/yr)	P Removed ($/lb/ac/yr)	
Fertility							
Reduced P Fertilization (testing, placement, and type)	Owner	0 to10	5	0	0	0	Slow
Dry Retention/Swales 0.25"	Cost share	20 to 80	50	6400	2048	2001	Fast
Wet Detention - 0.25"	Cost share	30 to 90	80	8000	2560	1563	Fast
Street Sweeping	Cost share	0 to 25	15	20	6.4	21	Fast
Sediment/Baffle Boxes	Cost share	10 to 60	20	440	140.8	344	Fast
Dry Detention - Regional	Alternative	15 to 35	25	3200	1024	2001	Fast
Wet Detention - Regional	Alternative	40 to 80	65	4000	1280	962	Fast
Stormwater R/D and Chemical Treatment[4]	Alternative	20 to 90	70	3200	1024	715	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMPs
2 Costs presented on per acre of entire development basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Program	Range %	Typical %	Initial Cost ($/ac)	per acre ($/ac/yr)	P Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced P Fertilization, Swales, and limited Dry Retention/Sweeping	0 to 20	10	6400	2048	10003	Moderate
Owner BMP Program Reduced P Fertilization	0 to 10	5	0	0	0	Slow
Cost Share BMP Program Limited Dry Retention, Street Sweeping, Sediment R/D and Wetland Restoration	5 to 50	5	6400	2048	20006	Fast
Alternative BMP Program Stormwater R/D with Chemical Treatment	20 to 90	70	3200	1024	715	Fast

BMPs for Cow Calf Production

Improved Pastures

Assume for Typical Condition

3 ac / cow		
Assumed average farm size of 500 ac		
Existing P fertilization of 3 lbs P/ac		
No retention or wetland restoration		
Bahia grass		
Animals have access to streams		
Existing P Load	1.93	lbs-P/ac/yr
Existing P Concentration	0.29	mg/l
Average Annual Runoff	29.93	in/yr

BMPs	**Type**	**P Reduction[1]**		**Initial Cost of BMP[2]**	**Annual Cost[3]**		**Quickness of Response**
		Range %	Typical %	($/ac)	**per acre** ($/ac/yr)	**P Removed** ($/lb/ac/yr)	
Fertility							
Reduced P Fertilization (testing, split, placement, and type)	Owner	0 to 30	10	2.2	2.2	11	Slow
Better N and Micros Fertilization	Owner	0 to 20	3	5.5	5.5	95	Slow
Grass Management (variety, mowing, burning, irrigation, etc.)	Owner	0 to 20	2	5.5	1.76	46	Slow
Improved Grazing Management							
Rotational Grazing	Cost share	0 to 30	3	5.5	1.76	30	Moderate
Reduced Stocking Rate[4] (4ac /cow)	Owner	0 to 10	3	165	52.8	911	Slow
HIA and Direct Water Access Prevention							
Improved Watering Facilities to move cattle from streams	Cost share	0 to 20	10	11	3.52	18	Fast
Provide Alternative Shade to move cattle from streams	Alternative	0 to 10	2	16.5	5.28	137	Fast
Feeder/Minerals and Water Placement	Owner	0 to 30	3	2.2	0.704	12	Fast
Critical Area Fencing	Cost share	2 to 20	5	44	14.08	146	Fast
Retention Basin by Working Pens	Cost share	2 to 10	5	3.3	1.056	11	Fast
Buffer Strips	Cost share	0 to 10	5	44	14.08	146	Fast
Stormwater R/D	Cost share	5 to 40	15	44	14.08	49	Fast
Wetland Restoration	Cost share	2 to 15	5	11	3.52	36	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[5]	Alternative	20 to 90	70	220	70.4	52	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 This practice would typically be unacceptable to most farmers, but if significant feed is being purchased then it should be considered
5 High O&M Costs

Program	Range %	Typical %	Initial Cost ($/ac)	per acre ($/ac/yr)	P Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program P reduced to zero, Better N Management, Rotational Grazing, New Water Facilities, Retention Basin by Working Pens, Improved Grass Management, Feed Placement, Critical Area Fencing, and Moderate Wetland Restoration/Retention	10 to 50	30	49.5	15.84	27	Moderate
Owner BMP Program P Reduced to zero, Better N Management, Grass Management, and Feeder/Minerals and Water Placement	0 to 25	11	11	4	17	Slow
Cost Share BMP Program Rotational Grazing, New Water Facilities, Retention Basin by Working Pens, Critical Area Fencing, and Moderate Wetland Restoration/Retention	10 to 50	19	38.5	12	34	Moderate
Alternative BMP Program Provide Alternative Shade to move cattle from streams and Edge-of-farm Stormwater R/D and Chemical Treatment	20 to 90	49	110	35	37	Fast

BMPs for Cow Calf Production

Unimproved Pasture

Assume for Typical Condition

8 ac per cow		
Assumed average farm size of 500 ac		
Existing P fertilization of 1 lbs P/ac		
No retention or wetland restoration		
Bahia grass / native		
Animals have access to streams		
Existing P Load	0.99	lbs-P/ac/yr
Existing P Concentration	0.18	mg/l
Average Annual Runoff	24.94	in/yr

BMPs	**Type**	**P Reduction[1]**		**Initial Cost**	**Annual Cost[3]**		**Quickness**
		Range	Typical	**of BMP[2]**	**per acre**	**P Removed**	**of**
		%	%	($/ac)	($/ac/yr)	($/lb/ac/yr)	**Response**
Fertility							
Better N and Micros Fertilization - No P added	Owner	0 to 10	1	2.2	2.2	221	Slow
Grass Management (chopping, mowing, burning, etc.)	Owner	0 to 10	2	2.2	0.704	35	Slow
Improved Grazing Management							
Rotational Grazing (limited)	Cost share	0 to 5	3	5.5	1.76	59	Moderate
HIA and Direct Water Access Prevention							
Improved Watering Facilities to move cattle from streams	Owner	0 to 10	5	5.5	1.76	35	Fast
Feeder/Minerals and Water Placement	Owner	0 to 10	3	2.2	0.704	24	Fast
Critical Area Fencing	Alternative	2 to 10	3	11	3.52	118	Fast
Retention Basin by Working Pens	Cost share	2 to 10	3	3.3	1.056	35	Fast
Stormwater R/D	Cost share	2 to 15	7	22	7.04	101	Fast
Wetland Restoration	Cost share	2 to 10	4	11	3.52	89	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	20 to 70	50	110	35.2	71	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Owner/Cost Share BMP Program Some rotational grazing, new water facilities, retention basin basin by working pens, improved grass management, feed placement, and moderate wetland restoration/retention	5 to 30	20	13.2	4.224	21	Moderate
Owner BMP Program Improved Grass Management, Watering Facilities, and Feed Placement	0 to 20	7	2.2	1	10	Slow
Cost Share BMP Program Some Rotational Grazing, retention basin basin by working pens, and moderate wetland restoration/retention	5 to 25	13	11	4	27	Moderate
Alternative BMP Program Critical Area Fencing and Edge-of-farm Stormwater R/D and Chemical Treatment	20 to 70	44	55	18	40	Fast

BMPs for Cow Calf Production

Rangeland and Wooded Pasture

Assume for Typical Condition		
16ac per cow		
Assumed average farm size of 500 ac		
Existing P fertilization of 0 lbs P/ac		
No retention or wetland restoration		
Bahia grass / native		
Animals have access to streams		
Existing P Load	0.40	lbs-P/ac/yr
Existing P Concentration	0.08	mg/l
Average Annual Runoff	21.24	in/yr

BMPs	**Type**	**P Reduction[1]**		**Initial Cost of BMP[2]**	**Annual Cost[3]**		**Quickness of Response**
		Range %	Typical %	($/ac)	**per acre** ($/ac/yr)	**P Removed** ($/lb/ac/yr)	
Fertility							
Better N and Micros Fertilization - No P added	Owner	0 to 10	1	2.2	2.2	552	Slow
Grass Management (chopping, mowing, burning, etc.)	Owner	0 to 10	2	2.2	0.704	88	Slow
Improved Grazing Management							
Rotational Grazing (limited)	Cost share	0 to 5	3	5.5	1.76	147	Moderate
HIA and Direct Water Access Prevention							
Improved Watering Facilities to move cattle from streams	Owner	0 to 10	5	5.5	1.76	88	Fast
Feeder/Minerals and Water Placement	Owner	0 to 10	3	2.2	0.704	59	Fast
Critical Area Fencing	Alternative	2 to 10	3	11	3.52	294	Fast
Retention Basin by Working Pens	Cost share	2 to 10	3	3.3	1.056	88	Fast
Stormwater R/D	Cost share	2 to 20	10	22	7.04	177	Fast
Wetland Restoration	Cost share	2 to 10	4	11	3.52	221	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	20 to 70	40	110	35.2	221	Fast
Owner/Cost Share BMP Program Some rotational grazing, new water facilities, retention basin basin by working pens, improved grass management, feed placement, and moderate wetland restoration/retention		5 to 30	10	13.2	4.224	106	Moderate
Owner BMP Program Improved Grass Management, Watering Facilities, and Feed Placement		0 to 20	4	2.2	1	44	Slow
Cost Share BMP Program Some Rotational Grazing, retention basin basin by working pens, and moderate wetland restoration/retention		5 to 25	6	11	4	147	Moderate
Alternative BMP Program Critical Area Fencing and Edge-of-farm Stormwater R/D and Chemical Treatment		20 to 70	35	55	18	126	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

BMPs for Row Crop

Assume for Typical Condition

Potatoes Spring Crop
Assumed average farm size of 100 ac
Existing P fertilization of 100 lbs P/ac
No retention or wetland restoration
Seepage Irrigation with 60' furrows

Existing P Load	3.45	lbs-P/ac/yr
Existing P Concentration	0.44	mg/l
Average Annual Runoff	34.91	in/yr

BMPs	**Type**	**P Reduction[1]**		**Initial Cost of BMP[2]**	**Annual Cost[3]**		**Quickness of Response**
		Range %	Typical %	($/ac)	**per acre** ($/ac/yr)	**P Removed** ($/lb/ac/yr)	
Fertility							
Reduced P Fertilization (testing, split, placement, and type)	Owner	20 to 70	30	11	11	11	Slow
Water Management (irrigation and drainage, riser board control)	Cost share	0 to 40	10	11	3.52	10	Fast
Water Reuse from Retention/Detention Ponds	Alternative	0 to 20	10	33	10.56	31	Fast
Erosion Control (sediment trap in front of risers)	Alternative	0 to 5	2	11	3.52	51	Fast
Off Season In-Field Retention	Cost share	0 to 15	5	11	3.52	20	Fast
Off Season Cover Crop	Cost share	0 to 10	4	55	17.6	128	Fast
Stormwater R/D	Cost share	10 to 55	25	220	70.4	82	Fast
Wetland Restoration	Cost share	5 to 20	10	11	3.52	10	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	20 to 90	50	550	176	102	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Owner/Cost Share BMP Program Reduced P Fertilization, Water Management, additional Stormwater Retention, Cover Crop, and limited Wetland Restoration/Retention	10 to 80	60	220	70.4	34	Moderate
Owner BMP Program Reduced P Fertilization	20 to 70	30	11	3.52	3	Slow
Cost Share BMP Program Water Management, additional Stormwater Retention, Cover Crop, and limited Wetland Restoration/Retention	10 to 50	30	209	66.88	65	Fast
Alternative BMP Program Water Reuse from Retention/Detention Ponds, Erosion Control, and Edge-of-farm stormwater R/D and Chemical Treatment	20 to 90	50	440	140.8	82	Fast

BMPS for Sugarcane

Assume for Typical Condition

- 3 year ratoon
- Assumed average farm size of 400 ac
- Existing P fertilization of 30 lbs P/ac
- Limited retention or wetland restoration
- Seepage Irrigation with 330' furrows

Existing P Load	0.55	lbs-P/ac/yr
Existing P Concentration	0.08	mg/l
Average Annual Runoff	29.93	in/yr

BMPs	Type	P Reduction[1]		Initial Cost	Annual Cost[3]		Quickness
		Range %	Typical %	of BMP[2] ($/ac)	per acre ($/ac/yr)	P Removed ($/lb/ac/yr)	of Response
Fertility pH management		0 to 20	10	0	0	0	Fast
Reduced P Fertilization (testing, split, placement, and type)	Owner	10 to 50	20	0	0	0	Slow
Water Management (irrigation and drainage, in-field retention)	Cost share	0 to 20	10	11	3.52	64	Fast
Water Reuse from Retention/Detention Ponds	Alternative	0 to 20	10	33	10.56	191	Fast
Stormwater R/D	Cost share	5 to 45	15	110	35.2	425	Fast
Wetland Restoration	Cost share	2 to 15	7	11	3.52	91	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	20 to 90	70	220	70.4	182	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP

2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.

3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.

4 High O&M Costs

Program	Range %	Typical %	Initial Cost ($/ac)	Annual Cost per acre ($/ac/yr)	P Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced P fertilization, water management, and limited wetland restoration/retention	10 to 70	33	110	35	193	Moderate
Owner BMP Program Reduced P Fertilization	10 to 50	10	2.2	0	0	Slow
Cost Share BMP Program Water Management and limited Wetland Restoration/Retention	10 to 60	23	107.8	34	272	Fast
Alternative BMP Program Water Reuse from Retention/Detention Ponds and Edge-of-farm stormwater R/D and Chemical Treatment	20 to 90	52	275	88	307	Fast

BMPs for Citrus

Assume for Typical Condition

Two row crown bedded		
Assumed average farm size of 200 ac		
Grass Management between Trees		
Pond retention with limited wetland restoration		
Micro jet irrigation and fertigation of young stock		
Existing P Load	0.90	lbs-P/ac/yr
Existing P Concentration	0.13	mg/l
Average Annual Runoff	29.93	in/yr

BMPs	Type	P Reduction[1]		Initial Cost of BMP[2]	Annual Cost[3]		Quickness of Response
		Range %	Typical %	($/ac)	per acre ($/ac/yr)	P Removed ($/lb/ac/yr)	
Fertility							
Reduced P Fertilization (testing, placement, and type)	Owner	0 to 25	10	0	0	0	Slow
Better N and Micros Fertilization	Owner	0 to 5	2	0	0	0	Slow
Water Management (irrigation and drainage)	Cost share	0 to 20	5	0	0	0	Fast
Water Reuse from Retention/Detention Ponds[4]	Cost share	0 to 50	10	33	10.56	118	Fast
Grass Management between Trees	Owner	0 to 5	2	22	7.04	392	Moderate
Grassed Waterways	Alternative	0 to 15	5	110	35.2	785	Fast
Stormwater R/D[5]	Cost share	10 to 60	40	440	140.8	392	Fast
Wetland Restoration	Cost share	5 to 20	10	44	14.08	157	Fast
Edge-of-farm Stormwater R/D and Chemical Treatment[6]	Alternative	20 to 90	70	220	70.4	112	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 Values shown are for using existing ponds for water reuse, if new facilities are needed then cost would increase significantly.
5 Average of pre/post 1984 stormwater management requirements, i.e. P > .6ppm if developed prior to 1984 and less if developed after 1984.
Groves developed after 1984 would probably have stormwater R/D systems, so little addition benefit would be expected for newer groves.
6 High O&M Costs

Program	Range %	Typical %	Initial Cost ($/ac)	per acre ($/ac/yr)	P Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced P Fertilization, Better N Management, Grass Management between Trees, additional Stormwater Retention, and limited Wetland Restoration/Retention	10 to 50	32	75	24	261	Moderate
Owner BMP Program Reduced P Fertilization, Better N Management, and Grass Management between Trees	0 to 25	12	5.5	0	0	Slow
Cost Share BMP Program Stormwater R/D and Wetland Restoration	5 to 50	20	77	24.64	137	Fast
Alternative BMP Program Fertigation, Grassed Waterways, and Edge-of-farm Stormwater R/D with Chemical Treatment	20 to 90	42	242	77	206	Fast

BMPS for Sod / Turf Grass

Assume for Typical Condition		
Bermudagrass		
Assumed average farm size of 100 ac		
Existing P fertilization of 70 lbs P/ac		
No retention or wetland restoration		
Seepage Irrigation with 100' furrows		
Existing P Load	2.79	lbs-P/ac/yr
Existing P Concentration	0.41	mg/l
Average Annual Runoff	29.93	in/yr

BMPs	Type	P Reduction[1]		Initial Cost of BMP[2]	Annual Cost[3]		Quickness of Response
		Range %	Typical %	($/ac)	per acre ($/ac/yr)	P Removed ($/lb/ac/yr)	
Fertility							
Reduced P Fertilization (testing, split, placement, and type)	Owner	10 to 50	20	2.2	2.2	4	Slow
Water Management (irrigation and drainage, riser board control)	Cost share	0 to 20	10	11	3.52	13	Fast
Erosion Control (Buffer Strips and sediment traps)	Alternative	0 to 15	5	55	17.6	126	Fast
Stormwater R/D	Cost share	5 to 40	25	110	35.2	51	Fast
Wetland Restoration	Cost share	2 to 15	8	11	3.52	16	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	20 to 90	50	330	105.6	76	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Program	Range %	Typical %	Initial Cost ($/ac)	per acre ($/ac/yr)	P Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced P fertilization, water management, additional stormwater retention, and limited wetland restoration	10 to 70	47	110	35.2	27	Moderate
Owner BMP Program Reduced P Fertilization	10 to 50	20	2.2	2.2	4	Slow
Cost Share BMP Program Water Management, additional Stormwater Retention, Cover Crop, and limited Wetland Restoration/Retention	10 to 50	27	107.8	34	46	Fast
Alternative BMP Program Erosion Control, and Edge-of-farm stormwater R/D and Chemical Treatment	20 to 70	50	330	105.6	76	Fast

BMPs for Ornamentals

Assume for Typical Condition

Ornamental Nursery		
Assumed average farm size of 10 ac		
Existing P fertilization of 160 lbs P/ac		
No retention or wetland restoration		
Overhead Irrigation		
Existing P Load	4.00	lbs-P/ac/yr
Existing P Concentration	0.59	mg/l
Average Annual Runoff	29.93	in/yr

BMPs	**Type**	**P Reduction[1]**		**Initial Cost of BMP[2]**	**Annual Cost[3]**		**Quickness of Response**
		Range %	Typical %	($/ac)	**per acre** ($/ac/yr)	**P Removed** ($/lb/ac/yr)	
Fertility							
Reduced P Fertilization (testing, split, placement, and type)	Owner	20 to 70	30	11	11	9	Slow
Water Management (irrigation and drainage, riser board control)	Cost share	0 to 40	10	11	4	9	Fast
Water Reuse from Retention/Detention Ponds	Alternative	0 to 20	10	33	11	26	Fast
Erosion Control (sediment trap in front of risers)	Alternative	0 to 5	2	11	4	44	Fast
Off Season In-Field Retention	Cost share	0 to 15	5	11	4	18	Fast
Off Season Cover Crop	Cost share	0 to 10	4	55	18	110	Fast
Stormwater R/D	Cost share	10 to 65	40	220	70	44	Fast
Wetland Restoration	Cost share	0 to 10	4	11	4	22	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	20 to 90	50	550	176	88	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Program	Range %	Typical %	Initial Cost ($/ac)	per acre ($/ac/yr)	P Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced P Fertilization, Water Management, additional Stormwater Retention, Cover Crop, and limited Wetland Restoration/Retention	10 to 80	67	220	70	26	Moderate
Owner BMP Program Reduced P Fertilization	20 to 70	32	11	4	3	Slow
Cost Share BMP Program Water Management, additional Stormwater Retention, Cover Crop, and limited Wetland Restoration/Retention	10 to 50	35	209	67	48	Fast
Alternative BMP Program Water Reuse from Retention/Detention Ponds, Erosion Control, and Edge-of-farm stormwater R/D and Chemical Treatment	20 to 90	50	440	141	70	Fast

BMPs for Horse Farms

Assume for Typical Condition

1 ac / horse
Assumed average farm size of 10 ac
Existing P fertilization of 5 lbs P/ac
No retention or wetland restoration
Bahia grass

Existing P Load	2.51	lbs-P/ac/yr
Existing P Concentration	0.44	mg/l
Average Annual Runoff	24.94	in/yr

BMPs	**Type**	**P Reduction[1]**		**Initial Cost of BMP[2]**	**Annual Cost[3]**		**Quickness of Response**
		Range %	Typical %	($/ac)	**per acre** ($/ac/yr)	**P Removed** ($/lb/ac/yr)	
Fertility							
Reduced P Fertilization (testing, split, placement, and type)	Owner	0 to 30	15	2.2	2.2	6	Slow
Better N and Micros Fertilization	Owner	0 to 20	10	5.5	5.5	22	Slow
Grass Management (variety, mowing, burning, irrigation, etc.)	Owner	0 to 20	2	5.5	1.76	35	Slow
Improved Grazing Management							
Rotational Grazing	Cost share	0 to 30	3	5.5	1.76	23	Moderate
Reduced Stocking Rate[4] (2ac /horse)	Owner	0 to 10	20	165	52.8	105	Slow
HIA and Direct Water Access Prevention							
Improved Watering Facilities to move animals from streams	Cost share	0 to 20	5	11	3.52	28	Fast
Provide Alternative Shade to move animals from streams	Alternative	0 to 10	1	16.5	5.28	210	Fast
Feeder/Minerals and Water Placement	Owner	0 to 30	3	2.2	0.704	9	Fast
Critical Area Fencing	Cost share	2 to 20	2	44	14.08	280	Fast
Buffer Strips	Cost share	0 to 10	5	44	14.08	112	Fast
Stormwater R/D	Cost share	5 to 40	15	44	14.08	37	Fast
Wetland Restoration	Cost share	2 to 15	5	11	3.52	28	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[5]	Alternative	20 to 90	70	220	70.4	40	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
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3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 This practice would typically be unacceptable to most farmers, but if significant feed is being purchased then it should be considered
5 High O&M Costs

	Range %	Typical %	Initial Cost ($/ac)	per acre ($/ac/yr)	P Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program P reduced to zero, Better N Management, Rotational Grazing, New Water Facilities, Retention Basin by Working Pens, Improved Grass Management, Feed Placement, Critical Area Fencing, and Moderate Wetland Restoration/Retention	10 to 50	42	49.5	15.84	15	Moderate
Owner BMP Program P Reduced to zero, Better N Management, Grass Management, and Feeder/Minerals and Water Placement	0 to 25	20	11	4	7	Slow
Cost Share BMP Program Rotational Grazing, New Water Facilities, Retention Basin by Working Pens, Critical Area Fencing, and Moderate Wetland Restoration/Retention	10 to 50	22	38.5	12	22	Moderate
Alternative BMP Program Provide Alternative Shade to move cattle from streams and Edge-of-farm Stormwater R/D and Chemical Treatment	20 to 90	49	110	35	29	Fast

BMPs for Dairies

Assume for Typical Condition

1000 head Dairy, dry cows pastured on site, 400 heifer/springers on site		
Assumed average farm size of 700 ac		
Existing P fertilization of 0 lbs P/ac		
No existing retention or wetland restoration		
Stargrass Pastures		
Animals are fenced from streams		
Existing P Load	12.94	lbs-P/ac/yr
Existing P Concentration	2.29	mg/l
Average Annual Runoff	24.94	in/yr

BMPs	**Type**	**P Reduction[1]**		**Initial Cost**	**Annual Cost[3]**		**Quickness**
		Range	Typical	**of BMP[2]**	**per acre**	**P Removed**	**of**
		%	%	($/ac)	($/ac/yr)	($/lb/ac/yr)	**Response**
Barn Waste							
Feed Ration Management	Owner	0 to 25	8	2.2	2.2	2	Slow
Solids Separation for Off Site Disposal	Alternative	0 to 10	3	5.5	1.76	5	Slow
Expanded Waste Storage Ponds	Alternative	----	----	----	----	----	----
Expanded Sprayfields	Alternative	----	----	----	----	----	----
Improved Pasture Management (See Cow-Calf Imp.. Pasture)	Owner	10 to 40	20	16.5	5.28	2	Moderate
Improved Forage/Sprayfield Management - P balanced, new crops	Owner	0 to 15	5	0	0	0	Slow
HIA Management							
Add Housing to Move Animals off Fields[4]	Alternative	30 to 70	50	3,929	1257	194	Slow
Stormwater Retention / Expanded Sprayfield	Alternative	20 to 70	40	440	140.8	27	Moderate
Edge-of-field Chemical Treatment[5]	Alternative	50 to 90	70	550	176	19	Fast
Buffer Strips	Alternative	0 to 10	5	44	14.08	22	Moderate
Stormwater R/D	Cost share	15 to 50	30	1100	352	91	Fast
Wetland Restoration	Cost share	5 to 20	10	11	3.52	3	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[5]	Alternative	50 to 90	70	550	176	19	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
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3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 Includes associated waste pond and sprayfield expansions
5 High O&M Costs

Owner/Cost Share BMP Program	20 to 65	37	1045	334.4	218	Moderate
Stormwater R/D and Wetland Restoration						
Feed Management						
Owner BMP Program	0 to 25	9	2.2	2	7	Slow
Feed Ration Management						
Cost Share BMP Program	20 to 60	28	1042.8	333.696	316	Fast
Stormwater R/D and Wetland Restoration						
Alternative BMP Program	20 to 90	48	550	176	28	Fast
Barn Waste						
Solids Separation for Off Site Disposal	0 to 10	3	6	1.76	5	Slow
Expanded Waste Storage Ponds[4]	----	----	----	----	----	----
Expanded Sprayfields[4]	----	----	----	----	----	----
HIA Management						
Add Housing to Move Animals off Fields[4]	30 to 70	50	3929	1257	194	Slow
Stormwater Retention / Expanded Sprayfield	20 to 70	40	440	141	27	Moderate
Edge-of-field Chemical Treatment[5]	50 to 90	70	550	176	19	Fast
Buffer Strips	0 to 10	5	44	14	22	Moderate
Edge-of-farm stormwater R/D and Chemical Treatment[5]	50 to 90	70	550	176	19	Fast

BMPs for Field Crop (Hayland) Production

Assume for Typical Condition		
Assumed average farm size of 500 ac		
Existing P fertilization of 60 lbs P/ac		
No retention or wetland restoration		0.14
Various Land Uses including hay, orchards, poultry, etc.		
Existing P Load	3.20	lbs-P/ac/yr
Existing P Concentration	0.53	mg/l
Average Annual Acres	26.63	in/yr

BMPs	**Type**	**P Reduction[1]**		**Initial Cost**	**Annual Cost[3]**		**Quickness**
		Range	Typical	**of BMP[2]**	**per acre**	**P Removed**	**of**
		%	%	($/ac)	($/ac/yr)	($/lb/ac/yr)	**Response**
Fertility							
Reduced P Fertilization (testing, split, placement, and type)	Owner	0 to 50	15	2.2	2.2	5	Slow
Better N and Micros Fertilization	Owner	0 to 20	3	5.5	5.5	57	Slow
Grass Management (variety, mowing, burning, irrigation, etc.)	Owner	0 to 20	2	5.5	1.76	28	Slow
Buffer Strips	Cost share	0 to 10	5	44	14.08	88	Fast
Stormwater R/D	Cost share	10 to 40	20	55	17.6	28	Fast
Wetland Restoration	Cost share	5 to 20	10	11	3.52	11	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	20 to 90	36	220	70.4	61	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
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3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Owner/Cost Share BMP Program P reduced to zero, Better N Management, Rotational Grazing, New Water Facilities, Retention Basin by Working Pens, Improved Grass Management, Feed Placement, Critical Area Fencing, and Moderate Wetland Restoration/Retention	10 to 60	40	50	15.84	12	Moderate
Owner BMP Program P Reduced to zero, Better N Management, Grass Management, and Feeder/Minerals and Water Placement	0 to 25	15	11	4	7	Slow
Cost Share BMP Program Rotational Grazing, New Water Facilities, Retention Basin by Working Pens, Critical Area Fencing, and Moderate Wetland Restoration/Retention	10 to 50	25	39	12	15	Moderate
Alternative BMP Program Provide Alternative Shade to move cattle from streams and Edge-of-farm Stormwater R/D and Chemical Treatment	20 to 90	36	110	35	31	Fast

BMPS for Pine Plantation

Assume for Typical Condition

Planted Pine Plantation (20 yr rotation)
Assumed average farm size of 200 ac
Existing P fertilization of 5 lbs P/ac
No retention or wetland restoration

Existing P Load	0.21	lbs-P/ac/yr
Existing P Concentration	0.06	mg/l
Average Annual Runoff	14.96	in/yr

BMPs	**Type**	**P Reduction[1]** Range %	**P Reduction[1]** Typical %	**Initial Cost of BMP[2]** ($/ac)	**Annual Cost[3]** **per acre** ($/ac/yr)	**Annual Cost[3]** **P Removed** ($/lb/ac/yr)	**Quickness of Response**
Reduced P Fertilization (testing, placement, and type)	Owner	0 to 10	1	0	0	0	Slow
Stormwater R/D	Cost share	2 to 15	8	22	22	1329	Fast
Wetland Restoration	Cost share	1 to 5	2	11	3.52	850	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	20 to 70	50	110	35.2	340	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
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3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Program	Range %	Typical %	Initial Cost ($/ac)	per acre ($/ac/yr)	P Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced P Fertilization, Stormwater R/D, and limited Wetland Restoration	2 to 25	11	22	22	1111	Moderate
Owner BMP Program Reduced P Fertilization	0 to 25	1	0	0	0	Slow
Cost Share BMP Program Stormwater R/D and limited Wetland Restoration	10 to 50	10	22	20	1111	Fast
Alternative BMP Program Edge-of-farm Stormwater R/D and Chemical Treatment	20 to 70	50	100	32	355	Fast

BMPS for Transportation Corridors

Assume for Typical Condition			
	50% Paved Surface		
	Bahia Grass Shoulders		
	Existing P fertilization of 15 lbs P/ac		
	Limited retention or wetland restoration		
	Existing P Load	2.28	lbs-P/ac/yr
	Existing P Concentration	0.20	mg/l
	Average Annual Runoff	49.88	in/yr

BMPs		**Type**	**P Reduction[1]**		**Initial Cost**	**Annual Cost[3]**		**Quickness**
			Range %	Typical %	**of BMP[2]** ($/ac)	**per acre** ($/ac/yr)	**P Removed** ($/lb/ac/yr)	**of Response**
Fertility	pH management		0 to 20	10	0	0	0	Fast
	Reduced P Fertilization (testing, split, placement, and type)	Owner	10 to 50	20	0	0	0	Slow
Stormwater R/D		Cost share	5 to 45	15	110	35.2	103	Fast
Wetland Restoration		Cost share	2 to 15	7	11	3.52	22	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]		Alternative	20 to 90	70	220	70.4	44	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
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3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Owner/Cost Share BMP Program Reduced P fertilization, water management, and limited wetland restoration/retention	10 to 70	33	110	35	47	Moderate
Owner BMP Program Reduced P Fertilization	10 to 50	10	2.2	0	0	Slow
Cost Share BMP Program Water Management and limited Wetland Restoration/Retention	10 to 60	23	107.8	34	66	Fast
Alternative BMP Program Water Reuse from Retention/Detention Ponds and Edge-of-System stormwater R/D and Chemical Treatment	20 to 90	52	275	88	74	Fast

BMPs for Communications and Utilities

Assume for Typical Condition

Marginally Maintained Bahia Grass
No Pond retention

Existing P Load	0.66	lbs-P/ac/yr
Existing P Concentration	0.12	mg/l
Average Annual Runoff	25.05	in/yr

BMPs	**Type**	**P Reduction[1]** Range %	Typical %	**Initial Cost of BMP[2]** ($/ac)	**Annual Cost[3]** **per acre** ($/ac/yr)	**P Removed** ($/lb/ac/yr)	**Quickness of Response**
Fertility							
Reduced P Fertilization (testing, placement, and type)	Owner	0 to10	5	0	0	0	Slow
Dry/Wet Retention 0.25"	Cost share	0 to 20	2	1280	409.6	30918	Fast
Wet Restoration	Cost share	0 to 20	3	1600	512	25765	Fast
Dry Detention - Regional	Alternative	15 to 35	25	3200	1024	6184	Fast
Wet Detention - Regional	Alternative	40 to 80	65	4000	1280	2973	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMPs
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3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Owner/Cost Share BMP Program Reduced P Fertilization,limited dry/wet retention, and wetland restoration	0 to 20	10	6400	2048	30918	Moderate
Owner BMP Program Reduced P Fertilization	0 to 10	5	0	0	0	Slow
Cost Share BMP Program Selective limited dry/wet retention and Wetland Restoration	5 to 50	5	6400	2048	61836	Fast
Alternative BMP Program Stormwater R/D with Chemical Treatment	15 to 80	50	3200	1024	3092	Fast

BMPs for Low Density Residential

Assume for Typical Condition

Low Density Residential
Assumed average development size of 200 ac
Moderately Managed Lawns Mid-IFAS 1.5 lb-N/1000ft2
Limited Pond retention
Limited Lawn Irrigation

Existing N Load	7.26	lbs-P/ac/yr
Existing N Concentration	1.17	mg/l
Average Annual Runoff	27.43	in/yr

BMPs	Type	N Reduction[1]		Initial Cost	Annual Cost[3]		Quickness
		Range	Typical	of BMP[2]	per acre	N Removed	of
		%	%	($/ac)	($/ac/yr)	($/lb/ac/yr)	Response
Fertility							
Reduced N Fertilization (IFAS low, placement, and type)	Owner	0 to 30	15	11	3.52	3	Fast
Dry Retention/Swales[4] 0.25"	Cost share	10 to 40	15	6400	2048	1881	Fast
Wet Detention - 0.25"	Cost share	10 to 40	20	8000	2560	1763	Fast
Street Sweeping	Cost share	0 to 10	2	20	6.4	44	Fast
Sediment/Baffle Boxes	Cost share	2 to 30	15	440	140.8	129	Fast
Dry Detention - Regional	Alternative	5 to 35	15	3200	1024	940	Fast
Wet Detention - Regional	Alternative	5 to 30	15	4000	1280	1175	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMPs
2 Costs presented on per acre of entire development basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 Adjusted down to correct for reported Dry Detention reductions not including ground water re-emergent N loads.

Program	Range %	Typical %	Initial Cost ($/ac)	per acre ($/ac/yr)	N Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced N Fertilization, Swales, and limited Dry Retention/Sweeping	0 to 50	30	6411	2051.52	942	Fast
Owner BMP Program Reduced N Fertilization	0 to 30	15	11	3.52	3	Fast
Cost Share BMP Program Limited Dry Retention, Street Sweeping, Sediment R/D and Wetland Restoration	10 to 40	15	6400	2048	1881	Fast
Alternative BMP Program Stormwater R/D with Chemical Treatment	5 to 35	15	3200	1024	940	Fast

BMPs for Medium Density Residential

Assume for Typical Condition

Medium Density Residential
Assumed average development size of 200 ac
Moderately Managed Lawns Mid-IFAS 3.5 lb-N/1000ft2
Limited Pond retention
Limited Lawn Irrigation

Existing N Load	10.56	lbs-N/ac/yr
Existing N Concentration	1.44	mg/l
Average Annual Runoff	32.42	in/yr

BMPs	Type	N Reduction[1]		Initial Cost	Annual Cost[3]		Quickness
		Range %	Typical %	of BMP[2] ($/ac)	per acre ($/ac/yr)	N Removed ($/lb/ac/yr)	of Response
Fertility							
Reduced N Fertilization (IFAS low, placement, and type)	Owner	0 to 50	25	15	4.8	2	Fast
Dry Retention/Swales[4] 0.25"	Cost share	10 to 50	25	6400	2048	776	Fast
Wet Detention - 0.25"	Cost share	10 to 40	20	8000	2560	1212	Fast
Street Sweeping	Cost share	0 to 10	2	20	6.4	30	Fast
Sediment/Baffle Boxes	Cost share	2 to 30	15	440	140.8	89	Fast
Dry Detention - Regional	Alternative	5 to 35	15	3200	1024	646	Fast
Wet Detention - Regional	Alternative	5 to 30	15	4000	1280	808	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMPs
2 Costs presented on per acre of entire development basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 Adjusted down to correct for reported Dry Detention reductions not including ground water re-emergent N loads.

Program	Range %	Typical %	Initial Cost ($/ac)	per acre ($/ac/yr)	N Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced N Fertilization, Swales, and limited Dry Retention/Sweeping	0 to 70	50	6415	2052.8	389	Fast
Owner BMP Program Reduced N Fertilization	0 to 60	25	15	4.8	2	Fast
Cost Share BMP Program Limited Dry Retention, Street Sweeping, Sediment R/D and Wetland Restoration	5 to 50	25	6400	2048	776	Fast
Alternative BMP Program Stormwater R/D with Chemical Treatment	5 to 35	15	3200	1024	646	Fast

BMPs for High Density Residential

Assume for Typical Condition

High Density Residential
Assumed average development size of 200 ac
Moderately Managed Lawns Mid-IFAS 3.5 lb-N/1000ft2
Limited Pond retention
Limited Lawn Irrigation

Existing N Load	15.84	lbs-N/ac/yr
Existing N Concentration	1.75	mg/l
Average Annual Runoff	39.90	in/yr

BMPs	**Type**	**N Reduction[1]**		**Initial Cost**	**Annual Cost[3]**		**Quickness**
		Range	Typical	**of BMP[2]**	**per acre**	**N Removed**	**of**
		%	%	($/ac)	($/ac/yr)	($/lb/ac/yr)	**Response**
Fertility							
Reduced N Fertilization (IFAS low, placement, and type)	Owner	0 to 60	30	15	4.8	1	Fast
Dry Retention/Swales[4] 0.25"	Cost share	10 to 50	25	6400	2048	517	Fast
Wet Detention - 0.25"	Cost share	10 to 40	20	8000	2560	808	Fast
Street Sweeping	Cost share	0 to 10	2	20	6.4	20	Fast
Sediment/Baffle Boxes	Cost share	2 to 30	15	440	140.8	59	Fast
Dry Detention - Regional	Alternative	5 to 35	15	3200	1024	431	Fast
Wet Detention - Regional	Alternative	5 to 30	15	4000	1280	539	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMPs
2 Costs presented on per acre of entire development basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 Adjusted down to correct for reported Dry Detention reductions not including ground water re-emergent N loads.

Owner/Cost Share BMP Program Reduced N Fertilization, Swales, and limited Dry Retention/Sweeping	0 to 70	55	6415	2052.8	236	Fast
Owner BMP Program Reduced N Fertilization	0 to 60	30	15	4.8	1	Fast
Cost Share BMP Program Limited Dry Retention, Street Sweeping, Sediment R/D and Wetland Restoration	5 to 50	25	6400	2048	517	Fast
Alternative BMP Program Stormwater R/D with Chemical Treatment	5 to 35	15	3200	1024	431	Fast

BMPs for Other Urban

Assume for Typical Condition

Mixed Commercial, Industrial, institutional, recreation
Assumed average development size of 200 ac
Moderately Managed Lawns Mid-IFAS 3.5 lb-N/1000ft2
Limited Pond retention
Limited Lawn Irrigation

Existing N Load	11.68	lbs-N/ac/yr
Existing N Concentration	1.42	mg/l
Average Annual Runoff	36.34	in/yr

BMPs	Type	N Reduction[1]		Initial Cost	Annual Cost[3]		Quickness
		Range	Typical	of BMP[2]	per acre	N Removed	of
		%	%	($/ac)	($/ac/yr)	($/lb/ac/yr)	Response
Fertility							
Reduced N Fertilization (IFAS low, placement, and type)	Owner	0 to 50	25	15	4.8	2	Fast
Dry Retention/Swales[4] 0.25"	Cost share	10 to 50	25	6400	2048	701	Fast
Wet Detention - 0.25"	Cost share	10 to 40	20	8000	2560	1096	Fast
Street Sweeping	Cost share	0 to 10	2	20	6.4	27	Fast
Sediment/Baffle Boxes	Cost share	2 to 30	15	440	140.8	80	Fast
Dry Detention - Regional	Alternative	5 to 35	15	3200	1024	584	Fast
Wet Detention - Regional	Alternative	5 to 30	15	4000	1280	731	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMPs
2 Costs presented on per acre of entire development basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 Adjusted down to correct for reported Dry Detention reductions not including ground water re-emergent N loads.

Owner/Cost Share BMP Program Reduced N Fertilization, Swales, and limited Dry Retention/Sweeping	0 to 70	50	6415	2052.8	352	Fast
Owner BMP Program Reduced N Fertilization	0 to 50	25	15	4.8	2	Fast
Cost Share BMP Program Limited Dry Retention, Street Sweeping, Sediment R/D and Wetland Restoration	10 to 50	25	6400	2048	701	Fast
Alternative BMP Program Stormwater R/D with Chemical Treatment	5 to 35	15	3200	1024	584	Fast

BMPs for Cow Calf Production

Improved Pastures

Assume for Typical Condition

3 ac / cow		
Assumed average farm size of 500 ac		
Existing N fertilization of 120 lbs N/ac		
No retention or wetland restoration		
Bahia grass		
Animals have access to streams		
Existing N Load	14.65	lbs-N/ac/yr
Existing N Concentration	2.16	mg/l
Average Annual Runoff	29.93	in/yr

BMPs	Type	N Reduction[1]		Initial Cost	Annual Cost[3]		Quickness
		Range	Typical	of BMP[2]	per acre	N Removed	of
		%	%	($/ac)	($/ac/yr)	($/lb/ac/yr)	Response
Fertility							
Reduced N Fertilization (IFAS, placement, and type)	Owner	0 to 30	15	2.2	2.2	1	Fast
Better Micros Fertilization	Owner	0 to 20	3	5.5	5.5	13	Fast
Grass Management (variety, mowing, burning, irrigation, etc.)	Owner	0 to 20	2	5.5	1.76	6	Fast
Improved Grazing Management							
Rotational Grazing	Cost share	0 to 30	3	5.5	1.76	4	Fast
Reduced Stocking Rate[4] (4ac /cow)	Owner	0 to 10	5	165	52.8	72	Fast
HIA and Direct Water Access Prevention							
Improved Watering Facilities to move cattle from streams	Cost share	0 to 20	10	11	3.52	2	Fast
Provide Alternative Shade to move cattle from streams	Alternative	0 to 10	2	16.5	5.28	18	Fast
Feeder/Minerals and Water Placement	Owner	0 to 30	3	2.2	0.704	2	Fast
Critical Area Fencing	Cost share	2 to 20	5	44	14.08	19	Fast
Retention Basin by Working Pens	Cost share	2 to 10	5	3.3	1.056	1	Fast
Buffer Strips	Cost share	0 to 10	5	44	14.08	19	Fast
Stormwater R/D	Cost share	5 to 40	15	44	14.08	6	Fast
Wetland Restoration	Cost share	2 to 15	5	11	3.52	5	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[5]	Alternative	5 to 70	50	220	70.4	10	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 This practice would typically be unacceptable to most farmers, but if significant feed is being purchased then it should be considered
5 High O&M Costs

Program	Range %	Typical %	Initial Cost ($/ac)	per acre ($/ac/yr)	N Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program P reduced to zero, Better N Management, Rotational Grazing, New Water Facilities, Retention Basin by Working Pens, Improved Grass Management, Feed Placement, Critical Area Fencing, and Moderate Wetland Restoration/Retention	10 to 50	27	49.5	15.84	4	Fast
Owner BMP Program Reduced N Fertilization (IFAS, placement, and type) Grass Management, and Feeder/Minerals and Water Placement	0 to 25	17	11	4	1	Fast
Cost Share BMP Program Rotational Grazing, New Water Facilities, Retention Basin by Working Pens, Critical Area Fencing, and Moderate Wetland Restoration/Retention	10 to 50	10	38.5	12	8	Fast
Alternative BMP Program Provide Alternative Shade to move cattle from streams and Edge-of-farm Stormwater R/D and Chemical Treatment	5 to 60	30	110	35	8	Fast

BMPs for Cow Calf Production

Unimproved Pasture

Assume for Typical Condition

8 ac per cow		
Assumed average farm size of 500 ac		
Existing N fertilization of 60 lbs N/ac		
No retention or wetland restoration		
Bahia grass / native		
Animals have access to streams		
Existing N Load	7.26	lbs-N/ac/yr
Existing N Concentration	1.29	mg/l
Average Annual Runoff	24.94	in/yr

BMPs	**Type**	**N Reduction[1]**		**Initial Cost of BMP[2]**	**Annual Cost[3]**		**Quickness of Response**
		Range %	Typical %	($/ac)	**per acre** ($/ac/yr)	**N Removed** ($/lb/ac/yr)	
Fertility							
Reduced N Fertilization (IFAS, placement, and type)	Owner	0 to 20	9	1.2	1.2	2	Fast
Grass Management (chopping, mowing, burning, etc.)	Owner	0 to 10	2	2.2	0.704	5	Fast
Improved Grazing Management							
Rotational Grazing (limited)	Cost share	0 to 5	3	5.5	1.76	8	Fast
HIA and Direct Water Access Prevention							
Improved Watering Facilities to move cattle from streams	Owner	0 to 10	5	5.5	1.76	5	Fast
Feeder/Minerals and Water Placement	Owner	0 to 10	3	2.2	0.704	3	Fast
Critical Area Fencing	Alternative	2 to 10	3	11	3.52	16	Fast
Retention Basin by Working Pens	Cost share	2 to 10	3	3.3	1.056	5	Fast
Stormwater R/D	Cost share	2 to 15	7	22	7.04	14	Fast
Wetland Restoration	Cost share	2 to 10	4	11	3.52	12	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	5 to 50	25	110	35.2	19	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

	Range %	Typical %	Initial Cost ($/ac)	per acre ($/ac/yr)	N Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Some rotational grazing, new water facilities, retention basin basin by working pens, improved grass management, feed placement, and moderate wetland restoration/retention	5 to 30	19	13.2	4.224	3	Fast
Owner BMP Program Improved Grass Management, Watering Facilities, and Feed Placement	0 to 20	11	2.2	1	1	Fast
Cost Share BMP Program Some Rotational Grazing, retention basin basin by working pens, and moderate wetland restoration/retention	5 to 30	8	11	4	6	Fast
Alternative BMP Program Critical Area Fencing and Edge-of-farm Stormwater R/D and Chemical Treatment	5 to 60	30	55	18	8	Fast

BMPs for Cow Calf Production

Rangeland and Wooded Pasture

Assume for Typical Condition

16ac per cow		
Assumed average farm size of 500 ac		
Existing N fertilization of 10 lbs N/ac		
No retention or wetland restoration		
Bahia grass / native		
Animals have access to streams		
Existing N Load	5.41	lbs-N/ac/yr
Existing N Concentration	1.12	mg/l
Average Annual Runoff	21.24	in/yr

BMPs	**Type**	**N Reduction[1]**		**Initial Cost of BMP[2]**	**Annual Cost[3]**		**Quickness of Response**
		Range %	Typical %	($/ac)	**per acre** ($/ac/yr)	**N Removed** ($/lb/ac/yr)	
Fertility							
Better N and Micros Fertilization - No P added	Owner	0 to 10	1	2.2	1	18	Fast
Grass Management (chopping, mowing, burning, etc.)	Owner	0 to 10	2	2.2	0.704	7	Fast
Improved Grazing Management							
Rotational Grazing (limited)	Cost share	0 to 5	3	5.5	1.76	11	Fast
HIA and Direct Water Access Prevention							
Improved Watering Facilities to move cattle from streams	Owner	0 to 10	5	5.5	1.76	7	Fast
Feeder/Minerals and Water Placement	Owner	0 to 10	3	2.2	0.704	4	Fast
Critical Area Fencing	Alternative	2 to 10	3	11	3.52	22	Fast
Retention Basin by Working Pens	Cost share	2 to 10	3	3.3	1.056	7	Fast
Stormwater R/D	Cost share	2 to 20	10	22	7.04	13	Fast
Wetland Restoration	Cost share	2 to 10	4	11	3.52	16	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	5 to 50	25	110	35.2	26	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Owner/Cost Share BMP Program Some rotational grazing, new water facilities, retention basin basin by working pens, improved grass management, feed placement, and moderate wetland restoration/retention	5 to 30	10	13.2	4.224	8	Fast
Owner BMP Program Improved Grass Management, Watering Facilities, and Feed Placement	0 to 20	4	2.2	1	3	Fast
Cost Share BMP Program Some Rotational Grazing, retention basin basin by working pens, and moderate wetland restoration/retention	5 to 25	6	11	4	11	Fast
Alternative BMP Program Critical Area Fencing and Edge-of-farm Stormwater R/D and Chemical Treatment	5 to 50	20	55	18	16	Fast

BMPs for Row Crop

Assume for Typical Condition

Potatoes Spring Crop		
Assumed average farm size of 100 ac		
Existing N fertilization of 225 lbs N/ac		
No retention or wetland restoration		
Seepage Irrigation with 60' furrows		
Existing N Load	19.80	lbs-N/ac/yr
Existing N Concentration	2.50	mg/l
Average Annual Runoff	34.91	in/yr

BMPs	Type	N Reduction[1]		Initial Cost of BMP[2]	Annual Cost[3]		Quickness of Response
		Range %	Typical %	($/ac)	per acre ($/ac/yr)	N Removed ($/lb/ac/yr)	
Fertility							
Reduced N Fertilization (testing, split, placement, and type)	Owner	20 to 70	30	18	18	3	Fast
Water Management (irrigation and drainage, riser board control)	Cost share	0 to 40	10	11	3.52	2	Fast
Water Reuse from Retention/Detention Ponds	Alternative	0 to 20	10	33	10.56	5	Fast
Erosion Control (sediment trap in front of risers)	Alternative	0 to 5	2	11	3.52	9	Fast
Off Season In-Field Retention	Cost share	0 to 15	5	11	3.52	4	Fast
Off Season Cover Crop	Cost share	0 to 10	4	55	17.6	22	Fast
Stormwater R/D	Cost share	10 to 55	25	220	70.4	14	Fast
Wetland Restoration	Cost share	5 to 20	10	11	3.52	2	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	5 to 70	50	550	176	18	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Program	Range %	Typical %	Initial Cost ($/ac)	per acre ($/ac/yr)	N Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced N Fertilization, Water Management, additional Stormwater Retention, Cover Crop, and limited Wetland Restoration/Retention	10 to 80	60	220	70.4	6	Fast
Owner BMP Program Reduced N Fertilization	20 to 70	30	11	3.52	1	Fast
Cost Share BMP Program Water Management, additional Stormwater Retention, Cover Crop, and limited Wetland Restoration/Retention	10 to 50	30	209	66.88	11	Fast
Alternative BMP Program Water Reuse from Retention/Detention Ponds, Erosion Control, and Edge-of-farm stormwater R/D and Chemical Treatment	5 to 70	50	440	140.8	14	Fast

BMPS for Sugarcane

Assume for Typical Condition

3 year ratoon on organic soils
Assumed average farm size of 400 ac
Existing N fertilization of 30 lbs N/ac
Limited retention or wetland restoration
Seepage Irrigation with 330' furrows

Existing N Load	10.56	lbs-N/ac/yr
Existing N Concentration	1.56	mg/l
Average Annual Runoff	29.93	in/yr

BMPs	**Type**	**N Reduction2**		**Initial Cost of BMP[2]**	**Annual Cost[3]**		**Quickness of Response**
		Range %	Typical %	($/ac)	**per acre** ($/ac/yr)	**N Removed** ($/lb/ac/yr)	
Fertility pH management		0 to 20	10	1	1	1	Fast
Reduced N Fertilization (testing, split, placement, and type)	Owner	10 to 50	20	2	2	1	Fast
Water Management (irrigation and drainage, in-field retention)	Cost share	0 to 20	10	11	3.52	3	Fast
Water Reuse from Retention/Detention Ponds	Alternative	0 to 20	10	33	10.56	10	Fast
Stormwater R/D	Cost share	5 to 45	15	110	35.2	22	Fast
Wetland Restoration	Cost share	2 to 15	7	11	3.52	5	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	5 to 70	50	220	70.4	13	Fast
Owner/Cost Share BMP Program Reduced N fertilization, water management, and limited wetland restoration/retention		10 to 70	33	110.8	35	10	Fast
Owner BMP Program Reduced N Fertilization		10 to 50	10	3	1	1	Fast
Cost Share BMP Program Water Management and limited Wetland Restoration/Retention		10 to 60	23	107.8	34	14	Fast
Alternative BMP Program Water Reuse from Retention/Detention Ponds and Edge-of-farm stormwater R/D and Chemical Treatment		5 to 70	52	275	88	16	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

BMPs for Citrus

Assume for Typical Condition

Two row crown bedded
Assumed average farm size of 200 ac
Grass Management between Trees
Pond retention with limited wetland restoration
Micro jet irrigation and fertigation of young stock

Existing N Load at 160 lb-N/ac/yr fertilizer	11.22	lbs-N/ac/yr
Existing N Concentration	1.66	mg/l
Average Annual Runoff	29.93	in/yr

BMPs	**Type**	**N Reduction[1]**		**Initial Cost of BMP[2]**	**Annual Cost[3]**		**Quickness of Response**
		Range %	Typical %	($/ac)	**per acre** ($/ac/yr)	**N Removed** ($/lb/ac/yr)	
Fertility							
Reduced N Fertilization (IFAS, placement, and type)	Owner	0 to 25	10	20	6.4	6	Fast
Better Micros Fertilization	Owner	0 to 5	2	0	0	0	Fast
Water Management (irrigation and drainage)	Cost share	0 to 20	5	0	0	0	Fast
Water Reuse from Retention/Detention Ponds[4]	Cost share	0 to 50	10	33	10.56	9	Fast
Grass Management between Trees	Owner	0 to 5	2	22	7.04	31	Fast
Grassed Waterways	Alternative	0 to 15	5	110	35.2	63	Fast
Stormwater R/D[5]	Cost share	10 to 60	40	440	140.8	31	Fast
Wetland Restoration	Cost share	5 to 20	10	44	14.08	13	Fast
Edge-of-farm Stormwater R/D and Chemical Treatment[6]	Alternative	5 to 70	50	220	70.4	13	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 Values shown are for using existing ponds for water reuse, if new facilities are needed then cost would increase significantly.
5 Average of pre/post 1984 stormwater management requirements, i.e. P > .6ppm if developed prior to 1984 and less if developed after 1984.
Groves developed after 1984 would probably have stormwater R/D systems, so little addition benefit would be expected for newer groves.
6 High O&M Costs

Program	Range %	Typical %	Initial Cost ($/ac)	per acre ($/ac/yr)	N Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced P Fertilization, Better N Management, Grass Management between Trees, additional Stormwater Retention, and limited Wetland Restoration/Retention	10 to 50	30	490	156.8	47	Fast
Owner BMP Program Reduced N Fertilization (IFAS, placement, and type) Better Micros Fertilization	0 to 25	10	20	6.4	6	Fast
Cost Share BMP Program Stormwater R/D and Wetland Restoration	5 to 50	20	470	150.4	67	Fast
Alternative BMP Program Fertigation, Grassed Waterways, and Edge-of-farm Stormwater R/D with Chemical Treatment	5 to 70	42	242	77	16	Fast

BMPS for Sod / Turf Grass

Assume for Typical Condition

Bermudagrass
Assumed average farm size of 100 ac
Existing N fertilization of 190 lbs N/ac
No retention or wetland restoration
Seepage Irrigation with 100' furrows

Existing N Load	11.88	lbs-N/ac/yr
Existing N Concentration	1.75	mg/l
Average Annual Runoff	29.93	in/yr

BMPs	Type	N Reduction[1]		Initial Cost of BMP[2]	Annual Cost[3]		Quickness of Response
		Range %	Typical %	($/ac)	per acre ($/ac/yr)	N Removed ($/lb/ac/yr)	
Fertility							
Reduced N Fertilization (testing, split, placement, and type)	Owner	10 to 50	20	2.2	2.2	1	Fast
Water Management (irrigation and drainage, riser board control)	Cost share	0 to 20	10	11	3.52	3	Fast
Erosion Control (Buffer Strips and sediment traps)	Alternative	0 to 15	5	55	17.6	30	Fast
Stormwater R/D	Cost share	5 to 40	25	110	35.2	12	Fast
Wetland Restoration	Cost share	2 to 15	8	11	3.52	4	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	20 to 70	50	330	105.6	18	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
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3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Program	Range %	Typical %	Initial Cost ($/ac)	per acre ($/ac/yr)	N Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced N fertilization, water management, additional stormwater retention, and limited wetland restoration	10 to 70	47	110	35.2	6	Fast
Owner BMP Program Reduced N Fertilization	10 to 50	20	2.2	2.2	1	Fast
Cost Share BMP Program Water Management, additional Stormwater Retention, Cover Crop, and limited Wetland Restoration/Retention	10 to 50	27	107.8	34	11	Fast
Alternative BMP Program Erosion Control, and Edge-of-farm stormwater R/D and Chemical Treatment	20 to 70	50	330	105.6	18	Fast

BMPs for Ornamentals

Assume for Typical Condition

Ornamental Nursery		
Assumed average farm size of 10 ac		
Existing N fertilization of 160 lbs N/ac		
No retention or wetland restoration		
Overhead Irrigation		
Existing N Load	15.84	lbs-N/ac/yr
Existing N Concentration	2.34	mg/l
Average Annual Runoff	29.93	in/yr

BMPs	**Type**	**N Reduction[1]** Range %	Typical %	**Initial Cost of BMP[2]** ($/ac)	**Annual Cost[3]** **per acre** ($/ac/yr)	**N Removed** ($/lb/ac/yr)	**Quickness of Response**
Fertility							
Reduced N Fertilization (testing, split, placement, and type)	Owner	10 to 50	25	11	11	3	Fast
Water Management (irrigation and drainage, riser board control)	Cost share	0 to 40	10	11	4	2	Fast
Water Reuse from Retention/Detention Ponds	Alternative	0 to 20	10	33	11	7	Fast
Erosion Control (sediment trap in front of risers)	Alternative	0 to 5	2	11	4	11	Fast
Off Season In-Field Retention	Cost share	0 to 15	5	11	4	4	Fast
Off Season Cover Crop	Cost share	0 to 30	15	55	18	7	Fast
Stormwater R/D	Cost share	10 to 65	40	220	70	11	Fast
Wetland Restoration	Cost share	0 to 10	4	11	4	6	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	5 to 70	50	550	176	22	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

	Range %	Typical %	Initial Cost ($/ac)	per acre ($/ac/yr)	N Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced N Fertilization, Water Management, additional Stormwater Retention, Cover Crop, and limited Wetland Restoration/Retention	10 to 80	50	220	70	9	Fast
Owner BMP Program Reduced N Fertilization	10 to 50	25	11	4	1	Fast
Cost Share BMP Program Water Management, additional Stormwater Retention, Cover Crop, and limited Wetland Restoration/Retention	10 to 50	25	209	67	17	Fast
Alternative BMP Program Water Reuse from Retention/Detention Ponds, Erosion Control, and Edge-of-farm stormwater R/D and Chemical Treatment	10 to 50	25	440	141	36	Fast

BMPs for Horse Farms

Assume for Typical Condition

- 1 ac / horse
- Assumed average farm size of 10 ac
- Existing N fertilization of 180 lbs N/ac
- No retention or wetland restoration
- Bahia grass

Existing N Load	21.12	lbs-N/ac/yr
Existing N Concentration	3.74	mg/l
Average Annual Runoff	24.94	in/yr

BMPs	**Type**	**N Reduction[1]**		**Initial Cost of BMP[2]**	**Annual Cost[3]**		**Quickness of Response**
		Range %	Typical %	($/ac)	**per acre** ($/ac/yr)	**N Removed** ($/lb/ac/yr)	
Fertility							
Reduced N Fertilization (IFAS, placement, and type)	Owner	0 to 60	30	4.2	4.2	1	Fast
Better Micros Fertilization	Owner	0 to 20	3	5.5	5.5	9	Fast
Grass Management (variety, mowing, burning, irrigation, etc.)	Owner	0 to 20	2	5.5	1.76	4	Fast
Improved Grazing Management							
Rotational Grazing	Cost share	0 to 30	3	5.5	1.76	3	Fast
Reduced Stocking Rate[4] (2ac /horse)	Owner	0 to 20	10	165	52.8	25	Fast
HIA and Direct Water Access Prevention							
Improved Watering Facilities to move animals from streams	Cost share	0 to 20	5	11	3.52	3	Fast
Provide Alternative Shade to move animals from streams	Alternative	0 to 10	1	16.5	5.28	25	Fast
Feeder/Minerals and Water Placement	Owner	0 to 30	3	2.2	0.704	1	Fast
Critical Area Fencing	Cost share	2 to 20	2	44	14.08	33	Fast
Buffer Strips	Cost share	0 to 10	5	44	14.08	13	Fast
Stormwater R/D	Cost share	5 to 40	15	44	14.08	4	Fast
Wetland Restoration	Cost share	2 to 15	5	11	3.52	3	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[5]	Alternative	5 to 70	50	220	70.4	7	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 This practice would typically be unacceptable to most farmers, but if significant feed is being purchased then it should be considered
5 High O&M Costs

Program	Range %	Typical %	Initial Cost ($/ac)	Annual Cost per acre ($/ac/yr)	N Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program P reduced to zero, Better N Management, Rotational Grazing, New Water Facilities, Retention Basin by Working Pens, Improved Grass Management, Feed Placement, Critical Area Fencing, and Moderate Wetland Restoration/Retention	10 to 70	52	49.5	15.84	1	Fast
Owner BMP Program Reduced N Fertilization (IFAS, placement, and type) Grass Management, and Feeder/Minerals and Water Placement	0 to 60	30	11	4	1	Fast
Cost Share BMP Program Rotational Grazing, New Water Facilities, Retention Basin by Working Pens, Critical Area Fencing, and Moderate Wetland Restoration/Retention	10 to 50	22	38.5	12	3	Fast
Alternative BMP Program Provide Alternative Shade to move cattle from streams and Edge-of-farm Stormwater R/D and Chemical Treatment	5 to 60	30	110	35	6	Fast

BMPs for Dairies

Assume for Typical Condition

- 1000 head Dairy, dry cows pastured on site, 400 heifer/springers on site
- Assumed average farm size of 700 ac
- Existing N fertilization of 100 lbs N/ac
- No existing retention or wetland restoration
- Stargrass Pastures
- Animals are fenced from streams

Existing N Load	26.40	lbs-N/ac/yr
Existing N Concentration	4.67	mg/l
Average Annual Runoff	24.94	in/yr

BMPs	**Type**	**N Reduction[1]**		**Initial Cost**	**Annual Cost[3]**		**Quickness**
		Range	Typical	**of BMP[2]**	**per acre**	**N Removed**	**of**
		%	%	($/ac)	($/ac/yr)	($/lb/ac/yr)	**Response**
Barn Waste							
Feed Ration Management	Owner	0 to 25	1	2.2	2.2	8	Fast
Solids Separation for Off Site Disposal	Alternative	0 to 10	1	5.5	1.76	7	Fast
Expanded Waste Storage Ponds	Alternative	----	----	----	----	----	----
Expanded Sprayfields	Alternative	----	----	----	----	----	----
Improved Pasture Management (See Cow-Calf Imp.. Pasture)	Owner	10 to 40	20	16.5	5.28	1	Fast
Improved Forage/Sprayfield Management - N/P balanced, new crops	Owner	0 to 15	5	0	0	0	Fast
HIA Management							
Add Housing to Move Animals off Fields[4]	Alternative	30 to 70	50	3,929	1257	95	Fast
Stormwater Retention / Expanded Sprayfield	Alternative	20 to 70	40	440	140.8	13	Fast
Edge-of-field Chemical Treatment[5]	Alternative	5 to 30	15	550	176	44	Fast
Buffer Strips	Alternative	0 to 10	5	44	14.08	11	Fast
Stormwater R/D	Cost share	15 to 50	30	1100	352	44	Fast
Wetland Restoration	Cost share	5 to 20	10	11	3.52	1	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[5]	Alternative	5 to 70	50	550	176	13	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Value only include implementation cost, i.e. doesn't include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 Includes associated waste pond and sprayfield expansions
5 High O&M Costs

Owner/Cost Share BMP Program Stormwater R/D and Wetland Restoration N Fertilizer Reduction	20 to 65	60	1045	334.4	66	Fast
Owner BMP Program N Fertilzer Management	10 to 40	20	2.2	0.704	0	Fast
Cost Share BMP Program Stormwater R/D and Wetland Restoration	20 to 60	40	1042.8	333.696	32	Fast
Alternative BMP Program	20 to 90	48	750	240	19	Fast
Barn Waste						
Solids Separation for Off Site Disposal	0 to 10	1	6	1.76	7	Fast
Expanded Waste Storage Ponds[4]	----	----	----	----	----	----
Expanded Sprayfields[4]	----	----	----	----	----	----
HIA Management						
Add Housing to Move Animals off Fields[4]	30 to 70	50	3929	1257	95	Fast
Stormwater Retention / Expanded Sprayfield	20 to 70	40	440	141	13	Fast
Edge-of-field Chemical Treatment[5]	5 to 30	15	550	176	44	Fast
Buffer Strips	0 to 10	5	44	14	11	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[5]	5 to 70	50	550	176	13	Fast

BMPs for Field Crop (Hayland) Production

Assume for Typical Condition

Assumed average farm size of 500 ac		
Existing N fertilization of 180 lbs N/ac		
No retention or wetland restoration		
Various Land Uses including hay, orchards, poultry, etc.		
Existing N Load	10.18	lbs-N/ac/yr
Existing N Concentration	1.69	mg/l
Average Annual Acres	26.63	in/yr

BMPs	Type	N Reduction[1]		Initial Cost	Annual Cost[3]		Quickness
		Range	Typical	of BMP[2]	per acre	N Removed	of
		%	%	($/ac)	($/ac/yr)	($/lb/ac/yr)	Response
Fertility							
Reduced N Fertilization (IFAS, placement, and type)	Owner	0 to 50	15	2.2	2.2	1	Fast
Better Micros Fertilization	Owner	0 to 20	3	5.5	5.5	18	Fast
Grass Management (variety, mowing, burning, irrigation, etc.)	Owner	0 to 20	2	5.5	1.76	9	Fast
Buffer Strips	Cost share	0 to 10	5	44	14.08	28	Fast
Stormwater R/D	Cost share	10 to 40	20	55	17.6	9	Fast
Wetland Restoration	Cost share	5 to 20	10	11	3.52	3	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	5 to 70	50	220	70.4	14	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Program	Range %	Typical %	Initial Cost ($/ac)	Annual Cost per acre ($/ac/yr)	N Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program P reduced to zero, Better N Management, Rotational Grazing, New Water Facilities, Retention Basin by Working Pens, Improved Grass Management, Feed Placement, Critical Area Fencing, and Moderate Wetland Restoration/Retention	10 to 60	40	58	18.56	5	Fast
Owner BMP Program Reduced N Fertilization (IFAS, placement, and type) Grass Management, and Feeder/Minerals and Water Placement	0 to 25	15	11	4	2	Fast
Cost Share BMP Program Rotational Grazing, New Water Facilities, Retention Basin by Working Pens, Critical Area Fencing, and Moderate Wetland Restoration/Retention	10 to 50	25	47	15	6	Fast
Alternative BMP Program Provide Alternative Shade to move cattle from streams and Edge-of-farm Stormwater R/D and Chemical Treatment	5 to 70	36	110	35	10	Fast

BMPS for Pine Plantation

Assume for Typical Condition

Planted Pine Plantation (20 yr rotation)
Assumed average farm size of 200 ac
Existing N fertilization of 5 lbs N/ac
No retention or wetland restoration

Existing N Load	4.09	lbs-N/ac/yr
Existing N Concentration	1.21	mg/l
Average Annual Runoff	14.96	in/yr

BMPs	Type	N Reduction[1]		Initial Cost of BMP[2]	Annual Cost[3]		Quickness of Response
		Range %	Typical %	($/ac)	per acre ($/ac/yr)	N Removed ($/lb/ac/yr)	
Reduced N Fertilization (testing, placement, and type)	Owner	0 to 15	5	3	3	15	Fast
Stormwater R/D	Cost share	2 to 15	8	22	22	67	Fast
Wetland Restoration	Cost share	1 to 5	2	11	3.52	43	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	5 to 50	25	110	35.2	34	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Owner/Cost Share BMP Program Reduced N Fertilization, Stormwater R/D, and limited Wetland Restoration	2 to 25	15	22	22	36	Fast
Owner BMP Program Reduced N Fertilization	0 to 15	5	3	0	0	Fast
Cost Share BMP Program Stormwater R/D and limited Wetland Restoration	3 to 20	10	16.5	12.76	31	Fast
Alternative BMP Program Edge-of-farm Stormwater R/D and Chemical Treatment	5 to 50	25	110	35.2	34	Fast

BMPS for Transportation Corridors

Assume for Typical Condition

- 50% Paved Surface
- Bahia Grass Shoulders
- Existing N fertilization of 35 lbs N/ac
- Limited retention or wetland restoration

Existing N Load	12.14	lbs-N/ac/yr
Existing N Concentration	1.07	mg/l
Average Annual Runoff	49.88	in/yr

BMPs		**Type**	**N Reduction1**		**Initial Cost**	**Annual Cost[3]**		**Quickness**
			Range %	Typical %	**of BMP[2]** ($/ac)	**per acre** ($/ac/yr)	**N Removed** ($/lb/ac/yr)	**of Response**
Fertility	pH management		0 to 20	3	2	2	5	Fast
	Reduced N Fertilization (testing, split, placement, and type)	Owner	10 to 50	20	2	2	1	Fast
Stormwater R/D		Cost share	5 to 45	15	110	35.2	19	Fast
Wetland Restoration		Cost share	2 to 15	7	11	3.52	4	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]		Alternative	5 to 50	25	220	70.4	23	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP
2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

	Range %	Typical %	Initial Cost of BMP ($/ac)	Annual Cost per acre ($/ac/yr)	Annual Cost N Removed ($/lb/ac/yr)	Quickness of Response
Owner/Cost Share BMP Program Reduced N fertilization, water management, and limited wetland restoration/retention	10 to 70	43	111.8	36	7	Fast
Owner BMP Program Reduced N Fertilization	10 to 50	20	4	1	6	Fast
Cost Share BMP Program Water Management and limited Wetland Restoration/Retention	10 to 60	23	107.8	34	12	Fast
Alternative BMP Program Water Reuse from Retention/Detention Ponds and Edge-of-System stormwater R/D and Chemical Treatment	5 to 50	25	220	70	23	Fast

BMPs for Communications and Utilities

Assume for Typical Condition

Marginally Maintained Bahia Grass		
No Pond retention		
Existing N Load	7.92	lbs-N/ac/yr
Existing N Concentration	1.40	mg/l
Average Annual Runoff	25.05	in/yr

BMPs	**Type**	**N Reduction[1]**		**Initial Cost**	**Annual Cost[3]**		**Quickness**
		Range %	Typical %	**of BMP[2]** ($/ac)	**per acre** ($/ac/yr)	**N Removed** ($/lb/ac/yr)	**of Response**
Fertility							
Reduced P Fertilization (testing, placement, and type)	Owner	0 to10	5	0	0	0	Fast
Dry/Wet Retention 0.25"	Cost share	0 to 20	2	1280	409.6	2586	Fast
Wet Restoration	Cost share	0 to 20	3	1600	512	2155	Fast
Dry Detention - Regional	Alternative	15 to 35	25	3200	1024	517	Fast
Wet Detention - Regional	Alternative	40 to 80	65	4000	1280	249	Fast

1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMPs
2 Costs presented on per acre of entire development basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs.
3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M.
4 High O&M Costs

Owner/Cost Share BMP Program Reduced N Fertilization,limited dry/wet retention, and wetland restoration	0 to 20	10	6400	2048	2586	Moderate
Owner BMP Program Reduced N Fertilization	0 to 10	5	0	0	0	Fast
Cost Share BMP Program Selective limited dry/wet retention and Wetland Restoration	5 to 50	5	6400	2048	5172	Fast
Alternative BMP Program Stormwater R/D with Chemical Treatment	15 to 80	50	3200	1024	259	Fast

APPENDIX E

RESEARCH & WATER QUALITY MONITORING PROGRAM

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1.0 INTRODUCTION

1.1 Background

The St. Lucie River and Estuary, located on the southeast coast of Florida, and the Caloosahatchee River and Estuary, located on the southwest coast of Florida, are coastal systems that have been highly altered from their natural state by hydrologic modification and land use changes. Drainage in the south Florida region has been modified on a regional scale by the Central and Southern Florida Flood Control Project (1948). Local watersheds of both estuaries have been drained to accommodate agriculture and urban development. The estuaries themselves have been dredged for navigation and shorelines bulk headed.

Both suffer from a disruption in the natural magnitude and timing of freshwater inflows which result in fluctuations of salinity large enough to cause mortality of estuarine and marine organisms (Chamberlain and Doering, 1998; Haunert and Startzman, 1985). Both also exhibit signs of over fertilization with nutrients (eutrophication) which include: blooms of algae (micro, macro and nuisance), low dissolved oxygen and periodic fish kills (Chamberlain and Hayward, 1996; DeGrove, 1981). In addition to mortality, critical habitat has also been degraded. The water quality and quantity problems experienced by the two estuaries are not independent. The nutrient load that causes eutrophication of an estuary is a function of both water quality (nutrient concentration) and water quantity; the freshwater inflow that transports the nutrient. The solution to problems in the two estuaries will involve changes in the quality and quantity of freshwater inflow as outlined in the Lake Okeechobee Watershed Construction Project, Phase II Technical Plan (2008).

While the primary intent of the St. Lucie River Watershed Protection Plan is to address these problems, it is important to consider the context within which the Plan will be implemented. Current assumptions regarding planned projects, land use, and water supply demand may change and lead to improvements above and beyond those anticipated by the St. Lucie River Watershed Protection Plan. Ongoing and future water management operations should be coordinated among the Federal, State and Local entities that all influence the fate of water resources in the River Watersheds. Additionally, continued population growth and predicted changes in climate may also affect the future water quality and quantity.

To deal with the complexity of interactions between the water management system, its operation and the response of the natural system, it is imperative that a robust research, modeling and monitoring program be in place to guide adaptive management strategies. Such strategies will ensure cumulative benefits and optimization of water management.

1.2 Enabling Legislation

In response to the water quality and quantity problems in both estuaries, the Florida Legislature passed the Northern Everglades and Estuaries Protection Program (Senate Bill 392, Florida Senate 2007), which modified Section 373.4595, F.S. This new legislation requires the South Florida Water Management District (District), in collaboration with the Florida Department of Environmental Protection (FDEP) and the Florida Department of Agriculture and Consumer

Services (FDACS), to develop watershed protection programs for Lake Okeechobee, the St. Lucie Estuary and the Caloosahatchee Estuary.

The protection plans are composed of three parts: a construction project, a pollutant control program and a research and water quality monitoring program. This document describes the Research and Water Quality Monitoring Plan for the St. Lucie Estuary River Watershed. Subsections 373.4595(4)(a)3 and (4)(b)3, F.S., specifically require that the District develop research and water quality monitoring plans for the Caloosahatchee River and St. Lucie River Watersheds.

This document will set forth research and monitoring programs that support the goals of the River Watershed Protection Plan by building on existing research and monitoring conducted both by the District, other State and Federal Agencies, as well as non-governmental organizations. One purpose of the Research and Water Quality Monitoring Plan is to serve a coordinating function that focuses activities specifically on the St. Lucie and Caloosahatchee Estuaries and their associated watersheds.

Research and monitoring in the St. Lucie and Caloosahatchee have been on-going for more than 40 years (Gunter and Hall, 1962; Phillips, 1960). A variety of recent programs including Surface Water Improvement and Management (SWIM), Comprehensive Everglades Restoration Plan/Restoration Coordination & Verification (CERP/RECOVER) and water supply planning and rule making efforts have added to this body of knowledge. However, our ability to predict the outcomes of solutions to water quantity and water quality problems is hampered by significant gaps and uncertainties in the understanding of the two estuarine systems and their watersheds. For example, despite its importance we do not yet fully understand how various factors interact to control the concentration of dissolved oxygen in either estuary. By reducing uncertainty and filling gaps in our knowledge, the Research and Water Quality Monitoring Plan will increase our ability to find robust, scientifically based solutions and more accurately predict the response of these estuaries to changes in water quality and quantity.

1.3 Document Structure

This document consists of five (5) chapters. Chapter 2 identifies the specific goals and objectives of the Research and Monitoring Plans based on the Northern Everglades Legislation. This chapter specifies how research, modeling and monitoring contribute to the adaptive management of nutrient load reduction goals and the implementation and operation of programs and projects designed to achieve them.

Chapter 3 presents the current state of knowledge regarding hydrology, water quality and aquatic habitat. Of particular relevance to the Plan are reviews of nutrient loading, salinity envelopes and effects of Lake Okeechobee on delivery of water to the St. Lucie.

Chapter 4 is a summary of existing monitoring programs for hydrology, water quality, and aquatic habitat. The programs are evaluated based on their ability to meet program goals and potential improvements are identified. Finally a recommended monitoring plan, along with associated costs of implementation is described.

Chapter 5 summarizes on-going research and modeling applicable to program goals. Plans for future research and modeling are described and prioritized. Integration of research, modeling and monitoring will establish scientifically sound performance measures and support improvements to the estuary through the adaptive management process.

The general background information for the St. Lucie and Caloosahatchee estuaries provided in Chapters 1 and 2 of the Research and Water Quality Monitoring Plan, is described in detail in the corresponding watershed protection plans.

1.4 Literature Cited

Chamberlain, R.H. and P.H. Doering. 1998. Preliminary estimate of optimum freshwater inflow to the Caloosahatchee Estuary: A resource-based approach. Proceedings of the Charlotte Harbor Public Conference and Technical Symposium; 1997 March 15-16; Punta Gorda, FL. Charlotte Harbor National Estuary Program Technical Report No. 98-02. 274 p.

Chamberlain, R. and D. Hayward. 1996. Evaluation of water quality and monitoring in the St. Lucie Estuary, Florida. Water Resources Bulletin 32: 681-696.

Degrove, B. 1981. Caloosahatchee River wasteload allocation documentation. Florida Dept. of Env. Reg., Water Quality Tech ser. 2. No. 52. 17 pp.

Gunter, G. and G.E. Hall 1962. Biological investigation of the Caloosahatchee Estuary in connection with Lake Okeechobee discharges through the Caloosahatchee River. Consultant Report to the U.S. Corps of Engineers, Jacksonville District. Serial No. 25, 59 pp.

Haunert, D.E. and J.R. Startzman. 1985. Some short term effects of a freshwater discharge on biota of the St. Lucie Estuary, Florida. South Florida Water Management District Pub. 85-1. 65 pp.

Phillips, R.C. 1960. Observations on the ecology and distribution of the Florida seagrasses. Professional papers series. Number 2. Contribution Number 44. Florida State Board of Conservation Marine Laboratory. St. Petersburg, Florida. 72 pp.

2.0 GOALS AND OBJECTIVES OF MONITORING AND RESEARCH

2.1 Goals and Objectives

Section 373.4595, F.S. specifically identifies three goals for the St. Lucie and the Caloosahatchee River Watershed Protection Programs: (1) pollutant load reductions based upon adopted total maximum daily loads (TMDL); (2) salinity envelopes and freshwater inflow targets; and (3) reduce the frequency and duration of undesirable salinity ranges while meeting other water – related needs in the region. The legislation also requires an annual progress report as part of the consolidated annual report required in Section 373.036(7), also known as the South Florida Environmental Report (SFER). The report includes a summary of the conditions of hydrology, water quality and aquatic habitat in the Northern Everglades based on the results of the Research and Water Quality Monitoring Programs. Lastly, the legislation requires that the District conduct an evaluation of the Programs every three years. The evaluation shall identify modifications to facilities of the River Watershed Construction Projects, as appropriate, or any other elements of the River Watershed Protection Plans.

This latter requirement is particularly important because it specifies how the River Watershed Research and Water Quality Monitoring Plans will be integrated with the River Watershed Protection Programs and their component parts. This requirement defines an adaptive management feedback loop that allows information generated by monitoring, modeling and research to assist and support the periodic assessments and identify potential modifications.

Research, modeling and monitoring are essential for the design and operation of programs to restore and protect the Caloosahatchee and St. Lucie estuaries. The following objectives are key to the success of the Plan. Section 373.4595 requires the establishment of a program that:

1. Builds upon the District's existing monitoring, research and modeling programs.
2. Is sufficient to carry out, comply with, or assess the plans, programs, and other responsibilities of Section 373.4595.
3. Provide for an assessment of the water volumes and timing from Lake Okeechobee and the watersheds and their relative contributions to the timing and volume of water delivered to each estuary. The research program must provide technical information regarding inflow targets and salinity envelopes for both estuaries.
4. To facilitate creation of predictive and/or numeric modeling tools in order to fulfill the requirement to assess plans and programs and to predict and evaluate progress toward overall protection program objectives. These tools can be used to 1) evaluate and quantify the nutrient load reduction achieved by construction projects and/or operational modifications and progress toward restoration of natural hydrology and targeted water quality; and 2) evaluate the effectiveness of collective source control programs developed by the District, FDEP and FDACS.
5. The research program should also provide the empirical data and conceptual understanding of the St. Lucie River and Caloosahatchee River Watersheds and estuarine receiving waters to support and improve predictive models and identify new water quality management measures.

6. Collect data necessary to quantify loads for pollutants requiring a TMDL, including concentration and freshwater discharge.
7. Monitoring of salinity should be sufficient to measure the frequency and duration of salinities that are undesirable for those biotic resources upon which salinity envelopes are based.
8. Monitoring of the biotic resources (oysters and seagrasses) is required to determine if reductions in undesirable salinities and/or nutrient loads have the desired ecological result.
9. Monitoring will also support annual reporting of the conditions of hydrology, water quality and aquatic habitat required by the legislation.
10. The application of adaptive management is an integral part of the River Watershed Protection Plan. **Figure 2-1** depicts the role of monitoring, modeling and research in adaptive management. Analysis of monitoring results determines if the frequency and duration of undesirable salinity ranges is declining and if load reductions are being met. If progress is not being met, results of research and modeling can identify reasons why. Information from monitoring, modeling and research can be used to identify refinements to flow and salinity envelopes, pollutant load reduction goals and changes to facility operations and implementation priorities.

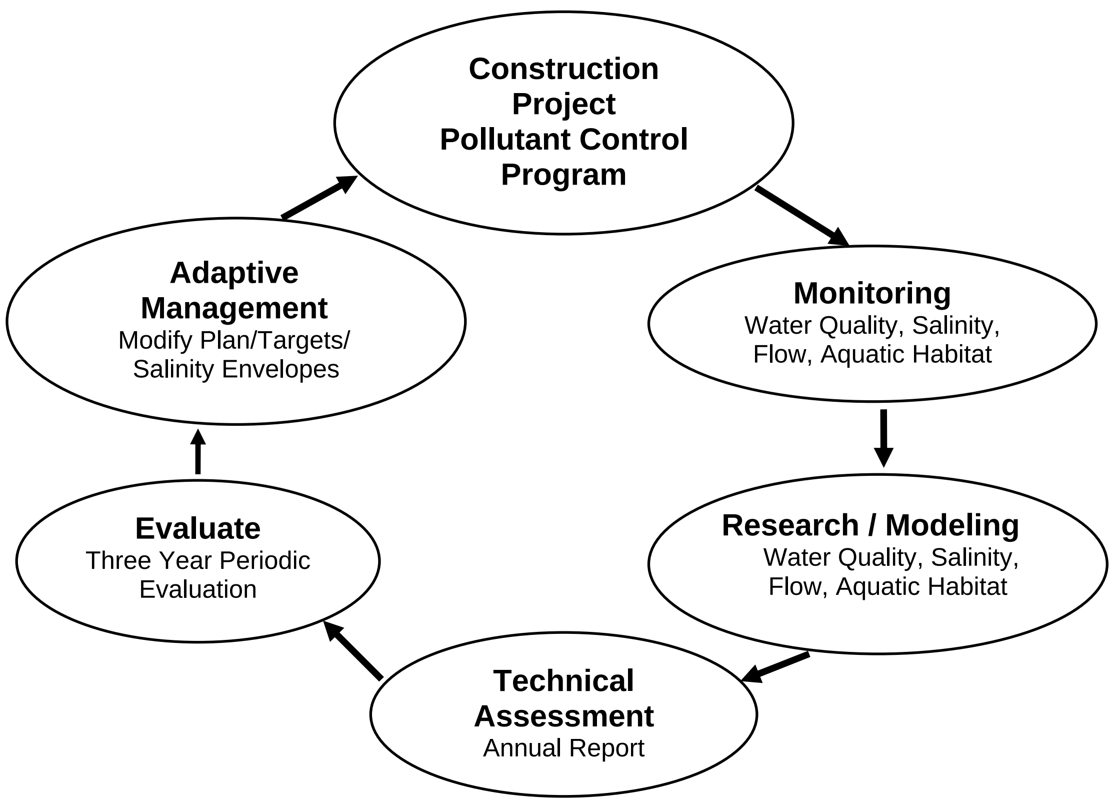


Figure 2-1. Monitoring, modeling, research and adaptive management in the River Watershed Protection Program.

3.0 THE RIVER AND ITS WATERSHED: STATUS, TRENDS AND TARGETS IN HYDROLOGY, WATER QUALITY, AND AQUATIC HABITATS

By Coastal Ecosystem Division and Environmental Resource Assessment Department of the South Florida Water Management District

This chapter addresses three requirements of the River Watershed Protection Programs: 1) salinity and freshwater inflow goals, 2) effects of discharges from Lake Okeechobee on delivery of water to the estuaries, and 3) the status and trends in hydrology, water quality, and aquatic habitat.

The St. Lucie Estuary receives excessive freshwater discharges from its local watersheds, especially during the wet season. This situation is often exacerbated by regulatory discharges from Lake Okeechobee. Recognizing these facts, the legislation enabling the Caloosahatchee and St. Lucie River Watershed Protection Programs requires inclusion of a "goal for salinity envelopes and freshwater inflow targets for the estuaries based upon existing research and documentation. The goal may be revised as new information is available. This goal shall seek to reduce the frequency and duration of undesirable salinity ranges while meeting other water related needs of the region, including water supply and flood protection, while recognizing the extent to which inflows are within the control and jurisdiction of the district." The legislation further requires "an assessment of the water volumes and timing from the Lake Okeechobee and St. Lucie watersheds and their relative contributions to the timing and volume of water delivered to the estuary." Lastly, the legislation requires an annual report that, "shall include a summary of the conditions of the hydrology, water quality, and aquatic habitat in the Northern Everglades."

This chapter begins with a description of the St. Lucie River Watershed Protection Program study area and the historical changes that have occurred. A discussion of the current status and trends in hydrology, nutrient loading, water quality, salinity envelopes, freshwater inflow targets, and aquatic habitat follow.

3.1 Delineation of Study Area

3.1.1 The River and Estuary

The St. Lucie Estuary and its associated watershed are located on the central east coast of Florida (**Figure 3.1-1).** The estuary is a drowned river valley type and was formed at the confluence of two rivers which account for its forked shape. The system is composed of four major geographically identifiable parts: the North and South Forks; the mid-estuary, consisting of the area from the junction of the North and South Forks to Hell's Gate; and the outer estuary extending from Hell's Gate to the St. Lucie Inlet **(Figure 3.1-1)**.

The main body of the North Fork is about 4 miles long, with a surface area of approximately 4.5 sq. mi. and a total volume of 998.5 x 10^6 cu. ft. at mean sea level. The South Fork is approximately half the size of the North Fork with a surface area of about 1.9 sq. mi. and a total

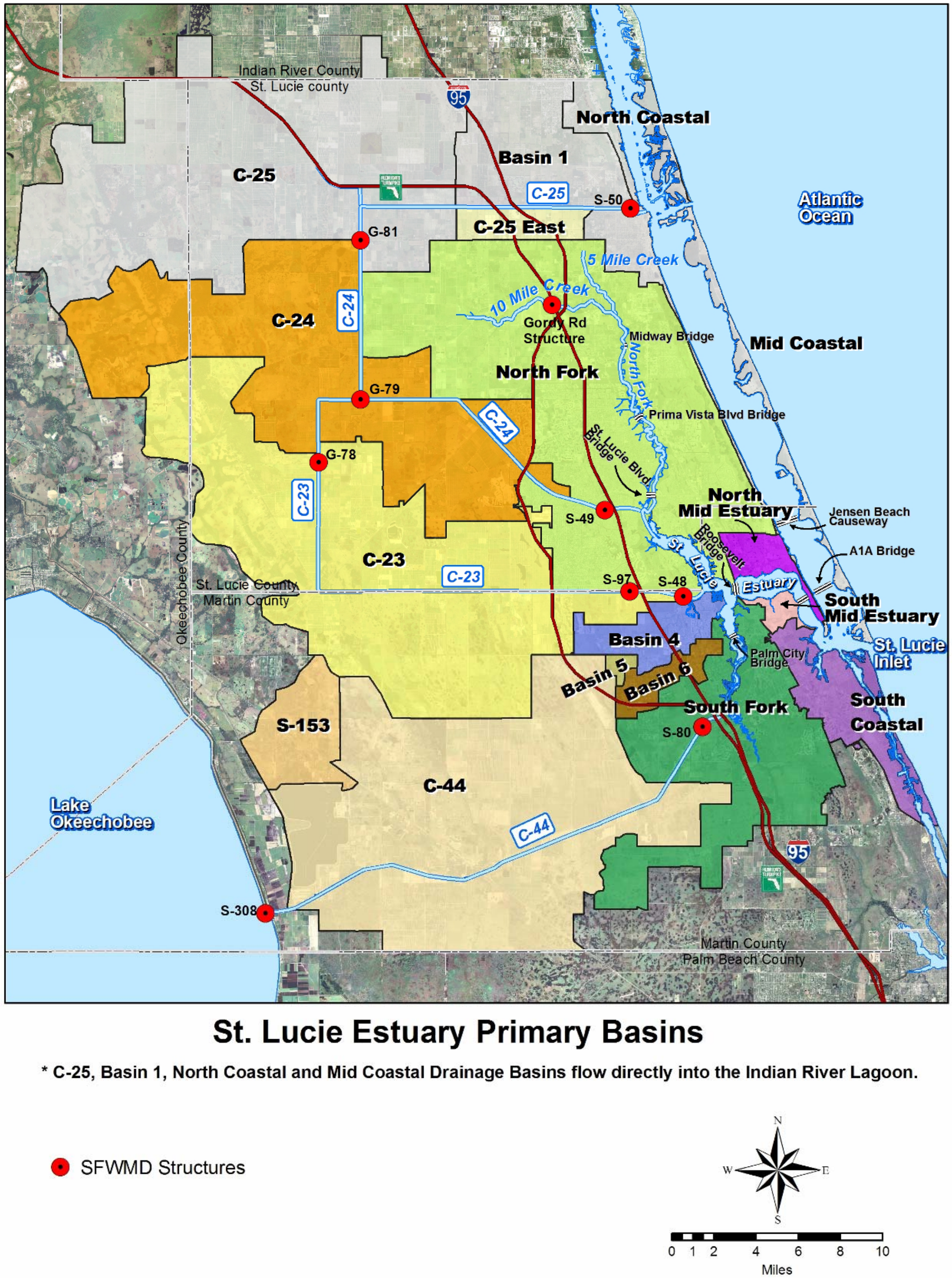


Figure 3.1-1. St. Lucie Estuary Watershed Map showing primary basins.

volume of 468.7 x 10^6 cu. ft.. The mid-estuary extends approximately 5 miles from the Roosevelt Bridge to Hell's Gate and has an area and volume of 4.7 sq. mi. and 972.7 x 10^6 cu. ft. respectively (Haunert and Startzman, 1985).

The study area of the St. Lucie Estuary Watershed Protection Plan covers some 780 sq. mi. encompassing St. Lucie County, a large part of Martin County, and a portion of eastern Okeechobee County (**Figure 3.1-1**).

3.1.2 Watershed Changes and Connection to Lake Okeechobee

The St. Lucie Estuary and its watershed have been altered by human engineering and development. Historically, rainfall on the watershed was held in forests and natural wetland systems and gradually percolated into the aquifer, evaporated and/or flowed overland into tributaries. The northern tributaries, such as Ten Mile Creek historically received most of the flow, since the western watershed topography slopes northward and a coastal ridge acted as a barrier to flow to the central portion of the inner estuary. The cumulative flow from the natural watershed, which included flows from the smaller South Fork tributaries, flowed into the St. Lucie Estuary, which provided freshwater to the Indian River Lagoon (Woodward Clyde, 1998).

3.1.2.1 Drainage Alternations

The historic watershed has been extensively modified through regional flood control projects and secondary drainage systems for agricultural and urban development. The C-44 Canal that connects Lake Okeechobee to the South Fork of the St. Lucie and associated locks and structures were constructed between 1916 and 1928 as part of the Intracoastal Waterway. Extensive local agricultural drainage canal systems were constructed in the 1920s-1930. During the 1950s, the watershed was enlarged when the North Fork was connected to the C-23/C-24 system. Watershed runoff from the North Fork drainage basins was diverted into canals that transverse the coastal ridge (C-23, C-24) instead of being detained, evaporated, cleansed, and attenuated by the natural system. The St. Lucie Estuary watershed now has an extensive set of large-scale primary, secondary, and tertiary canals and ditches intended to provide flood protection in the wet season and irrigation in the dry season. Another purpose of the extended drainage system is to lower the groundwater table which makes otherwise undevelopable land useful for agriculture and urban development.

Historically, the St. Lucie was primarily a freshwater river with no permanent connection to the ocean. Natural inlets to the sea were only periodically open in the southern Indian River Lagoon. The St. Lucie Inlet was excavated by non-federal interests in 1892 to provide navigational access to the ocean as well as tidal exchange. This tidal exchange transformed the once freshwater St. Lucie River (SLR) into an estuary. The St. Lucie Inlet is now a shallow draft navigation channel that is maintained by the Army Corps of Engineers at 16 ft below Mean Low Water in the entrance channel. The inlet is considered a permanent part of today's landscape; hence, restoration efforts in the study area are directed toward creating a healthy estuarine environment, not "restoring" it to the former freshwater river and lagoon system (Haunert and Konyha, 2001).

The combination of enhanced drainage in the watershed, flood control releases from Lake Okeechobee, population growth and urban and agricultural development have created problems for the St. Lucie Estuary. Seasonal and short term fluctuations in stormwater runoff drive changes in salinity that are beyond the tolerance limits of most marine and estuarine organisms. The estuary shows the typical signs of eutrophication including intense algal blooms and periods of hypoxia and anoxia. Other environmental problems include accumulation of "muck" sediments, fish lesions, and decreases in seagrasses and degraded benthic communities.

3.2 Watershed Hydrology and Loading

3.2.1 Hydrology

The hydrology of the St. Lucie Watershed is summarized in this sub-section, which focuses on the timing and distribution of rainfall in the water shed and runoff to the estuary. A map of the watershed is provided in **Figure 3.1-1**.

3.2.1.1 Rainfall

Daily rainfall data from 1995 to 2005 were used for rainfall analysis. These rainfall data were taken from the South Florida Water Management Model (SFWMM) database. The rainfall gauges used are listed in **Table 3.2-1.** According to SFWMM model description, the rainfall data were extracted from SFWMD's DBHYDRO database. Missing data were interpolated from adjacent stations.

Table 3.2-1. Summary of Rainfall Gauges Used for Rainfall Analysis

Identification Number	Station Name
Daily Rainfall Stations	
NOAA 6032	Ft. Pierce
MRF-39	Scotto Groves
MRF-37	Ft. Pierce Field Station
MRF-37	Ft. Pierce Field Station
MRF-148	Cow Creek Ranch
MRF-40	Hayes Property
MRF-241	Bluegoose
NOAA-6082	Stuart 1N
MRF-7035	S80 (NOAA-7859)
MRF-54	Pratt and Whitney
MRF-7037	S-308(NOAA-7293)
MRF-150	S-153
Hourly Stations	
MRF-40	Hayes Property
MRF-148	Cow Creek Ranch
MRF-241	Bluegoose
MRF-7035	S-80(NOAA-7859)
MRF7037	S-308(NOAA-7293)
NOAA-9219	Vero Beach 4W

The mean annual, mean wet season, dry season, and monthly average distribution for each sub-basin are calculated for the selected period of record. The computation results are shown in **Table 3.2-2** and **Figure 3.2-1**.

Table 3.2-2. 1995-2005 Rainfall for Monthly Averaged, Mean Annual, Mean Wet Season, and Mean Dry Season (unit: inches).

Month	Basin1	C23	C24	C25	C44	South Fork	North Fork	Averaged
Jan	2.25	1.67	1.80	2.02	1.67	2.10	1.96	1.87
Feb	2.43	1.86	1.92	2.22	2.01	2.37	2.25	2.10
Mar	3.71	3.44	3.42	3.61	3.60	4.25	3.75	3.64
Apr	3.12	2.40	2.96	3.13	2.32	3.19	3.13	2.83
May	3.13	2.82	3.16	3.67	3.19	3.91	3.03	3.24
Jun	7.17	7.45	8.24	8.50	7.18	7.80	6.79	7.59
Jul	5.84	5.75	6.51	7.21	5.45	6.27	5.79	6.11
Aug	8.50	7.82	8.69	8.98	7.57	8.43	8.13	8.24
Sep	7.49	8.21	8.37	8.08	7.87	8.60	7.09	7.94
Oct	5.50	5.04	4.73	4.75	5.14	6.30	5.56	5.20
Nov	3.11	2.83	2.57	2.65	2.77	3.36	3.16	2.87
Dec	2.19	1.54	1.76	2.14	1.64	1.87	1.76	1.79
Mean Annual	54.44	50.82	54.11	56.96	50.40	58.46	52.40	53.43
Mean Wet Season	37.64	37.08	39.68	41.19	36.40	41.30	36.38	38.32
Mean Dry Season	16.80	13.74	14.43	15.77	14.00	17.15	16.02	15.11

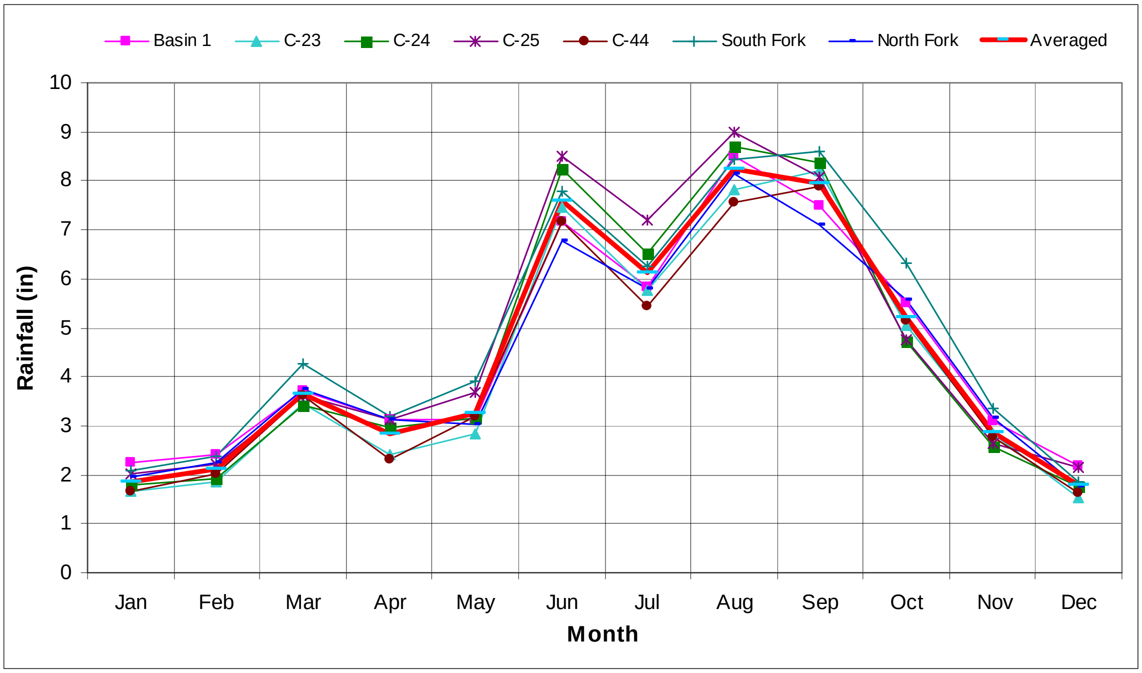


Figure 3.2-1. 1995 – 2005 Monthly Averaged Rainfall Distribution

Examination of monthly average rainfall (**Table 3.2-3** and **Figure 3.2-2**) indicates that the highest rainfall occurs during the wet season months of August and September. December is the driest month in all basins. **Figure 3.2-2** shows annual rainfall distribution from 1995-2005.

Table 3.2-3. 1995-2005 Monthly Average, Mean Annual, Mean Wet Season, and Mean Dry Season Flow Data and Total Inflow to SLE (unit: acre feet).

Month	S97	S50	S49	S80	North Fork	South Fork	Total Inflow to SLE[1]
Jan	2129	3970	4741	6392	4948	3015	21225
Feb	3815	4225	4415	7855	5792	3394	25271
Mar	6423	8532	7044	10219	8237	4058	35982
Apr	2099	2769	3523	4734	3046	2043	15445
May	1150	3339	3143	5636	3814	2109	15852
Jun	14134	17608	18990	16601	14272	6049	70046
Jul	17730	25562	24707	19676	15092	6271	83477
Aug	26212	30658	31848	30769	26500	12183	127512
Sep	29870	30386	33633	34883	35262	17103	150751
Oct	30226	25547	31011	33186	32947	15981	143352
Nov	10979	6583	11784	18003	15039	8003	63808
Dec	2160	3435	4013	6438	4762	2838	20210
Mean Annual	146927	162614	178853	194392	169711	83047	772930
Mean Wet Season	119321	133100	143332	140752	127887	59698	590989
Mean Dry Season	27605	29515	35521	53640	41824	23350	181941

1Total inflows to SLE is the summation of S-97, S-49, S-80, North Fork, and South Fork flows, and does not include flow from the Lake Okeechobee. Lake Okeechobee flows have been subtracted from the measured flow at S-80. S-50 flow discharges from the north coastal basin into the IRL instead of the SLE.

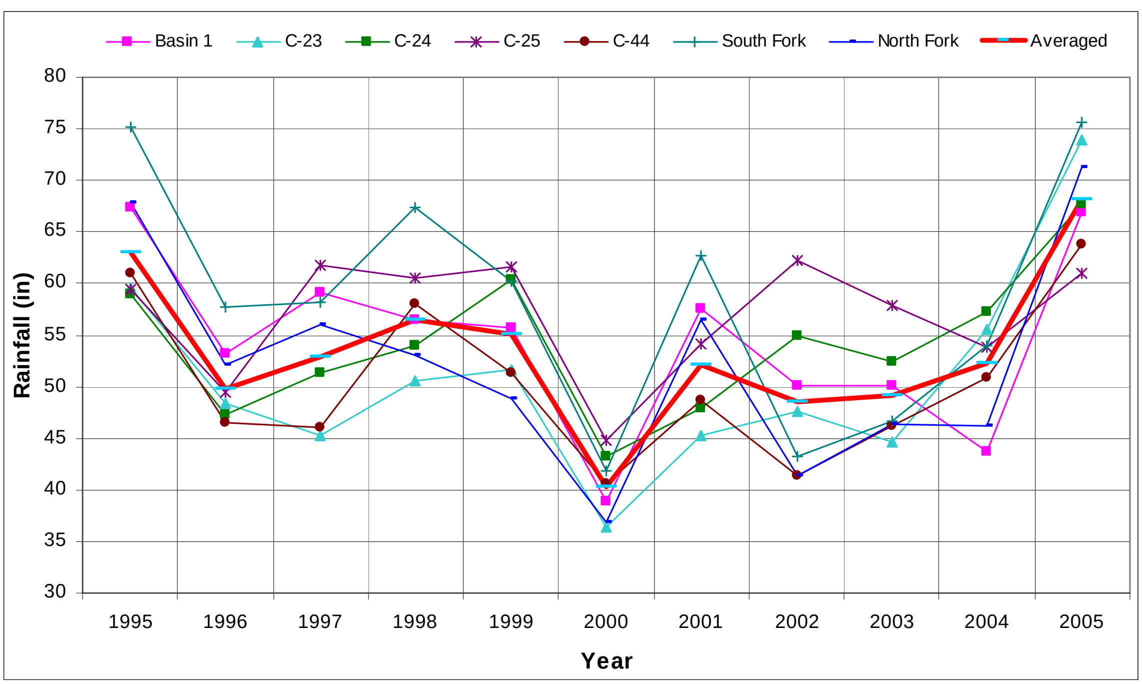


Figure 3.2-2. 1995 – 2005 Annual Rainfall Distribution

3.2.1.2 Flow

The daily flow data used in the analysis presented here were obtained from two sources:

1. Output from a hydrologic model (WaSh) was used to estimate daily flow from ungauged areas, including the surface flow and groundwater flow discharged into the St. Lucie Estuary from South Fork River and Basins 4, 5, and 6.
2. Measured data retrieved from the DBHYDRO database, including flows through S-48, S-49, S-50, S-308, and S-80.

The monthly average flow, mean annual flow, mean wet season flow, and mean dry season flow are calculated and presented in **Table 3.2-3**. Also, the total inflow to St. Lucie Estuary is computed which is the summation of S-97, S-49, S-80, North Fork, and South Fork flows. The S-80 flow does not include the flow through S-308 from Lake Okeechobee, which is subtracted from the measured flow at S-80. There are two structures controlling water from the C-24 sub-basin: S-97 and S-48. Due to the incomplete record flow at S-48, the flow recorded at S-97 is selected for C-24 sub-basin outflow. The S-50 flow discharges from the North Coastal basin into the Indian River Lagoon instead of into the St. Lucie Estuary (SLE).

The calculated mean annual inflow to SLE is 772,930 acre feet (ac-ft), of which 25% is from C-44 sub-basin, 23% from C-24 sub-basin, 19% from C-23 sub-basin, 22% from North Fork sub-basin, and 11% from South Fork sub-basin (**see Figure 3.2-3**). The two natural sub-basin systems (North Fork and South Fork) contribute 33% of the total flow to the SLE while the other three controlled outflow sub-basins (C-23, C-24 and C-44) contribute 67%. Mean wet season flow to SLE is 590,989 ac-ft, 76.5% of mean annual inflow to SLE.

The annual runoff coefficient (0.34) calculated using yearly rainfall, basin area, and yearly flow data indicates that 34% of the annual rainfall in the St. Lucie Estuary Watershed contributes to channel runoff.

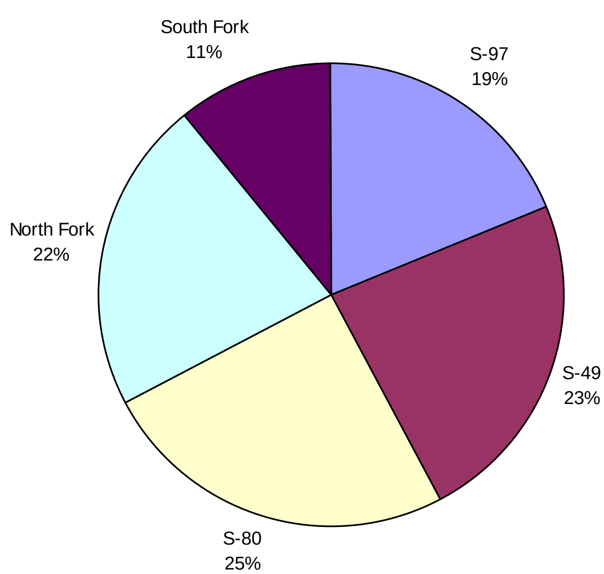


Figure 3.2-3. 1995 – 2005 Sub-basin Flow in Percentage to Mean Annual Total Inflow to SLE.

3.2.1.3 Groundwater

Groundwater seepage also contributes to the freshwater inflow to the estuary. A computer model was used to "back calculate" groundwater seepage to quantify the amount of groundwater seepage into the St. Lucie Estuary during a dry period, (Morris, 1987). The model simulation was conducted for a 22-day period from February 18 to March 11, 1981. Rainfall recorded during 18 of those 22 days ranged from 0.7 to 0.05 inches or less. Discharge at S-80 decreased from 500 cubic feet per second (cfs) to 150 cfs on February 8 and remained steady for the simulation period. An estimated amount of groundwater seepage was added to the simulation so that the model output would match the measured salinity. A total groundwater inflow of 149 cfs was found to balance the observed salinity gradients over the simulation period.

3.2.2 Influence of Lake Okeechobee and Watershed Sub Basins Discharge on Freshwater Inflow to Estuaries

Lake Okeechobee has had significant impact on freshwater flows to the St. Lucie Estuary. This subchapter discusses the extent of that influence and demonstrates that, according to 11 years of data, Lake Okeechobee discharge is the largest freshwater source to the St. Lucie Estuary. The lake discharge is more than twice the volume as any other watersheds of the St. Lucie Estuary.

This section quantifies the freshwater inflows from Lake Okeechobee to the St. Lucie Estuary as directed in the enabling legislation.

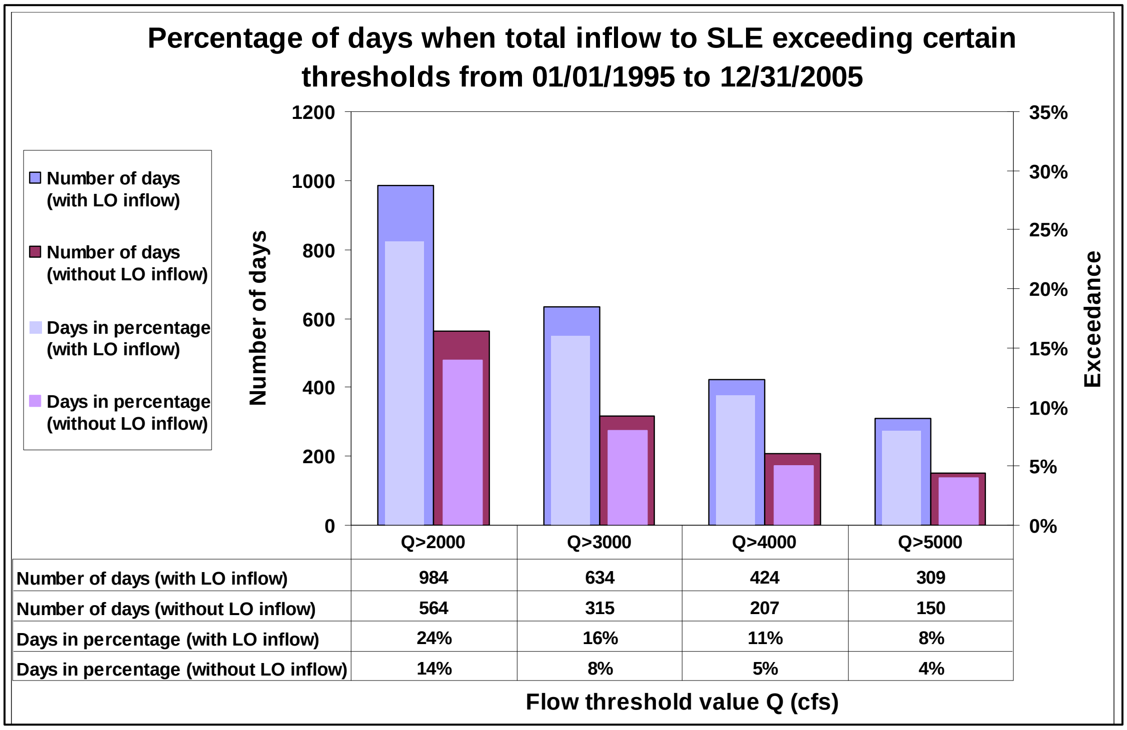
3.2.2.1 St. Lucie Estuary

In order to quantify the impact of Lake Okeechobee releases to the estuary, the historic flow record was analyzed in this study. The period of analysis is was from 01/01/1995 to 12/31/2005. The data set analyzed includes included flow data over a 4018-day period. All flow data at hydraulic control structures were from the district database DBHydro with preferred DB keys. For the areas not actually gauged, a WaSH watershed model (Wan, 2003) was applied to estimate the amount of freshwater outflow from North Fork, South Fork, as well as Basins 4,5, and 6. All analysis, tables and figures in this section are based on this assembled data set.

In order to separate the influence of the discharge of Lake Okeechobee from the other freshwater sources, the flow data from structures S-308 and S-80 were processed so that the release from Lake Okeechobee was tabulated separately from the runoff of local watersheds sub-basins such as C-44. Such a method made it possible to compare the impact of lake release with that of sub-basins runoff.

Based on the salinity envelope that was established in Subchapter 3.4, 350 cfs is the lower limit for optimal salinity range and 2000 cfs to 3000 cfs are flow levels that would cause certain levels of stress to the ecosystem due to low salinity. In addition to an analysis of the entire 11-year period, the dataset was also examined particularly for those periods when the total inflow to the estuary exceeded these thresholds. **Figure 3.2-4** lists the number of days in the 11-year period when the total inflow exceeded flow thresholds. For example, total inflow to the estuary exceeded the 2000 cfs threshold 24% of the time in the eleven year period. The table in the figure also lists the days when flow exceeded 5000 cfs that would have extended low salinity zone further down the estuary. To illustrate the influence of freshwater releases from Lake

Okeechobee, **Figure 3.2-4** also illustrates shows how the number of exceeding values would reduce when lake releases were excluded from the calculation.



	Q>2000	Q>3000	Q>4000	Q>5000
Number of days (with LO inflow)	984	634	424	309
Number of days (without LO inflow)	564	315	207	150
Days in percentage (with LO inflow)	24%	16%	11%	8%
Days in percentage (without LO inflow)	14%	8%	5%	4%

Figure 3.2-4. Total number of days and percentage of total inflow to SLE exceeding certain threshold.

The total volume of freshwater inflow from each source was summarized for the entire period. The accumulated volume and percentage from each watershed and Lake Okeechobee are listed in **Table 3.2-4.** The separation of Lake Okeechobee discharge and the C-44 watershed discharge made it possible to assess how much influence the lake had on the total inflow into the estuary. Based on the 11-year dataset, the freshwater contribution from the Lake Okeechobee made up 37% of the freshwater discharge into the estuary.

Table 3.2-4. The total volume of freshwater flow from each watershed and Lake Okeechobee over the 11-year period.

Freshwater Source	Total Volume (AC-FT)	Daily Average Flow (CFS)	Percentage
LO to SLE	4,562,302	572	37.43%
C44 to SLE	1,740,138	218	14.28%
S49	1,967,388	247	16.14%
S97	1,616,194	203	13.26%
Basins 4 & 5*	142,148	18	1.17%
North Fork*	1,388,001	174	11.39%
South Fork*	653,640	82	5.36%
Basin 6*	117,731	15	10.97%
Total to SLE	12,187,543	1529	100.00%
* Based on Watershed Model WaSH hind cast.			

Figure 3.2-5 and **3.2-6** are the graphic presentation of the results in **Table 3.2-4**. Apparently Lake Okeechobee discharge was the largest single freshwater source to the St. Lucie Estuary. The lake discharge was more than twice the volume as any other watersheds sub-basins of the St. Lucie Estuary.

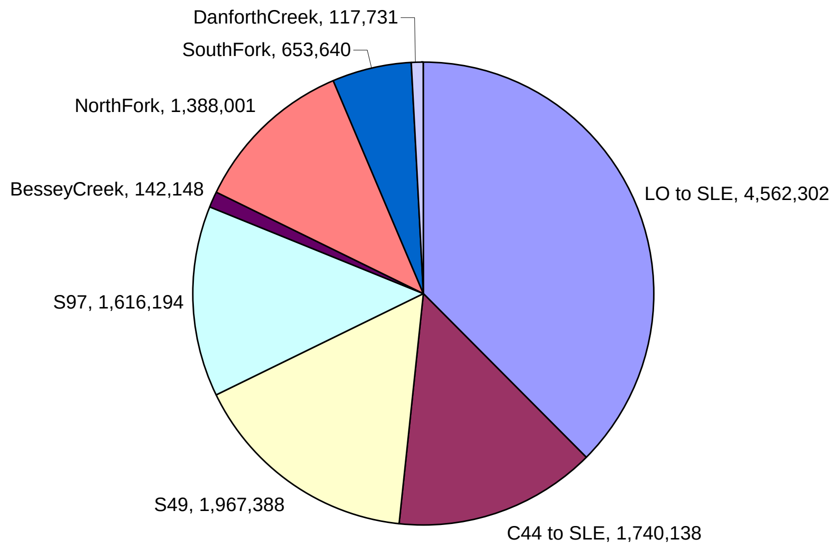


Figure 3.2-5. Total freshwater Inflow to St. Lucie Estuary in acre-feet during 1995 to 2005.

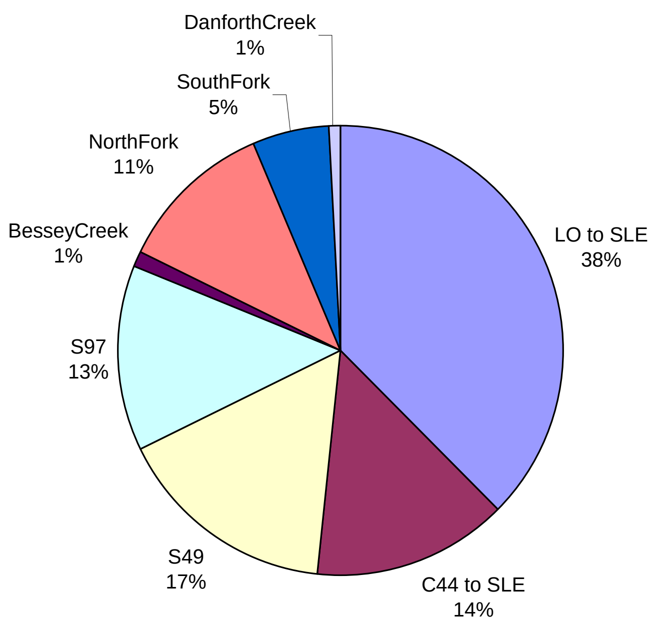


Figure 3.2-6. Freshwater Inflow to St. Lucie Estuary in percentage.

The percentage of Lake Okeechobee release volume was also examined for the high flow periods. High freshwater inflow to the estuary usually occurs during or after major storm events or at high lake levels when the operational schedule calls for large amounts of discharge into the estuary. The volume and percentage of freshwater contributions from each source are calculated for high flow periods when the total inflow to the estuary exceeded the flow thresholds. **Tables 3.2-5** through **3.2-8** tabulate the results at each flow level.

Tables 3.2-5 through **3.2-8** demonstrate that the percentage of Lake Okeechobee discharge falls in the range between 36% and 39%. That is approximately 37% for the entire 11-year period (**Figure 3.2-7)**. The runoff from other local watersheds also holds a relatively stable percentage. These are typical characteristics of rainfall driven hydrology.

Table 3.2-5. The total volume of freshwater flow from each watershed sub-basin and Lake Okeechobee over the 11-year period when total inflow exceeded 2000 cfs.

Freshwater Source	Total Volume (AC-FT)	Daily Average Flow (cfs)	Percentage
LO to SLE	3,532,996	1810	38.74%
C44 to SLE	1,280,256	656	14.04%
S49	1,384,261	709	15.18%
S97	1,267,048	649	13.89%
Basins 4 & 5*	96,951	50	1.06%
North Fork*	1,010,365	518	11.08%
South Fork*	463,485	237	5.08%
Basin 6*	83,440	43	10.92%
Total to SLE	9,118,802	4672	100.00%
* Based on Watershed Model WaSH hind cast.			

Table 3.2-6. The total volume of freshwater flow from each watershed and Lake Okeechobee over the 11-year period when total inflow exceeded 3000 cfs.

Freshwater Source	Total Volume (AC-FT)	Daily Average Flow (cfs)	Percentage
LO to SLE	2,857,183	2272	38.59%
C44 to SLE	1,084,565	862	14.65%
S49	1,055,868	840	14.26%
S97	1,021,350	812	13.79%
Basins 4 & 5*	83,277	66	1.12%
North Fork*	839,304	667	11.33%
South Fork*	391,210	311	5.28%
Basin 6*	71,841	57	10.97%
Total to SLE	7,404,598	5888	100.00%
* Based on Watershed Model WaSH hind cast.			

Table 3.2-7. The total volume of freshwater flow from each watershed and Lake Okeechobee over the 11-year period when total inflow exceeded 4000 cfs.

Freshwater Source	Total Volume (AC-FT)	Daily Average Flow (cfs)	Percentage
LO to SLE	2,178,876	2591	36.60%
C44 to SLE	907,790	1079	15.25%
S49	828,610	985	13.92%
S97	854,814	1016	14.36%
Basins 4 & 5*	72,602	86	1.22%
North Fork*	713,304	848	11.98%
South Fork*	334,141	397	6.61%
Basin 6*	62,732	75	1.05%
Total to SLE	5,952,869	7078	100.00%
* Based on Watershed Model WaSH hind cast.			

Table 3.2-8. The total volume of freshwater flow from each watershed and Lake Okeechobee over the 11-year period when total inflow exceeded 5000 cfs.

Freshwater Source	Total Volume (AC-FT)	Daily Average Flow (cfs)	Percentage
LO to SLE	1,729,391	2822	35.04%
C44 to SLE	751,983	1227	15.24%
S49	679,425	1109	13.77%
S97	726,182	1185	14.71%
Basin 4 & 5*	65,679	107	1.33%
North Fork*	630,438	1029	32.77%
South Fork*	295,434	482	6.99%
Basin 6*	56,681	92	1.15%
Total to SLE	4,935,213	8052	100.00%
* Based on Watershed Model WaSH hind cast.			

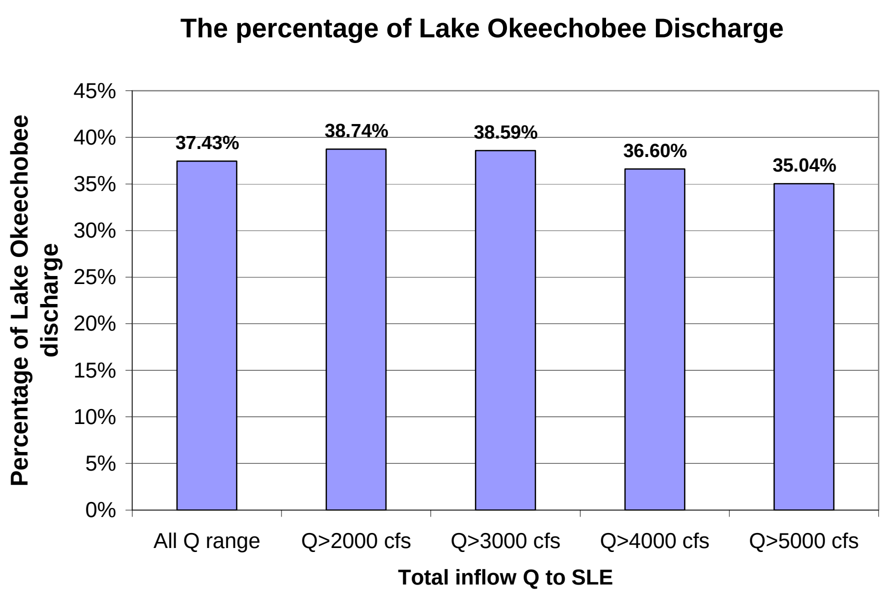
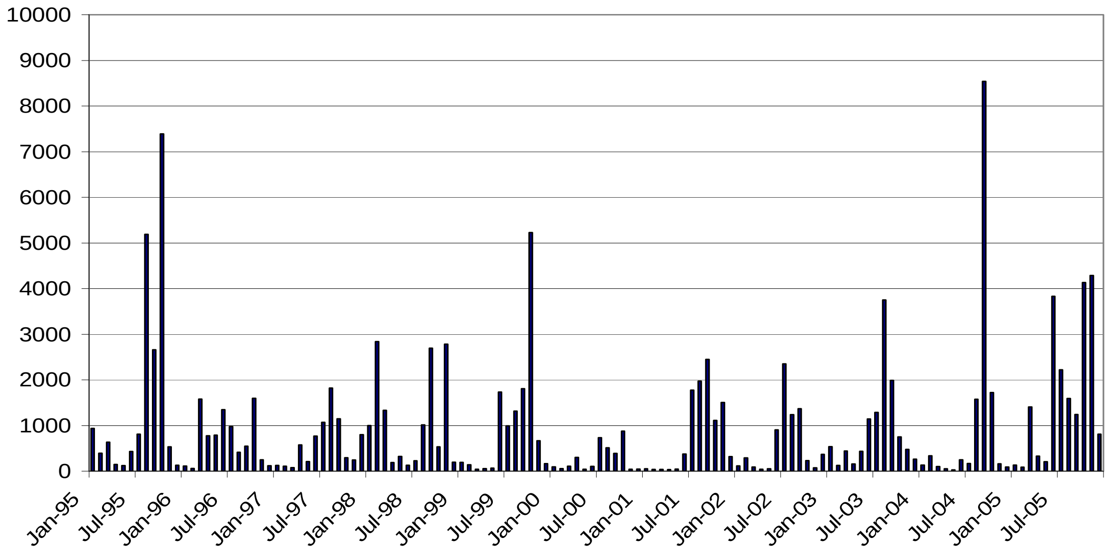


Figure 3.2-7. Percentage of Lake Okeechobee discharge.

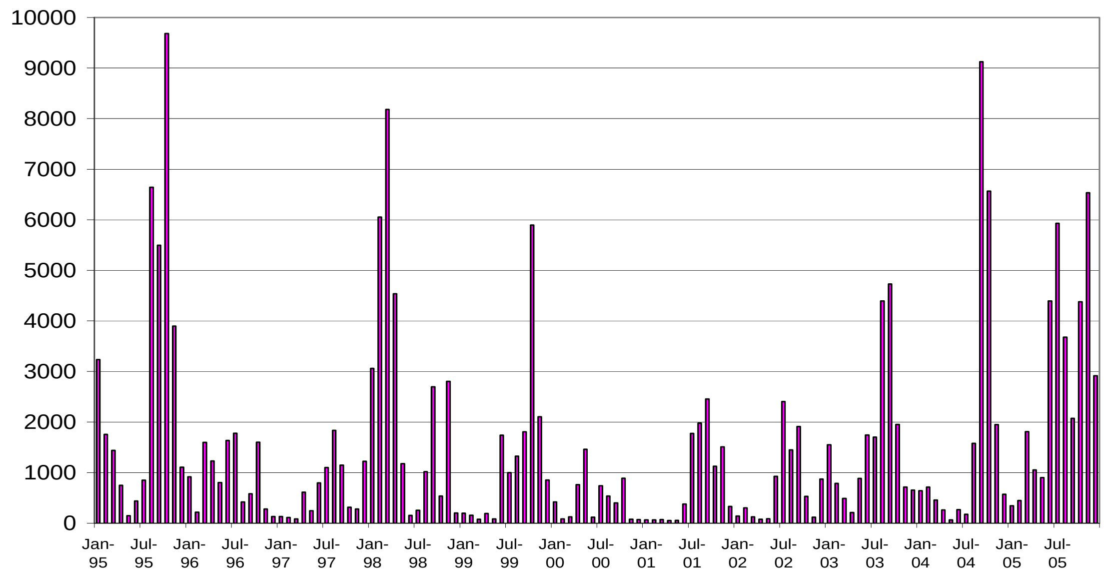
While total volume and flow rate indicates the relative magnitude of the impact of Lake Okeechobee releases, the timing of lake releases is another issue that needs to be examined. **Figure 3.2-8** compares monthly average inflows to the St. Lucie Estuary including and excluding discharges from Lake Okeechobee. Monthly average flows are generally higher when Lake releases are included.

Table 3.2-9 shows the monthly average mean inflow into the St. Lucie Estuary from Lake Okeechobee only**.** It is apparent that the discharges from the lake tend to be highly concentrated in a few short time periods such as in 1995 and 1998. The lake release in 1998 was the most significant freshwater discharge into the St. Lucie Estuary over the 11-year period.

Table 3.2-10 represents the monthly average inflow into the St. Lucie Estuary from all sources. By contrast, **Table 3.2-11** excludes discharges from the Lake. It is clear that high flow events increase in both numbers and magnitude with the lake releases. All, but one, high flow events that exceeded 3000 cfs had significant volumes from the lake. The exception was October 1999 when total freshwater flow to the estuary exceeded 6000 cfs. The record indicates that there was zero lake release during that month with most freshwater inflow coming from local sub-basins.



(a)



(b)

Figure 3.2-8. Freshwater inflow to the St. Lucie Estuary where (a) Without lake releases (b) With lake releases.

Table 3.2-9. Monthly average discharge in cfs from Lake Okeechobee to St. Lucie Estuary.

Month	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Jan	2295	804	5	2059	6	322	16	22	1012	508	207
Feb	1361	154	4	3215	17	26	25	10	660	376	356
Mar	801	15	6	6849	32	17	27	34	43	355	401
Apr	597	452	34	4345	137	456	13	34	51	208	721
May	20	11	35	854	17	1416	7	33	446	35	693
Jun	8	287	30	22	4	11	1	19	599	15	563
Jul	35	804	25	26	5	8	0	51	410	7	3705
Aug	1452	5	12	0	5	26	1	212	645	2	2084
Sep	2831	30	2	1	0	9	3	540	2737	447	826
Oct	2290	5	19	4	667	10	9	298	1201	4843	244
Nov	3361	31	31	22	1439	35	6	42	235	1788	2242
Dec	976	12	422	3	687	22	14	506	390	479	2101

Note, 2000 cfs < Q < 3000 cfs Q > 3000 cfs

Month	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	2295	804	5	2059	6	322	16	22	1012	508	207
2	1361	154	4	3215	17	26	25	10	660	376	356
3	801	15	6	6849	32	17	27	34	43	355	401
4	597	452	34	4345	137	456	13	34	51	208	721
5	20	11	35	854	17	1416	7	33	446	35	693
6	8	287	30	22	4	11	1	19	599	15	563
7	35	804	25	26	5	8	0	51	410	7	3705
8	1452	5	12	0	5	26	1	212	645	2	2084
9	2831	30	2	1	0	9	3	540	2737	447	826
10	2290	5	19	4	667	10	9	298	1201	4843	244
11	3361	31	31	22	1439	35	6	42	235	1788	2242
12	976	12	422	3	687	22	14	506	390	479	2101

Note, 2000 cfs < Q < 3000 cfs Q > 3000 cfs

Table 3.2-10. Monthly average discharge in cfs into St. Lucie Estuary from all sources.

Month	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Jan	3277	924	140	3113	219	427	72	157	1597	651	354
Feb	1779	222	121	6235	169	92	71	321	794	739	454
Mar	1460	1727	90	8252	81	143	73	135	522	464	1892
Apr	759	1270	638	4547	198	773	55	84	219	266	1066
May	156	871	262	1191	92	1468	59	91	912	69	915
Jun	482	1712	850	169	1839	134	411	949	1799	273	4660
Jul	894	1858	1140	279	1027	830	1907	2523	1738	183	6019
Aug	6975	453	1918	1100	1419	569	2172	1484	4559	1677	3744
Sep	5662	628	1224	2919	1912	429	2672	1945	4844	9597	2124
Oct	10165	1743	341	568	6227	974	1220	543	1988	6636	4577
Nov	3931	308	310	3037	2137	85	1618	126	765	1971	6698
Dec	1119	150	1276	223	871	76	353	898	674	582	2937

Note, 2000 cfs < Q < 3000 cfs Q > 3000 cfs

Table 3.2-11. Monthly average discharge in cfs into St. Lucie Estuary without lake releases.

Month	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Jan	982	120	258	1053	213	105	56	135	585	143	147
Feb	418	68	310	3020	152	65	46	316	135	363	98
Mar	659	1712	245	1402	50	125	60	106	488	109	1491
Apr	162	817	606	203	78	317	52	51	167	58	344
May	136	860	227	337	186	171	116	58	466	35	245
Jun	474	1425	873	153	2305	414	658	1000	1201	323	4123
Jul	859	1054	1233	417	1144	1059	2404	2883	1328	240	2313
Aug	5523	447	1906	1309	1414	580	2645	1276	3915	2137	1660
Sep	2831	599	1222	2918	1912	1052	3050	1405	2107	9474	1298
Oct	7875	1738	322	564	5560	1197	1220	247	787	1793	4341
Nov	570	278	279	3049	698	50	1612	84	530	184	4462
Dec	143	202	854	220	185	59	339	392	283	103	836

Note, 2000 cfs < Q < 3000 cfs   Q > 3000 cfs

If there were no lake releases into the estuary (**Table 3.2-11**), the number of months that average flow exceeded 2000 cfs would be reduced from 27 to 20. The reduction of several events would be more significant. Without lake releases, the number of months that average flow exceeded 3000 cfs would be reduced from 20 to 11.

3.2.3 Water Quality and Nutrient Loading

The objective of this section is to provide a review of status and trends in water quality and nutrient loading in freshwater inflows into the St. Lucie River and Estuary. The data used in this evaluation were primarily collected by the District at the water management structures in the St. Lucie River watershed. Grab samples taken in the tributary basins, where flow is not controlled by these structures, were also used in this analysis. The sampling locations are shown in **Figure 3.2-9**. Over 15,000 points of water quality and quantity data were collected and analyzed.

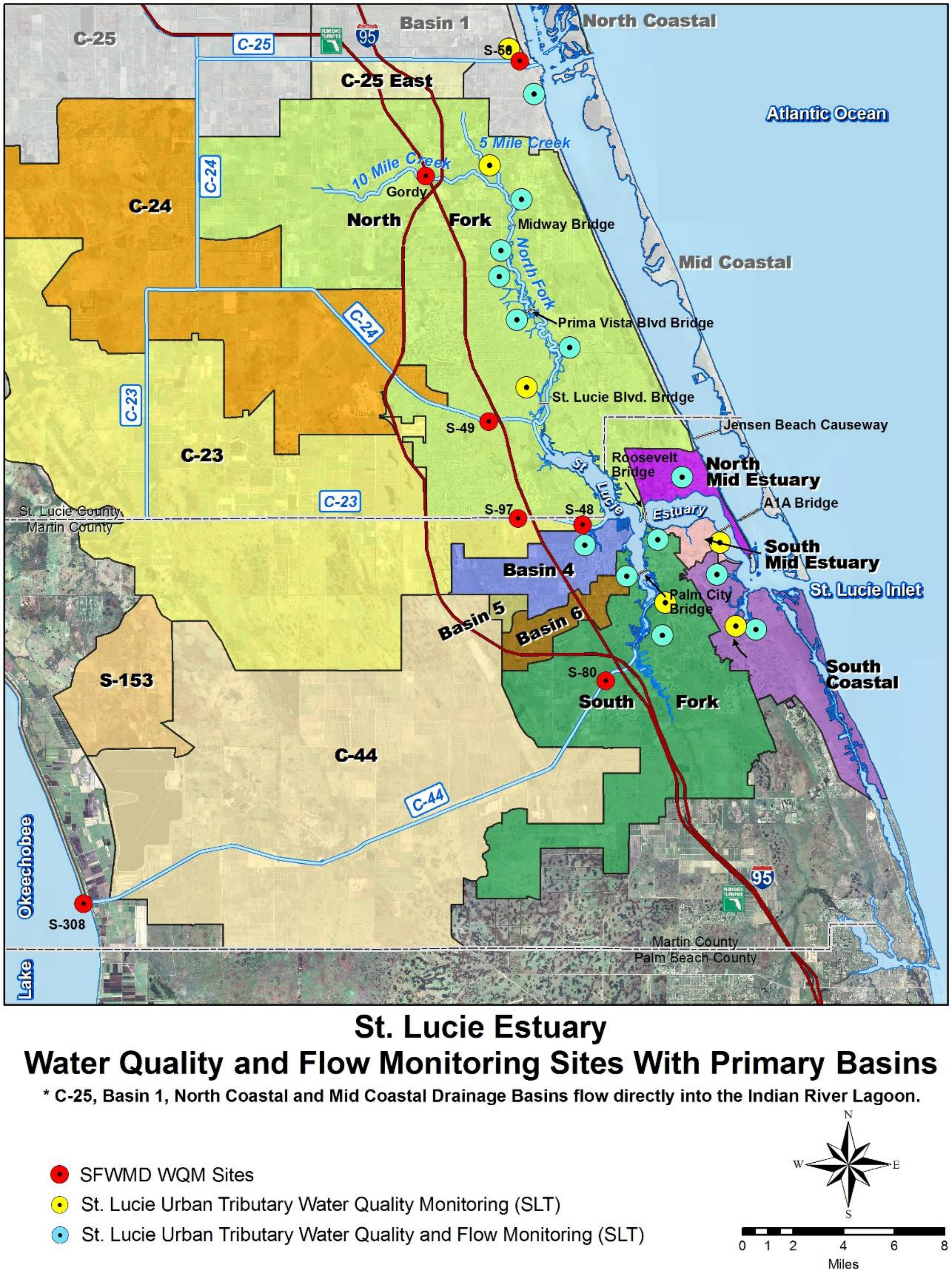


Figure 3.2-9. Watershed water quality monitoring sites in the St. Lucie River Watershed.

3.2.3.1 Water Quality Status

Most waters in the St. Lucie Estuary are classified as Class III in accordance with the Florida Administrative Code (F.A.C.), Section 62-302.400(1). Class III is defined for use as recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife. A recent water quality assessment of the St. Lucie Estuary conducted by FDEP (2004) for the development of Total Maximum Daily Loads (TMDLs) indicates that the common parameters causing water quality impairment throughout the St. Lucie Estuary are dissolved oxygen (DO) and nutrients. The purpose of this section is not to duplicate the FDEP assessment. However, an overview of DO and nutrients in relation to basins and land management are discussed here for the development of the Research and Water Quality Monitoring Plan.

3.2.3.1.1 Dissolved Oxygen

Figure 3.2-10 is time-series plots of DO in C-24, C-23, and C-44 for the period of 1990 to 1995. These data were collected 0.5 m below the surface on a monthly basis during daylight. Thus the diurnal DO pattern is not captured by this data set. Among the three canals, from 1979 to 2007, the median DO was 4.72 mg/L for C-24, 5.47 mg/L for C-23, and 6.33 gm/L for C-44. For all three canals, DO was periodically below the Florida State Class III water quality standard (5 mg/L). This occurs mostly in the wet season when temperature is high and stormwater comes mostly from nutrient-rich surface runoff.

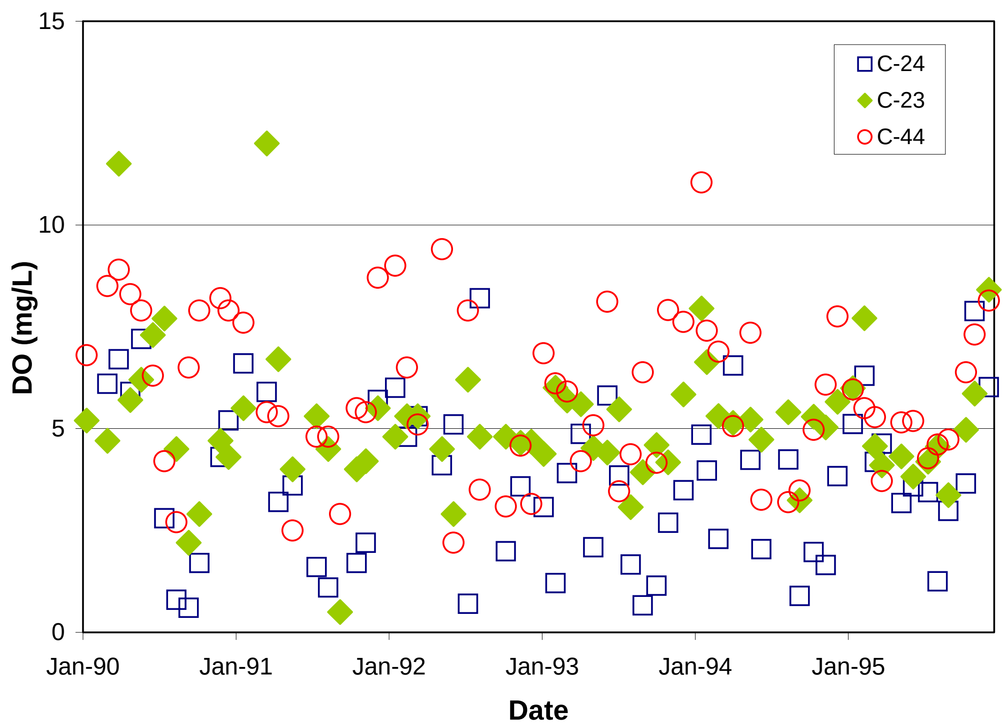


Figure 3.2-10. DO concentration in C-24, C-23, and C-44 during the period from 1990-95.

Graves et al. (2004) collected data from stormwater runoff in the watershed representing major land use types (**Figure 3.2-11**). For each land use, DO concentrations ranged from less than 2 to about 10 mg/L, with about 70% of the samples below the 5.0 mg/L standard. The mean DO concentration of wetland runoff was higher than from other land use types. The higher DO concentration in wetland runoff may be related partly to wind driven mixing in open wetlands whereas runoff from other land use types were directly collected in tertiary canals where wind action would have less influence. In addition, submerged aquatic vegetation in a wetland releases oxygen during photosynthesis and thereby increases DO in the water column. The DO concentration from citrus, golf and pasture was significantly lower than for urban land.

In summary, low DO conditions in the St. Lucie River Watershed occur mostly during the wet season. This is partly due to the higher temperatures and enhanced primary productivity under elevated nutrient concentrations. Graves et al. (2004) noted that variations in DO concentrations in runoff could not be explained by the 5-day Biological Oxygen Demand - BOD5 (correlation not significant p = 0.21), which was low with 80% samples less than 3 mg/L. Stormwater runoff from most land use types was found to routinely falls below the 5.0 mg/L standard. This was true even in pristine wetland, suggesting that low DO conditions in the summer could be characteristic of South Florida. The low terrain and stagnation of water in canals may also inhibit wind-induced mixing and aeration of the water column. High sediment oxygen demand from decomposing vegetative matter in the bottom of canals may also contribute to low DO. The DO dynamics remains an area of further research to support the TMDL development process.

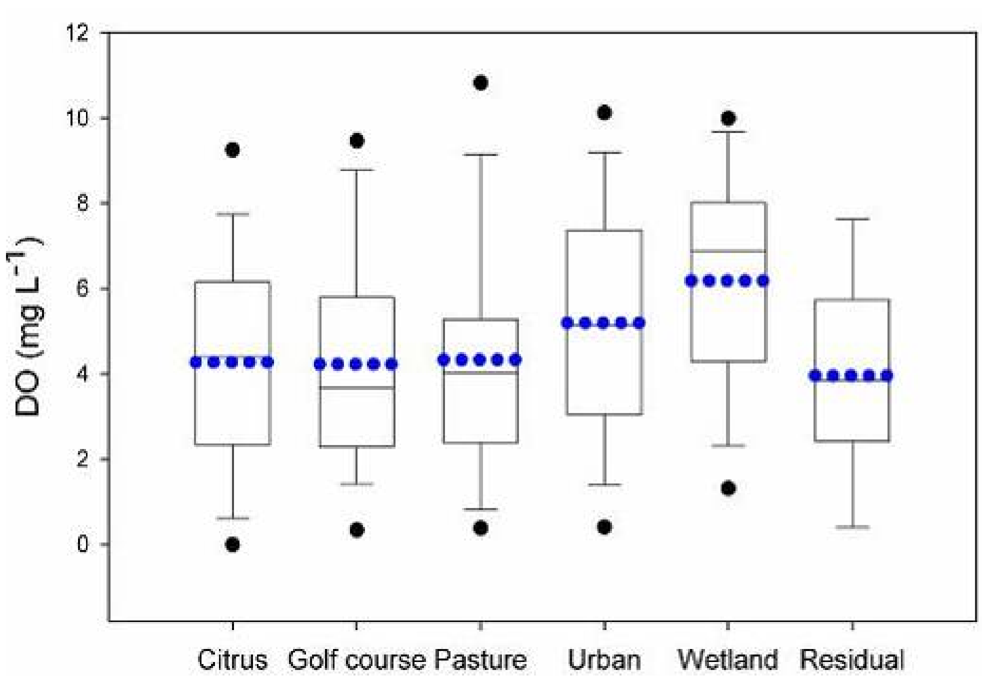


Figure 3.2-11. Box and whisker plot of DO concentration in stormwater from major land use types. Mean and median concentrations are shown as dotted and solid lines, respectively, within the box. The box covers the 25th/75th percentiles of the data with bars representing the 5th/95th percentiles and dots as outliers. The number of samples is 105 for citrus, 27 for golf course, 47 for pasture, 112 for urban, 40 for wetland, and 18 for residual (Graves et al., 2004).

3.2.3.2 Nutrients

Table 3.2-12 is the statistical summary of nutrient concentrations in C-24, C-23, C-44 and from the St. Lucie Tributary (SLT) basins. Data collection in C-24, C-23, C-44 started in 1979 while the SLT monitoring program started in 2001. Nitrite plus nitrate (NOX–N), nitrite (NO2–N), nitrate (NO3–N), ammonia (NH4–N), total Kjeldhal nitrogen (TKN), total nitrogen (TN), orthophosphate (PO4–P), and total phosphorus (TP) are included in this analysis. Overall, the mean concentrations are greater than the median concentration, with positive skewness values indicating that the data are skewed towards the high concentration side. In general, nutrient concentrations (TP, PO4-P, TKN, and NH4-N) showed greater medians in C-23 and C-24 than in C-44 and SLT, whereas the medians of NOx-N concentration were greater in C-44 than in C-23 and C-24.

In order to compare nutrient concentrations throughout the entire watershed, average nutrient concentrations were computed for each sub-basin (**Figures 3.2-12 through 3.2-14)**. The sub-basins within the C-44, C-23, and C-24 are not delineated since data are not available. The ratings were based on the concentration distribution of over 2400 data points collected in the SLT basin. These figures show that over 60% of the watershed has average TP concentrations higher than 0.19 mg/L (red color designation). The high TP concentration areas are primarily in the C-23 Basin, C-24 Basin, and the Ten Mile Creek sub-basin in North Fork. Note that the average TP concentration of the St. James sub-basin in North Fork is less than 0.06 mg/L. A reason for the low TP concentration may be that these long linear canals in this sub-basin likely serve as retention ponds (high canal/land area ratio), thereby providing water quality treatment benefits. For NOx-N, about 70% the watershed has average NOx-N concentrations higher than 0.12 mg/L. These areas include the C-23 Basin, C-44 Basin, and the Ten Mile Creek sub-basin in North Fork.

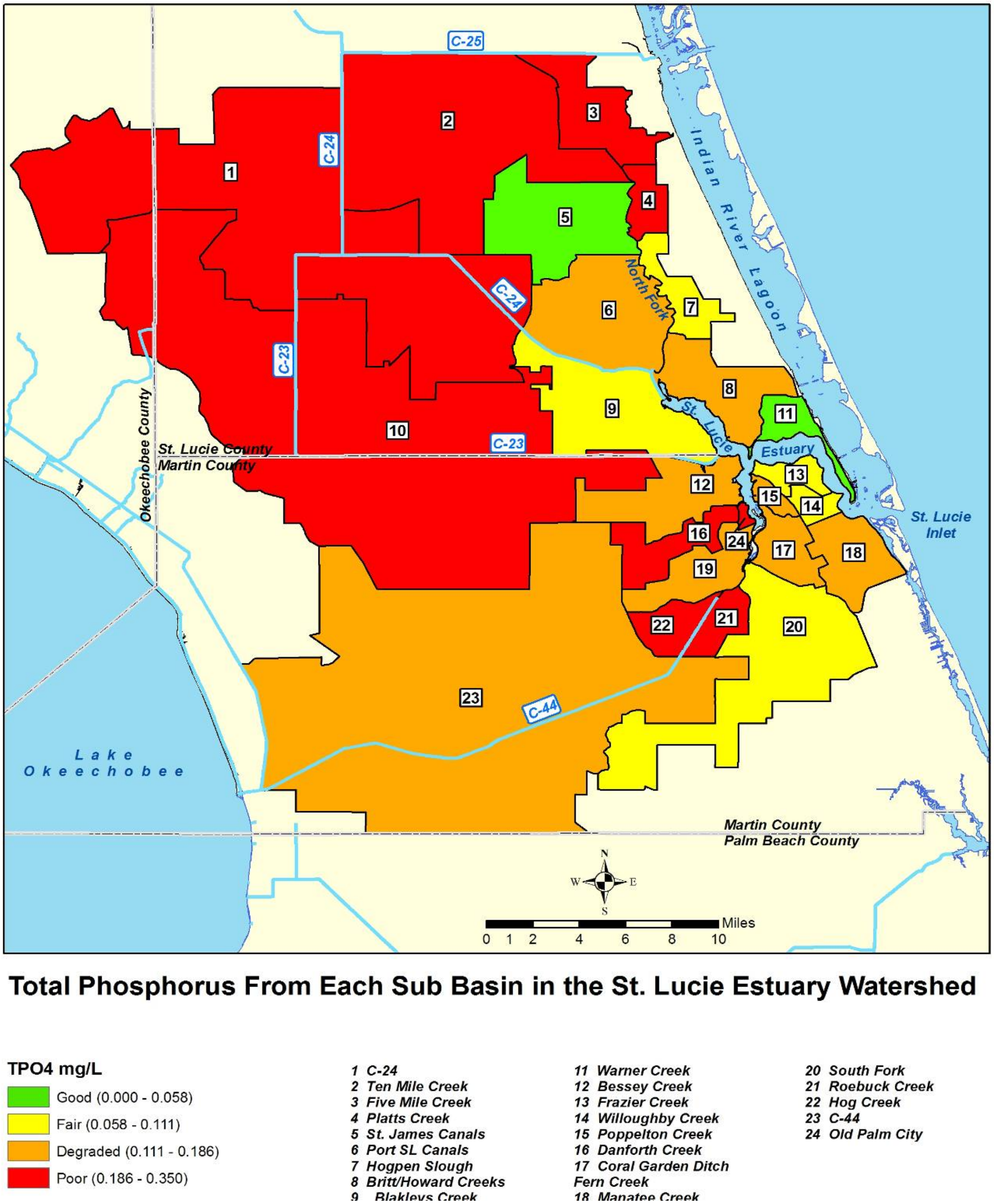


Figure 3.2-12. Aerial distribution of total phosphorus concentration in the St. Lucie Watershed. The sub-basins within the North and South Forks are based on field verification and water management permit information.

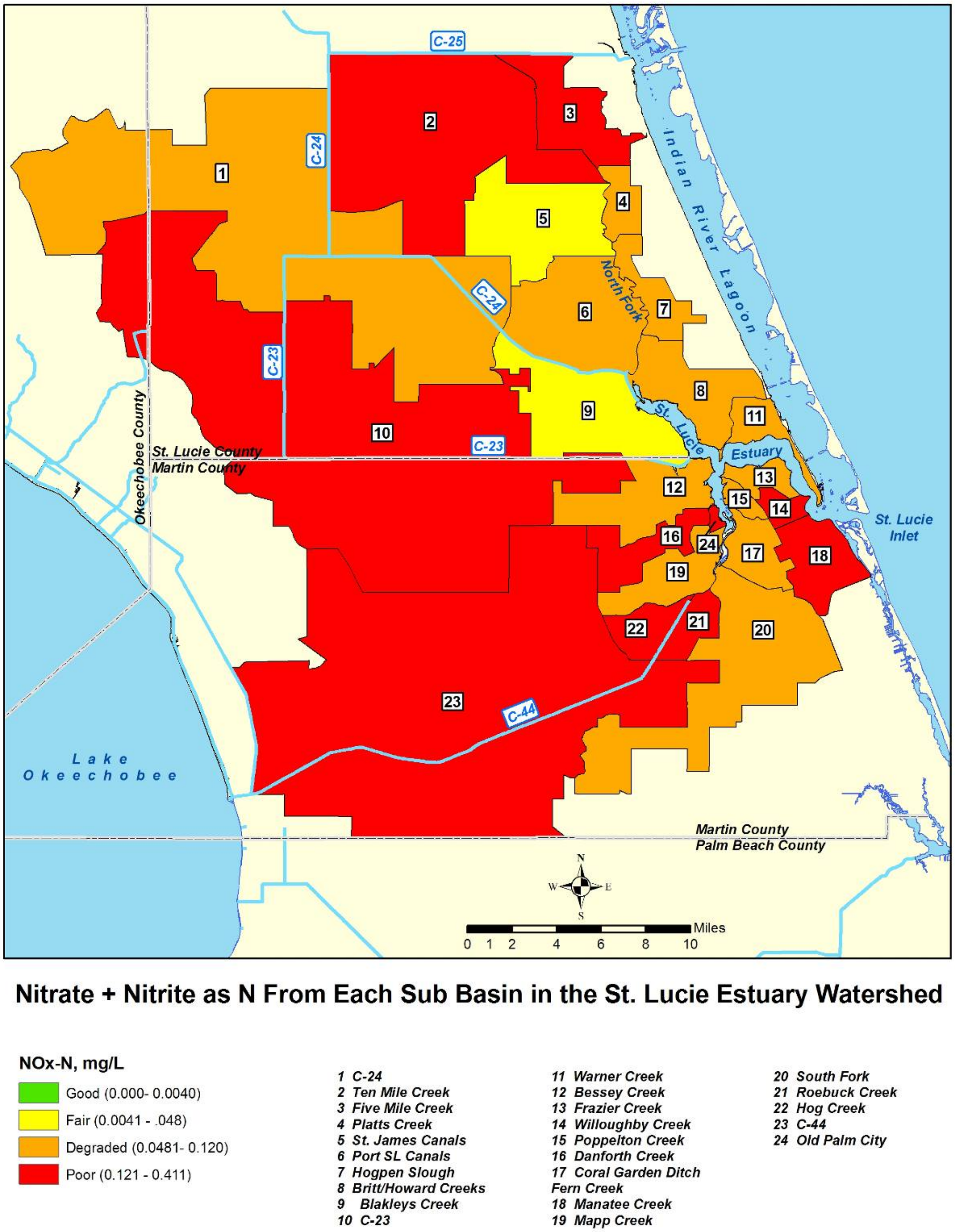
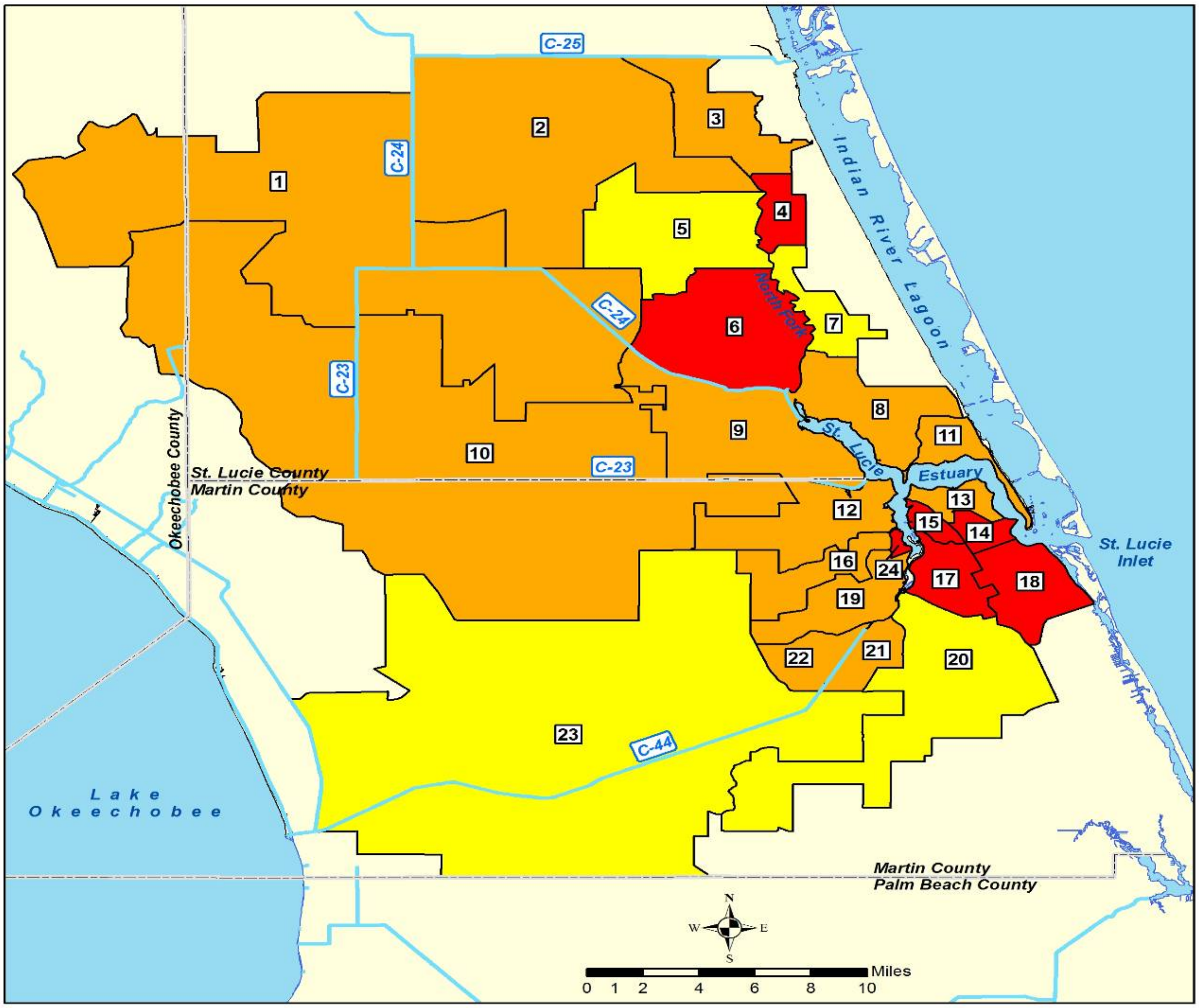


Figure 3.2-13. Aerial distribution of NOx concentration in the St. Lucie Watershed. The sub-basins within the North and South Forks are based on field verification and water management permit information.



Ammonium as N From Each Sub Basin in the St. Lucie Estuary Watershed

NH4-N mg/L

- Good (0.000- 0.009)
- Fair (0.0091 - .050)
- Degraded (0.051- 0.117)
- Poor (0.1171 - 0.386)

1 C-24
2 Ten Mile Creek
3 Five Mile Creek
4 Platts Creek
5 St. James Canals
6 Port SL Canals
7 Hogpen Slough
8 Britt/Howard Creeks
9 Blakleys Creek
10 C-23
11 Warner Creek
12 Bessey Creek
13 Frazier Creek
14 Willoughby Creek
15 Poppelton Creek
16 Danforth Creek
17 Coral Garden Ditch Fern Creek
18 Manatee Creek
19 Mapp Creek
20 South Fork
21 Roebuck Creek
22 Hog Creek
23 C-44
24 Old Palm City

Figure 3.2-14 Aerial distribution of NH4-N concentration in the St. Lucie Watershed. The sub-basins within the North and South Forks are based on field verification and water management permit information.

Table 3.2-12. Descriptive statistics for the basins in the St Lucie Watershed.

Basin		NO_X-N (mg/L)	NH_4-N (mg/L)	TKN (mg/L)	TN (mg/L)	PO_4-P (mg/L)	TP (mg/L)
C-44 (S80)	Mean	0.26	0.05	1.21	1.47	0.09	0.16
	Median	0.23	0.04	1.14	1.39	0.06	0.14
	Standard Deviation	0.18	0.06	0.41	0.47	0.07	0.08
	Skewness	0.73	2.57	3.20	2.47	1.84	1.15
	Minimum	-†	-	0.250	0.252	-	0.045
	Maximum	0.86	0.44	5.87	6.16	0.40	0.52
	Count	650	584	655	644	384	651
C-23 (S48)	Mean	0.13	0.11	1.30	1.43	0.18	0.32
	Median	0.09	0.07	1.29	1.43	0.15	0.30
	Standard Deviation	0.14	0.10	0.46	0.48	0.14	0.19
	Skewness	2.72	1.72	0.70	0.68	1.43	1.00
	Minimum	-	-	0.250	0.252	0.01	0.03
	Maximum	1.29	0.78	3.73	4.04	0.88	1.40
	Count	665	590	680	650	339	676
C-24 (S49)	Mean	0.09	0.10	1.41	1.48	0.19	0.27
	Median	0.05	0.06	1.33	1.41	0.17	0.25
	Standard Deviation	0.13	0.10	0.62	0.62	0.13	0.15
	Skewness	4.46	1.71	6.07	5.98	1.15	1.25
	Minimum	-	-	0.250	0.25	-	0.031
	Maximum	1.64	0.68	10.48	10.50	0.80	1.10
	Count	634	594	652	626	337	651
SLT (Multiple)	Mean	0.11	0.10	0.90	1.01	0.08	0.14
	Median	0.05	0.05	0.81	0.89	0.05	0.11
	Standard Deviation	0.23	0.23	0.45	0.53	0.09	0.13
	Skewness	7.88	9.14	5.77	4.86	2.75	2.83
	Minimum	-	-	0.280	0.285	-	0.005
	Maximum	4.70	4.97	8.62	8.65	1.03	1.46
	Count	2356	2358	2346	2341	2354	2272

† Minimum values were below the detection limits.

For NH4, the hot spots are in the Port St. Lucie Canal sub-basin in North Fork and a cluster of small creeks in South Fork. These areas are all residential with potential leaking septic tanks or horse farms. Note that the St. James Canal sub-basin is also low in both NOx and NH4.

Elevated nutrient concentrations in the St. Lucie River Watershed can be understood in the context of land use changes and drainage practices. The C-23 and C-24 basins have similar land use and development histories. Agriculture, primarily citrus and pasture, dominates land use in the basin, accounting for about 77% of land area. Citrus groves in these basins are typically older, requiring both fertilization and drainage to sustain viable production. Wetland and forest accounted for about 13.5% of C-24 basin and 2.6 % of C-23 basin, respectively. Urban land use was about only about 4.2% in these two basins. In the C-44 basin, land use is about 9% urban and 64.3% agriculture. In contrast, over 50% of the SLT basins were developed as urban and residential land.

The relationship of nutrient concentrations and land use between the sub-basins is consistent with the data collected by Graves et al. (2004) representing major land use types in the watershed. Graves et al. (2004) indicated that agricultural land, including citrus, pasture, and row crops, contributed to the highest N and P concentrations due to fertilization. Wetland runoff had the lowest concentrations in TP and inorganic N. However, TN concentration in wetland runoff was not the lowest, primarily due to plant detritus contributing to dissolved organic N in wetland stormwater. TN and TP concentrations in urban runoff were less than any other land use except wetland. The lower concentrations were probably due to the fact that most (100 out of 116) of the urban samples were collected in residential areas, where grassed swales may enhance nutrient removal as documented and recommended by Livingston et al. (1988). Nutrient loading abatement efforts in the watershed may still need to focus on implementation of Best Management Practices (BMPs). Particular attention needs to be paid to the fate and transport of dissolved organic N since storm water treatment areas (STAs) are not as effective for reducing TN as for TP.

3.2.3.3 Water Quality Trends

Trend analyses of nutrient concentrations in the St. Lucie River Watershed were performed on the following nutrient species: nitrite plus nitrate (NOX–N), nitrite (NO2–N), nitrate (NO3–N), ammonium (NH4–N), total Kjeldhal nitrogen (TKN), orthophosphate (PO4–P), and total phosphorus (TP). The analyses are part of District's water quality data analysis project and the results are published by Qian et al. (2007). When the data set contained more than 5% censored data, the parametric Tobit test was used. Otherwise, nonparametric Seasonal Kendall test was used for trend detection. The trend is further defined by the rate of changeover time, which is referred to as the trend slope as a percent of the mean concentration of water quality variable S(%). .

During the long-term period, some of the selected nutrient species exhibited significant positive or negative trends ($p<0.1$). The pattern of trend was found to be dependent upon individual nutrient species as well as upon the location of monitoring stations. More positive trends were observed in comparison with negative trends. In C-23 basin at station S48, annual positive trends were observed for NO3–N, NH4–N, PO4–P, and TP and no trends were detected for other species. At S-80 on the C-44, annual positive trends were observed for NOx–N (1979 to 2002), NH4–N (1979 to 2002), PO4–P (1979 to 2004), and TP (1979 to 2004) while annual negative trend was observed only for TKN (1979 to 2004). At S-50 on the C-25, representing areas immediately adjacent to the St. Lucie Estuary Watershed, NOx–N decreased with a slope of 3.19% and PO4–P increased with a slope of 2.15% between 1979 and 2004. The situation was quite different at S-49 on the C-24. Almost all of the seven nutrient species, except NO3–N for which no trend was detected, showed negative annual trends during 1979 to 2004 at this station.

3.2.4 Nutrient Loading

The loadings of TN and TP are calculated using flow and nutrient concentration data collected by the District from 1995 through 2005. In the tributary basins where flow data are not available, the St. Lucie Watershed Water Quality model was used to predict the corresponding flow and nutrient concentration for loading estimation (Wan et al., 2003). **Figure 3.2-15** shows the annual TN and TP loading into the estuary from 1995 to 2005. The average annual loading totals 2,217 tons/year for TN and 372 tons/year for TP. Annual loadings vary from year to year. The years of 1995, 2004 and 2005 were wet years and the annual nutrient loading amounts to

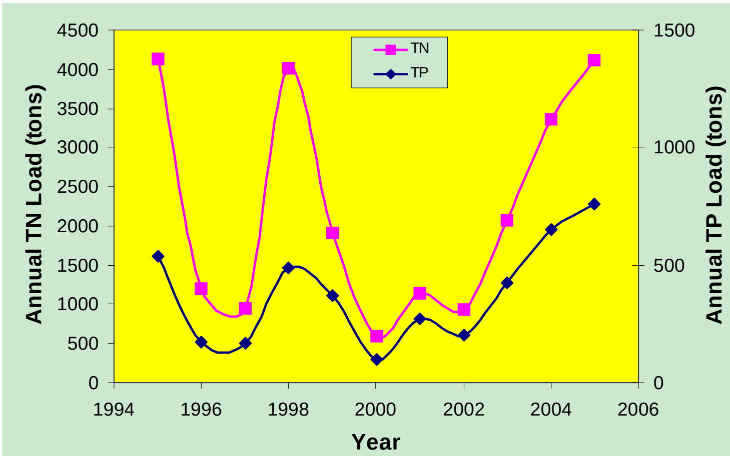


Figure 3.2-15. Annual loading of TN and TP into the St Lucie Estuary from 1995 to 2005.

about 4,000 tons for TN and 600 tons for TP. Lake Okeechobee discharge contributes substantially to nutrient loadings in some years such as 1998. For dry years such as 1996, 1997, and 2000, the loading was only about 1,000 tons for TN and 100-170 tons for TP.

Figures 3.2-16 and 3.2-17 show average annual loading of TN and TP partitioned into seven source areas including: South Fork basin, North Fork basin, C-24 basin, C-23, basin, C-44 basin, Basins 4,5,6 and the Lake Okeechobee discharges. Among the seven source areas, Lake Okeechobee contributed most TN, accounting for 41%, followed by C-24 (16%), C-23(15%), C-44 (14%), North Fork (8%), South Fork (4%), and Basins 4, 5, and 6 (Bessey and Danforth Creek basins) (2%). The Lake Okeechobee and C-23 basin contributed most TP loading, accounting for 26 and 24%, respectively, followed by C-24 (20%), C-44 basin itself (11%),

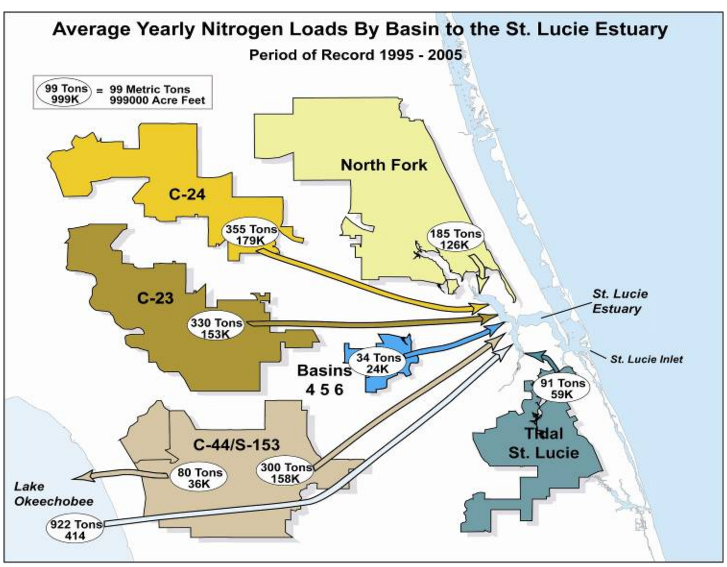


Figure 3.2-16. Average annual TN loading into the St. Lucie Estuary for the period of 1995 to 2005. Loadings are partitioned into 7 source areas including the Lake.

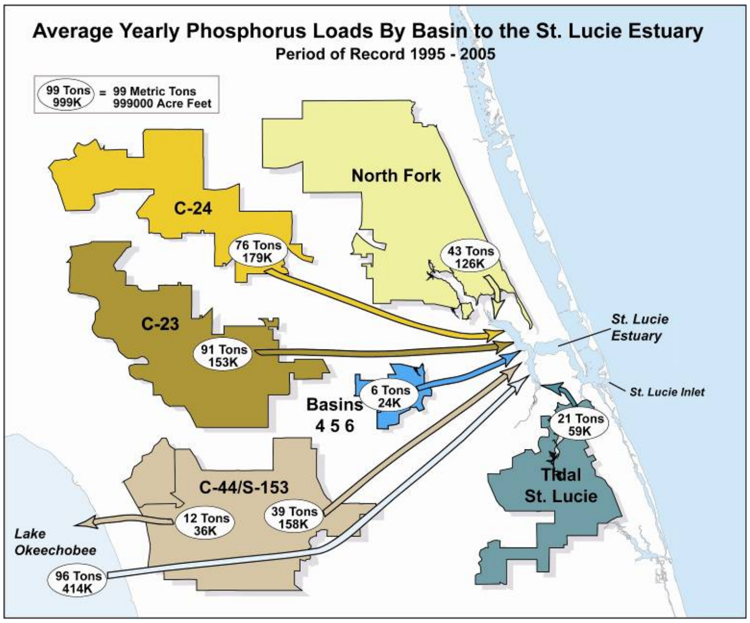


Figure 3.2-17. Average annual TP loading into the St. Lucie Estuary for the period of 1995 to 2005. Loadings are partitioned into 7 source areas including the Lake discharge.

North Fork (12%), South Fork (6%), and Basins 4, 5, and 6 (2%). The Lake Okeechobee contribution was particularly pronounced during a wet year such as 2005 when regulatory releases were made.

Also note that the nutrient mass loading is a function of discharge and nutrient concentrations. **Figure 3.2-18** shows the relationship between the total annual flow and annual loading of TN and TP developed using data during 1995 to 2005. The figure shows that annual loading is largely controlled by flow, which explains about 81% of loading variation for both TN and TP. The dominant effect of discharge rate on loading can also been seen in **Figure 3.2-19**, which shows the monthly flow and flow-weighted mean TP concentration of C-23 from 2000 to 2005. TP concentration and flow peak together during the wet season. Reduction of nutrient loadings should focus on the wet season discharges.

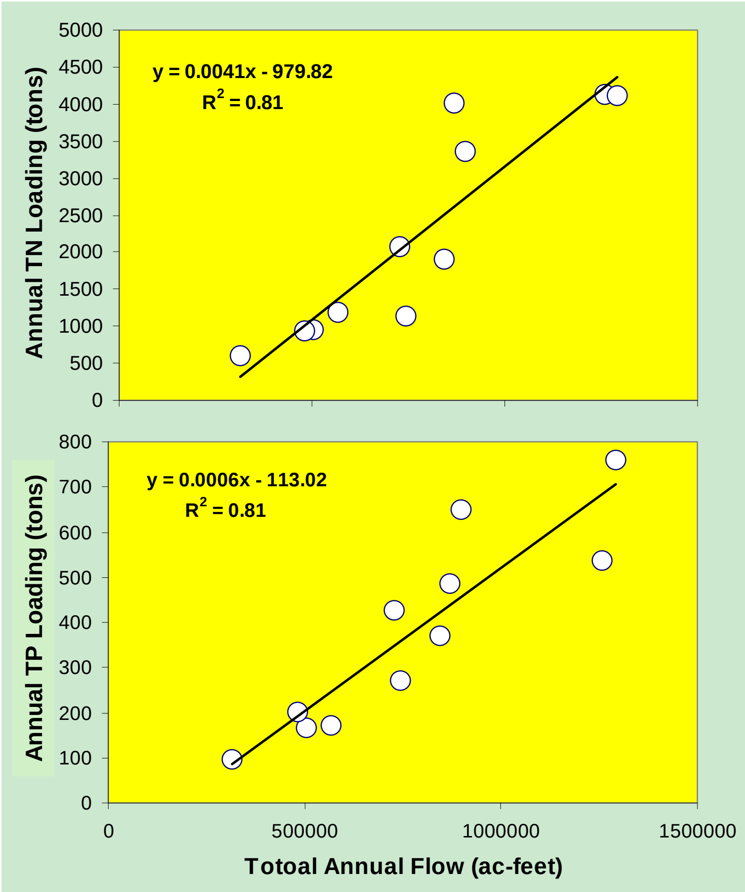


Figure 3.2-18. Regressions between total annual flow and annual loadings of TN and TP into the St. Lucie Estuary fro the period from 1995 to 2005.

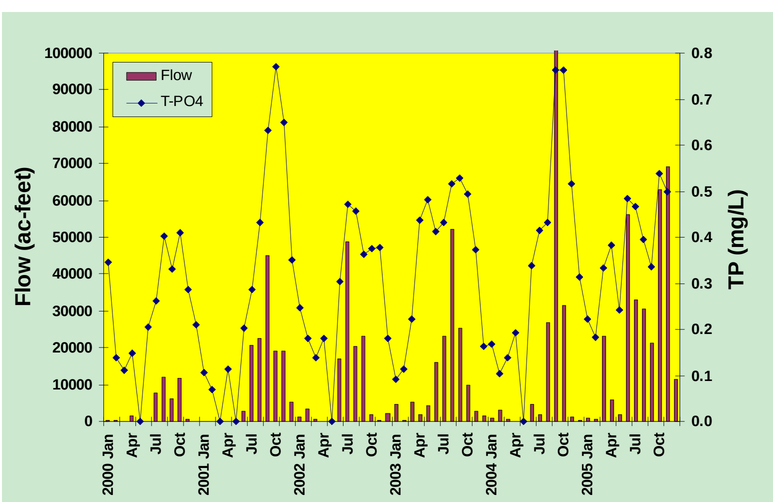


Figure 3.2-19. Temporal variation of flow and flow weighted mean TP concentration of C-23 during 2000 to 2005.

3.3 Estuary Salinity, Water Quality, Aquatic Habitats, and Floodplain Vegetation

The section begins with a discussion of salinity and water quality. While salinity is a water quality parameter, it is treated separately because of its ecological importance and because the District has based its management of freshwater inflows on the salinity requirements of estuarine organisms. The discussion of water quality focuses on nutrients and other water quality parameters of concern (e.g., dissolved oxygen). Finally, the distribution of important aquatic habitats and their relationship to water quality, including salinity, is discussed.

3.3.1 Salinity: Range, stratification and flow correlation

3.3.1.1 Introduction

Estuaries are transition zones where seawater from the ocean is measurably diluted by freshwater from the land. Spatial and temporal salinity gradients typify estuarine environments and these vary as a function of winds, tides, evaporation and freshwater flow. This section describes the spatial and temporal variation of salinity in the St. Lucie Estuary with emphasis on the influence of freshwater inflow. The discussion of spatial variation considers both longitudinal variation (variation from the head to the mouth) as well as variation in the vertical dimension. The latter is important because when the estuary stratifies, bottom waters can become anoxic.

3.3.1.2 Methods

The discussion here is primarily based on continuous salinity monitoring sites at: A1A Bridge, Roosevelt Bridge, Palm City Bridge, HR1, Veteran's Park, Prima Vista Bridge, and Midway Bridge (**Figure 3.3-1**). Measurements are made electronically every 15 minutes at each of these locations. Monthly salinity measurements, taken manually at eleven estuarine stations as part of the District's SE Water Quality Monitoring Program are also summarized (**Table 3.3-1)**. For more information on these programs see Chapter 4.

Table 3.3-1. Statistical summary of monthly salinity measurements in practical salinity units(psu) for the St. Lucie River Estuary from July 1992 through December 2006.

Section	mean	Standard deviation	Min	Percentile 5	25	50	75	95	Max
South Fork (SE08)	3.8	5.1	<0.1	0.1	0.2	0.4	6.3	15.5	23.6
North Fork (SE03-06)	7.1	7.2	<0.1	0.1	0.5	4.9	12.2	20.9	39.0
Main Estuary (SE01-03)	17.4	10.3	<0.1	0.4	8.6	18.6	26.1	32.4	36.4
Inlet area (SE11)	27.2	7.9	0.6	9.6	22.9	29.6	33.3	35.7	36.5
Entire Estuary	11.0	10.5	<0.1	0.1	0.6	8.2	19.1	31.0	39.0

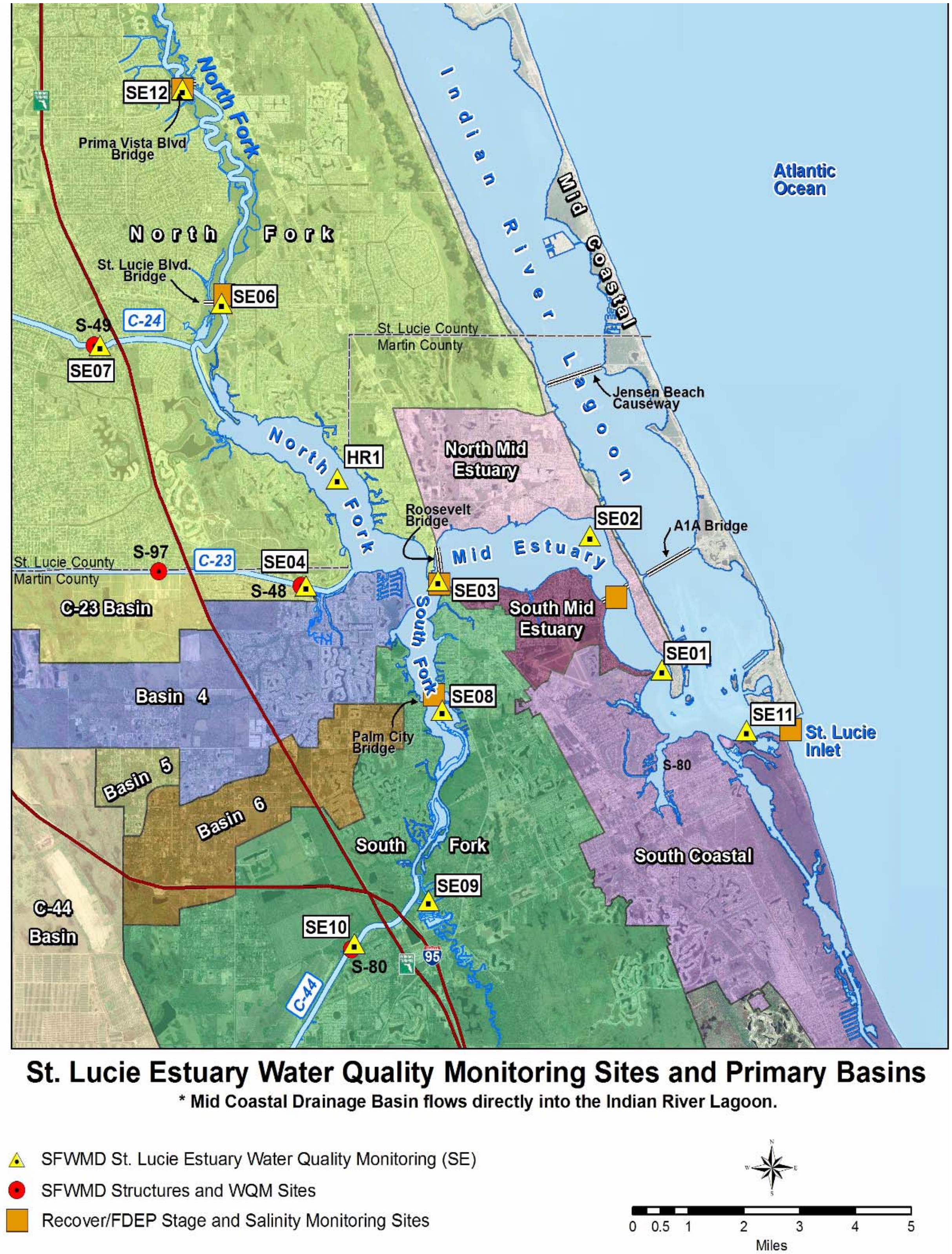


Figure 3.3-1. Map showing surface water quality monitoring stations, inflow structures and regions of the St. Lucie River Estuary. SE13 located on the North Fork upstream of SE12 is not pictured.

3.3.2 Results and Discussion

3.3.2.1 Range and variation

Salinity varies on daily, monthly, seasonal and annual time scales (**Figure 3.3-2**). As is true for many estuaries, such variation is largely driven by freshwater inflow. This is visually apparent in **Figure 3.3-2**, and verified by a correlation analysis of salinity and freshwater inflow at the continuous monitoring stations (**Table 3.3-2**).

Overall, the inverse correlation between flow and salinity is very strong with inflow accounting for 74% to 89% of the variation in salinity in the St. Lucie Estuary. Notice that total flow was used for the calculations except at Veteran's Park (North Fork) and Palm City Bridge (South Fork) Also, salinity computed from a hydrodynamic model was used at Palm City Bridge where there were no data until June 2007.

Table 3.3-2. Correlation coefficients between freshwater inflow and daily averaged salinity for the period 1998 to 2007.

Station	R^2	Flow used
Inlet	0.89	Total
A1A Bridge	0.87	Total
US1 Bridge	0.88	Total
HR1	0.83	Total
Veteran's Park	0.74	Gordy + C23+C24
Palm City Bridge	0.85	S80

Table 3.3-3. Average daily range of salinity (psu) and minimum and maximum of daily averaged salinity at four continuous salinity stations for the period from 1998 to 2007.

	A1A Bridge	US1 Bridge	Palm City Bridge	Veteran's Park
M_2 amplitude (cm)	15	14	NA	14
Mean daily range	9.38	4.45	3.28	4.22
Min (daily mean)	0.12	0.1	0.22	0.1
Max (daily mean)	34.31	31.33	22.13	35.9

Within a single day, salinity can vary by several practical salinity units (PSU) depending on location (**Table 3.3-3**). Monthly grab samples of salinity show a strong seasonal pattern driven by freshwater inflow, being lower in the wet season and higher in the dry season (**Figure 3.3-6**). **Figure 3.3-6** also illustrates the expected spatial trends in salinity, with highest salinity near the ocean and lowest salinity in the North and South Forks where major freshwater inflows occur.

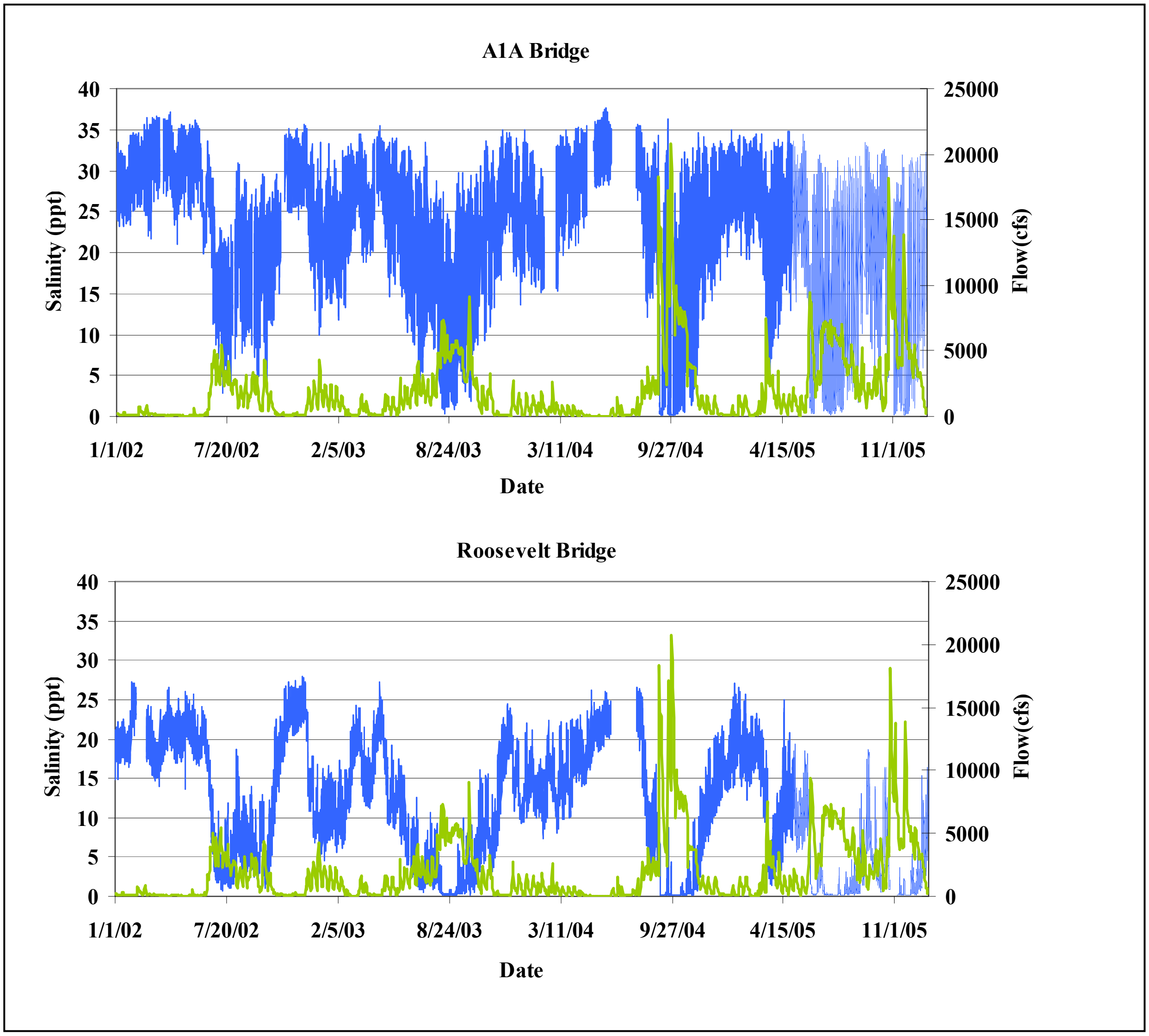


Figure 3.3-2. Time series plot of total daily freshwater inflow to the estuary and associated mean daily salinity levels at the A1A Bridge and the Roosevelt Bridge.

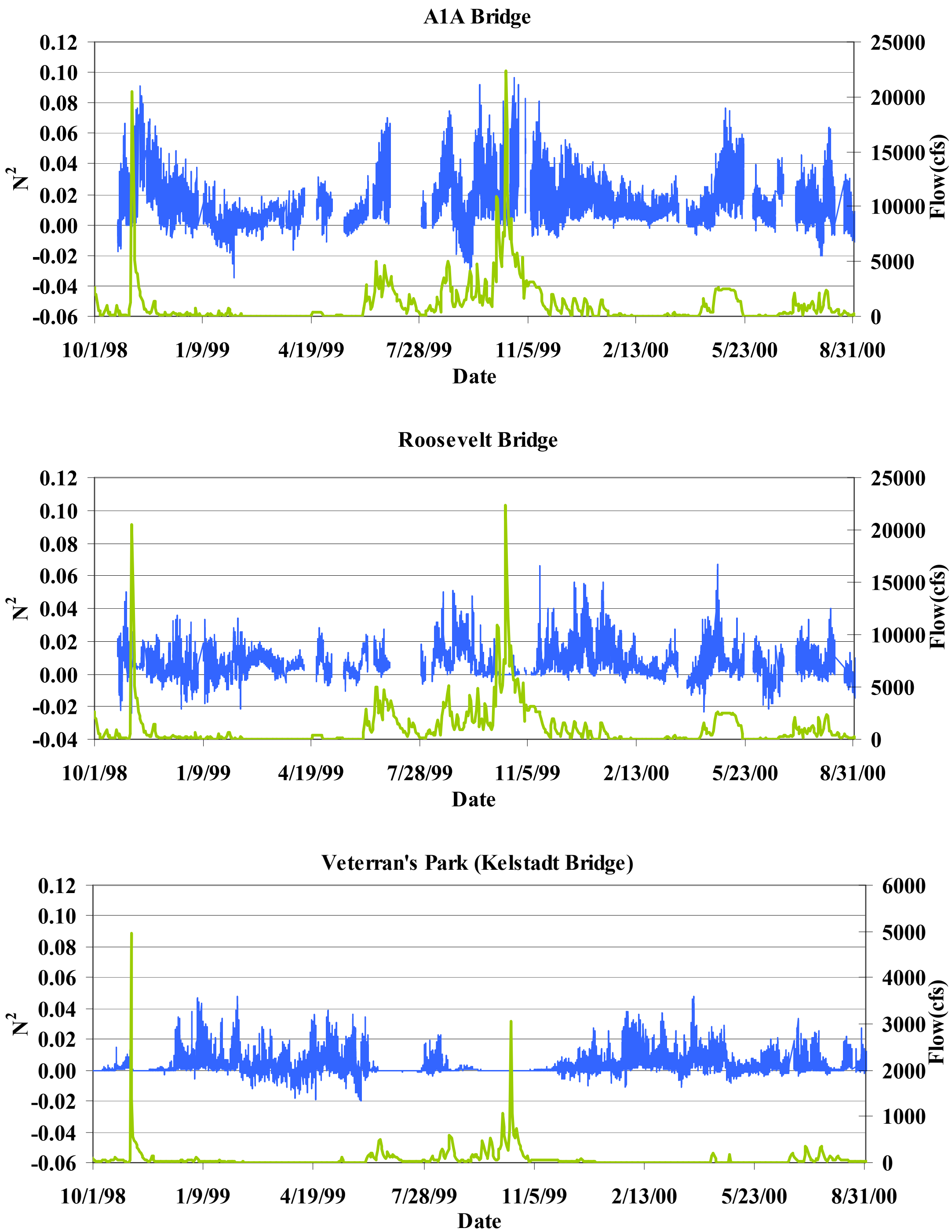


Figure 3.3-3. Buoyancy frequency (blue) computed at A1A Bridge, Roosevelt Bridge and Kelstadt Bridge for the period from October 1998 to August 2000. Also shown is the freshwater inflow (green). A higher N^2 indicates stronger stratification.

3.3.2.2 Stratification

Observed data indicate that stratification tends to occur during wet events. To illustrate the strength of the stratification quantitatively, the buoyant frequency is computed at three salinity monitoring stations (Figure 3.3-3). Buoyancy frequency is defined as:

$$N^2 = -\frac{g}{\rho}\frac{\partial\rho}{\partial z}$$

Where N is the buoyancy frequency, g is gravity, ρ is density and z is vertical coordinate. Figure 3.3-3 confirms that N^2 is significantly higher at A1A than at US1 and Kelstadt Bridge (Veteran's Park). At A1A, stratification tends to be stronger during higher flow. However, the same thing cannot be said for either US1 or Kelstadt Bridge where stratification disappears when total freshwater inflow exceeds 100 m^3/s (3000 cfs). Stratification occurs at lower flow. Flow of just a few cubic meter per second to 20 m^3/s (50 to 500 cfs) could already cause stratification at Kelstadt Bridge while stratification seems to favor a relative larger range of flow in 20 to 50 m^3/s (500 to 1500 cfs).

3.3.2.3 Summary

Salinity is one of the most important water quality parameters for an estuary. Salinity in an estuary is the result of interaction between freshwater and ocean water through complicated hydrodynamic processes. The Main Estuary (Estuary Proper) shows the widest salinity range. Strong correlation can be seen between salinity and freshwater inflow in the estuary although other factors such as tide and wind can also contribute significantly to the salinity variation. Strong stratification tends to occur downstream of the estuary while stratification is less profound upstream of the Roosevelt Bridge. The North Fork tends to be more susceptible to stratification than the South Fork.

3.3.2.4 Water quality status: DO, nutrients, and Chlorophyll

This section provides an overview of water quality status within the St. Lucie Estuary. Salinity is a key water quality indicator and is treated in depth in the previous section. Here, other important water quality parameters are discussed including: dissolved oxygen (DO), nutrients, and chlorophyll *a*.

3.3.2.5 Data

As part of the SWIM initiative a long-term water quality-monitoring program was started in October of 1990 in the SLE. Ten water quality monitoring stations (SE 01, SE 02, SE 03, SE 04, HR1, SE 06, SE 07, SE 08, SE 09 and SE 10) were established to detect long-term spatial and temporal trends in the SLE. In 1997 an eleventh station (SE 11) was added in the St. Lucie inlet to better characterize the water quality values in the estuary (Figure 3.3-1). The period of record for the most recently added stations (SE12 and SE13) is only a couple of years and these stations were not included in the analysis.

3.3.2.6 Method

For the purpose of this discussion, a limited number of parameters are used to summarize water quality in the SLE. Those parameters are:

- dissolved oxygen (DO)
- color
- chlorophyll *a*
- total nitrogen (TN)
- total phosphorus (TP)
- salinity

The SLE was divided into four sections: the inlet (SE 11); main estuary (SE 01, SE 02 and SE 03); North Fork (SE 04, HR1, SE 06 and SE 07); and South Fork (SE 08, SE 09, SE 10) Figure 3.3-1. The period of record used in this summary was from July 1992 through December 2006. Further details are available in Chapter 4.

3.3.2.7 Results

On average, the St Lucie receives about 818,000 acre-feet of freshwater inflow from the three major canals draining into the estuary (**Table 3.3-4**). The concentration of total phosphorus in this water averages 260 µg/L, while total nitrogen averages 1.68 mg/L. There is a strong seasonal signal in both quantity of inflow and in nutrient concentrations **(Figures 3.3-4 through 3.3-6**) with a clear demarcation between the wet season (May through October) and the dry season (November through April). As seen in the previous section, salinity fluctuates seasonally with freshwater inflow. Nutrients concentrations in the estuary also reflect seasonal fluctuations in concentrations of the canal inflow, with TP showing a more pronounced seasonal difference than TN (**Figures 3.3-4 through 3.3-6**).

Notched box and whisker plots were used to analyze seasonal differences for the six parameters in the four regions of the SLE (**Figure 3.3-7 and Figure 3.3-8**). The *notch* in the *box* is the 95% confidence interval around the median. In addition, the Mann-Whitney test was used to determine seasonal changes were statistically significant (**Table 3.3-5**). Based on these plots and the information in **Table 3.3-5**, salinity and dissolved oxygen exhibited significant increases during the dry season in four regions of the SLE. Color, TP, TN and chlorophyll *a* exhibited increases during the wet season. Only color and TP exhibited statistically significant increases in all portions of the SLE. Total nitrogen did not exhibit a significant increase in the South Fork, while chlorophyll *a* did not exhibit a significant increase in the inlet region (**Table 3.3-5**).

3.3.2.8 DO

Dissolved Oxygen values have been a source of concern in the SLE. The Environmental Protection Agency sets guidelines for hypoxic waters as <4 mg/L and anoxic waters as <2 mg/l. These guidelines were used to generate **Figure 3.3-9** which shows the number of dissolved oxygen measurements: <2 mg/L, between 2 and 4 mg/L and ≥4.0 mg/L. It is important to note that ≥4 mg/L is the Class III limit for marine waters set by the FDEP. The majority of dissolved oxygen measurements were ≥4 mg/L in all regions of the SLE. While the main region of the estuary exhibited some dissolved oxygen levels indicative of hypoxic conditions, the North and South Forks exhibited more dissolved oxygen levels in the hypoxic range as well as some measurements indicative of anoxic waters (<2 mg/L).

Table 3.3-4. Annual summary of combined freshwater inflows from the major canals (C-44, C23, C24) and flow weighted nutrient concentrations.

Water Year[a]	Freshwater Inflow[b] (1000s of Acre-feet)	Total Phosphorus (mg/L)[c]	Total Nitrogen (mg/L)[c]
1993	747	221	1.27
1994	175	301	2.52
1995	1,128	170	1.46
1996	1,539	205	1.67
1997	346	167	1.54
1998	1,531	210	1.89
1999	383	270	1.60
2000	777	320	1.75
2001	199	215	1.41
2002	392	389	1.65
2003	590	260	1.45
2004	986	242	1.46
2005	1,192	409	2.19
2006	1,745	295	1.62
Mean	**818**	**260**	**1.68**

a water year based on 12 month period starting in may and ending in April
b combined flow from gauged structures S-80, S-49 and S-48.
c Mean of concentrations measured at S-80, S-49 and S-48. Contribution of each structure to the mean is weighted by its contribution to combined flow.

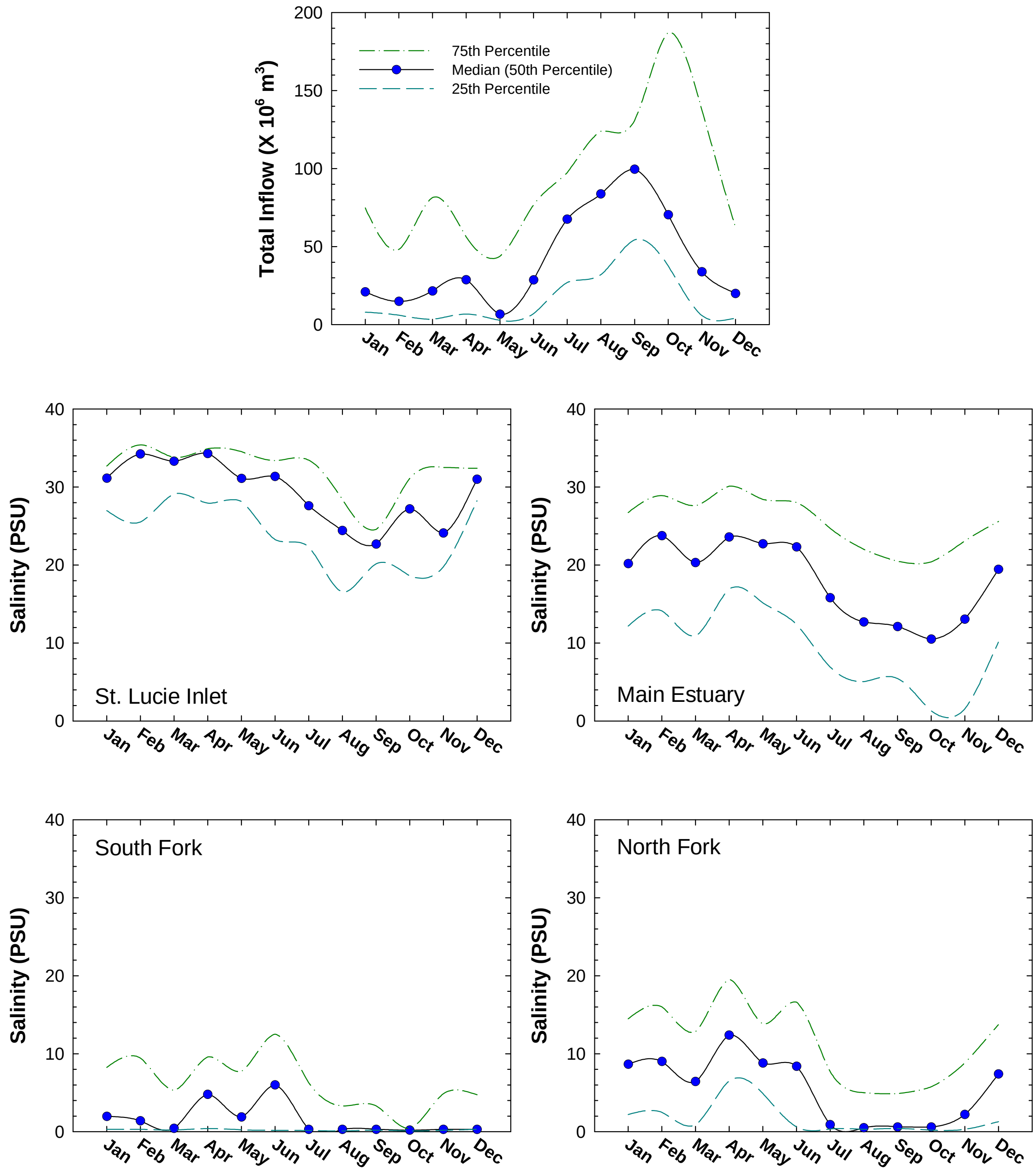


Figure 3.3-4. Monthly distribution of freshwater inflow to the estuary and associated median salinity levels in the four regions of the St. Lucie River Estuary. Graphs show distribution of monthly median values with the inter quartile range (i.e., 25th and 75th percentiles) for the period from July 1992 through December 2006.

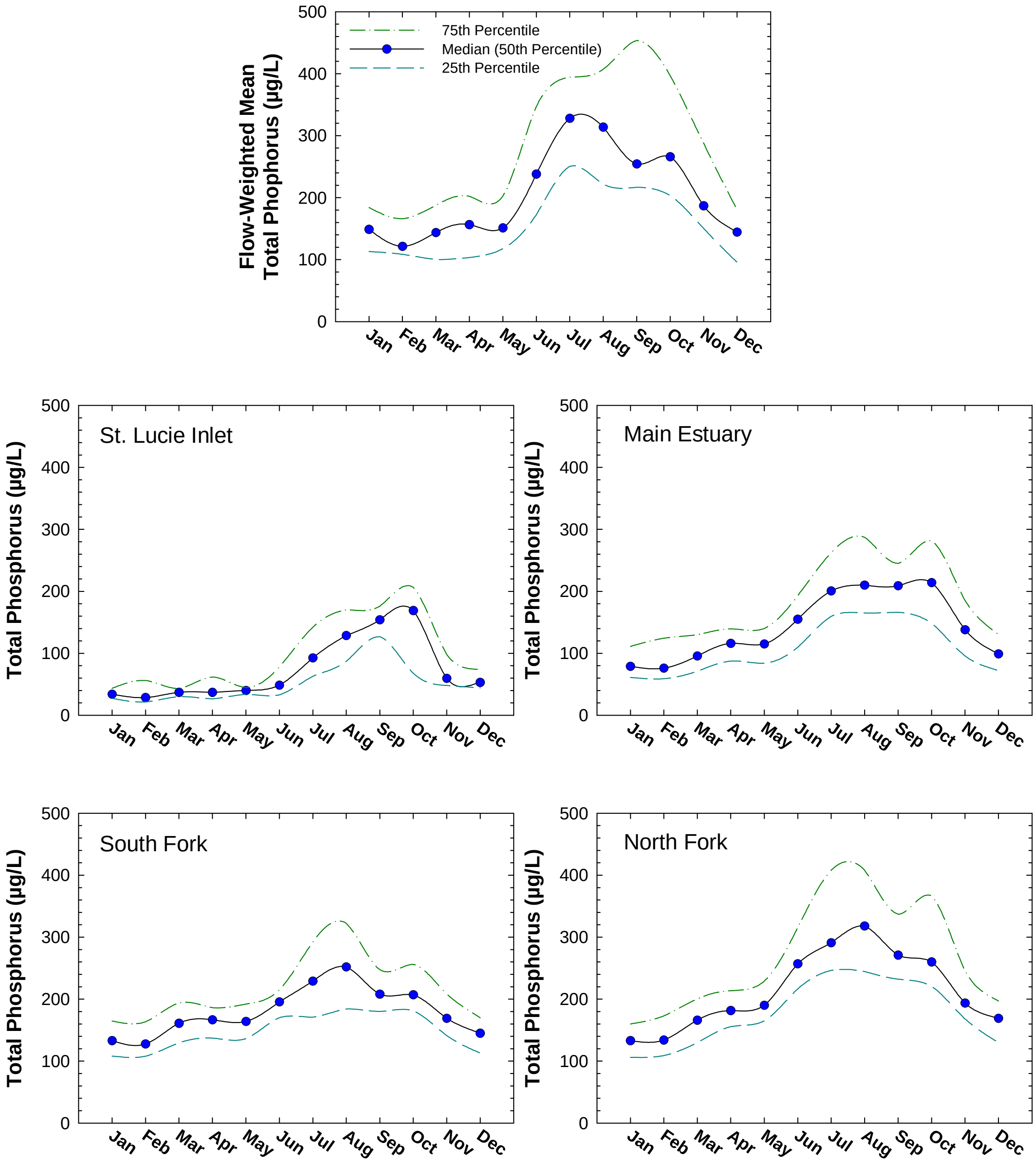


Figure 3.3-5. Monthly distribution of flow weighted mean total phosphorus concentrations at the three gauged inflow structures to the estuary and associated median total phosphorus concentrations in the four regions of the St. Lucie River Estuary. Graphs show monthly median distribution values with the inter quartile range (i.e., 25th and 75th percentiles) for the period from July 1992 through December 2006.

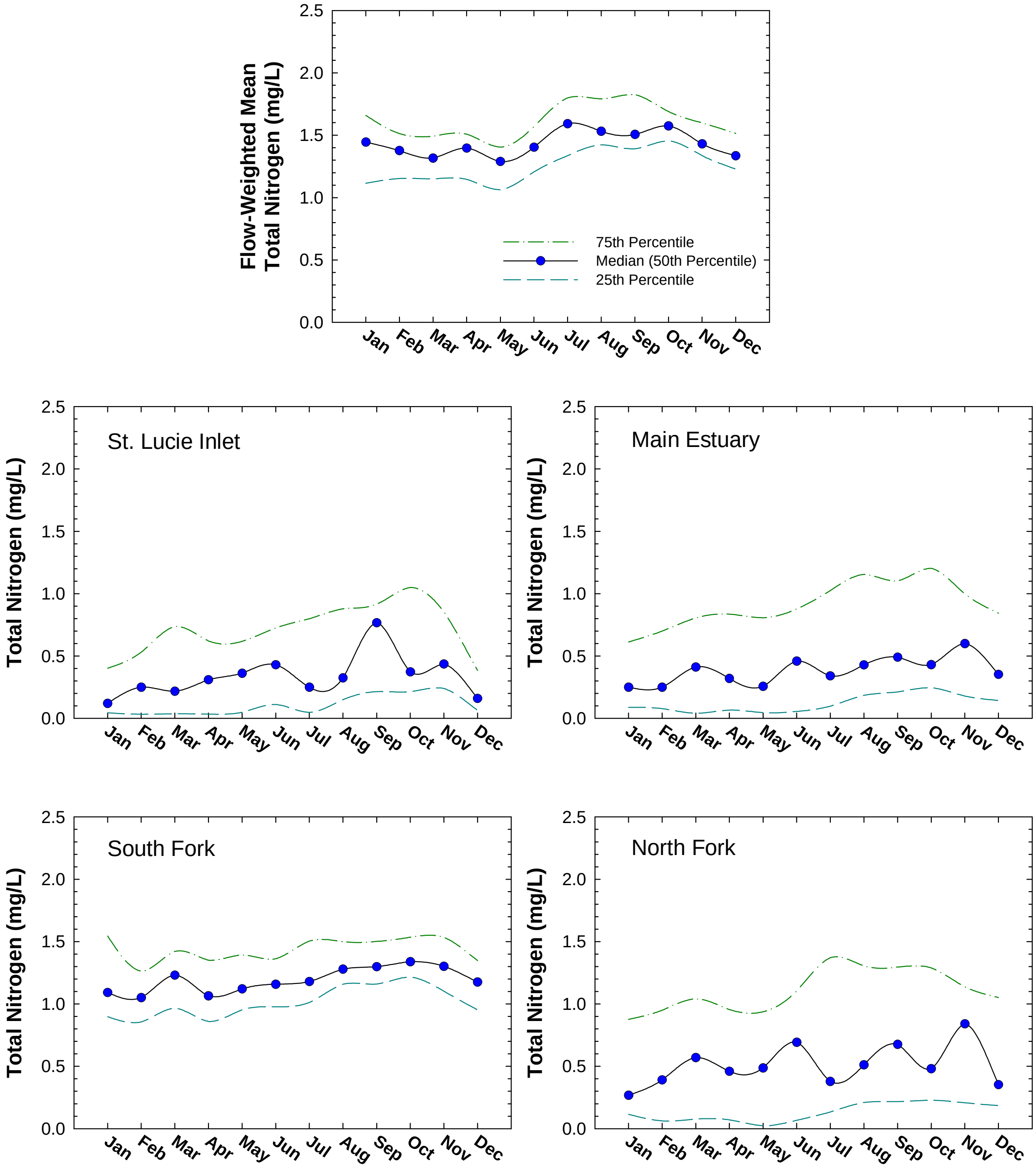


Figure 3.3-6. Monthly distribution of flow weighted mean total; nitrogen concentrations at gauges inflow point to the estuary and associated median total nitrogen concentrations in the four regions of the St. Lucie River Estuary. Graphs show distribution of monthly median values with the inter quartile range (i.e., 25th and 75th percentiles) for the period from July 1992 through December 2006.

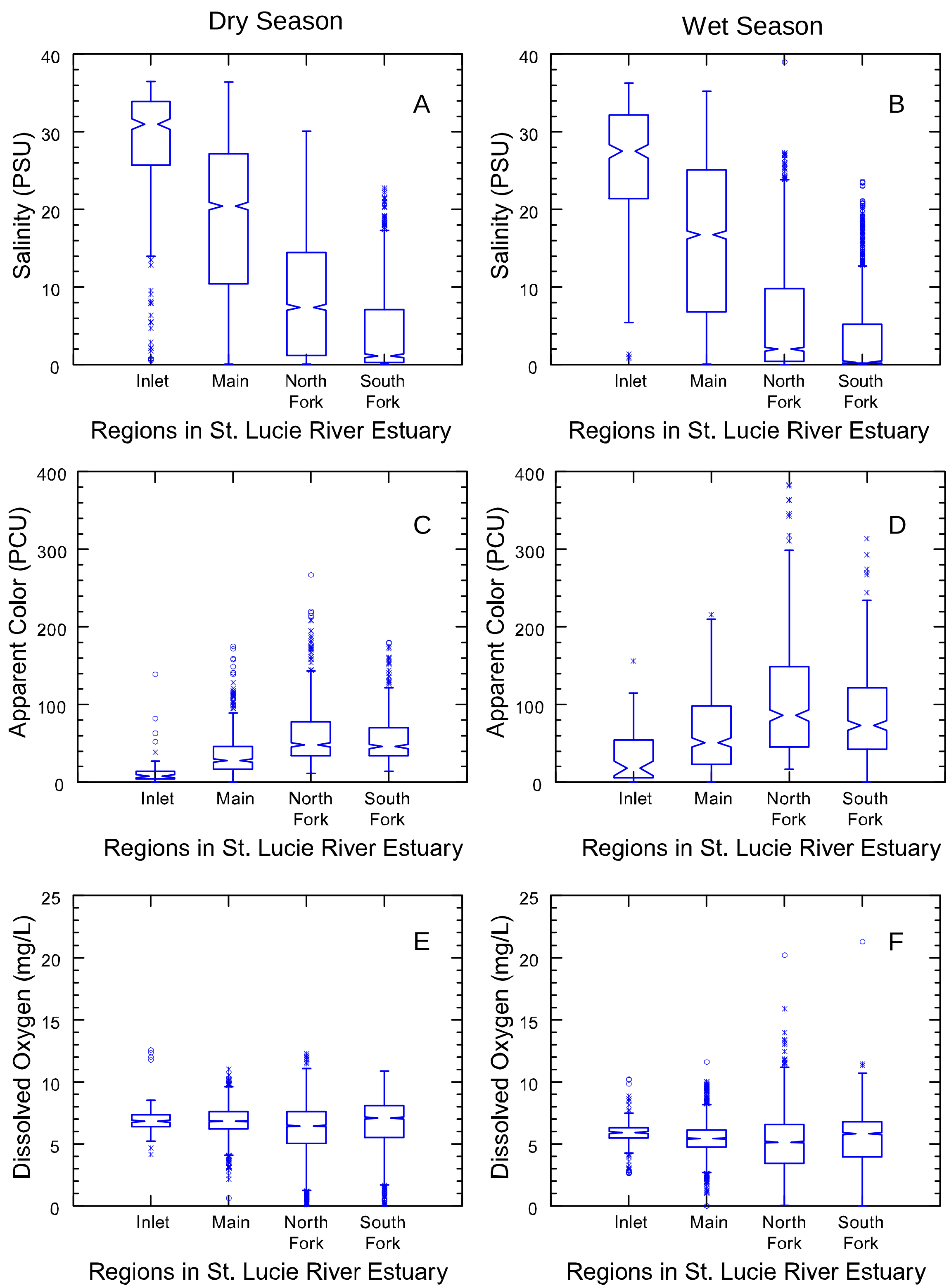


Figure 3.3-7. Notched box and whisker plots comparing dry and wet season concentrations of salinity (A and B); color (C and D); and dissolved oxygen (E and F) levels in four regions of the St. Lucie River Estuary for the period from July 1992 through December 2006.

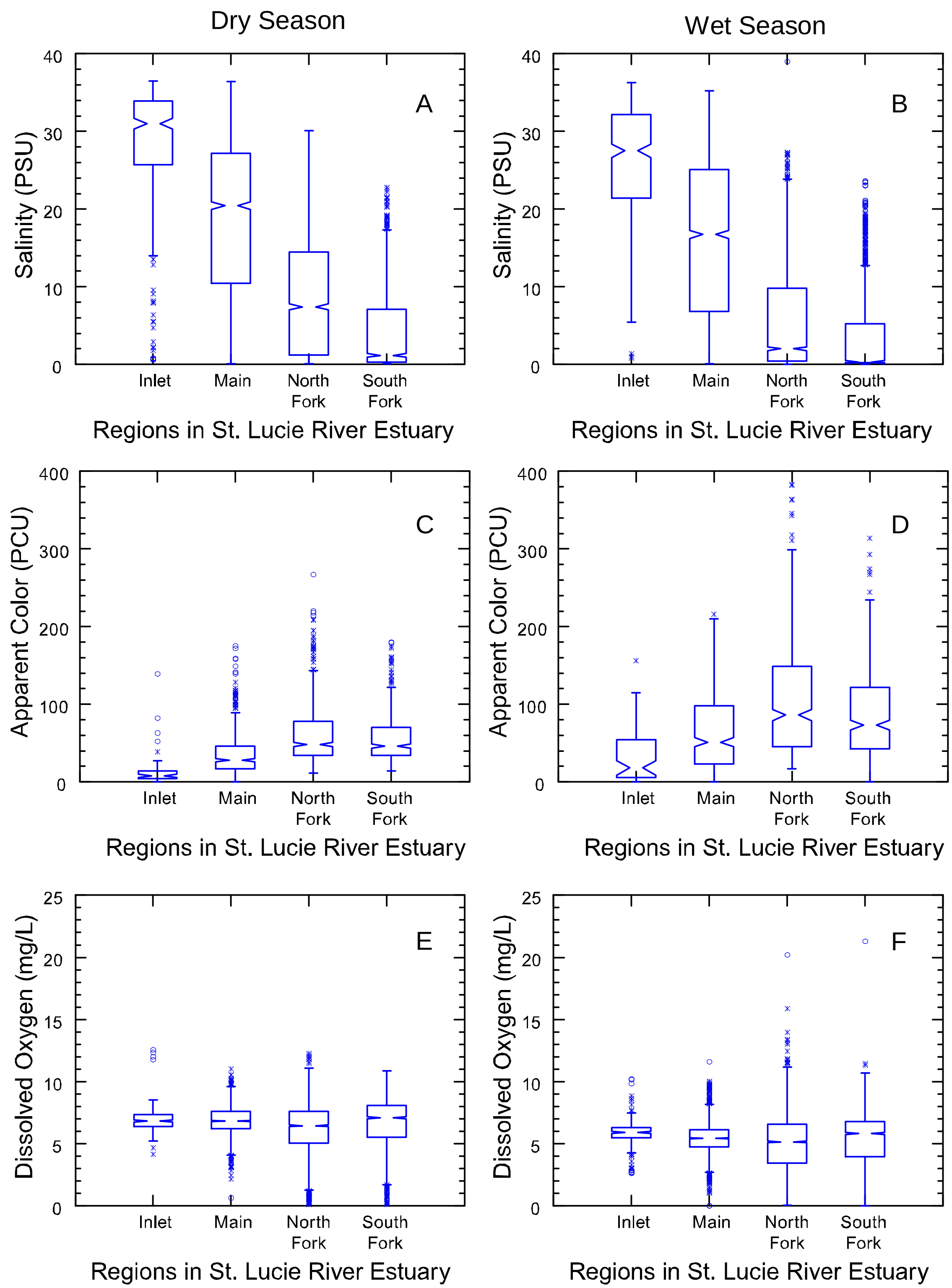


Figure 3.3-8. Notched box and whisker plots comparing dry and wet season concentrations of salinity (A and B); color (C and D); and dissolved oxygen (E and F) levels in four regions of the St. Lucie River Estuary for the period from July 1992 through December 2006.

Table 3.3-5. Summary of seasonal comparison (dry versus wet) using the Mann-Whitney test for significance. Significant at the $p<0.05$ level. Season with the higher parameter concentration is identified for each parameter and region.

Parameters	North Fork	South Fork	Main Estuary	St. Lucie Inlet
Salinity	Dry [1]	Dry [1]	Dry [1]	Dry [1]
Dissolved Oxygen	Dry [1]	Dry [1]	Dry [1]	Dry [1]
Color	Wet [1]	Wet [1]	Wet [1]	Wet [1]
Total Phosphorus	Wet [1]	Wet [1]	Wet [1]	Wet [1]
Total Nitrogen	Wet [1]	Wet [1]	Wet [1]	Wet [1]
Chlorophyll [1]	Wet [1]	Wet [1]	Wet [1]	Wet [1]
1 Season exhibited a statistically significant increase in concentration				

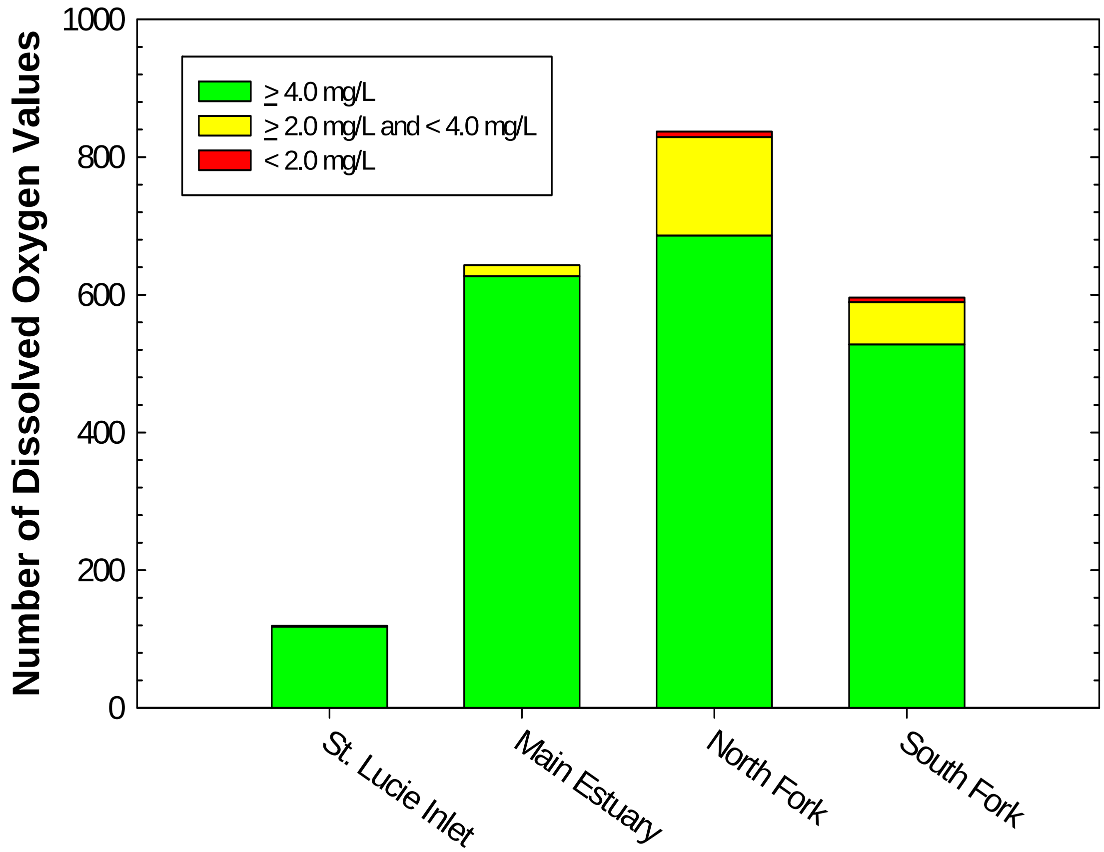


Figure 3.3-9. Number of dissolved oxygen values measured in the four regions of the St. Lucie River Estuary from July 1992 through December 2006 that were less than 2.0 mg/L, greater or equal to 2.0 and less than 4.0 mg/L, and greater than or equal to 4.0 mg/L. Each dissolved oxygen value was calculated as a mean of the vertical profile of monthly water quality stations in the four regions.

3.3.2.9 Discussion

Concentrations of most water quality parameters decreased in a westerly direction from the mouth of the SLE as a result of nutrient-laden freshwater inflows to both the North and South

Forks. Although the North and South Forks drain different basins, water quality for these two regions is similar. The increased freshwater inputs observed during the wet season through the North and South Forks tend to explain the majority of the seasonal variability (Doering, 1996).

Hand (2004) established median water quality standards for four parameters: chlorophyll *a* (7.2 mg/m^3), TN (0.67 mg/L), TP (100 µg/L), and Secchi depth (1.0 m) for Florida Estuaries. Although the median TN concentration for the four regions of the SLE ranged from 0.3 mg/L for the inlet and 0.6 mg/L for the South Fork (**Table 3.3-6**), they were below the 0.67 mg/L criteria established by Hand (2004). Median TP levels for the SLE far exceeded the median value for comparable Florida estuarine systems (**Table 3.3-6**). These higher TP values can be attributed to increased nutrient laden fresh water inflows (Chamberlain and Hayward, 1996). Chamberlain and Hayward (1996) found that the highest chlorophyll *a* values were associated with low flow conditions resulting in low nutrient concentrations and color levels. Long flushing time and high light availability under low flow conditions favor the accumulation of chlorophyll *a* biomass.

Dissolved oxygen is a critical indicator of the health of an estuarine ecosystem (Engle *et al*, 1999). The majority of stations in the North and South Forks of the SLE exhibit hypoxia with some of the stations exceeding the EPA standards more then 20 percent of the time over the last decade. Since measurements of DO are performed during optimal photosynthetic conditions, the DO levels can be assumed to be lower periods of the diel cycle when respiration is optimal. Stations co-located with water control structures tended to have higher incidents of exhibiting hypoxic and anoxic conditions. This is believed to be a result of stratification between fresh and brackish waters under low or no flow conditions. Sites not adjacent to structures and still exhibiting hypoxic conditions are of concern.

3.3.3 Aquatic Habitats

This subsection discusses aquatic habitats found in the St. Lucie Estuary. The ecological importance of submerged aquatic vegetation, their diminishing distribution in the estuary, and the relationship of seagrasses to water quality are treated here. The discussion then turns to the importance of oyster beds, their distribution and importance, as well as their relationship with water quality. The chapter closes with a discussion of the ecological importance of the floodplain to the water quality and hydrology of the St. Lucie Estuary.

3.3.3.1 Submerged Aquatic Vegetation (SAV): Ecological Importance, Relationship To Water Quality, and Distribution

3.3.3.1.1 Ecological importance

Submerged aquatic vegetation (SAV) is a critical component of a healthy estuarine ecosystem. In the St. Lucie Estuary/Indian River Lagoon (SLE/IRL), the SAV community includes both seagrasses and algae. If healthy SAV beds are present, then a diverse and productive faunal community will also be present.

Table 3.3-6. Statistical summary of selected water quality parameters in the St. Lucie River Estuary for the period from July 1992 through December 2006

Parameter	Mean	±	Standard Deviation	Minimum	Percentiles					Maximum
					5th	25th	50th	75th	95th	
South Fork										
Salinity (PSU)	3.8	±	5.1	<0.1	0.1	0.2	0.4	6.3	15.5	23.6
Dissolved Oxygen (mg/L)	6.1	±	2.1	<0.1	2.0	4.8	6.4	7.5	9.0	21.3
Apparent Color (PCU)	72.1	±	47.5	0.5	27.0	37.0	55.0	93.8	167.6	314.0
Secchi disk depth (m)	0.8	±	0.4	<0.01	0.2	0.5	0.8	1.0	1.4	7.5
Total Nitrogen (mg/L)	0.75	±	0.63	<0.05	<0.05	0.20	0.63	1.23	1.75	7.09
Total Phosphorus (µg/L)	192.2	±	84.8	72.0	99.0	136.0	174.0	220.0	352.8	710.0
Chlorophyll *a* (mg/m^3)	10.4	±	9.5	0.3	1.6	3.9	7.8	13.3	29.1	73.3
North Fork										
Salinity (PSU)	7.1	±	7.2	<0.1	0.1	0.5	4.9	12.2	20.9	39.0
Dissolved Oxygen (mg/L)	5.6	±	2.2	<0.1	1.5	4.1	5.8	7.1	8.7	20.2
Apparent Color (PCU)	85.1	±	64.5	11.0	25.0	38.0	60.0	115.0	220.0	383.0
Secchi disk depth (m)	1.0	±	0.4	0.1	0.5	0.7	1.0	1.2	1.6	10.0
Total Nitrogen (mg/L)	0.65	±	0.58	<0.05	<0.05	0.13	0.47	1.10	1.65	4.68
Total Phosphorus (µg/L)	236.5	±	120.7	49.0	101.4	159.0	207.0	280.0	466.2	1040.0
Chlorophyll *a* (mg/m^3)	12.2	±	11.4	0.5	2.0	5.0	9.2	16.0	30.9	157.0
Main Estuary										
Salinity (PSU)	17.4	±	10.3	<0.1	0.4	8.6	18.6	26.1	32.4	36.4
Dissolved Oxygen (mg/L)	6.2	±	1.3	<0.1	4.0	5.4	6.2	7.0	8.4	11.6
Apparent Color (PCU)	52.8	±	46.6	0.5	9.0	19.0	35.0	74.0	160.5	216.0
Secchi disk depth (m)	1.0	±	0.4	0.1	0.3	0.7	1.0	1.3	1.7	4.8
Total Nitrogen (mg/L)	0.55	±	0.53	<0.05	<0.05	0.11	0.35	0.90	1.50	3.37
Total Phosphorus (µg/L)	154.4	±	94.0	8.0	54.0	86.0	131.0	200.0	333.0	631.0
Chlorophyll *a* (mg/m^3)	8.3	±	7.7	<0.3	2.0	3.9	6.0	10.0	23.9	63.3
Inlet										
Salinity (PSU)	27.2	±	7.9	0.6	9.6	22.9	29.6	33.3	35.7	36.5
Dissolved Oxygen (mg/L)	6.4	±	1.1	2.6	4.8	5.8	6.4	6.9	8.0	12.6
Apparent Color (PCU)	25.0	±	31.3	0.5	0.7	6.0	11.0	35.3	91.8	156.0
Secchi disk depth (m)	1.1	±	0.5	0.2	0.4	0.8	1.1	1.4	1.9	2.5
Total Nitrogen (mg/L)	0.43	±	0.41	<0.05	0.02	0.06	0.30	0.73	1.17	2.03
Total Phosphorus (µg/L)	82.5	±	71.9	7.0	22.0	36.0	53.0	106.0	265.0	341.0
Chlorophyll *a* (mg/m^3)	4.1	±	3.4	0.5	1.3	2.0	3.0	4.4	11.1	23.1
Entire Estuary										
Salinity (PSU)	11.0	±	10.5	<0.1	0.1	0.6	8.2	19.1	31.0	39.0
Dissolved Oxygen (mg/L)	5.9	±	1.9	<0.1	2.4	4.9	6.1	7.2	8.7	21.3
Apparent Color (PCU)	69.6	±	56.5	0.5	12.0	31.0	50.0	95.0	186.0	383.0
Secchi disk depth (m)	1.0	±	0.4	<0.01	0.3	0.7	1.0	1.2	1.6	10.0
Total Nitrogen (mg/L)	0.64	±	0.58	<0.05	0.01	0.14	0.45	1.07	1.64	7.09
Total Phosphorus (µg/L)	194.3	±	110.4	7.0	61.0	124.0	174.5	235.0	410.0	1040.0
Chlorophyll *a* (mg/m^3)	10.2	±	9.9	<0.3	1.8	4.0	7.0	13.0	28.1	157.0

A number of important functions are attributed to SAV, including providing food for estuarine organisms. SAV forms the base of a complex food web by providing sustenance for bacteria and microscopic animals. Epiphytes that grow on seagrass blades provide a food source for animals such as snails, sea slugs, and herbivorous fish. Organisms that feed directly on the seagrass blades include green sea turtles and manatees. Additionally, wading birds frequent SAV beds at low tides to feed on fish that use the seagrass canopy and root/rhizome mat for shelter (Sogard et al., 1989).

Numerous studies have shown high densities and diversities of animals in SAV beds (Gilmore, 1995; Lewis, 1984; Thayer et al., 1984; Virnstein et al., 1983). The physical structure of SAV provides a refuge and nursery ground for numerous commercially and recreationally important fin and shell fish species. Some of the invertebrate fauna associated with SAV beds include: snails, star fish, sea urchins, sea cucumbers, pink shrimp, blue crab, and spiny lobster. SAV also provides habitat (including nursery habitat) for fish such as: drums, sea bass, porgies, grunts, snappers, and mojarras (Odum and McIvor, 1991).

Water quality may be enhanced by SAV. The SAV roots and rhizomes help bind shallow underwater sediments. The leafy canopy baffles waves and currents (Fonseca et al., 1983; Fonseca and Fisher, 1986; Fonseca, 1989; Fonseca and Cahalan, 1992) inhibiting re-suspension of fine particles and trapping sediments, providing water column cleansing (Ward et al., 1984). Additionally, seagrasses and associated epiphytes and macro-algae take up dissolved nutrients.

Seagrasses are a key component of the IRL SAV community. Although currently sparse in the SLE, seagrasses have historically occurred in this system. All seven seagrass species that occur in South Florida have been found within the SLE/southern Indian River Lagoon (SIRL) system. Six species of seagrasses are currently found in the SIRL near the mouth of the SLE. The seventh species, widgeon grass (*Ruppia maritima*), has been observed in the North Fork of the SLE . The six species of seagrass found within the IRL are: shoal grass (*Halodule wrightii*), manatee grass (*Syringodium filiforme*), turtle grass (*Thalassia testudinum*), paddle grass (*Halophila decipiens*), star grass (*Halophila engelmannii*), and Johnson's seagrass (*Halophila johnsonii*). Shoal and manatee grass tend to be the dominant seagrass species in the SIRL near the mouth of the St. Lucie Estuary.

Johnson's seagrass occurs in both the SLE and SIRL. It is the only seagrass species listed as "threatened" by the Federal Government. Johnson's seagrass is listed as "threatened" because of its limited geographic distribution. It has only been found from Sebastian Inlet to northern Biscayne Bay. On April 5, 2000 (65 Federal Register 17786), the National Marine Fisheries Service (NMFS) published a final rule designating critical habitat for Johnson's Seagrass. One of 10 sites identified as critical habitat is located in the SIRL, near the mouth of the SLE (**Figure 3.3-10**). The designation as "critical habitat" means that the federal government has determined that the designated area is vital to the conservation of the listed species. Any proposals to alter flow conditions in the SLE to the extent that they may impact the local population of Johnson's Seagrass will have to be reviewed and approved by the NMFS.

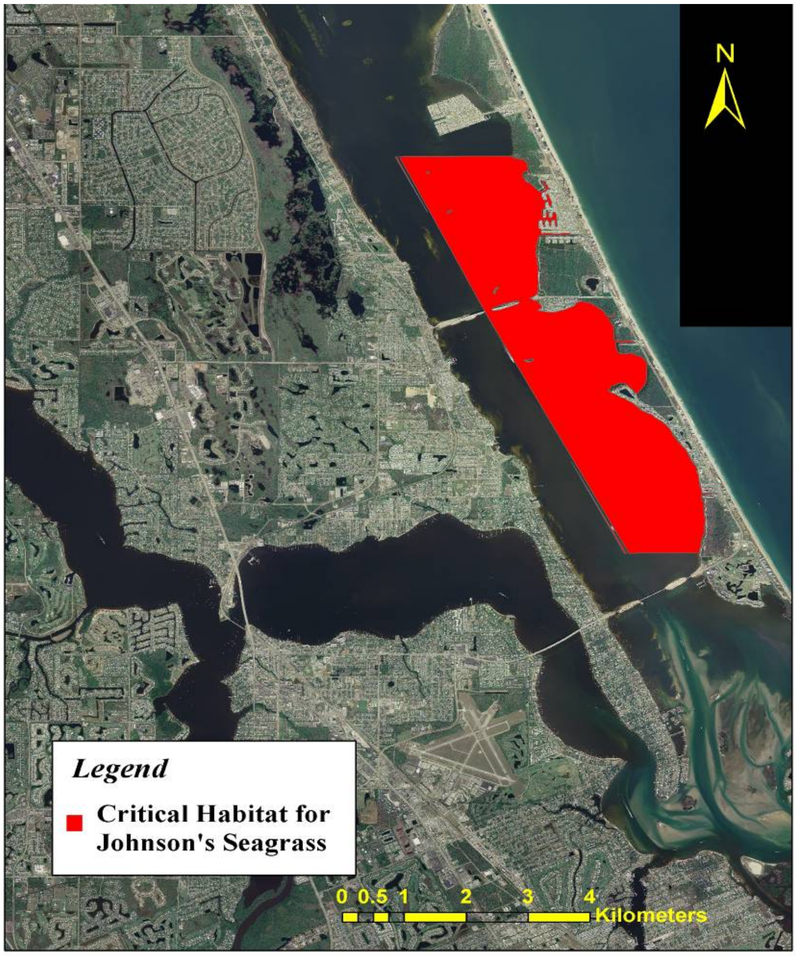


Figure 3.3-10. Critical Habitat for Johnson's Seagrass.

3.3.3.1.2 Relationship with Water Quality

Seagrasses require light to survive. Accordingly, water quality parameters that diminish light can negatively affect seagrass. Several water quality parameters are particularly important to seagrass: total suspended solids, turbidity, color, chlorophyll *a*, total phosphorus, and total nitrogen. Total suspended solids, turbidity, and color have all been shown to be negatively related to light availability (Dennison et al., 1993; Gallegos, 1994; Gallegos and Kenworthy, 1996); thus an increase in any or all these factors results in a decrease in the ability of seagrass to photosynthesize. Similarly, increased concentrations of nutrients can indirectly reduce the amount of light penetrating through the water column by promoting the growth of phytoplankton, epiphytic algae, and /or macro-algae, each of which may be detrimental to seagrass. **Table 3.3-7** summarizes light requirements for the seagrass species found in the SLE/IRL.

Table 3.3-7. Salinity and Light Requirements of SAV Found in the SLE/IRL (from URS Greiner Woodward Clyde 1999).

Species	Light Compensation Point % of SI[1]	Optimum Salinity Range (ppt)	Normal Salinity Tolerance Range (ppt)
Widgeon grass	5 – 20	5-15	0-45
Shoal grass	10-20	24-36	5-55
Manatee grass	10-20	23-30	17-44
Turtle grass	10-25	25-35	16-50
Johnson's grass	2-5	25-35	15-43
Paddle grass	2-5	27-34	22-38
Star grass	2-20	25-35	10-40
1 Surface Irradiance (SI) is the intensity of full sunlight hitting the water surface.			

Salinity is also a key water quality parameter that can affect seagrass health. Freshwater inflow to the St. Lucie is an important determinant of the environmental conditions experienced by the submerged aquatic vegetation. Freshwater runoff not only causes salinity to decline but can add nutrients that can fuel algal blooms, thus reducing light available to seagrasses. Freshwater runoff can also increase suspended solids (increased turbidity) and dissolved organic matter (tannins that color the water) reducing light available for seagrass growth.

3.3.3.1.3 SAV Distribution (Historic, Current, and Potential)

3.3.3.1.3.1 St. Lucie Estuary

Field investigations conducted in the late 1950s by Phillips and Engle (1960) documented the presence of submerged aquatic vegetation (SAV) in the SLE. Three species of rooted submerged aquatic vegetation were documented: 1) manatee grass near the mouth of the river, 2) "very abundant" shoal grass in the mid and lower estuary, and 3) widgeon grass in the mid and lower estuary. Their study included four trips to the SLE between September 1957 and March 1959. SAV decreased sharply after their first trip, presumably because of fresh water discharges. No distribution maps were created from their field efforts. A subsequent investigation (approximately 10 years later) by Teas (1971) re-sampled near most of the Phillips and Ingle (1960) stations and found no sign of SAV at any of the sites.

The first known SAV map of the St. Lucie Estuary was prepared in 1997 by URS Greiner Woodward Clyde (1999) based on detailed field investigations using sub-meter accuracy GPS technology.

The most recent SLE SAV map was completed in the summer of 2007 (Ibis Environmental, Inc., 2007). Most areas inspected did not support SAV (**Figure 3.3-11**). Very sparse (< 10% cover in most areas) SAV was present in the lower and mid-estuary, but not in either of the Forks. Three seagrass species occurred within the project boundary: shoal grass, Johnson's seagrass, and paddle grass. The majority of the SAV occurred in small isolated patches. The dominant SAV species in the project area in 2007 was Johnson's seagrass. It also extended farther upstream than any other SAV species.

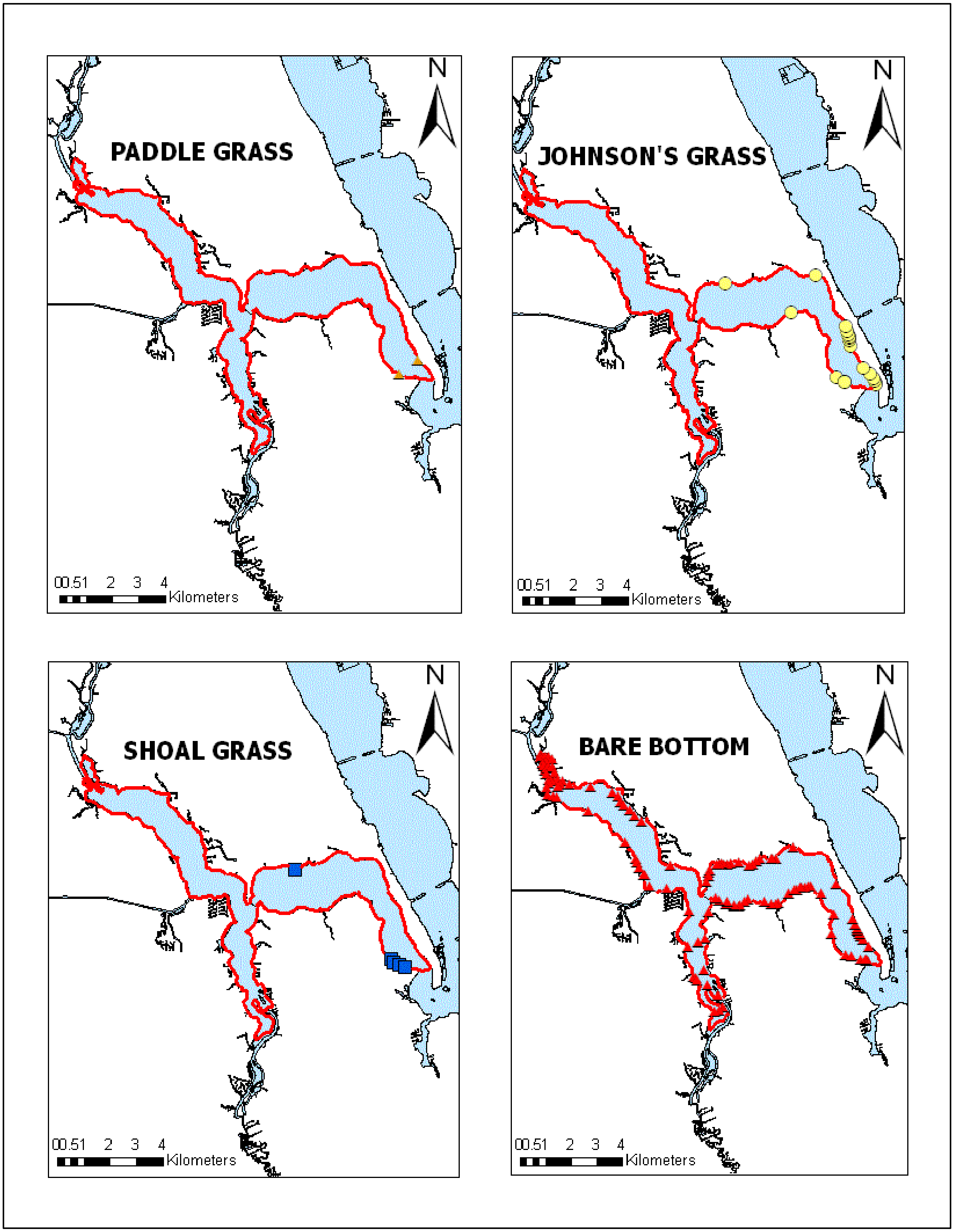


Figure 3.3-11. Results of SAV mapping project conducted in the summer of 2007

Historic SAV distribution maps (URS Greiner Woodward Clyde, 1999) indicate relatively large SAV beds in the North Fork (especially in the Kitching Cove area). No SAV was found in the North Fork during either the 1997 or 2007 surveys (URS Greiner Woodward Clyde, 1999; Ibis Environmental 2007). The current substrate conditions in the North Fork include up to 3 feet of silt, which cannot sustain seagrass (Ibis Environmental Inc., 2007). Based on historic records, the South Fork has never supported much SAV. Very small amounts of SAV were found in the South Fork in 1997 (mouth of Danforth Creek). Those areas were devoid of vegetation in the summer of 2007.

The middle estuary historically supported SAV. However, by 1997 no SAV was observed in the middle estuary. The 2007 study documented the presence of small amounts of both Shoal and Johnson's seagrasses in the middle estuary. It is likely that the drought conditions experienced prior to the field survey helped provide suitable conditions (higher/more stable salinities and clearer water) for this upstream expansion.

Through Indian River Lagoon Surface Water Improvement and Management (SWIM) efforts, a "deep edge of bed" depth target of approximately 1 m was recommended for SAV restoration in the SLE (Steward et al., 1994). **Figure 3.3-12** shows that meeting this depth target would result in a thin fringe of SAV throughout much of the estuary. Restoration efforts will focus on meeting oyster salinity requirements in the middle estuary. Widgeon grass is the most likely SAV species to be successful in the North and South Forks once the restoration salinity regime is in place (lower salinity conditions). The middle estuary will most likely be able to support SAV species such as shoal and Johnson's seagrass. The lower estuary, where highest salinities (and clearest water) will be experienced, will most likely continue to support shoal and Johnson's seagrasses and may eventually be able to support manatee grass (as observed by Phillips and Engle, 1960).

Other influences that may play a role in SLE/IRL SAV recovery include appropriate substrate, wave energy (including boat wakes), and shoreline structures (especially docks and vertical seawalls). Additionally, very little SAV has been documented in the South Fork (historically or current), consequently factors outside the control of water management practices may prevent successful SAV recruitment in this area

3.3.3.1.4 Indian River Lagoon

SAV monitoring data are used to evaluate species specific responses near the St. Lucie Inlet. See Chapter 4 for further details. An example of impacts to manatee grass following hurricanes and prolonged freshwater discharges exists near the inlet. At Boy Scout Island, manatee grass was the dominant species prior to hurricane impacts and associated prolonged freshwater discharges. Manatee grass was virtually eliminated from the site by the winter of 2006, but began recovering in 2007.

Currently, shoal and manatee grass dominate the SAV habitat near the mouth of the St. Lucie Estuary. SLE restoration efforts are expected to increase abundance and distribution of both species. Additionally, the diminutive *Halophila* species will most likely expand at the deep edge of these more robust species.

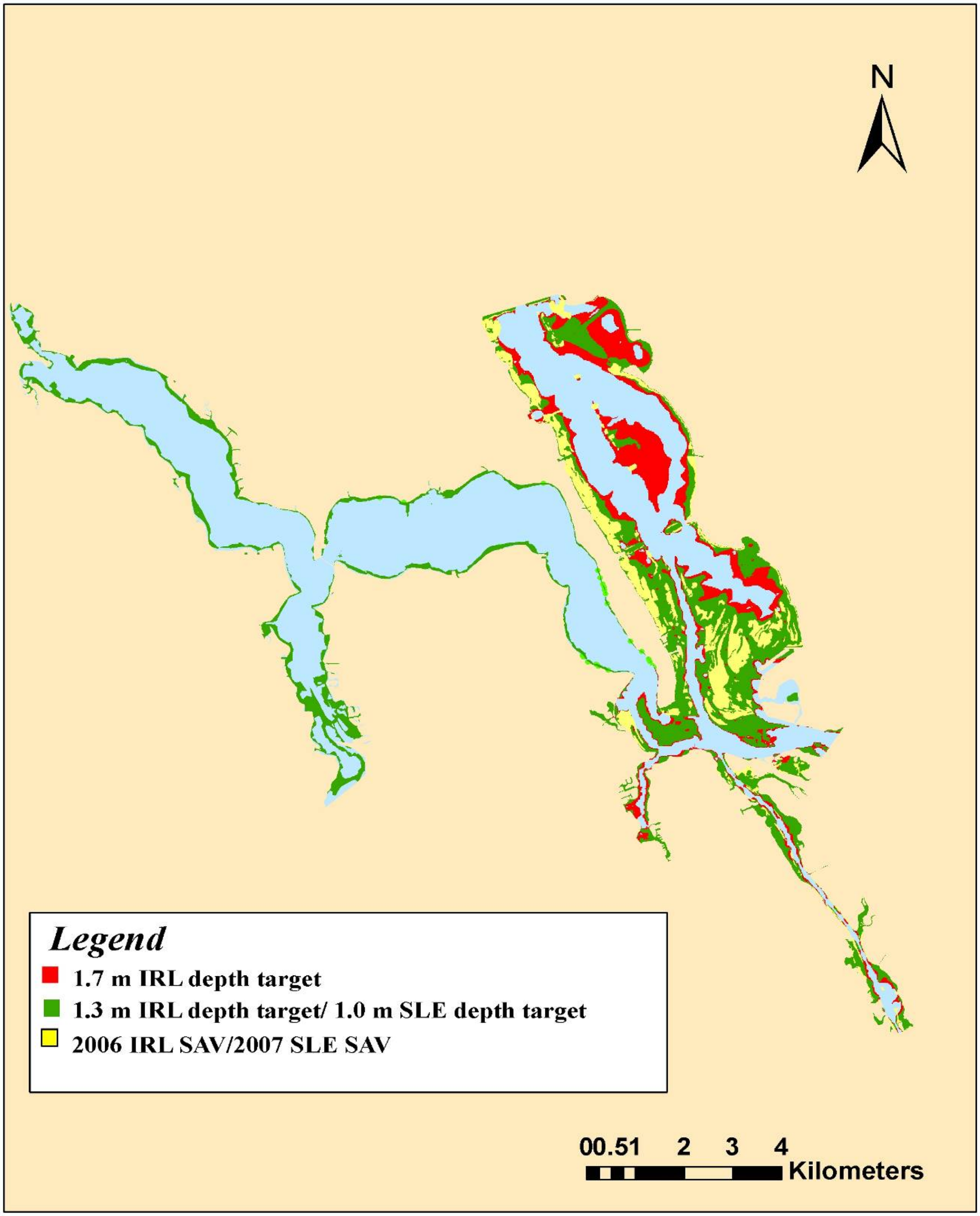


Figure 3.3-12. Potential SAV depth targets and 2006/2007 SAV distribution.

3.3.3.2 Oysters: Ecological Importance, Relationship to Water Quality, and Distribution

This subsection discusses the ecological importance of oysters as a "keystone estuarine species." Not only do oysters provide valuable physical habitat for other species, but their ability to improve water quality by filtering is an important consideration in the health of an estuary.

3.3.3.2.1 Ecological Importance

The Eastern Oyster (*Crassostrea virginica*) forms large, complex, three-dimensional reef structures (Coen et al., 1999) that provide important habitat for over 300 macrofauna species (Wells, 1961; Crabtree and Dean, 1982; Abbe, 1992; Wenner et al., 1996; Coen et al., 1999) and therefore qualify as a Keystone Estuarine Species (Coen et al., 1999b) and a Valued Ecosystem Component , (SFWMD, 2006). Among the species utilizing oyster reefs are oyster predators such as the mud crab (*Panopeus herbstii*) and crown conch (*Melongena corona*). Important fisheries species that forage the reef include: the spotted seatrout (*Cynoscion nebulosus)*; red drum (*Sciaenops ocellatus)*; black drum (*Pogonias cromis*), and common snook (*Centropomus undecimalis).* Oyster shells serve as sites for egg laying for the crown conch (Peters, 1981) and gobies, especially the extremely abundant naked goby (*Gobiosoma bosci*). In addition, the reef structure provides shelter from predation for many species including the mud crabs (*Eurypanopeus depressus*) and *P. herbstii* (McDonald, 1982).

An oyster can filter 4 to 34 liters of water per hour, removing phytoplankton, particulate organic carbon, sediments, pollutants, and microorganisms from the water column. Therefore, large populations of oysters can significantly increase water quality including water clarity (Newell et al., 2002; Cerco and Noel, 2007). As water clarity increases, photosynthetic active radiation can penetrate to greater depths creating additional potential habitats for desirable submerged aquatic vegetation. Furthermore, as a result of filter feeding, oysters assist in transferring organic carbon to other oyster reef invertebrates by producing dense organic waste particles that quickly become populated with high protein bacteria. These waste particles provide a nutritious food source for numerous deposit feeding benthic inhabitants that in turn increases estuarine productivity (Dame and Patten, 1981).

3.3.3.2.2 Relationship with Salinity

Salinity is a key factor that determines oyster distribution within an estuary. Although able to survive at salinities ranging from 5-40 ppt, the optimum range for oyster reef growth and reproduction is in the range of 10-30 ppt (Galtsoff, 1964). Highest populations of oysters develop in estuaries where salinities fluctuate between 10-20 ppt with an annual average of near 15 ppt (Woodward-Clyde, 1998). The 10-20 ppt salinity range is near optimal for larval production and survival, and is low enough to restrict predation and disease of sessile spat and adult oysters. As salinities increase above approximately 20 ppt to near marine conditions, oysters can become extremely stressed and may perish from disease caused by *Perkinsus marinus* (Dermo) and *Haplosporidium nelsoni* (MSX), (Quick and Mackin, 1971; Powell et al., 1992; Ragone and Burreson, 1993, Haskin and Ford, 1972). High salinity also makes oysters more vulnerable to predators such as the southern oyster drill, whelks, and boring sponges (Woodward-Clyde, 1998). *Perkinsus marinus* infection intensity in the St. Lucie Estuary was generally found to be higher at higher salinity and temperatures (Wilson, et al,. 2005). Short pulses of freshwater inflow to temporarily reduce high salinity at oyster reefs have been shown to benefit oyster populations by killing predators that cannot tolerate low salinity water (Owen, 1953), while excessive freshwater inflows may kill entire populations of oysters (Gunter, 1953; Schlesselman, 1955; MacKenzie, 1977). In the St. Lucie Estuary, large freshwater releases from the well-drained watershed cause a dramatic reduction in salinity that results in significant oyster mortality (Woodward-Clyde, 1998). Numerous studies cite 10 ppt as the lower threshold for normal oyster growth and development while prolonged salinities less than 5 ppt can result in mortality of adult oysters depending on condition, age, temperature, and other factors (Mackin and Hopkins, 1962).

Table 3.3-8 provides a summary of salinity values and exposure durations that cause stress, harm, and mortality for all four oyster life stages: eggs, larvae, spat, and adult (SFWMD, 2006). The majority of these salinity values and durations were obtained from the literature for oyster populations from coastal areas other than Florida, however recent information on oyster life history and salinity effects on juvenile and adult oysters from the St. Lucie and Caloosahatchee Estuaries (Wilson et al., 2004; Volety et al., 2003; Roesijadi ,2004) are also included in **Table 3.3-8.** The oyster life history study (Wilson et al., 2004) was used to define the timing of key oyster life stages within the St. Lucie Estuary. For example in **Table 3.3-8**, a major spawn occurs in the spring of the year (March and April) with no documented spawning in the fall. Therefore, larvae are present from March to May following egg development and spawning. Spat and juvenile oysters are present from April to August. Because oysters in South Florida usually live 2 to 3 years, adults are present throughout the year. Oysters are known to spawn in South Florida from March to September, however, Wilson's (2004) work shows that if protracted spawning occurs, the sampling device (oyster shell hanger) does not document significant spat recruitment beyond the spring. Using this life history information and a time series of salinity at specific locations, a reasonable qualitative estimate of habitat suitability for oysters can be determined (SFWMD, 2006).

Table 3.3-8. Salinity tolerances for life stages of the Eastern Oyster (Crassostrea virginica).

Life Stage	Salinity (ppt)	Duration (days)	J	F	M	A	M	J	J	A	S	O	N	D	Reference
Eggs			X	X	X	X									Wilson et al. 2004
Harm	7.5 - 10.0	1													Burrel 1986
Mortality	0.0 - 7.5	1													Burrel 1986
Larvae					X	X	X								Wilson et al. 2004
Stress	10.0 - 12.0	1													Loosanoff 1965; Davis 1958
Harm	0.0 - 10.0	1													Davis 1958
Mortality	0.0 - 10.0	14													Davis 1958
Spat & Juveniles						X	X	X	X						Wilson et al. 2004
Stress	5.0 – 10.0	1													Ray and Benefield 1997
Harm	0.0 -5.0	1													Loosanoff 1953
Mortality	0.0 – 5.0	7													Volety et al. 2003
Adults			X	X	X	X	X	X	X	X	X	X	X	X	
Stress	7.5 - 10.0														Woodward-Clyde 1998
Harm	5.0 – 7.5	1													Loosanoff 1953, 1965
Mortality	2.0 – 5.0	28													Loosanoff 1953; Volety et al 2003
Mortality	0.0 – 2.0	14													Roesijadi 2004

(From: Restoration Plan for the N.W. Fork of the Loxahatchee River [SFWMD, 2006]).

3.3.3.2.3 Oyster Distribution (Historic, Current, and Potential)

In 1997, Woodward Clyde produced the first quantification of oyster distribution in the SLE which is shown in **Figure 3.3-13**. Approximately 207 acres were identified. Anecdotal reports suggest that prior to 1960, there were about 1400 acres of oyster habitat.

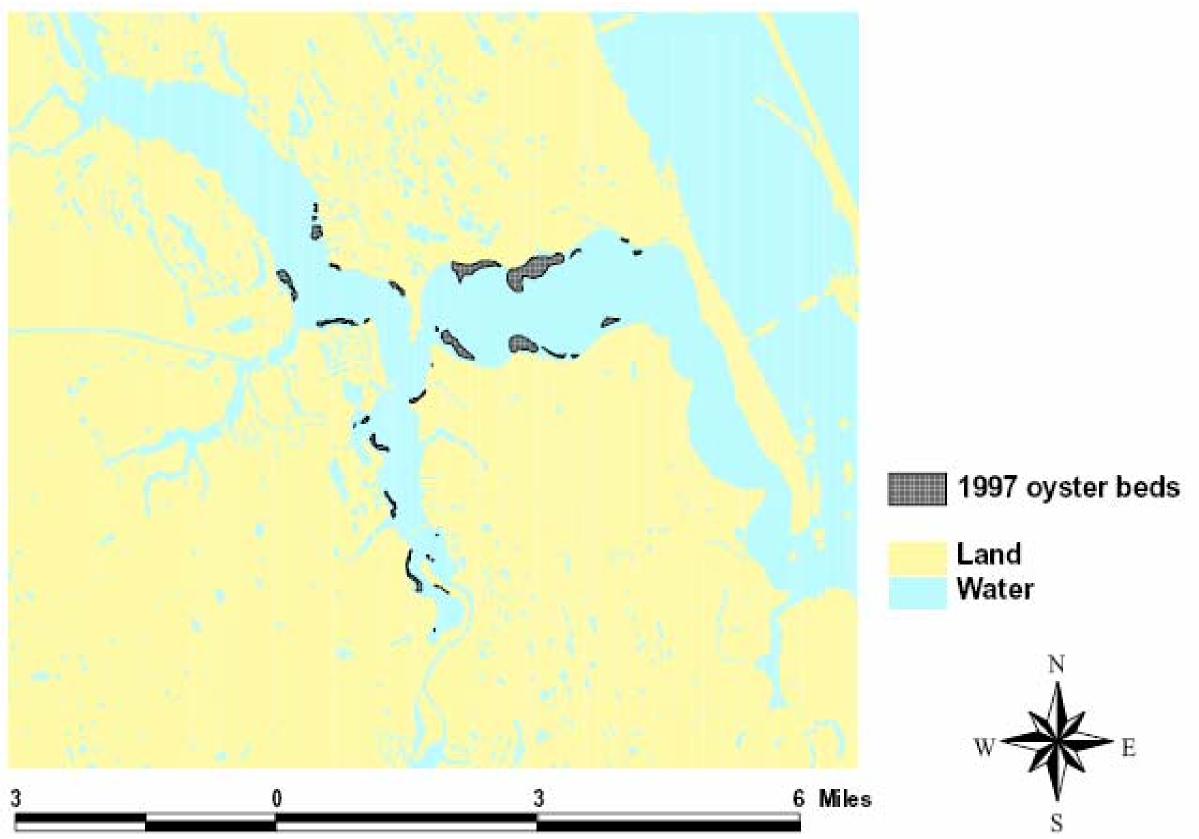


Figure 3.3-13. 1997 oyster bed distribution within St. Lucie Estuary.

More recently, in September of 2003, a survey of oysters in the North and South Forks and middle estuary was conducted and significant changes in oyster reef growth and condition were determined (Ibis Environmental Inc., 2004). In 1997, the average density of live oysters in the North and South Forks of the estuary was about 1 oyster per square meter of substrate. Although the live density was low, the reefs were alive and functioning. In 2003 no live oysters were documented in the North and South Forks. However, dead oyster shell size in these beds increased from less the 5 cm in 1997 to an average of 5 – 10 cm with some larger the 10 cm. Dead oyster density in this area also increased in some reefs to more than twice the amount found in 1997. The presence of new beds, larger shell size and greater density of dead oyster shells indicates successful productivity for the oysters at some time between 1997 and 2003.

Table 3.3-9 contrasts the results of the 1997 and 2003 oyster surveys and reveals a loss of about 90 acres of functioning oyster reefs. It should be noted, however, that monthly sampling of some of the same oyster reefs from 2006 to present shows live oysters are again present in the North and South Forks. Data from these most recent studies being conducted as part of the Comprehensive Everglades Restoration Plan/Restoration Coordination and verification

Table 3 3-9. Live Oyster Acreage in the St. Lucie estuary (1997 and 2003).

St. Lucie estuary Reach	Acreage Live Reefs 1997	Acreage Live Reefs 2003	Live Function Loss (acres)
Middle	149.7	116.9	- 32.8
North Fork	34.4	0	- 34.4
South Fork	23.4	0	- 23.4
Total	207.5	116.9	- 90.6

(CERP/RECOVER) Monitoring and Assessment Program are presently being evaluated to refine our understanding of the response of endemic oyster populations to field conditions.

Additional laboratory efforts may be needed to confirm parameter sensitivity for the development of a predictive tool that can better simulate oyster population response to water quality and food availability.

Restoration expectations for the St. Lucie Estuary are to promote the expansion of oyster reef communities and add substrate to increase the areal extent of oyster reefs, where ecologically appropriate. The overall restoration target for the St. Lucie Estuary, with full implementation of the Indian River Lagoon South Project Implementation Report (USACE, 2004), is to restore approximately 900 acres of suitable oyster habitat.

3.3.3.3 Floodplain Vegetation Ecological Importance, Relationship to Water Quality, Hydrology and Distribution

This subsection describes the floodplains of the St. Lucie Estuary, distribution of its key vegetation, and the importance of floodplain ecology as it related to estuarial water quality and hydrology.

3.3.3.3.1 Ecological Importance

River floodplains are an important part of every watershed system. They provide storage and filtration of surface water, diverse habitats for plants and animals, corridors for the movement of animals and dissemination of plants, and provide a supply of nutrients to estuarine environments (Darst and Light et al., 2003).

The floodplains of the North Fork of the St. Lucie Estuary (**Figure 3.3-14**) consist of tropical and temperate zone riparian forest and marshes. As a riparian forested wetland system, these vegetative communities vary from dry to occasionally flooded stages as the river and its tributaries react to local rainfall events. The major forest types are hammock and swamp with some components of bottomland hardwood species. Hydric hammocks are generally defined as "tree islands" that signify a change in elevation within the floodplain topography and are generally associated with transitional species. The dominant hammock species on the St. Lucie River are: cabbage palm (*Sabal palmetto*), laurel oak (*Quercus laurifolia*), and live oak (*Quercus virginica*). The riparian forests are generally referred to in the Southeastern United States as bottomland hardwood forests. They contain diverse vegetation that varies along gradients of flooding frequency. They are generally considered to be more productive than the adjacent uplands because of the periodic inflow of nutrients, especially when flooding is seasonal rather than continuous (Mitsch and Gosselink, 1993). In freshwater reaches of the St. Lucie River, the

Figure 3.3-14. 2004 Digital Ortho Quads of the North Fork of the St .Lucie with highlighted river miles.

dominant bottomland hardwood species are: red maple (*Acer rubrum*), water hickory (*Carya aquatica*), and a variety of bay (*Persea* sp.). Swamps are defined as woody wetlands that have standing water for most or all of the growing season. Swamps on the floodplains of the St. Lucie River consist primarily of red and white mangroves (*Rhizophora mangle* and *Laguncularia racemosa*), pondapple (*Annona glabra*), and popash (*Fraxinus caroliniana*). Noticeably reduced in number are bald cypress (*Taxodium distichum*), which were probably logged as the river and tributaries were dredged and channelized.

3.3.3.3.1.1 Relationship with Water Quality and Hydrology

Manmade impacts have greatly affected the distribution of floodplain vegetation on the St. Lucie River and its major tributaries. The formation of a regional flood control system and the stabilization of the St. Lucie Inlet resulted in a redistribution of vegetative communities in the floodplains. Salt tolerant mangrove systems, from the Indian River Lagoon system, eventually established further upstream within the St. Lucie Estuary and lower reaches of the tributaries. On the North Fork, nearly the entire lengths of Ten Mile and Five Mile Creeks have been altered by dredging of a deeper channel (PBS&J, 2003). Spoil material from the dredging was placed in the floodplain to form berms that still exist today. During the 1920s-40s, the main branch of the North Fork and its associated floodplains were dredged for flood control and navigation by the North St. Lucie Water Control District and the United States Army Corps of Engineers. In the process, dredge material was placed along the banks of the river creating berms that ranged between 2 and 25 feet high and from 10 to 50 ft wide (**Figure 3.3-15**). Since their placement, the berms have isolated floodplain forests, oxbows, and marshes from the main river channel. This isolation has resulted in altered salinity gradients, stagnant stream reaches, and sedimentation within the isolated oxbows (PBS&J, 2003).

3.3.3.3.1.2 Floodplain Vegetation Distribution (Historic and Current)

In an analysis of pre-drainage landscape ecology and hydrology of the St. Lucie Watershed (SFWMD, 2001), McVoy concluded that three main physiographic regions appear to have been present in the pre-drainage watershed: pine and pond mosaic, prairie and pond mosaic, and the area known as Halpatta Swamp. The Halapatta Swamp, which was later renamed the Allapattah Swamp, consisted of saw grass marshes bordered by forested wetlands of bay galls and cypress swamps along the western edge of the watershed. Cypress occurred more commonly in the southernmost townships of the watershed. In McVoy's report, an 1853 U.S. Bureau of Topographical Engineers map of southern Florida showed much of western St. Lucie and Martin Counties as the "Alpatiokee Swamp". In Davis's 1943 map of south Florida vegetation, much of the original extent and character of the Halapatta Swamp had already been lost or altered.

Teas (1971) investigated the ferns, vines, orchids, and bromeliads associated with the freshwater swamp forest on the North Fork of the St. Lucie River. Also, Teas collected cores from trees within the watershed to examine annual rings for age determination. In the river forest hardwood community, he collected cores from red maple and water hickory. The mature red maple and hickory canopy was estimated as approximately 50 years old. He estimated that most of the live oak canopy was about 100 years old.

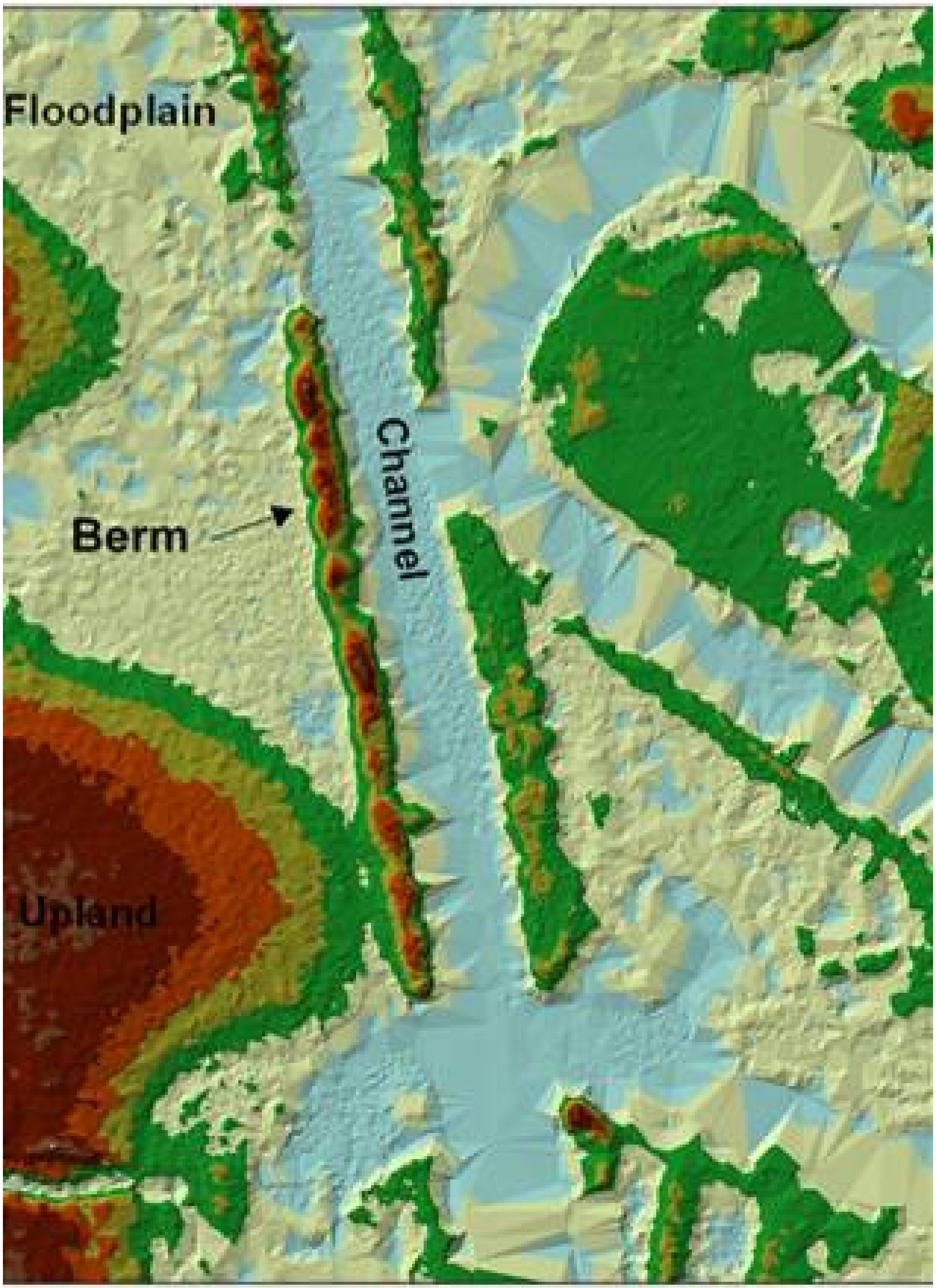


Figure 3.3-15. Processed LiDAR data from the North Fork of the St. Lucie illustrating the changes in elevation in the floodplain and surrounding upland areas.

Additionally, Teas noted that tidally inundated systems contained all four species of mangrove: red (*Rhizophora mangle*), black (*Avicennia germinans*), white (*Laguncularia racem*osa), buttonbush (*Conocarpus erectus*), as well as leather fern (*Acrostichum danaeifolium*).

3.4 Salinity Envelopes and Freshwater InFlow targets

The estuarine environment is sensitive to freshwater inflows. Modifications of the volume, distribution, circulation, temporal patterns or water quality of freshwater inflows can place severe stress upon the entire ecosystem. Although the quality of water is very important, much of the environmental stress can result from modified salinity changes caused by freshwater inflows. This is because salinity is the master ecological variable that influences productivity, population distribution, community composition, predator-prey relationships and food web structure (Myers and Ewel 1990). Furthermore, freshwater inputs through the North and South Forks of the SLE tend to explain the majority of the seasonal water quality variability (Doering, 1996). Therefore, salinity may, in general, act as a surrogate for some important water quality parameters.

3.4.1 Technical Basis

The potential of the St. Lucie Estuary (SLE) to function as a productive ecosystem that provides vital habitat for numerous biological and economically important biota has been adversely affected by the modification of watershed hydrology for urban and agricultural development. Modifications include construction of a high density drainage conveyance system connected to major canals that discharge to the SLE. Most of the runoff flows quickly into these major canals instead of being detained, evaporated, cleansed and attenuated by natural wetlands. In addition to this watershed runoff, the St. Lucie Canal (C-44) provides a route for excessive Lake Okeechobee watershed runoff to the SLE. Discharges from the Lake are conducted to avoid high lake levels that jeopardize the integrity of the levee surrounding the Lake. Overall, the current management of inflows results in excessive volumes of water to the SLE that compromises its ability to sustain healthy biological communities.

Environmentalists have long considered Lake Okeechobee regulatory discharges to the SLE to be harmful. In the late 1970's, the SFWMD began obtaining biological and physical information to determine the effects of low salinity caused by releases from Lake Okeechobee and/or the watershed on fishes and benthic organisms (Haunert and Startzman 1980; Haunert 1985). These studies revealed that fishes susceptible to capture by seine and trawl nets have a wide salinity tolerance. In contrast, many estuarine benthos were sensitive to low salinity conditions. Since oysters were once abundant in the estuary, are ecologically important, and all stages of their life history (eggs, larvae, juveniles, and adults) are sensitive to low levels of salinity or high discharges, they are considered to be a good candidate to indicate problems associated with excessive inflows.

In 1987, SFWMD research began to support the application of a resource-based management strategy similar to the Valued Ecosystem Component (VEC) approach developed by the U.S. Environmental Protection Agency (USEPA 1987) as part of its National Estuary Program. Through this strategy, a suitable salinity and water quality environment for key species attains management objectives. The key species, or VECs, sustain an important ecological or water resource function by providing food, living space, refuge, and foraging sites for other desirable species in the estuary. This approach assumes that environmental conditions suitable for VECs also are suitable for other desirable species and that enhancement of VECs will lead to enhancement of other species. Specific VECs identified to promote and sustain the SLE are: (1) oyster populations; (2) fresh water, brackish, and marine submerged aquatic vegetation (SAV); and (3) fish larvae (Mote Marine Laboratory 1995). All three of these VECs have been used to formulate water management objectives for the SLE, but oysters and SAV have been more widely applied since they:

- are accepted as indicators of healthy estuarine systems;
- are currently present in the estuary;
- were present historically (post inlet construction) in the St. Lucie Estuary;
- are sessile and therefore can not avoid harmful salinity;
- have significant literature addressing the salinity tolerance; and
- have well-established monitoring methods with reliable results.

An important function of an estuary is to provide a suitable low salinity nursery habitat for the development of estuarine resident and dependent fish larvae and juveniles. Although fish larvae are mobile and there is limited literature addressing salinity tolerances, further insight into the relationship between inflows and the response of fish larvae and juveniles is needed to mature the concept of fish larvae as a VEC.

To develop a more comprehensive quantitative understanding of these relationships, several field studies are being conducted with major emphasis on determining a time series of low flows to enhance the area and quality of fish nursery habitat in the North and South Forks. The objective is to develop flows that would increase the probability of larvae and juvenile fish survival in the nursery area. Information from these studies will be used to address an environmentally optimum low flow regime in the near future.

The development of a favorable inflow range for the SLE focuses on the environmental requirements of oyster populations as a VEC. Utilizing the application of the resource-based management strategy or VEC approach, a favorable range of inflow and related salinity is established. This favorable range of flows is referred to as the "salinity envelope" and reflects the salinity requirements for a healthy oyster population in the middle estuary just downstream of the confluence of the North and South Forks (U.S. 1 Bridge) where healthy historical oyster reefs existed. To develop the salinity envelope, a family of salinity gradient curves was calculated using a hydrodynamic/salinity model that simulated many different constant inflows until a steady salinity gradient was established (Hu 2000). **Figure 3.4-1** shows the SLE family of curves for total inflow, salinity and distance (miles) upstream from the St. Lucie inlet. Total inflow includes freshwater inflows from all surface water inflow, groundwater, lockage and leakage from the St. Lucie Lock and Dam (S-80) and rainfall on the estuary. Documenting the various salinity gradients associated with total inflows provided the information required to predict locations where healthy populations of oysters could exist if the salinity envelope, based on VEC salinity requirements, was not violated beyond the frequency that could be attributed to natural variation of flows from the watershed. The upper inflow salinity gradient of 2000 cubic

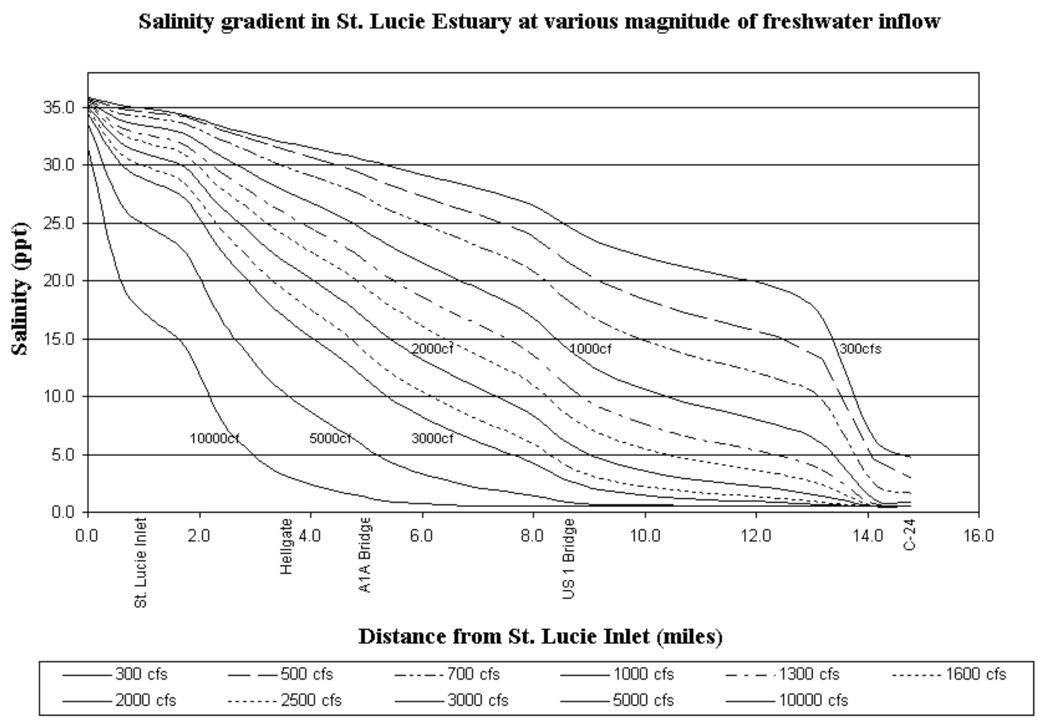


Figure 3.4-1. Family of curves for inflow and salinity in the St. Lucie Estuary

feet per second (cfs) was selected based on literature reviews and laboratory experiments of low salinity tolerances of oysters.

Therefore, a maximum flow of about 2000 cfs provides for minimal salinity stress to juvenile and adult oysters located downstream of the U.S. 1 Bridge which equates to a salinity of about 8 ppt at the U.S. 1 Bridge (**Figure 3.4-1**). If salinity is not reduced below about 8 ppt at the U.S. 1 Bridge, the lower salinity level for healthy oysters of about 10 ppt will occur immediately downstream in the area of interest. The recommended low flow gradient (350 cfs) was based on a literature review that revealed the prevalence of disease and potential mortality of oysters increases when salinity is greater than about 25 ppt, especially when water temperatures are above approximately 20 degrees C. Furthermore, when salinity is above about 25 ppt, marine oyster predators are no longer restricted to the outer estuary salinity habitats and therefore can inhabit the oyster reefs being protected in the middle estuary (see Section 3.3.3). The 350 cfs equates to a salinity of about 22 ppt at the U.S. 1 Bridge. Hence, from a water management perspective, if all inflows other than surface water discharges were about 150 cfs from the inner estuary, the recommended low surface water inflow should be about 200 cfs to protect oysters from disease and predation. It should be noted, however, the 200 cfs surface water should be introduced to the SLE in a natural fashion that would enhance the fish nursery function of the estuary and not cause high salinity stratification in the receiving waters. Introduction of low flows to the head waters of the North Fork is a favorable option included in the Indian River Lagoon South Project Implementation Report. If this low flow recommendation could be accomplished, it may benefit several VECs concurrently which is the ultimate goal. Under the same scenario of 150 cfs inflows from all other sources than surface water discharges, the recommended high surface water inflows should not exceed about 1850 cfs to protect oysters from unfavorable low salinities.

Although the salinity envelope defines a range of desirable flows and provides useful flow management guidelines, a more detailed understanding of ecologically optimal flows is needed to develop a watershed management plan. The full distribution and timing of flows from the watershed that accounts for natural variation of flows needed to be determined. Fortunately, there are recent advances in flow analysis in relation to flora and fauna. It now is understood that native aquatic biodiversity depends on maintaining or creating "some semblance" of natural flow variability and that native species and natural communities will perish if the environment is pushed outside the range of natural variability. Where rivers are concerned, a natural flow paradigm is gaining acceptance. It states, "the full range of natural intra-annual and inter-annual variation of hydrologic regimes, and associated characteristics of timing, duration, frequency and rate of change, are critical in sustaining the full native biodiversity and integrity of aquatic ecosystems" (Poff, et. al., 1997). There is growing sentiment for a similar paradigm/hypothesis in estuaries. In riverine estuaries, like the SLE, it is appropriate to evaluate both flow and salinity with respect to their multiple forms of variation, in the latter case leading to the idea that the full range of natural intra-annual and inter-annual variation of <u>salinity</u> regimes, and associated characteristics of timing, duration, frequency and rate of change, are critical in sustaining the full native biodiversity and integrity of estuarine ecosystems (Estevez 2000). Marshall (2005), supports this hypothesis when discussing the alterations of the hydrological cycle in the Everglades and its effects on salinity variation in Florida Bay ecosystems: "The effects of these (hydrological) alterations on the diverse ecosystems within Everglades National Park are still being evaluated. However, it is accepted that the overall health of the biota of the region including Everglades National Park will benefit from hydrologic modifications that restore the historic hydrological cycle as much as possible." Additional efforts are definitely required to test this hypothesis for the SLE. However, at this point in time it appears to be a reasonable direction to proceed. The most challenging problems associated with confirming this line of thinking include: 1) describing the quantity of historical natural inflows and salinities without historical data (before hydrological and physical alterations); and 2) a lack of documentation of detailed short and long term physiological responses of VECs to salinity, temperature, and those parameters that vary with them.

Watershed flow targets are aimed at protection of the salinity-sensitive biota in the estuary. It is assumed that species diversity and healthy VEC in these estuaries require watershed inflows to have characteristics of a natural system and that the monthly flow distribution is a critical hydrologic characteristic. Particularly, the desirable flow range and frequency of low monthly flows and high monthly flows should be similar to that of a natural system in order for the salinity range and variation to emulate the natural conditions that influenced the evolution of salinity-sensitive biota. This assumption has the most validity if both the inflows and estuarine physical characteristics (bathymetry) are consistent with natural watershed hydrology and estuarine hydrodynamics respectively. Therefore, once a natural flow regime is developed, the salinity in the estuary should be determined with natural bathymetry without anthropogenic alterations such as the canalization of the North and South Forks. These steps obviously necessitate the use of mathematical models based on reasonable assumptions of natural conditions. Inherent in these assumptions are uncertainties that must be taken into consideration when formulating management objectives and targets.

In efforts to development a natural watershed flow distribution, three "natural" flow scenarios were evaluated (Haunert and Konyha, 2004). These three scenarios consisted of:

1. Simulated flow data from the St. Lucie Estuary Watershed Natural System Model, (NSM-SLE);
2. Simulated flow data from the Hydrologic Systems Program: Fortran (HSPF) Wetland/Forest Model developed for the present St. Lucie Estuary watershed that also simulates natural flow conditions;
3. Selected measured flow data for the Peace River, Florida watershed that has similar topography and rainfall patterns to the SLE watershed and does not have major drainage conveyance systems.

3.4.1.1 Natural Systems Model (NSM-SLE)

The St. Lucie Estuary Watershed Natural Systems Model (NSM-SLE) was used to estimate the quantity, timing, distribution and frequency of water that historically flowed to the St. Lucie Estuary under pre-drainage (natural) conditions. The NSM-SLE is a relatively course (2 mile by 2 mile cells) finite element model that simulates all elements of the hydrologic cycle including groundwater flow and overland flow. NSM-SLE drainage basins are based only on topography without drainage infra-structure. Furthermore, the rainfall and evapotranspiration data was the same for the NSM-SLE and HSPF Models. Simulated daily natural system inflows were obtained for a 31-year (1965-1995) period. This 31-year daily time series was aggregated into a 31-year monthly time series and was used as the best estimate of pre-drainage hydrologic conditions within the watershed prior to drainage and development of the region.

These results were used to develop an understanding of the frequency that high and low flows historically impacted the estuary under natural conditions. NSM-SLE results indicated that the much smaller, undeveloped watershed had much less runoff (11.3 inches per year or 473,000 acre-feet per year) as compared to today's watershed (16.1 inches per year or 674,000 acre foot per year). The increase in volume of runoff can mostly be attributed to rapid drainage in today's watershed versus retained waters that could evaporate. The model also showed the distribution of inflows has been significantly altered. NSM-SLE shows that flows predominantly entered the estuary through the North Fork in contrast to current conditions in which large flows enter the estuary from C-23, C-24 and C-44.

3.4.1.2 HSPF Modeled Runoff for Wetlands and Forests

The HSPF Watershed Model was also used to simulate an undeveloped (natural system) for estimating of pre-drainage flow conditions. Since the model is driven by land use, the undeveloped watershed was estimated to contain a 50/50 mixture of forest and wetlands to provide an approximation of the undeveloped (natural) hydrology (Haunert and Konyha, 2004). Results showed an average annual runoff of 14.6 inches (611,119 acre-feet/yr).

3.4.1.3 Peace River

Measured inflow data from drainage basins in the Peace River watershed were chosen to represent general hydrological characteristics of a natural SLE watershed for comparison purposes. The hydrology of a relatively undeveloped portion of the Peace River in southwest Florida was developed from Peace River daily flow records (U.S. Geological Service) at Bartow and at Arcadia. The flow from the reach was calculated as the difference in flows at the two stations. The area drained by this reach is 625,280 acres, an area similar in size to the St. Lucie Watershed (500,838 acres). A complete set of daily flows was developed for the 58-year period of record from October 1939 through September 1997. For comparison against St. Lucie data, the flows were normalized to the area of the St. Lucie watershed by multiplying flow times the ratio of the basin areas (500838/625280). The data set was then divided into two sub-sets, with January 1940 through December 1964 being the first subset. The second data subset was used to compare against the two modeled data sets from January 1965 through December 1995.

Table 3.4-1 summarizes the measured flow, normalized flow, peak daily flow and rainfall for the two subsets. Figure 3.4-2 shows the monthly flow distribution for these two subsets of data.

Table 3.4-1. Summary of hydrology for Peace River - Bartow to Arcadia.

p.o.r.	Rain (inches)	Peak Runoff (cfs)	Annual Runoff (a f/y)	Annual Runoff (in/y)	Annual Runoff Normalized to St. Lucie (a f/d)
1940 to 1964	54.4	23,100	735,041	14.11	588,755
1965 to 1995	51.8	15,853	518,797	9.96	415,547

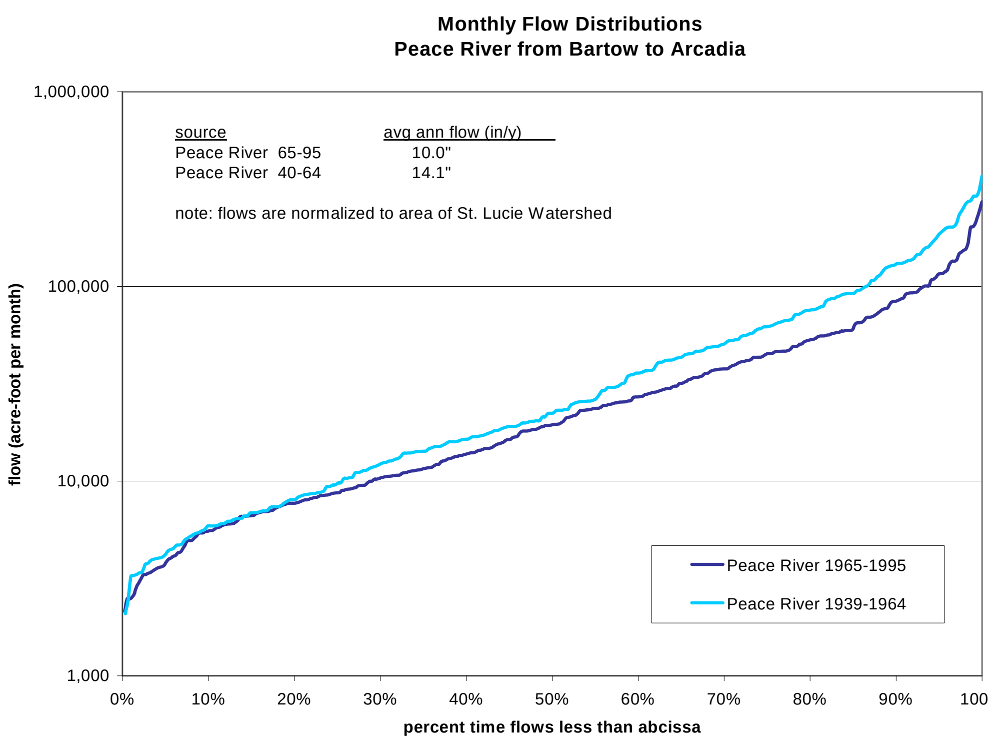


Figure 3.4-2. Flow Distribution for the Peace River with flows normalized to the area of the St. Lucie Watershed.

It is interesting to note that the 1940-1964 set has more runoff, higher peak flow rates and an upward shift in the flow distribution. This shift in flow distribution to lower overall flows is due to a change in the global climate or the Atlantic Multidecadal Oscillation that started in the mid-1960s and affects the continental U.S. (Enfield, et al.. 2001). Such shifts appear to be cyclic and would reoccur in the future. This observation would agree with the statistically significant declining trend of dry and wet season flows documented by Flannery and Barcelo (1998) in the recent past. The 'banana' shaped variation in flow distributions formed by the two data sets is natural. Sessile salinity-sensitive flora and fauna would have to shift in location accordingly.

3.4.2 Selecting a Natural Hydrology

Table 3.4-2 provides a comparison of the natural flow frequency distributions for the NSM, HSPF Models, measured Peace River data and existing conditions (1995 Base) as simulated from the HSPF Model with current land use. Results show that the three "natural" flow distributions are in rough agreement with one another. The low flows (<350) of the NSM and the Peace River were similar and the high flows (> 2000 cfs) of the NSM and HSPF were well matched. For these reasons, the NSM model results were selected as the most comprehensive assessment of natural flow conditions available; however, additional efforts are underway to reduce the uncertainty of this analysis.

The NSM flow-frequency distribution (**Table 3.4-2 and "Recommended Flow Targets" below)** was used to predict the frequency that the salinity envelope criteria would be violated under natural conditions. These data provided the frequency of historical high flows that may have impacted the mid-estuary under natural conditions thus providing the selected hydrologic high flow target for the mid-estuary (4.8% of flows between 2,000 and 3,000 cfs and 1.3% > 3,000 cfs). However, there is a greater uncertainty associated with the target for the low flow (54.8% of flows <350 cfs) portion of the flow distribution. Much of this uncertainty is associated with the NSM Model's lack of capabilities to estimate groundwater inflows to the estuary which is especially important when these flows are a significant part of the inflows during the dry season. It is conjectured that the low flows generated by the NSM Model under estimate the groundwater contribution to the system. Previous efforts have focused on the major problem associated with high flows and therefore this was not a problem in the development of the IRL

Table 3.4-2. Natural flow-frequency distributions compared to existing condition (1995) flow - frequency distributions based on 1965-1995 climatic conditions (Haunert and Konyha, 2004).

flow range		probability in each range (%)			
		NSM (target)	HSPF	Peace River	**1995 Base**
<350 cfs	<21,130 af/m	54.8%	47.6%	51.9%	31.2%
350 to 680 cfs	21,130 to 41,053 af/m	17.7%	19.9%	20.4%	24.2%
680 to 1010 cfs	41,053 to 60,976 af/m	6.5%	9.7%	12.6%	12.1%
1010 to 1340 cfs	60,976 to 80,898 af/m	6.5%	5.9%	4.3%	8.9%
1340 to 1670 cfs	80,898 to 100,821 af/m	4.3%	4.0%	4.6%	7.8%
1670 to 2000 cfs	100,821 to 120,744 af/m	3.0%	4.8%	2.2%	4.3%
2000 to 3000 cfs	120,744 to 181,116 af/m	4.6%	5.9%	2.4%	7.5%
>3000 cfs	>181116 af/m	2.7%	2.2%	1.6%	4.0%
average annual runoff (in/y)		11.3	14.6	10	16.1

South PIR. Realizing this low flow uncertainty, we conducted field investigations in an effort to develop a relationship between groundwater levels in the watershed to the quantity of groundwater introduced to the estuary. The analysis of this investigation, however, is still underway. Therefore, until we can confidently quantify the groundwater to calibrate models, we should use the present percentage of flows <350 cfs (47.8%) only for comparative purposes among alternative management scenarios and consider that an improvement in low flow conditions would be a decrease in the percentage of flows <350 cfs. This plan has highlighted the need for establishing a low flow target that is based on the flows required for the fish nursery function of the estuary in the Low Salinity Zone (LSZ) in contrast to upper salinity thresholds for oyster health which is more difficult to quantify. Both the oyster VEC and the fish nursery VEC will be used in future evaluations as measures of success in flow regimes. Additionally, since both of the upper reaches of the North and South Forks in the LSZ have been dredged and straightened, the relationship of flow and salinity in these areas has been significantly altered from natural conditions and may need greater low flows to restore former salinity gradients. For example, the present distance water travels downstream in the North Fork Narrows (from the Gordy Road Structure to the widening of the North Fork) is about 32 miles compared to approximately 38 miles before dredging occurred. Modeling efforts are planned to simulate salinity conditions with natural bathymetric features to contrast with existing conditions. Concurrently, investigations of the fish nursery function within the LSZ in relation to inflows are presently underway to address the low flow target.

3.5 Recommended Flow Targets

Based on updated modeling information the NSM targets were modified and a revised set (listed below) were used to evaluate each proposed alternative. The desired range of flows or salinity envelope needed to protect the St. Lucie Estuary is between 350 and 2,000 cfs of total freshwater inflow, which equates to a salinity range of about 22-8 ppt at the confluence of the North and South Forks.

- Flows less than 350 cfs for 178 months or less (or 47.8% of the time)
- Flows between 350 and 2,000 cfs for 171 months or more (or 46.0% percent)
- Flows between 2,000 and 3,000 cfs for 21 months or less (4.8%)
- Flows greater than 3,000 cfs for 6 months or less (1.3%)

3.6 Summary

The above recommended NSM flow targets provide a high flow distribution that can be used for comparing alternative water management scenarios. The chosen flow alternatives can then be subjected to a more refined analysis in which daily inflows are used to simulate daily salinity in the mid-estuary where the major oyster population of oysters exists. These daily salinities can, in turn, be used as input to the "Oyster Stress Model" that addresses the effects of low salinities (high flows) on the oyster as a VEC. Results of the oyster analysis can then be compared among water management alternatives.

As mentioned previously, the fish larvae nursery VEC is presently being developed and will provide an improved understanding of the effects of flows, especially low flows, on the fish nursery function in the LSZ of the inner estuary.

Since the North and South Forks of the estuary have been significantly modified by canalizations, the salinity gradients (salinity vs. distance) has also been significantly modified; which is especially relevant under low flow conditions. The CH3D hydrodynamic/salinity model for the SLE will be used to simulate the natural salinity gradients in both the North and South Forks by changing the bathymetry in the present set-up to, pre-canalized depths and using natural inflows. These natural gradients will be related to the amount of low salinity habitat that may have been present and will therefore give additional insight to low flow restoration targets related to the fish nursery function. The IRL South PIR and the Ten Mile Creek facility provides the opportunity to augment flows to the head waters of the North Fork to emulate, as much as possible, the natural amount of low salinity habitat available or to possibly increase fish nursery area beyond natural amounts, especially during the critical time of the year (April –June).

3.6.1 Literature Cited

Abbe, G.R., 1992. Population structure of the eastern oyster, *Crassostrea virginica* (Gmelin, 1791), on two oyster bars in Central Chesapeake Bay: further changes associated with shell planting, recruitment, and disease. Journal of Shellfish Reseach 11: 421-430.

Cerco, C.F. and Mark R. Noel. 2007. Can Oyster Restoration Reverse Cultural Eutrophication in Chesapeake Bay? Estuaries and Coast. Vol. 30 No. 2. p. 331-343.

Chamberlain, R. and D. Hayward, 1996. Evaluation of Water Quality and Monitoring in the St. Lucie Estuary, Florida. Water Resources Bulletin 32(4): 681-696.

Coen, L.D., M.W. Luckenbach, D.L. Breitburg. 1999. The role of oyster reefs as essential fish habitat: a review of current knowledge. American Fisheries Society Symposium.

Crabtree, R.E. and J.M. Dean. 1982. The Structure of Two South Carolina Estuarine Tide Pool Fish Assemblages. Estuaries, Vol. 5, No. 1 (Mar., 1982), pp. 2-9.

Crean, D.J., Robbins, R.M., and N. Iricanin. 2007. Water quality target development in the Southern Indian River Lagoon. Florida Scientist 70(4):5-22-531.

Dame, R.F. and Bernard C. Patten. 1981. Analysis of Energy Flows in an Intertidal Oyster Reef. Mar. Ecol. Prog. Ser. Vol. 5: 115-124.

Darst, M, H. M. Light, L. J. Lewis and A. A. Sepulveda. 2003. Forest types in the lower Suwannee River floodplain, Florida – A Report and Survey, Water Resources Map. U. S. Geological Investigations Report 03-4008, 24 pages.

Dennison, W. C., R. J. Orth, K. A. Moore, J. C. Stevenson, V. Carter, S. Kollar, P.W. Bergstrom, and R. A. Batiuk. 1993. Assessing water quality with submersed aquatic vegetation. BoSci. 43(2):86-94.

Doering, P. H. 1996. Temporal Variability of water quality in the St. Lucie Estuary, South Florida. *Water Resources Bulletin*. 32:1293-1306.

Enfield, B.E., A.M. Mestas-Nunez, and P.J.Trimble, 2001. The Atlantic Multidecadal Oscillation and its relation rainfall and River Flows in the Continental U.S.. Geophysical Research Letters, Vol. 28, No. 10, pp. 2077-2080.

Engle, Virginia, D., J. Kevin Summers and John M. Macauley, 1999. Dissolved Oxygen Conditions in Northern Gulf of Mexico Estuaries. Environmental Monitoring and Assessment, 57(1):1-20

Estevez, E.D. 2000. A Review and Application of Literature Concerning Freshwater Flow Management in Riverine Estuaries. Mote Marine Laboratory Technical Report Number 680, Sarasota, FL.

FDEP. 2004. *Water Quality Assessment Report: St. Lucie and Loxahatchee*. Florida Department of Envitonmental Protection, Tallahassee, Florida.

Flannery and Barcelo, (1998)

Florida Department of Environmental Protection. 2001. Basin Status Report: St. Lucie and Loxahatchee. 164 pgs.

Florida Department of Natural Resources. 1984. North Fork of the St. Lucie River : Aquatic Preserve Management Plan. Bureau of Aquatic Preserves, Division of State Lands, Tallahassee, FL.

Fonseca, M.S. 1989. Sediment stabilization by Halophila decipiens in comparison to other SAVes. Estuar. Coast. Shelf Sci. 29:501-507.

Fonseca, M.S. and J.S. Fisher. 1986. A comparison of canopy friction and sediment movement between four species of SAV with reference to their ecology and distribution. Mar. Ecol. Prog. Ser. 29:15-22.

Fonseca, M.S., Cahalan, J.A. 1992. A preliminary evalutaion of wave attentuation by four species of SAV. Est. Coast. Shelf Sci. 35:565-576.

Fonseca, M.S., J. C. Zieman, G. W. Thayer, J.S. Fisher. 1983. The role of current velocity in structureing eelgrass (Zostera marina) meadows. Estuar. Coast. Shelf Sci. 17: 367-380.

Gallegos, C. L. 1994. Refining habitat requirements of submersed aquatic vegetation: role of optical models. Estuaries 17 (1B): 187-199.

Gallegos, C. L. and W. J. Kenworthy. 1996. Seagrass depth limits in the Indian River Lagoon (Florida, U.S.A.): application of an optical water quality model. Estuar. Coast. Shelf Sci. 42:267 – 288.Gilmore, R.G. 1995. Environmental and biogeographic factors influencing ichthyofaunal diversity: Indian River Lagoon. Bulletin of Marine Science 57: 153-170.

Galtsoff, P., 1964. The American oyster, *Crassostrea virginica* (Gmelin). U.S. Fish and Wildlife Service. Fishery Bulletin 64:1-480.

Gilmore, R.G., C.J. Donohoe, D.W. Cooke. 1983. Observations on the distribution and biology of east-central Florida populations of the common snook, *Centropomus undecimalis* (Bloch). Florida Scientist.46:313-336.

Graves, G. A., Y. Wan, and D.L. Fike. 2004. Water quality characteristics of stormwater from major land uses in south Florida. *JAWRA* 40:1405-1419.

Gunter G. 1953. The relationship of the Bonnet Carre Spillway to oyster beds in Mississippi Sound and the “Louisiana Marsh” with a report on the 1950 opening. Publications of the Institute of Marine Science. University of Texas. 3:21-70.

Hand, J. J. 2004. Typical Water Quality Values for Florida's Lakes, Streams and Estuaries. Unpublished manuscript.

Haskin, H.H. and S.E. Ford. 1982. *Haplosporidium nelsoni* (MSX) on Delaware Bay seed oyster beds: a host-parasite relationship along a salinity gradient. Journal of Invertebrate Pathology. 40:388-405.

Haunert, D. E., and J.R. Startzman, 1985. Short Term Effects of a Freshwater Discharge on the Biota of the St. Lucie Estuary, Florida. South Florida Water Management District. Technical Publication. 85-1.

Haunert, D.E. and J.R. Startzman 1980. Some Seasonal Fisheries Trends and Effects of a 1000 cfs Freshwater Discharge on the Fishes and Macroinvertebrates in the St. Lucie Estuary, Florida. South Florida Water Management District.Technical Publication 80-3.

Haunert, D.E. and K. Konya. 2001. Establishing St. Lucie EstuaryWatershed Inflow Targets to Enhance Mesohaline Biota, in prep.

Haunert, D.E. and K. Konyha. 2004. Establishing St. Lucie Estuary Watershed Inflow Targets to Enhance Mesohaline Biota, E.7 2001 Report on Mesohaline Conditions, Appendix E., Indian River Lagoon – South Feasibility Study.

Hu, G., 1999. Two dimensional Hydrodynamic Model of the St. Lucie Estuary. In: Environmental Engineering, Proceedings of the ASCE-CSCE National Conference on Environmental Engineering , American Society of Civil Engineers. Pp 434-443.

Hu, Gordon. 2000. The application of the St. Lucie Estuary hydrodynamic/salinity model in Indian River Lagoon and the St. Lucie Estuary environmental studies. Technical Memorandum, South Florida Water Management District, West Palm Beach, FL.

Ibis Environmental Inc., 2007. 2007 St. Lucie Estuary Suberged Aquatic Vegetation Mapping Study. Prepared for the South Florida Water Management District. West Palm Beach, Florida.

Ibis Environmental, Inc., 2004. 2003 St. Lucie estuary American Oyster Mapping Study. South Florida Water Management District. Contract:

Ingle R.M. and F.G.W Smith, 1956. Oyster culture in Florida. Florida Board of Conservation Educational Series.

Lewis, F. G., III. 1984. Distribution of macrobenthic crustaceans associated with Thalassia, Halodule, and bare sand substrata. Marine Ecology Progress Series 19: 101-113.

Livingston, E., E. McCarron, M. Sheinkman, and S. Sullivan. 1988. *Florida Nonpoint Source Management Plan, Volume II.* Florida Department of Environmental Regulation, Tallahassee, Florida.

Mackin J.G. and S.H. Hopkins, 1962. Studies on oyster mortality in relation to natural environments and to oil fields in Louisiana. Publication of the Institute of Marine Science. University of Texas. 7:1-131.

Marshall, F.E. III, 2005. Using Statistical Models to Simulate Salinity Variability in Estuaries. In: *Estuarine Indicators.* Edited by Stephen A. Bortone. CRC Press. 2005. Pp 33-52.

Martin County 2006 Population Quick-Facts for Residents.

McDonald, J. 1982. Divergent life history patterns in the co-occurring intertribal crabs *Panopeus herbstii* and *Eurypanopeus depressus* (Crustacea: Brachyura: Xanthidae). Marine Ecology Progress Series 8: 173-180.

Mitsch, W. J. and J. G. Gosselink. 1993. *Wetlands*, 2nd ed. Van Nostrand Reinhold Publication , New York.

Morris, Frederick 1987. Modeling of Hydrodynamics and Salinity in the St. Lucie Estuary, South Florida Water Management District, Technical Publication 87-1. January 1987.

Mote Marine Laboratory. 1995. St. Lucie Estuary Nutrient Assessment Research Plan. contract No C-4148. Phase IIID – Report. Mote Marine Laboratory Technical Report No. 409. 81 p.

Myers, R.L. and J.J. Ewel 1990. *Ecosystems of Florida*. University Presses of Florida, Gainsville, FL.

Newell, R.I.E., M. K. Wood, R. E. Grizzle, E. Koch and R.R. Hood, 2002. Modeling the Influence of Filtration by Bivalve Stocks on Turbidity and Seagrass Growth. National Shellfisheries Association annual meeting, Mystic CT, April 2002.

NOAA/EPA, 1989. Susceptibility and Status of Gulf of Mexico Estuaries to Nutrient Discharges. Summary Report.

Odum, E.W. and C.C. McIvor. 1991. Mangroves. In Ecosystems of Florida edited by R.L. Myers and J.J. Ewel. University of Central Florida Press/Orlando. Pages 517-548.

Owen, H.M., 1953. The relationship of high temperature and low rainfall to oyster production in Louisiana. Bull.Mar Science. Gulf Caribbean 1:34-43.

Peters, K.M. 1981. Reproductive biology and developmental osteology of the Florida blenny, *Casmodes saburrae* (Perciformes: Blenniidae). Northeast Gulf Science 4(2):79-98.

Phillips, R. C. and R. M. Ingle. 1960. Report on the marine plants, bottom types and hydrography of the St. Lucie Estuary and adjacent Indian River, Florida. Board of Conservation Florida. Marine Laboratory. St. Petersburg.

Poff, N. L., D. Allan, M. B. Bain, J. R. Karr, K. L. Prestegaard, B. D. Richter, R. E. Sparks, and J. C. Stromberg. 1997. The Natural Flow Regime. BioScience, Vol. 47, No. 11. pp. 769-784.

Post, Buckley, Schuh & Jernigan, Inc. 1999. St. Lucie Watershed Assessment: Task A: Watershed Characterization Final Report. Prepared for South Florida Water Management District, Tampa, FL .

Post, Buckley, Schuh & Jernigan, Inc. 2003. Feasibility study for the reconnection of wetlands and oxbows along the North Fork of the St. Lucie River. Prepared for Florida Department of Environmental Protection. West Palm Beach, FL.

Powell, E. N., J.D. Gauthier, E.A. Wilson, A. Nelson, R.R. Fay and J.M. Brooks. 1992. Oyster disease and climate change. Are yearly changes in *Perkinsus marinus* parasitism in oysters (*Crassostrea virginica*) controlled by climate cycles in the Gulf of Maxico? Marine Ecology. 13:243-270.

Qian, Y., K. W. Migliaccio, Y. Wan, Y., C. Li. 2007. Trend analysis of nutrient concentrations and loads in selected canals of the Southern Indian River Lagoon, Florida. *Water, Air, & Soil Pollution.* 186: 195-208

Quick, J.A., Jr., and J.G. Mackin. 1971. Oyster parasitism by *Labyrinthomyxa marina* in Florida. Florida Department of Natural Resources. Marine Research Laboratory. Professional Paper Series. No. 13. 55p.

Ragone, L.M. and E.M. Burreson. 1993. Effect of salinity on infection progression and pathogenicity of *Perkinsus marinus* in the easter oytrer, *Crassostrea virginica* (Gmelin). Journal of Shellfish Research. 12:1-7.

Roesijadi, G., 2004. Oysters in the St. Lucie estuary. South Florida Water Management District. Contract: C-14047.

Schlesselman, G.W., 1955. The Gulf Coast Oyster Industry of the United States Geographical Review, Vol. 45, No. 4 (Oct., 1955), pp. 531-541.

Scripps Treasure Coast Newspaper, Port St. Lucie News Edition, May 7, 2006.

SFWMD, 2002. Technical Documentation to Support Development of Minimum Flows for the St. Lucie River and Estuary. South Florida Water Management District, Water Supply Department.

SFWMD, 2006. Restoration Plan for the Northwest Fork of the Loxahatchee River.

SJRWMD and SFWMD. 2003. Indian River Lagoon Surface Water Improvement & Management (SWIM) Plan 2002 Update, St. Johns River Water Management District, Palatka, FL and South Florida Water Management District, West Palm Beach, FL.

Sogrard, S.M., G.V.N Powell, and J.G. Holmquist. 1989. Utilization by fishes of shallow, SAV-covered banks in Florida Bay: 1. Species composition and spatial heterogeneity. Environ. biol. Gishes 24:53-65.

South Florida Water Management District. 1988. Technical Memorandum: An atlas of St. Lucie County surface water management basins. Water Resource Division. DRE 265, 40 pgs.

South Florida Water Management District. 1998. Upper East Coast Water Supply Plan - Support Documentation, Planning Department, SFWMD, West Palm Beach, FL.

South Florida Water Management District. 2001. Technical documentation to support development of minimum flows and levels for the St. Lucie River and Estuary.

South Florida Water Management District. 2003. Florida Forever Work Plan, 2004 Annual Update-Draft, Land Acquisition Department, SFWMD, West Palm Beach, FL.

South Florida Water Management District. 2006. Preliminary Report on the Riverine and Tidal Floodplains of the Loxahatchee River and Its major Tributaries.

South Florida Water Management District. 2007. Consolidated Water Supply Plan Support Document, Water Supply Department, SFWMD, West Palm Beach, FL.

South Florida Water Management District. 2008. Draft-The State of the St. Lucie Estuary, A Report to the Citizens of the Estuary Region 2008, Martin/St. Lucie Service Center, SFWMD, Stuart, Florida.

Steward, J., R. W. Virnstein, De. E. Hauner, and F. Lund. 1994. Surface Water improvement and Management (SWIM) Plan for the Indian River Lagoon, FL. St. Johns River Water Management District and South Florida Water Management District.

Teas, H. 1971. Biological survey of the North Fork of the St. Lucie River, University of Miami. Report to General Development Co. Port St. Lucie, Florida.

Teas, H. J. 1970. The St. Lucie Sanctuary: The Halpatiokee Natural Area. University of Miami, Department of Biology, Coral Gables, FL.

Thayer, G. W., W. J. Kenworthy, and M.S. Fonseca. 1984. The ecology of eelgrass meadows of the Atlantic coast: A community profile. U.S. Fish and Wildlife service USFWS/OBS-84/02. 148 p.

URS Greiner Woodward Clyde. 1999. Distribution of oysters and submerged aquatic vegetation in the St. Lucie Estuary. URS Greiner Woodward Clyde, Tampa, Florida. Prepared for the South Florida Water Management District. West Palm Beach, Florida.

USACE 2004. the Indian River Lagoon South Project Implementation Report (PIR)

USEPA, 1987. Estuary Program Primer, Office of Marine and Estuarine Protection, United States Environmental Protection Agency, Washington , D.C.

Virnstein, R. W., P.S. Mikkelsen, K.D. Cairns, and M. A. Capone. 1983. SAV beds versus sand bottoms: the trophic importance of their associated benthic invertebrates. Florida Scientist 46: 363-381.

Volety, A.K.,S.G. Tolley and J.T. Winstead. 2003. Effects of seasonal and water quality parameters on oysters (*Crassostrea virginica*) and associated fish populations in the Caloosahatchee River. Final Report to South Florida Water Management District. Contract: C-12412-A1.

Wan, Y., C. Reed, and E. Roaza. 2003. *Modeling watershed with high groundwater and dense drainage canals: Model Development.* Proceeding of AWRA 2003 International Congress, June 29 – July 2, 2003, New York.

Ward, L.G., Kemp, W.M., Boynton, W.R. 1984. The influence of waves and SAV communities on suspended particles in an estuarine embayment. Mar. Geol. 59:85-103.

Wells, H.W., 1961. The fauna of oyster beds, with special reference to the salinity factor. Ecological Monographs, 31:239-266.

Wenner, E., H.R. Beatty and L. Coen. 1996. A method for quantitatively sampling nekton on intertidal oyster reefs. Journal of Shellfish Research. 15:769-775.

Wilson C., L Scotto, J. Scarpa, A. Volety, S. Laramore, and D.Haunert (2005). Survey of Water Quality, Oyster Reproduction and Oyster Health Status in the St. Lucie Estuary. Jour. of Shellfish Research. Vol. 24, Issue 1. pp. 157-165.

Woodward Clyde International-Americas. 1998. St. Lucie Estuary Historical SAV, and American Oyster Literature Review, Final Report. Prepared for South Florida Water Management District. West Palm Beach, Florida.

Woodward-Clyde Inc., 1998a. Distribution of oysters and submerged aquatic vegetation in the St. Lucie estuary. South Florida Water Management District. Contract: C-7779.

Woodward-Clyde Inc., 1998b. St. Lucie estuary historical, SAV, and American oyster Literature Review. South Florida Water Management District. Contract: C-7779.

4.0 MONITORING ON A REGIONAL SCALE

By Coastal Ecosystem Division of the South Florida Water Management District

4.1 Introduction

Within the context of a River Watershed Protection Program, environmental monitoring has two major purposes: to quantify long term change and to support adaptive management. Quantification of long-term change measures progress towards program goals such as the Total Maximum Daily Load (TMDL). Application of adaptive management leads to improved infrastructure design, facility operations and habitat and water quality protection. These roles of monitoring have been endorsed by the National Oceanic and Atmospheric Administration (NOAA). They have defined ecological monitoring as, "*The systematic data collection that provides information on changes that can indicate problems and/or progress towards target criteria or performance standards, which, when met, indicated that established ecological goals have been reached*" (NOAA, 2002). More recently, NOAA has defined restoration monitoring as, "The *systematic collection of data that provides information useful for measuring project performance at a variety of scales (locally, regionally and nationally), determining when modification of efforts is necessary, and building long-term public support for habitat protection and restoration*" (NOAA, 2003).

These definitions identify four components of a monitoring program: (1) systematic collection of data that (2) measures change or progress towards (3) a goal, be it a level of project performance or a target and can be used to (4) determine when modifications to the program or project are required (support adaptive management). For the sampling locations to be representative of the whole watershed, analysis of the sampling locations with respect to their spatial scale was also considered.

An important first step in developing a program or project monitoring plan is to identify the goals of the program or project being monitored and identify the types of information that are required to measure progress towards those goals.

Relevant goals of the St. Lucie River Watershed Protection Program, as stated in Northern Everglades and Estuaries Protection Program (373.4595, F.S.), are:

1. Pollutant load reductions based upon adopted Total Maximum Daily Loads (TMDL).
2. Salinity envelopes and freshwater inflow targets.
3. Reduce the frequency and duration of undesirable salinity ranges while meeting other water-related needs of the region.

The legislation also requires an annual report that includes a summary of the conditions of hydrology, water quality and aquatic habitat in the Northern Everglades based on the results of the Research and Water Quality Monitoring Programs.

Chapter 373.4595, F.S. requires that monitoring for the St. Lucie River Watershed Protection Program (SLRWPP) build upon existing monitoring programs. There are a considerable number of ongoing or recently terminated water quality monitoring programs in the St. Lucie Estuary and Watershed. Summary details of these programs are provided in **Table 4.1-1**. This Chapter summarizes the existing long-term monitoring programs for water quality, salinity, freshwater inflow and biotic resources (oysters and seagrasses) that support goals of the St. Lucie River Watershed Protection Plan. An assessment of the ability of these monitoring programs to meet these goals in space and time also is presented.

Lastly, the recommended monitoring plan, which was formulated to fulfill the goals and reporting requirements, is presented. This monitoring plan will provide the concentration and flow data necessary to calculate and track nutrient and other material loads from the watershed to the estuary. The plan also includes salinity, water quality and aquatic habitat monitoring to quantify changes associated with anticipated reductions in flows and loads resulting from implementation of the SLRWPP. Additional water quality parameters are recommended to support adaptive management.

When monitoring is conducted by several organizations, methodological differences and central housing of data can become problematic. These problems will be addressed in the first three year review. For the SLRWPP, these kinds of problems are minimized because one agency, the District, conducts much of the monitoring.

Table 4.1-1. Water Quality Monitoring Inventory for the St. Lucie River Watershed Protection Plan Study Area.

Organization	Number of Stations	Location	Frequency	Period	Analytes
SFWMD / WQM-N	5 (Grab, A/S)	SLE Watershed District Structures	WQ: Monthly Grab; Quarterly Grab; Weekly A/S, Flow see notes	1982 - Present	Monthly Grab: Alkalinity, Ca, Cl, Color, Mg, NH4, NOx, OPO4, TKN, TotAs, TotCr, TotCu, TPO4, TSS, Turb, DO, Cond., Temp., pH. Quarterly Grab: includes all monthly parameters plus Na, K, SiO2, SO4, TotFe. Weekly A/S ACF: NOx, TKN, TPO4 (GORDYRD is ACT)
SFWMD / SE	13 (Grab)	SLE	Monthly	1991 - Present	Monthly Grab: Color, Chla, Chla2, NH4, NOx, NO2, OPO4, Pheo, TKN, TP, Turb., TSS, VSS, DO, Cond., Temp., pH, PAR, Secci, Total Depth.
SFWMD / SE Release	7 (Grab)	SLE	Sampled on request	1991 - Present	Monthly Grab: Chla, Chla2, Color, Pheo, TSS, Turb., DO, Cond., Temp., pH, PAR, Salinity, Secci, Total Depth at SE02, SE03, HR1, SE06, SE08B, IRL11B, IRL17.
SFWMD / SLT	19 Grab; Flow (12), Rainfall (8)	SLE Tributary including North Fork, South Fork, Bessey Creek, & Danforth Creek Basins	WQ: Monthly Grab; Biweekly Grab when flow; Flow/Rain, Continuous	2001 - Present	Biweekly Grab: Caro, Chla, Chla2, Chlb, Chlc, Pheo, OPO4, TKN, TPO4, TSS, Turb., NH4, NOx, Do, Cond., Temp., pH. Monthly Grab: includes all biweekly parameters plus Ca, Mg, TotAs, TotCu, TotCr. (Biweekly grabs are collected only when there is visible flow.)

Organization	Number of Stations	Location	Frequency	Period	Analytes
SFWMD	8 (In-situ)	SLE	15 minutes	1997 - Present	Near surface and bottom conductivity/salinity and temperature with water level, velocity, and DO at some stations
TBA / BGA	As required by the Blue Green Algae Inter - agency Coord. Com.	St. Lucie Estuary when blue-green algae is present	As required by the Blue Green Algae Inter - agency Coord. Com	2005 - Present	Chla
FDEP	16 (Grab); 3 (In-situ)	SLE & Watershed	Monthly	3/2008 - 4/2009	10 Estuary sites; 6 Upland sites; BOD, CBOD, Alkalinity, NH4, Chl-a, Color, NOx, OPO4, TKN, TP, TDS, TOC, TSS, and Turb, In-situ at 3 stations (DO, pH, Specific Conductivity, Temp., Depth)
St. Lucie County	15 (Grab)	SLE & Tributary	Monthly	2005 - Present	Fecal Coliform, Enterococci, Salinity, Temp, DO, pH (Nutrients may be added - TBD)
UF / IFAS	22 (Grab)	Watershed (Primarily Citrus Land Use)	Biweekly	2002 - 2005	Cu, TP, DO, TSS, TN, pH, EC, OPO4, TP, Rainfall, Depth, Flow
SFWMD / ACRA	6 (Grab); 2 (A/S); 4 (Fish)	Watershed (Allapattah Restoration Area)	WQ: Monthly Grab (6); Biweekly Grab (2); Weekly A/S (2); Quarterly Fish (4); Annual Fish (2)	2003-2010	Biweekly Grab: NH4, NOx, TKN, TPO4, DO, Cond., Temp., pH. Monthly Grab: includes all biweekly parameters plus SO4. Weekly A/S ACT: TP04 at ACRA1 and ACRA2 . Quarterly: Total Mercury, and Organochlorine pesticide compounds in mosquitofish at ACRA1, ACRA1B, ACRA7, and ACRA8. Annual Mercury and Organochlorine compounds in large bodied fish (e.g. Large Mouth Bass, Bluegill) at ACRA1 and ACRA1B.
Martin County Health Department	9 (Grab)	SLE	Weekly	5/2004 - Present	Fecal Coliform, Enterococci (SP6 at Roosevelt Bridge; 8 other stations outside of SLE)
Martin County Office of Water Quality	7 (at 2 STAs)	Stormwater Facilities	Weekly	2008 (1 to 3 years)	pH, Alkalinity, Cond., NOx, TKN, Part. N, TN, NH4 SRP, Part. P, TP, Turb., TSS, Cu, DO, Bulk Precip.
SFWMD / X	1 (S308C) Grab	C-44 and Lake Okeechobee S308 Lock	Biweekly	1973- Present	Biweekly Grab: Alkalinity, Cl, Color, NH4, NO2, NOx, OPO4, TDS, TKN, TPO4, TSS, Turb., DO, Cond., Temp., pH.
ACF= Auto sampler Composite Flow Proportional					
ACT= Auto sampler Composite Time					
A/S= Auto sampler					
PAR= Photosynthetically Active Radiation					

4.2 Watershed Monitoring Program

4.2.1 Flow Monitoring Program - SLE

One of the objectives of the flow monitoring program is to provide adequate flow data sufficient for calculation of nutrient and other loads relevant to the TMDL. Calculated loads will be used to measure progress towards achieving the TMDL. This section describes the existing flow monitoring network in the St. Lucie Estuary (SLE) watershed and evaluates the adequacy of the network.

4.2.1.1 Existing Flow Monitoring Network

The sub-watersheds comprising the SLE watershed can be divided into western and coastal groups. Western sub-watersheds include the C-44, C-23, and C-24. Coastal sub-watersheds include the North (North Fork, North Mid-Estuary) and South (South Fork, South Coastal, South Mid-Estuary) sub-watersheds (**see Figure 4.2-1**). In addition, water is released from Lake Okeechobee through S-308 into C-44. Generally, in the existing flow monitoring network, the flows from western sub-watersheds and the lake are well measured while the flows from coastal sub-watersheds are not being monitored adequately. Presently, the inflow data from coastal sub-watersheds are generated by the hydrologic Watershed (WaSh) model.

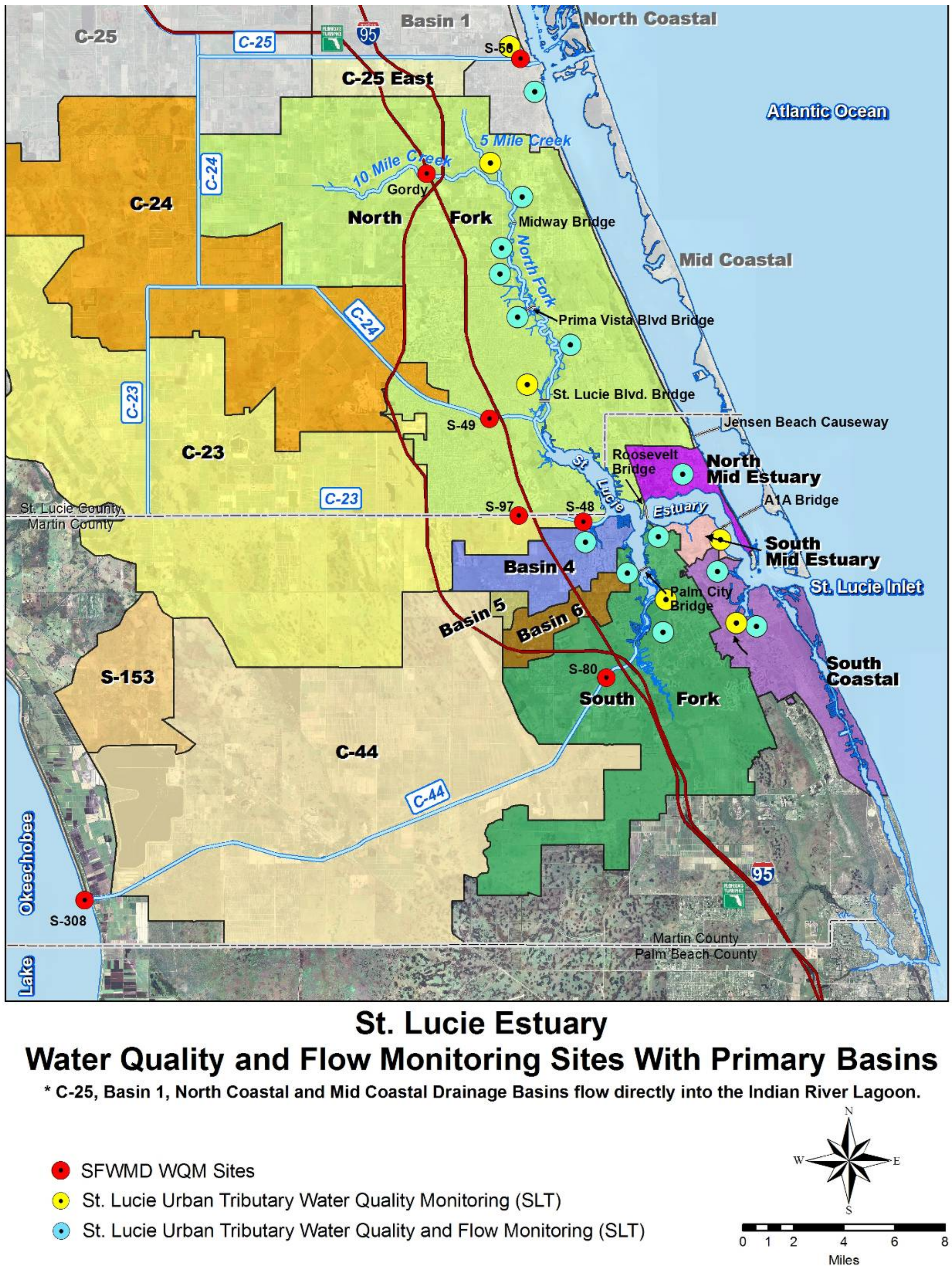
4.2.1.1.1 Western Sub-Watersheds

The existing gauges with available data for quantifying inflow to the SLE are: S-308, S-80, S-97, S-48, and S-49 (**see Figure 4.2-1**). The S-80 controls the flow discharging into the SLE from both the C-44 Basin and Lake Okeechobee. The S-308 controls the flow from the Lake into the C-44 Basin. The C-23 coastal weir, S-48 structure, is located approximately ½ miles downstream of the S-97 structure. The flow from C-23 Basin is discharged via S-97 and then to S-48. The flow from the C-24 Basin is controlled by S-49. The measured flows at these structures (**Table 4.2-1**) comprise all surface flows into SLE from the western basins and the Lake.

Table 4.2-1. Summary of flow gauges for western sub-basins.

Gauge Station Name	Drainage Basin	Structure Type	Recording Agency	Operation Agency
S-308	Lake Okeechobee	Gated Spillway	USGS/SFWMD	USACE
S-80	C-44	Gated Spillway	USACE/SFWMD	SFWMD
S-97	C-23	Gated Spillway	SFWMD	SFWMD
S-48	C-23	Fixed Crest Weir	SFWMD	SFWMD
S-49	C-24	Gated Spillway	SFWMD	SFWMD
USACE - United States Army Corps of Engineer SFWMD - South Florida Water Management District USGS – United States Geological Survey				

In actuality, flow is not measured directly but is calculated from rating curves based on gate openings and upstream and downstream stages. All flows through these structures are stored in the DBHYDRO database at the SFWMD.



Note: Only flow data is available for S-97.

Figure 4.2-1. St. Lucie Estuary Water Quality and Flow Monitoring Stations

4.2.1.2 Coastal Sub-Watersheds

The St. Lucie Tributary Monitoring Program (SLT) maintains 14 flow measurement stations along the major tributaries of the North Fork and South Fork basins (Figure 4.2-1). There is also a flow gauge at the Gordy Road Structure (maintained by North St. Lucie Water Management District) on Ten Mile Creek. The data are thought to be unreliable and need to be verified.

A number of tributaries flowing into the SLE from the North and South Forks remain un-gauged. Currently, un-gauged flow from the Ten Mile Creek enters into the North and South Forks. These flows have been estimated from the WaSh model.

In addition to the surface flow monitoring network mentioned above, several types of groundwater seepage meters were deployed to study groundwater seepage into the St. Lucie and the Indian River Lagoon. The measured groundwater seepage data can be used to quantify the groundwater contribution to SLE. Currently, the raw field measured data are being processed and verified to create a time series data set.

4.2.1.3 Assessment

In order to get an overview of the flow data quality, cumulative flow vs. cumulative rainfall is plotted for each western sub-watershed (C-23, C-24, C-44) in **Figure 4.2-2**. All four plots have R^2 very close to 1, which means, in these sub-watersheds, the outflow data is closely related to rainfall data. From the plots, it is obvious that the hydrologic response (outflow data) to the hydrologic input (rainfall data) in each sub-watershed is reasonable. Thus, generally speaking, the outflow data for C-44 Basin, C-23 Basin, and C-24 Basin are of good quality and sufficient to provide an adequate estimate of stormwater runoff.

The current flow monitoring network does not measure all inflow to SLE. Rather, ungauged flow from the eastern basins is currently estimated from a WaSh model. The current fourteen flow monitoring stations in the St. Lucie Tributary Monitoring Program will be sufficient for model support provided they can be periodically redistributed to provide for model updates.

4.2.2 Water Quality

The collection of water quality information to support a watershed-wide effort can be problematic from practical and resource requirement standpoints. Physical access to desirable collection points can be difficult or hazardous. Event-driven data collection requires extreme staff flexibility and/or expensive equipment installation and maintenance. Manpower costs are the most obvious resource requirement for the program, but often the cost of laboratory analyses can be prohibitive for some types of parameter coverage.

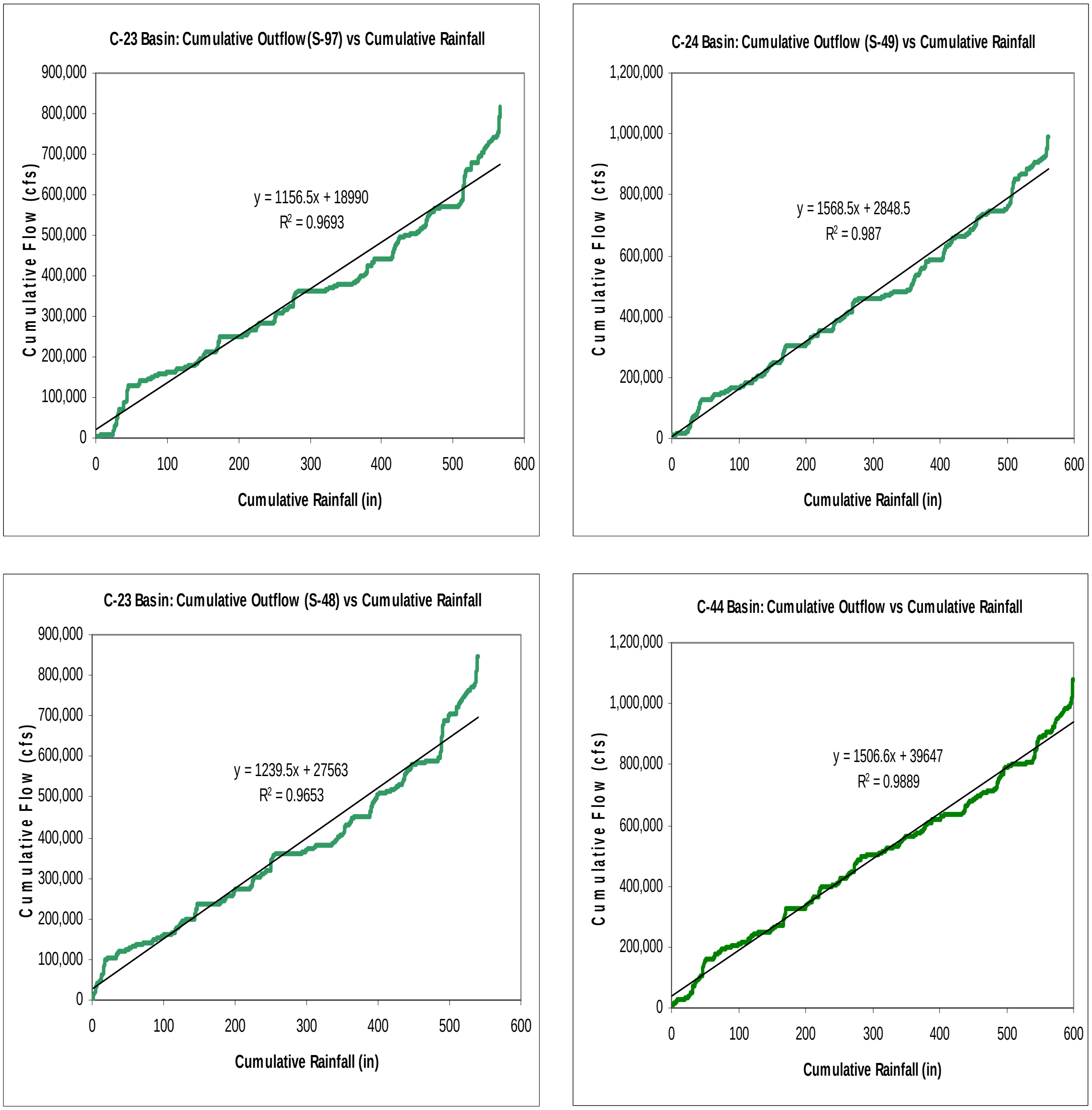


Figure 4.2-2. Cumulative flow vs. cumulative rainfall C-23, C-24, and C-44 Basins.

4.2.2.1 Existing Water Quality Monitoring Programs
Two programs, both conducted by the South Florida Water Management District, currently monitor water quality in the SLE Watershed. The Water Quality Monitoring (WQM) network monitors at major water control structures, while the St. Lucie Tributary (SLT) program monitors smaller tributaries. The following is a description of the WQM and SLT surface water quality monitoring networks associated with the St. Lucie Estuary watershed.

4.2.2.2 Water Quality Monitoring (WQM)
The WQM monitoring network collects water quality information on a large spatial scale. Collected data are used to calculate material loads to the receiving water body, identify long term trends and provide information for model calibration and verification. In addition, this information can be used to evaluate total watershed status and assist in determining the effectiveness of watershed BMP programs. The WQM network monitors water quality at five coastal structures located throughout the watershed (**Figure 4.2-1**). The coastal discharge structures are part of a large canal network that provides drainage, flood protection and water supply for the interior portions of Martin and St. Lucie Counties. This long-term routine monitoring network collects water quality grab samples monthly (nutrients, major ions, metals and physical parameters), while auto samplers are used to collect weekly flow/time proportional composite samples (**Table 4.2-1**).

4.2.2.3 St. Lucie Tributary (SLT)
The SLT monitoring network (**Figure 4.2-1)** is a short-term monitoring program designed to evaluate sub-watersheds and tributaries and the effectiveness of specific Best Management Practices (BMP). The SLT network provides increased spatial resolution in comparison to the WQM network. Data collected with the SLT network are used to characterize sub-basin and tributary water quality behavior while establishing a background or baseline data set. These data aid in determining source identification, prioritization to implement water resource projects, model development calibration/verification and sub-basin/tributary behavior. The SLT network collects daily flow measurements from 13 of the 19 sites. In addition, grab samples are collected every two weeks (bi-weekly) and ions/metals are collected monthly **(Table 4.2-2**).

Table 4.2-2. SLE Watershed Water Quality and Quantity Programs, Sample Frequencies, and Parameters

Project Code Frequency	WQM Parameters	SLT Parameters[1]
Continuous Daily	Flow	Flow @ 13 of 19 sites
Weekly Composite	Nutrients: T-PO_4, NO_x, NH_4, and TKN	
Bi-Weekly		Nutrients/Others: T-PO_4, O-PO_4, NO_x, NH_4, TKN, Chlorophyll Physicals: Temp, Sp. Cond, pH, Turb, TSS, DO
Monthly	Nutrients: T-PO_4, O-PO_4, NO_x, NH_4, TKN Physicals: Temp, Sp. Cond, Turb, TSS, DO Ions/Metals: Ca, Mg, Tot-Cu, Tot-As, Tot-Cr, Hardness	Nutrients/Physical: Same as bi-weekly Ions/Metals: Ca, Mg, Tot-Cu, Tot-As, Tot-Cr, Hardness

[1] St. Lucie Tributary

4.2.3 Assessment Summary of Existing Watershed Water Quality Monitoring

4.2.3.1 WQM

The temporal resolution of WQM network provides sufficient information on a large basin scale (80,000 – 140,000 acres). Concentration data are sufficient to characterize water quality and to detect long-term trends. The auto sampling component of the program allows robust estimation of TN and TP loads. The grab sample information can be used to partition these loads amongst the various chemical forms of nitrogen and phosphorus.

4.2.3.2 SLT

The present sampling frequency can typically detect a change in water quality >15% within five years. The effectiveness of the program is reviewed periodically. As part of this review the locations of stations are assessed. The present number of stations will be sufficient so long as their distribution can be periodically reconfigured based on programmatic review.

Neither of the two programs is designed to identify specific "hot-spot" sources.

4.3 Estuarine Monitoring Program

4.3.1 Salinity Monitoring in the St Lucie Estuary

The long-term tide and salinity monitoring network in the St. Lucie Estuary (SLE) was established in August 1997. Several stations have been added since that time (**Table 4.4-1**) with geographic locations of the stations shown in **Figure 4.3.1**.

Table 4.3-1. Salinity Monitoring Stations in the St. Lucie Estuary.

Station Name	Location	Measurements	Period of Record
Inlet	St. Lucie Inlet	Water level, temperature, conductivity	1997- 2000 2007 - present
Steele Point	SLR A1A Bridge	Water level, temperature, conductivity	1997 - present
Speedy Point	SLR US1 Bridge	Water level, temperature, conductivity	1997 - present
Prima Vista Road	North Fork	Water level, temperature, conductivity	2003 - present
Midway Road	North Fork	Water level, temperature, conductivity	2003 - present
Palm City Bridge	South Fork	Water level, temperature, conductivity	2007 - present

All tide and salinity monitoring stations take water level, temperature and conductivity measurements at 15 minute intervals. The measurements of temperature and conductivity were taken at two depths to detect stratification in the water column. Salinity is calculated from conductivity and temperature.

The data from the monitoring network have been used to establish freshwater inflow vs. salinity relationships in the St. Lucie Estuary. Several computer models have also depended on the measured data from the monitoring network for model calibration and validation. Since the data is constantly transferred to a USGS server through a satellite, the network can provide near-real time data that provides valuable information to system operation.

4.3.1.1 Assessment

The spatial and temporal scales of the current network are sufficient for basic salinity monitoring needs. Since its inception, the network has accumulated a large amount of high quality data.

4.3.2 Water Quality Monitoring in the St. Lucie River

4.3.2.1 General Description

As part of the SWIM initiative, a long-term water quality-monitoring program began in October of 1990 in the SLE. Ten water quality monitoring stations were established to detect long-term spatial and temporal trends in the SLE. In 1997, an eleventh station (SE11) was added in the St. Lucie inlet to better characterize the water quality values in the estuary (**Figure 4.3-1**). Data were collected bi-weekly from July 1992 through December 1996 and monthly from January 1997 until present. All samples are collected as close to low tide as possible. *In situ* physical parameters (e.g., temperature, pH, specific conductance, dissolved oxygen and salinity) are measured using a multi-parameter sampling device. These physical parameters are measured at half-meter increments from the bottom of the water column to the surface. Additionally, a Secchi disk depth is recorded at monitoring stations. Water samples for most parameters are collected at half of the total water depth at a station. Samples for chlorophyll *a* analysis are collected at one half of the Secchi disk depth.

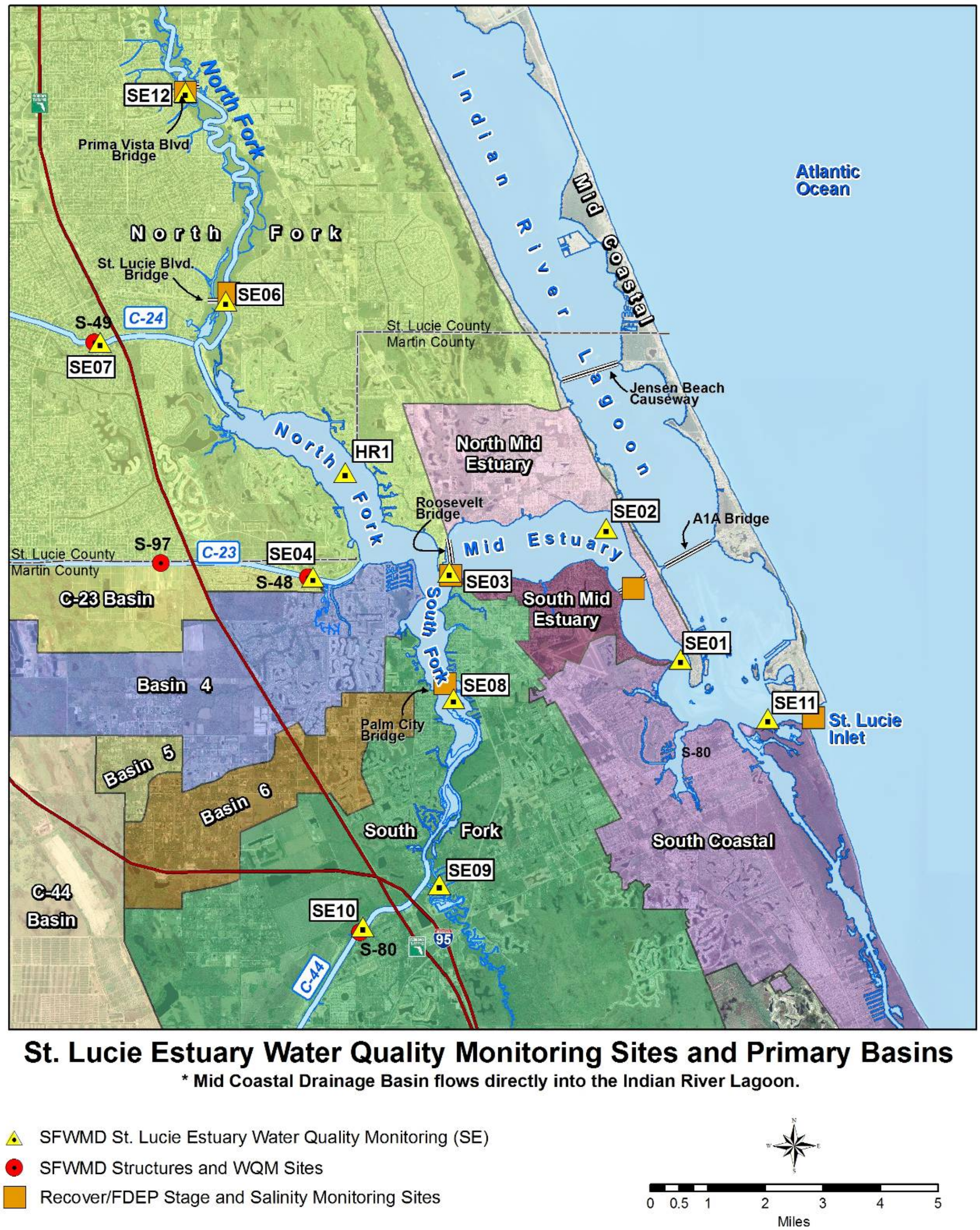


Figure 4.3-1. Map showing surface water quality monitoring stations, inflow structures and regions of the St. Lucie River Estuary.

4.3.2.2 Spatial Coverage

The water quality monitoring stations (**Figure 4.3-1**) were located to capture spatial variation of the water quality parameters and accurately reflect the water quality conditions in the estuary. There were specific considerations for some of the station locations. For example, SE01 and SE02 are located in the lower estuary and SE03 is located at Roosevelt Bridge where flow from the North Fork and the South Fork converge. HR1 is at the center of the North Fork. SE06 samples the North Fork Narrow. SE04 and SE07 can capture the immediate impact from C-23 and C-24 respectively, while SE09 and SE10 can monitor influence from the Old South Fork and C-44 respectively. SE11 was added to cover the inlet area.

In addition to the horizontal coverage of the estuary, there are profile data for some of the parameters such as pH, salinity, temperature and DO to provide vertical coverage at each station.

4.3.2.3 Temporal Coverage

The water quality data were collected bi-weekly from July 1992 through December 1996 and have been collected monthly since January 1997.

4.3.2.4 Water quality parameters monitored

Water quality parameters being collected by the monitoring program in the estuary are listed in **Table 4.3-2**.

Table 4.3-2. Water quality parameters monitored in St. Lucie Estuary

Parameter	Unit	Data type	Parameter	Unit	Data type
pH		P	Ammonia (NH_4)	mg/l	G
Temperature	^OC	P	Nitrite (NO_2)	mg/l	G
Salinity	PSU	P	Nitrate (NO_3)	mg/l	G
Conductivity	µS/cm	P	Total Kjeldahl Nitrogen (TKN)	mg/l	G
Dissolved Oxygen	mg/l	P	Nitrogen oxides (NOx)	mg/l	G
Pheophytin	mg/m^3	G	Total Nitrogen (TN)	mg/l	C
Chlorophyll a	mg/m^3	G			
Secchi Disk	meters		Orthophosphate (OPO_4)	mg/l	G
Turbidity	NTU	P	Total Phosphate (TPO_4)	mg/l	G
Total Suspended Solids (TSS)	mg/l	G			
Volatile Suspended Solids (VSS)	mg/l	G			

G = grab sample
P = profile data
C = calculated
PSU = Practical Salinity Unit

4.3.2.5 Assessment of the monitoring program

The water quality monitoring program for the St. Lucie Estuary has been statistically validated. The program is well designed and adequately characterizes water quality both spatially and temporally on a long-term basis. A statistical power analysis indicated that a monthly sampling frequency has a higher probability of detecting change than quarterly or seasonal (wet vs. dry) sampling schemes (Stanley Consultants, 2008). Therefore, the program is sufficient to measure progress towards targets or concentrations resulting from nutrient load reductions. However, the monthly data collection frequency, while sufficient to quantify long-term trends, may well miss important episodic events such as algal blooms.

4.3.3 Aquatic Habitat – Oyster and Seagrasses

4.3.3.1 Seagrass Mapping and Monitoring

Seagrasses, often referred to as Submerged Aquatic Vegetation (SAV), are considered important indicators of ecosystem health. Seagrass mapping and monitoring data provide valuable information for assessing the health of an estuary and for making water management decisions regarding the impacts of freshwater releases on marine resources (Doering et al., 2002; Tomasko et al., 1996; Thayer et al., 1984).

Seagrass monitoring in the SLE/IRL system is conducted at two spatial scales: landscape scale (mapping from aerial photographs) and patch scale (*in situ* monitoring using transects and/or quadrats). The map data provide an estuary-wide picture of SAV distribution and allows for evaluation of large-scale distribution changes (trends and natural variation) over time. Patch scale monitoring provides the ability to detect small-scale changes over time. Additionally, the *in situ* monitoring provides species-specific data, a level of detail which cannot be obtained from maps created from aerial photographs.

4.3.3.2 Seagrass Mapping

Seagrass mapping for the IRL has been conducted every 2-3 years since 1986 in cooperation with the St. Johns River Water Management District (SJRWMD) as directed by the Indian River Lagoon Surface Water Improvement and Management (IRL SWIM) and the Indian River Lagoon Comprehensive Conservation and Management (IRL CCMP) Plans. In 2004, the Comprehensive Everglades Restoration Plan's (CERP) REstoration COordination and VERification (RECOVER) program began funding the seagrass mapping efforts.

Since 1992, the IRL seagrass map boundary has included the portion of the SLE from the Roosevelt Bridge downstream to the IRL. Dark water upstream of the Roosevelt Bridge prevents seagrass mapping from aerial photographs. Recognizing the limitations of mapping submerged features from aerial photographs in dark water systems, the SFWMD contracted detailed field work to map seagrass in the SLE in 1997 and 2003.

4.3.3.3 Monitoring

In situ monitoring has been conducted at various time scales in the SLE/IRL system. **Figure 4.3-2** shows monitoring locations and indicates monitoring frequency at each location.

4.3.3.4 Semiannual Monitoring

The purpose of semiannual seagrass transect monitoring is to have a long-term data set for determining the health of seagrasses throughout the lagoon. Accordingly, transect locations were established through the IRL SWIM program to represent all segments of the lagoon. Sampling along fixed transects has the ability to detect small-scale changes in depth distribution, abundance, and species composition over time.

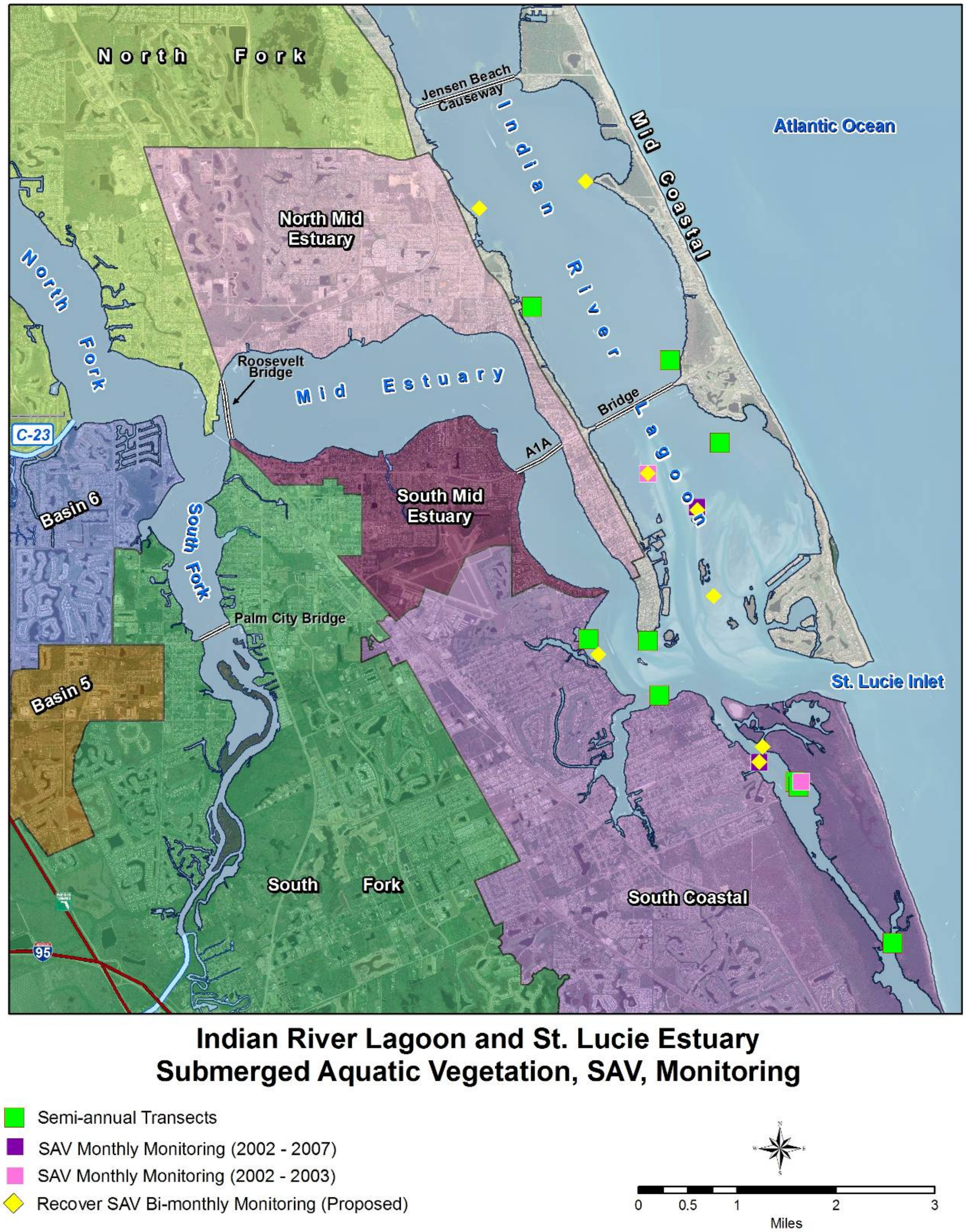


Figure 4.3-2. SAV monitoring locations and frequency.

Semiannual monitoring is a lagoon-wide, multi-agency effort consisting of over 80 transects. The data is maintained and analyzed by the SJRWMD. Semiannual monitoring is designed to sample repeatedly at the same location along the same line, quantitatively, non-destructively, and rapidly. Monitoring includes parameters related to species composition, epiphytes, coverage, abundance, drift algae, light extinction, salinity, temperature and dissolved oxygen.

4.3.3.5 Monthly Monitoring

The monthly monitoring project was designed to be a short-term (5-year) detailed seagrass monitoring program to help document seasonal changes in seagrass and associated macro-algae (epiphytes, attached algae, and drift algae) in the Southern Indian River Lagoon near the mouth of the St. Lucie River. In particular, the data collected will be used to better understand: (1) the natural seasonal variability of seagrass and macro-algae in the study area; and (2) the response of the seagrass community to freshwater discharge. The project was initiated in August 2002 and the final sampling event occurred in August 2007. The SFWMD is in the process of evaluating this five-year data set. This project was funded by RECOVER and reported in the 2007 Assessment Team System Status Report.

4.3.3.6 Bi-monthly Monitoring

Through the CERP/RECOVER Monitoring and Assessment Plan (MAP), a new monitoring program will be initiated in the IRL during 2008. The purpose of this program will be to: establish pre-CERP reference conditions and variability of seagrasses; determine the status and trends of seagrass in the project area; detect unexpected ecosystem responses to stressors which CERP activities may change; support scientific investigations designed to increase our understanding of ecosystem dynamics and cause and effect relationships; and better our ability to interpret unanticipated results.

As shown in **Figure 4.3-2**, eight (8) RECOVER seagrass monitoring sites (bi-monthly sites) have already been identified. Three of the selected sites are dominated by manatee grass and correspond with sites established for the monthly monitoring project described above. Additional sites selected for the RECOVER monitoring include sites in or near the mouth of the SLE that primarily support shoal grass and Johnson's seagrass.

Monitoring will be conducted every other month throughout the duration of the study (dependant upon assessments, funding and prioritization) using thirty 1 m^2 quadrats, each divided into twenty-five *20 cm x 20 cm* quadrants (cells). Seagrasses will be assessed within each quadrat by counting the number of cells (out of 25) housing each species and those cells that are bare. Total seagrass and total macroalgae cells will also be recorded. These data will be converted to overall percent cover data for each quadrat by species. Seagrass canopy height will also be monitored. During each seagrass monitoring event, surface and bottom water quality readings at or near each seagrass monitoring location will be collected in a minimum water depth of 1 m. These readings shall include dissolved oxygen (DO), pH, temperature, conductivity/salinity, and photosynthetically active radiation (PAR). PAR readings will be consistent with methods used for the District's IRL/SLE water quality monitoring network. Secchi depth (to the nearest 10 cm) will be recorded at each site.

4.3.3.7 Assessment

The semi-annual and bi-monthly monitoring described above are expected to meet River Watershed Protection Program monitoring goals in both space and time. It is recommended that IRL/SLE seagrass mapping from aerial photographs be continued in partnership with the SJRWMD on a 2-3 year mapping schedule. As detailed in Robbins and Conrad (2001), changes in seagrass distribution can be detected through large-scale mapping over a 2-3 year time period.

4.3.4 Aquatic Habitat – Oysters

Because of its wide distribution, historical context, and essential habitat value, the Eastern Oyster has been chosen as a target species for monitoring by the RECOVER program. Changes in oyster distribution and abundance are monitored at several sites within the St. Lucie Estuary (**Figure 4.3-3**.)

A long-term monitoring program of *Crassostrea virginica* or Eastern Oyster in the St. Lucie Estuary was implemented in 2004 through contract with the Florida Fish and Wildlife Conservation Commission (FFWCC) under the RECOVER MAP. This program emphasizes four aspects of oyster ecology: (1) spatial and size distribution patterns of adult oysters; (2) distribution and frequency patterns of the oyster diseases Perkinsus marinus ("dermo") and Haplosporidium nelsoni (MSX); (3) reproduction and recruitment; and (4) juvenile oyster growth and survival. The following is a description of the oyster monitoring project in the St. Lucie Estuary.

4.3.4.1 Overview of Oyster Monitoring Program

Adult oysters are sampled twice per year from replicate stations within the St. Lucie Estuary by the Florida Fish and Wildlife Conservation Commission. The size and vitality of adult oysters are sampled semi-annually from randomly located quadrats at each station. Monthly sampling is conducted to assess oyster reproduction, recruitment, and disease patterns. Recruitment is monitored from spat collectors that consist of axenic oyster shell (**Figures 4.3-4 and 4.3-5**). Reproductive development and disease (*Perkinsus marinus* or "dermo") and *Haplosporidium nelsoni* (MSX) occurrence is assessed at these same study sites by analyzing adult oyster samples using standard histological and microscopic analyses. Predation pressure is estimated by comparing survival of oysters in inside and outside protective cages. Juvenile oyster growth is estimated from measurements of wild oysters recruited to artificial substrate and tracked for approximately one year beginning with the early post-settlement phase at each of the study sites. In addition, water quality data (temperature, salinity, conductivity, pH, DO, turbidity) are also collected at each site during each monthly visit.

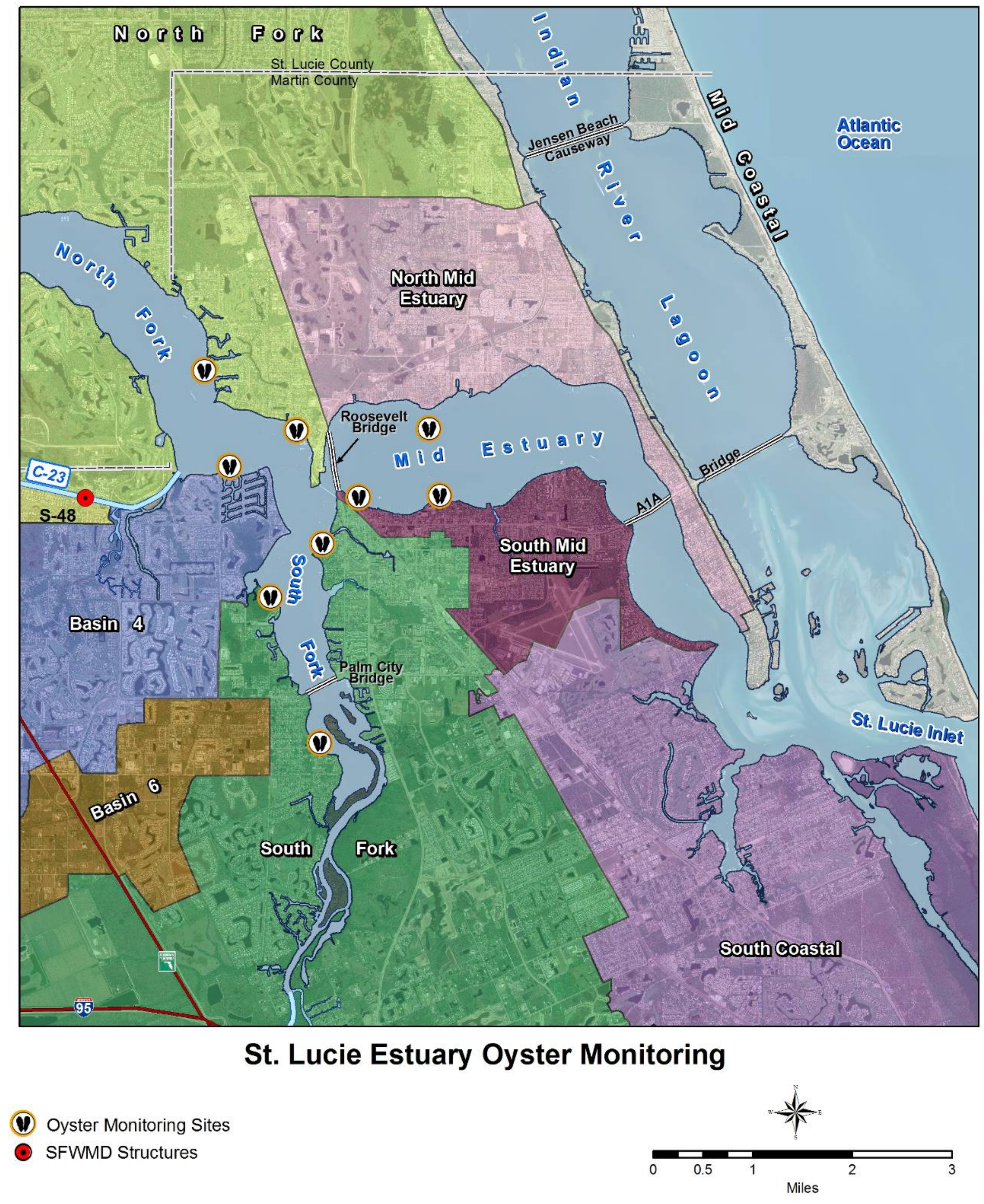


Figure 4.3-3. St. Lucie Estuary oyster monitoring sites.

Figure 4.3-4. Spat collector.

Figure 4.3-5. Attached oyster spat

4.3.4.2 Mapping

A baseline of oysters in this estuary is also being established by mapping the existing distribution of reefs and the mean density of living oysters on each bed. Historical distributions, as available, are being used to identify areas that may have suitable habitat conditions for reestablishment, given predicted changes in the salinity regime. Aerial assessment of oysters in the St. Lucie Estuary conducted in 1997 identified 208 acres of oyster habitat and in 2003 another aerial assessment identified only 117 acres of oyster habitat remaining. A map of oyster reefs within the St. Lucie Estuary including size distribution, density of living oysters, and height of the oyster reef will be prepared under the RECOVER program (US Army Corps of Engineers and South Florida Water Management District, 2007). This will be conducted at five year intervals during CERP implementation.

4.3.4.3 Assessment

A target for the St. Lucie Estuary is to achieve roughly 890 acres of suitable oyster habitat. These oyster habitats are predicted to occur in the middle estuary from the Roosevelt Bridge downstream to the A1A Bridge. The current sampling regime should adequately measure progress towards this goal. In addition, the program will capture responses to damaging fluctuations in salinity, thus providing a measure of progress towards the Protection Plan goal of reducing the frequency of undesirable salinity ranges.

4.4 Recommended Monitoring Plan

The recommended monitoring plan has been formulated to fulfill the goals and reporting requirements of the St. Lucie River Watershed Protection Program as well as to support adaptive management. Therefore, the monitoring program provides the concentration and flow data necessary to calculate and track nutrient and other material loads from the watershed to the estuary. Salinity, water quality and aquatic habitat are monitored in order to quantify changes associated with anticipated reductions inflows and loads effected by the SLRWPP within the estuary. Additional water quality parameters are recommended to support adaptive management.

4.4.1 Water Quality and Flow Monitoring in the Watershed

Currently, the WQM program (**Table 4.2-2**) measures both flow and water quality in the watershed of the St. Lucie Estuary. Assessment indicates that the existing number of stations and frequency of sampling is adequate to support adaptive management and to meet the goals of the St. Lucie River Watershed Protection Program. The program supports calculation of nutrient and organic loads to the St. Lucie Estuary that are required to monitor progress towards meeting TMDLs. A 30-month formal review of the data from this monitoring program will be used to improve numerical models that will be used in the waste load allocation process for predicting the effects of load reductions on estuarine receiving waters.

It is recommended that the program continue with the addition of three new water quality parameters to the monthly suite of grab sample analytes in order to support the TMDL. These parameters are: Dissolved Total Keldahl Nitrogen (DTKN), BOD5 (5-day biological oxygen demand) and Total Organic Carbon (TOC) (**Table 4.4-1**). The sampling suite will be reevaluated at the three year Plan reevaluation period.

Additional parameters are required to support adaptive management. BOD5 and TOC data will be used to improve the understanding and capacity to accurately model the dynamics of dissolved oxygen in the St. Lucie. The addition of DTKN allows calculation of the concentration of dissolved organic nitrogen (DON). Most of the total nitrogen in the waters of the St. Lucie estuary is dissolved organic nitrogen. The fate of DON and its response to load reductions may determine and help explain the response of TN.

Table 4.4-1. St. Lucie River Watershed Protection Program. List of water quality parameters to be measured for the monthly grab samples taken by the WQM and SLT Monitoring.

Water Quality Parameters
1) TN (cal), NH4, NO2/ NO3, TKN, DTKN
2) TP, OPO4= SRP
3) BOD5/TOC
4) Chlorophyll a
5) TSS
6) Turbidity
7) Color
8) Total hardness
9) Total Copper
10) Total Arsenic
Physical Parameters (taken electronically)
11) Temperature
12) Specific Conductivity
13) Dissolved Oxygen
14) pH

The St. Lucie Tributary (Table 4.2-2) (SLT) is initially a short-term monitoring program designed to identify nutrient sources, support adaptive management and measure tributary loads. As with the WQM program the addition of three new parameters (BOD5, TOC, DTKN) are recommended (Table 4.4-1). Data from this monitoring program will also be used to improve numerical models that will be used in the waste load allocation process and predicting the effects of load reductions on estuarine receiving waters.

The SFWMD will expand its Pollutant Source Control Program within the boundaries of the SLRWPP. On-going monitoring will be continued at a sub-watershed level to assess the collective performance and progress of FDACS, FDEP, SFWMD pollutant source control BMP programs; to support adaptive management within such programs; to identify priority areas of water quality concern and BMP optimization; and to provide data to evaluate and enhance performance of downstream treatment facilities. Monitoring will consist of flow weighted P and N concentrations and flow parameters measured daily during discharge. Because these will be long-term monitoring sites for regulatory purposes, every effort will be made to utilize existing sites where applicable. Once priority areas of concern are identified for BMP optimization activities using regional level monitoring data, a secondary level of local monitoring will be conducted by the SFWMD for a limited period of time to ascertain the most appropriate BMPs associated with the water quality concerns identified..

4.4.2 Water Quality and Salinity Monitoring in the St. Lucie Estuary

Currently, the SLE Program samples water quality at 13 stations in the St. Lucie Estuary on a monthly basis. It is recommended that this program continue as it is, with the addition of three new water quality parameters to be measured in monthly the grab samples in order to support the TMDL. These parameters are Dissolved Total Kjeldahl Nitrogen (DTKN), BOD5 (five –day biological oxygen demand) and Total Organic Carbon (TOC) (**Table 4.4.-2**). Data from the SLE program is required to measure water quality improvements due to load reductions. A 30-month formal review of the data will be used to refine numerical water quality models for predicting effects of changing freshwater inflows and nutrient loads on estuarine water quality.

Salinity is monitored continuously at eight stations. It is recommended that this program continue to support water quality modeling, refinement of salinity envelopes and quantifying the goal of reducing undesirable salinity ranges.

Table 4.4-2. St. Lucie River Watershed Protection Program. List of water quality parameters to be measured in monthly grab samples taken by the SLE Program**.**

Water Quality Parameters
1) TN (cal), NH4, NO2/ NO3, TKN, DTKN
2) TP, OPO4= SRP
3) BOD5/TOC
4) Chlorphyll a
5) Pheophytin
6) TSS
7) VSS
8) Turbidity
9) Color
Physical Parameters (taken electronically)
15) Temperature
16) Salinity
17) Specific Conductivity
18) Dissolved Oxygen
19) pH
20) Photosynthetically Active Radiation (PAR)

4.4.3 Monitoring of Estuarine Bacteria

Currently the St. Lucie County and the Martin County Health Department monitor Fecal Coliform and Enterococci bacteria in the St. Lucie Estuary to protect human health (**Figure 4.4-1**). Port St. Lucie monitors 15 stations in the North Fork on a monthly basis, while Martin County monitors a station near SE03 on a weekly basis. Because impairments for bacteria have been determined, these monitoring programs are necessary to monitor progress towards the TMDL.

4.4.4 Aquatic Habitat Monitoring

4.4.4.1 Seagrass

The bi-monthly monitoring conducted by RECOVER (**Figure 4.3-2**) will be sufficient to meet the goals of the St. Lucie River Watershed Protection program and it is recommended that this program continue. Specifically, results of this monitoring are critical for annual reporting requirements and documenting improvement in aquatic habitat as nutrient loads and stressful salinity fluctuations are curtailed.

Mapping of seagrasses by aerial photography should continue at its present frequency of 2-3 years. This sampling frequency should capture large scale changes in seagrass distribution resulting from extreme unpredictable events such as droughts, hurricanes, and El Nino. Continued coordination with the St. Johns River Water Management District will allow quantification of lagoon-wide patterns of change. RECOVER currently produce maps every five years. The 2-3 year preferred frequency can be achieved if the RECOVER mapping is supplemented through this or other programs on an alternating 2 to 3 year basis.

4.4.4.2 Oysters

The oyster monitoring conducted by RECOVER (**Figure 4.3-4**) will be sufficient to meet the goals of the St. Lucie River Watershed Protection program goals and it is recommended that this program continue. Specifically results of this monitoring are critical for: (1) annual reporting requirements and (2) tracking progress towards the restoration goal of 890 acres of oysters as nutrient loads and stressful salinity fluctuations are curtailed.

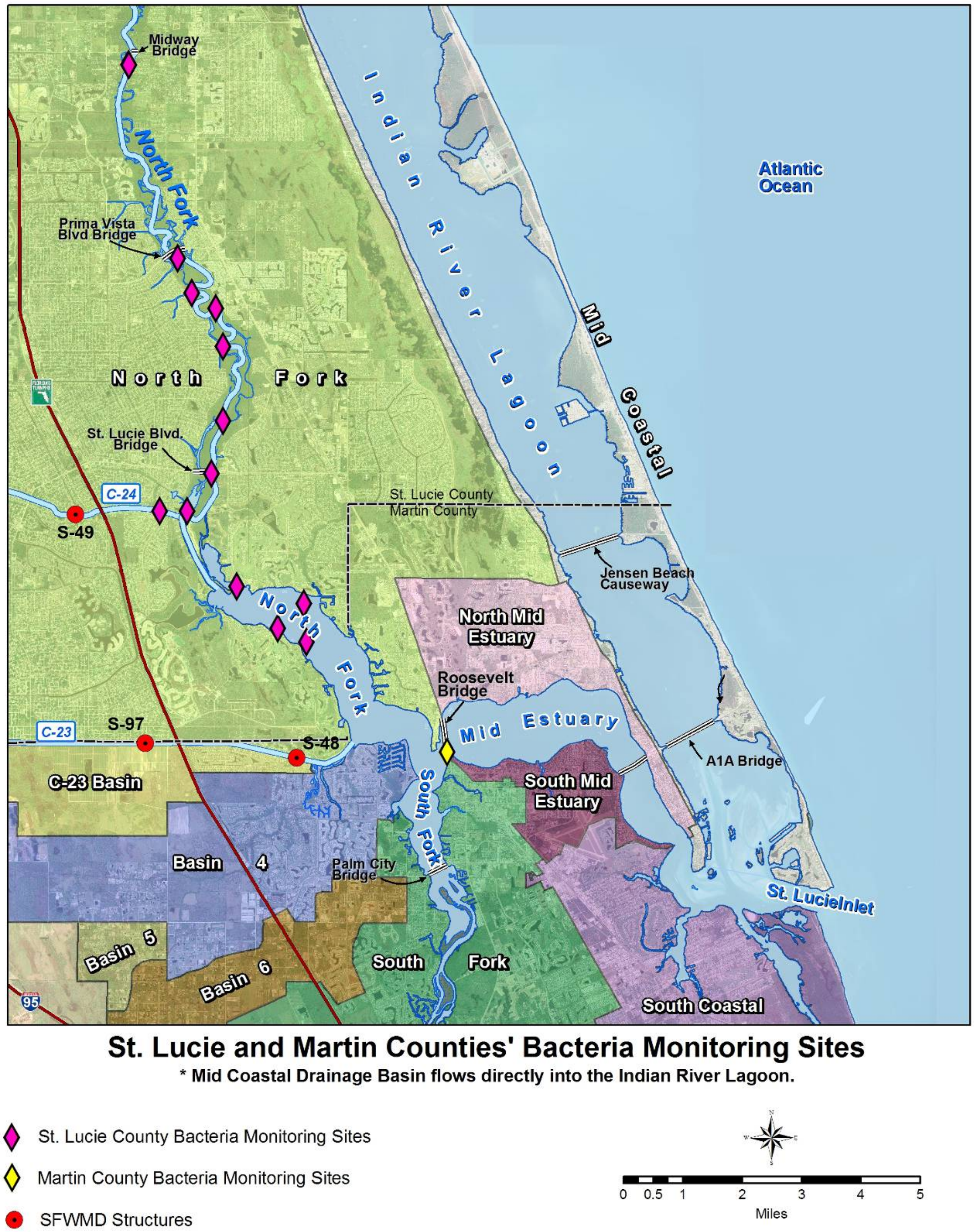


Figure 4.4-1. Location of St. Lucie County bacterial monitoring sites.

4.4.4.3 Literature Cited

Doering, P.H., R.H. Chamberlain, and D. E. Haunert 2002. Using submerged aquatic vegetation to establish minimum and maximum freshwater inflows to the Caloosahatchee Estuary, Florida. Estuaries 25(6B): 1343-1354.

Duarte, C. M. and H. Kirkman. 2001. Methods for the measurement of seagrass abundance and depth distribution. In Short, F. T., R. G. Coles (eds.). 2001. Global Seagrass Research Methods. Elsevier Science B.V., Amsterdam.

Irlandi, Elizabeth. 2006. Literature review of salinity effects on submerged aquatic vegetation (SAV) found in the Southern Indian River Lagoon and adjacent estuaries. Report submitted to the South Florida Water Management District, October 13, 2006.

Morris, L. J., R. W. Virnstein, J. D. Miller, L. M. Hall. 2000. Monitoring seagrass changes in Indian River Lagoon, Florida using fixed transects. In: Seagrasses monitoring, ecology, physiology, and management, S.A. Bortone (ed.). CRC Press, Boca Raton, FL, pp. 167-176.

National Oceanic and Atmospheric Administration, Environmental Protection Agency, Army Corps of Engineers, United States Fish and Wildlife Service, and Natural Resources Conservation Service 2002. An introduction and user's guides to wetland restoration, creation and enhancement. Silver Spring Maryland.

Robbins, R. M. and C. Conrad. 2001. Southern Indian River Lagoon Seagrass Change Analysis (1986 – 1999). Coastal Ecosystems Division. South Florida Water Management District. 32 pp.

Stanley Consultants Inc. 2008. Power analysis of water quality and seasgrass monitoring in the Caloosahatchee and St. Lucie Estuaries. Final Report. PO # 4500022527. South Florida Water Management District. 102pp.

Thayer, G. W., W.J. Kenworthy, and M.S. Fonseca 1984. The ecology of eelgrass meadows of the Atlantic Coast: A community profile. U.S. Fish and Wildlife Service Report No. FWS?OBS-84/02 147 pp.

Thayer, Gordon and others. 2003. Science –based restoration monitoring of coastal habitats, Volume One: A framework for monitoring plans under the Estuaries and Clean Waters Act of 2000 (Public Law 160-457). NOAA Coastal Ocean Program Decision Analysis Series No. 23, Volume 1. NOAA National centers for Coastal Ocean Science, Silver Spring , MD 35 pp.

Tomasko, D.A. , C.J. Dawes and M.O. Hall. 1996. The effects of anthropogenic enrichment on Turtle Grass (Thalassia testudinum) in Sarasota Bay, Florida. Estuaries 19 (2B): 448-456.

URS Greiner Woodward-Cyde. 1999. Final Report: Distribution of oysters and submerged aquatic vegetation in the St. Lucie Estuary. URS Greiner Woodward Clyde, Tampa, Florida. Prepared for the South Florida Water Management District. West Palm Beach, Florida.

5.0 WATERSHED AND ESTUARINE RESEARCH AND MODELING PROGRAM

By Coastal Ecosystem Division of the South Florida Water Management District

5.1 Introduction

Three major goals of the St. Lucie River Watershed Protection Program as stated in Sec. 373.4595(4)(a)3, F.S are (1) pollutant load reductions based upon adopted total maximum daily loads, (2) salinity envelopes and freshwater inflow targets, and (3) reduce the frequency and duration of undesirable salinity ranges while meeting other water – related needs in the region. River Watershed Protection Plans will be updated every three years.

Three research themes support these program goals: Total Daily Maximum Load (TMDL), Salinity Envelopes and Freshwater Inflow Targets, and Environmental Operations.

5.1.1 TMDL

A goal of the research program is to provide robust scientific support for and reduce the uncertainty in estimating TMDLs. The program should quantify: 1) the relationship between the biological resources upon which the TMDL may be based (e.g., seagrass) and aspects of water quality that the TMDL seeks to improve; and 2) the roles of nutrient loading and the dynamic biogeochemical processes in controlling TMDL water quality parameters (e.g., chlorophyll a, dissolved oxygen and nutrients).

5.1.2 Salinity Envelopes and Freshwater Inflow Targets

Salinity envelopes provide the basis for management of the quantity of freshwater discharged to the St. Lucie Estuary. The goal of the program is to reduce the uncertainty in these resource based targets and to quantify not only what are undesirable flows and salinities, but to identify critical periods when meeting targets is most ecologically beneficial.

5.1.3 Environmental Operations

In order to improve environmental conditions in both estuaries, protection plans will call for the construction of facilities designed to help meet TMDLs and flow/salinity targets by attenuating and storing storm water runoff, and reducing nutrient loads. Operation of these facilities will be vital to their success. Monitoring and short term studies will be required to adaptively manage these facilities to meet environmental objectives.

Research conducted within the context of an environmental protection program supports and informs adaptive management. Adaptive management is the iterative and deliberative process of applying the principles of scientific investigation to the design and implementation of a program to better understand the ecosystem and predict its response to implementation and to reduce key uncertainties. The basis of adaptive management is the use of feedback loops that iteratively feed new information into the decision-making process for planning, implementation and assessment of project components. The tri-annual assessment, specified in the legislation provides this feedback loop and ensures the incorporation of adaptive management in the River Watershed Protection Plans (see Chapter 2).

Research for adaptive management (**Figure 5.1-1**) uses a combination of models (conceptual to numeric) and observational and experimental studies to reduce uncertainty in the TMDL and salinity /flow targets, improve the operations of water storage and water quality projects and increase predictive capability. The role of modeling is to provide a mechanism for synthesis, hypothesis specification and preliminary testing and to enhance predictive capability.

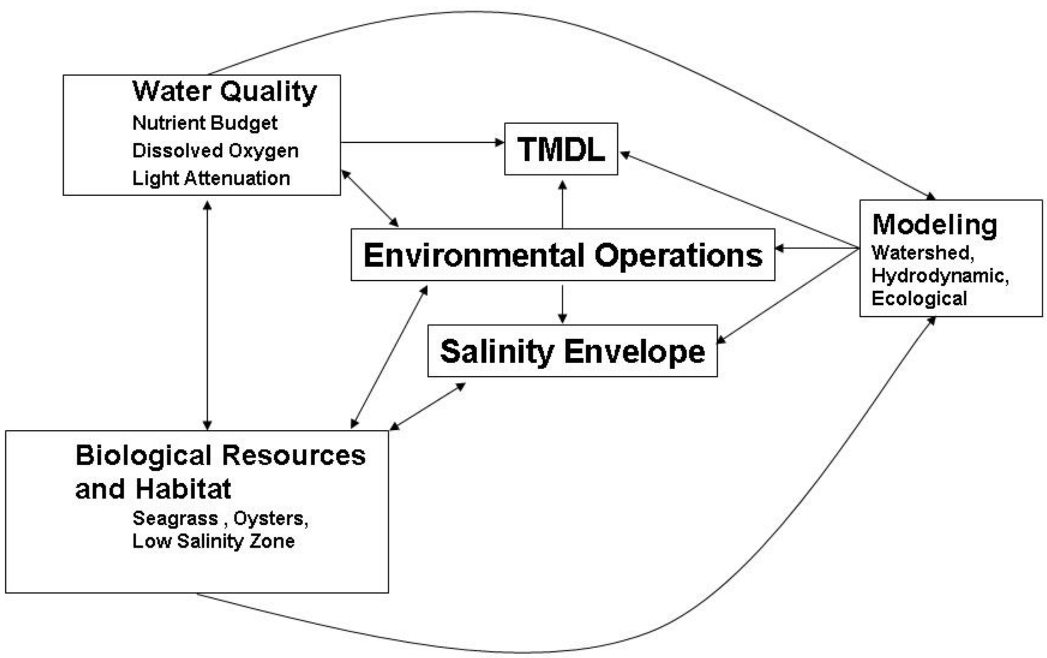


Figure 5.1-1. Relationship between applied research and modeling programs, driven by adaptive management, and TMDLs, salinity envelopes and environmental operations.

This chapter describes the research and modeling that supports the River Watershed Protection Plan. Research projects are intended to reduce or eliminate key uncertainties in the TMDL and in flow and salinity envelopes, and optimize the operation protocols. Three research projects are presented in order of priority. Each project is accompanied by a table of project elements or components along with an assessment of how information will be obtained (e.g. new measurements, existing data or estimates from a model). The section on modeling describes existing watershed, estuarine, and ecological models and summarizes additional modeling requirements.

5.2 Estuarine Nutrient Budget

5.2.1 Project Overview and Background

Over-fertilization of estuaries with nutrients from urban and agricultural sources is both a local problem for the St. Lucie Estuary (SLE) and a problem for estuaries worldwide (Gray, 1992). In the SLE, high chlorophyll *a* (algal biomass) and low dissolved oxygen concentrations have indicated nutrient enrichment (Chamberlain and Hayward, 1996).

The scientific foundation for the management of over-fertilization rests on the concept of nutrient limitation (Smith et al., 1999): the nutrient that is present in the environment in the least quantity relative to plant demands will limit growth. Controlling the effects of over-fertilization should be accomplished by restricting the loading of this key nutrient to the ecosystem (Smith et al., 1999). As a rule of thumb, nitrogen most often limits algal growth in marine systems, while phosphorus is limiting in fresh waters (Smith et al., 2006). While dissolved inorganic forms of nitrogen and phosphorus are readily available for plant growth, some organic forms can be taken up directly or converted to forms that can be taken up (Seitzinger et al., 2002). Therefore, the distribution of the nutrient load among available inorganic and organic forms and unavailable organic forms is an important consideration in quantifying the load to be controlled or restricted.

A well constrained nutrient budget is critical to understanding the origin, magnitude and management of problematic nutrient loads. A nutrient budget is simply an accounting or summing up of nutrient inputs, outputs and permanent losses (e.g. Nixon et al., 1995). Internal cycling terms are often included. For nutrients, inputs include among others, storm water runoff and atmospheric deposition. Outputs include, among others, export to the Atlantic Ocean. Burial in the bottom sediments is an example of a permanent loss term and the flux of nutrients out of the bottom sediments constitutes an internal cycling term.

5.2.2 Management Objective

This project supports the River Watershed Protection Plan goal of achieving the nutrient TMDL for the St. Lucie Estuary. The budget itself constitutes a tool that can be used to quantify nutrient loads from various sources and guide prioritization for load reductions.

5.2.3 Application of Results

Nutrient budgets assist with determining appropriate nutrient reduction approaches and with evaluating and optimizing project effectiveness. Meeting the TMDL relies on reducing nutrient loads that can be controlled. The relative magnitude of controllable and uncontrollable sources limits the extent of improvement that can be achieved. Since a nutrient budget is comprised of both types of sources, it provides the basic information required to quantify this limit. The inclusion of internal cycling terms, such as the regeneration of nutrients by bottom sediments, allows estimation of the time scale of system response to external load reductions. Results of this project can be used to support water quality modeling efforts which will reduce the uncertainty of the TMDL and increase the capability to predict effects of various management measures, including BMP’s.

5.2.4 Methodological Approach

This project will construct nutrient budgets of nitrogen and phosphorus for the St. Lucie Estuary. Terms in the nutrient budget will be determined by a variety of methods. Some of the terms in the budget can be derived from existing information (i.e. nutrient load from C-23, C-24 and C-44). Others such as storm water runoff from ungauged portions of the watershed may be available only from models. Still others such as the flux of nutrients out of the bottom sediments may require direct measurement (**Table 5.2-1**).

Table 5.2-1. Input, Internal Cycling and Output Terms included in the Nutrient Budget for the St. Lucie Estuary. Also given is the status of data required for each term.

INPUTS	STATUS
C23,C24,C44	Data Available
Ungauged Areas	
Surface Flows	Watershed Model and Measurements
Ground Water	Watershed Model and Measurements
Atlantic Ocean	Modeling Project
Atmospheric Deposition	Data Needed
Nitrogen Fixation	Require New Measurements
INTERNAL CYCLING	**STATUS**
Primary Productivity	Require New Measurements
Water Column Respiration	Require New Measurements
Benthic Nutrient Flux	One Dry Season Data Available, Need More Dry and Wet Season Data
OUTPUTS	**STATUS**
Export to Ocean	Require Modeling Project
Burial in Sediments	Some Sedimentation Rate Data Exist
Denitrification	One Dry Season Data Available, Need More Dry and Wet Season Data
Biomass	
Migration	Data Needed
Harvesting	Data Needed

5.2.5 Progress This Year

5.2.5.1 Nutrient Limitation of Phytoplankton Growth in the St. Lucie Estuary

Indirect evidence based on nutrient ratios suggests that nitrogen most often limits the growth of phytoplankton in the St. Lucie (Doering, 1996). However, no experimental studies have examined nutrient limitation in the St. Lucie. Therefore, a year long study was initiated in April of 2007.

The focus of this study was to examine the response of the phytoplankton community to shifting salinity and nutrient conditions in the estuary. The responses were evaluated within the context of spatial and temporal patterns in the abundance and composition of the phytoplankton community and nutrient elements, as well as variability in physical-chemical characteristics of the water column, including salinity, temperature and light availability. In order to evaluate the potential responsiveness of the phytoplankton community to changes in nutrient load, the nutrient limiting status of the community was determined in controlled bioassay experiments.

Five sites in the St. Lucie Estuary were sampled on a weekly basis from April 2007 through April 2008. Controlled bioassay experiments were conducted on a monthly basis. Site 7 was located in the North Fork of the inner estuary, near the inflow of Ten-mile Creek. Site 8 was located in the South Fork of the Inner estuary, near the inflow of the St. Lucie Canal (C-44). Site 9 was located in the mid estuary, near the confluence of North and South Fork. Site 10 was located several kilometers from the St. Lucie Inlet. Site 11 was located just inside the inlet to the Atlantic Ocean.

Preliminary results indicate that nitrogen most often limits phytoplankton production. Silica is also sometimes limiting, which suggests that at times diatoms, which require silica, may be at a competitive disadvantage to other species.

5.2.5.2 Short Term Water Quality Analysis

In 2006, the South Florida Water Management District (District) undertook the development of two identical platforms that would hold equipment designed to continuously record data in order to increase temporal resolution. The platforms, dubbed the **M**arine **E**nvironmental **R**esearch **L**aboratory for **In**-Situ Sampler, or MERLIN, are designed to collect high resolution water quality in the St. Lucie River Estuary (SLE). The initial tests over the next few months will take place in the SLE.

Various sensors are connected to a flow-through water system that takes discrete water samples. Onboard sensors will measure several variables including nutrients (nitrate, phosphate, silicate and ammonia), water temperature, dissolved oxygen, pH, salinity, and turbidity. MERLIN also records meteorological data including air temperature, precipitation, barometric pressure, relative humidity, and wind speed and direction.

The high resolution data acquisition and *in situ* nutrient analysis capabilities of MERLIN will help scientists to understand the processes leading to phytoplankton blooms in the St. Lucie on short time scales. This knowledge will help refine TMDLs by providing high resolution water quality data for determining maximum pollutant loads.

5.2.5.3 Benthic Nutrient Fluxes

In shallow coastal estuarine systems such as the St. Lucie, the water column and sediments can be tightly coupled with respect to the biogeochemical cycles of nitrogen and phosphorus. Sediment can function as a sink (i.e. permanent burial) or a source (i.e. inputs of nutrients to the estuary) through the transfer, or flux, of nutrients between the water column and sediments. Inorganic nutrients are produced during the microbial remineralization of organic matter within the sediments. Loads of nutrients from sediments can contribute significantly to the total nutrient load in sub-tropical estuaries (Day et al., 1989). A recent study of benthic fluxes in an estuary in northwestern Florida identified sediments as a significant source of inorganic nitrogen and phosphorus to the water column relative to inputs from the main freshwater source during drought conditions (DiDonato et al., 2006).

Due to a lack of information on benthic nutrient fluxes available for this system, two studies were conducted in February 2008 to estimate benthic fluxes of nitrogen and phosphorus; 1) “The Characterization and Quantification of Benthic Nutrient Fluxes in the St. Lucie River and Estuary” (Howes et al., 2008), and 2) “An Assessment of Processes Controlling Benthic Nutrient

Fluxes in the Caloosahatchee River and Estuary and the St. Lucie River and Estuary" (Cornwell et al., 2008).

The goals of the first study were to: 1) provide estimates representative of system-wide benthic nutrient flux rates in the St. Lucie; 2) identify "hot spots" of benthic nutrient; and 3) provide data in support of current and future water quality modeling efforts. System-wide estimates were based on measurements from sediment cores collected from 50 sites distributed throughout the estuary.

The goals of the second study were to identify the contribution of diffusive and advective fluxes in the St. Lucie, by comparing fluxes measured from cores in the laboratory with fluxes measured in the field with chambers. The results will guide future research and monitoring efforts in the application of appropriate methodology for measuring benthic nutrient fluxes.

Initial measurements were taken in February 2008, during the dry season in a drought year. Additional measurements are required to determine the relative contribution of the sediments to the total nutrient load.

5.3 Dissolved Oxygen Dynamics

5.3.1 Project Overview and Background

Low oxygen concentrations are often associated with excess nutrient loading (Gray, 1992) and have been a recognized problem in the St. Lucie (Chamberlain and Hayward, 1996). The Florida Department of Environmental Protection has determined that the St. Lucie Estuary is impaired for dissolved oxygen concentration. Causative agents for the dissolved oxygen impairment were both a high biological oxygen demand (BOD) and high levels of chlorophyll *a* (http://www.dep.state.fl.us/water/tmdl/adopted_gp2.htm). The two causative agents suggest different origins for the dissolved oxygen impairments. The high BOD suggests that loading of labile organic matter from external sources might cause low concentrations of dissolved oxygen. By contrast, high levels of chlorophyll suggest that excess nutrient loading leads to internal production of algae which fuel a high oxygen demand when they die. The two scenarios lead to different management actions.

5.3.2 Management Objective

This project supports the River Watershed Protection Plan goal of achieving the TMDL for the St. Lucie Estuary and improving dissolved oxygen conditions in the St. Lucie Estuary.

5.3.3 Application of Results

This project will identify the factors causing the dissolved oxygen impairment in the St. Lucie Estuary. Once causes are known, appropriate management solutions can be implemented. The results of this study will provide critical information that will guide the selection of these management solutions.

5.3.4 Methodological Approach

In order to determine if proposed TMDLs for nutrients will improve dissolved oxygen concentrations in the St. Lucie Estuary, it is necessary to quantify the relative importance of factors that control dissolved oxygen and how they interact to exert that control. This study will examine the role of internal and external factors in determining the concentration of dissolved oxygen (**Table 5.3-1**). These include stratification, algal blooms, sediment oxygen demand, and BOD loading. Emphasis will be on measuring diel (daytime-nighttime) fluctuations of dissolved oxygen in surface and bottom waters in different seasons and over a range of freshwater inflows and algal bloom conditions. The interpretation of these observations will be aided by measurements of sediment oxygen demand and BOD in the water column.

Table 5.3-1. Sources sinks and other measurements required to quantify the dynamics of dissolved oxygen in the St. Lucie Estuary

Sinks	**Status**
External BOD Load	Monitoring Planned
Benthic Sediment Oxygen Demand (SOD)	One Dry Season Data Available, Need More Dry and Wet Season Data
Water Column Respiration	Require New Measurements
Sources	**Status**
Primary Productivity	Require New Measurements
Re-aeration	Modeled
Physics	**Status**
Stratification	Require New Measurements
Concentration Time Series	**Status**
Dissolved Oxygen	Require New Measurements
Chlorophyll *a* Biomass	Require New Measurements
Light Extinction	Require New Measurements

5.3.5 Progress This Year

5.3.5.1 Benthic Oxygen Flux

Measurements of sediment oxygen demand were taken along with the nutrient flux measurements described above. These were obtained during the dry season of a drought year (2008). Further measurements are required.

5.4 Low Salinity Zone

5.4.1 Project Overview and Background

One of the goals of the St. Lucie River Watershed Protection Plan is to minimize the occurrence of undesirable salinity ranges in the St. Lucie Estuary. The low flow requirements of the St. Lucie have been based on salinity tolerances of the oyster, *Crassostraea virginica*, which prefers meso- to polyhaline waters (14-28 ppt) and inhabits the middle regions of the system.

Typically located near the head of an estuary, the low salinity zone (0-10 ppt, Holmes et al., 2000) is highly productive, serving as a nursery area for early life stages of economically important fish and shell fish (Day et al., 1989). Survival of these stocks is dependent on survival of juveniles within these low salinity nursery habitats which in turn depend on sufficient freshwater inflow. Whether the low flow targets based on salinity requirements of the oyster are sufficient to maintain the nursery function has yet to be determined.

Estuaries are characterized by high primary and secondary productivity (Nixon et al., 1986; Nixon, 1988). It is generally agreed that freshwater input maintains this production (Fisher et al., 1988; Day et al., 1989; Montagna and Kalke, 1992). This agricultural paradigm regards the nutrients carried to estuaries by freshwater inflows as beneficial, with higher freshwater inflows leading to higher yields of desirable species (Loneragan and Bun, 1999). Yet, the relationship between freshwater input and estuarine productivity is not completely understood (Livingston et al., 1997). While productivity is often positively correlated with the quantity of freshwater discharge, both reductions and increases in discharge can result in reduced productivity (Wilbur, 1992; Livingston et al., 1997; Turner, 2006).

In a recent review of recruitment of fish and other nekton, Petersen (2003) unifies the dynamic-stationary habitat overlap hypothesis of Browder and Moore (1981) with Cushing's (1990) match/mismatch hypothesis. Peterson (2003) notes that successful recruitment depends first on larvae approaching their physiological optima (salinity, temperature, dissolved oxygen) in the surrounding water (dynamic habitat) and then having available the appropriate habitat structure (e.g. grass bed, sediment type: stationary habitat) for other life requirements. Chief among these other requirements is the overlap between fish larvae and their prey. Annual variation in temporal and spatial overlap (match/mismatch) is reflected in subsequent recruitment. The dual role of freshwater inflow in positioning larvae with respect to physical habitat and food and supplying the nutrients to grow the food is evident here.

An important dynamic habitat in the low salinity zone is the estuarine turbidity maximum. Estuaries typically trap sediment in high concentrations at localized regions within the low salinity zone called the estuarine turbidity maximum (ETM). The ETM is a unique dynamic habitat that provides protection and nutrients to planktonic and larval fish (Roman et al., 2005; North and Houde, 2003). In SW Florida, estuarine dependent fish such as Perch and Bay Anchovy spend the juvenile phase of their life cycle foraging in the ETM (Peebles, 1996). Despite its importance to the ecology of the estuary, little or no work has been done to examine the dynamics of the ETM.

5.4.2 Management Objective

Mid-estuarine salinity envelopes at the Roosevelt Bridge and at the A1A Bridge are primarily based on providing tolerable physiological and ecological conditions for the oyster, *Crassostrea virginica* (see above). The relationship between freshwater inflow and estuarine productivity has not been described in the St. Lucie. It is not known whether freshwater inflow and salinity envelopes based on physiological tolerances also adequately support estuarine productivity.

This project examines the effects of freshwater discharges on the production of fish larvae and utilization of the low salinity zones in the North and South Forks of the St. Lucie estuary as a nursery area. The relationship between freshwater discharge and the nursery function of estuaries is not understood well enough to provide generic information relevant to the management of freshwater inflow to estuaries. Site specific determination of flows adequate to support and/or enhance the nursery function in the St. Lucie is required to maintain a healthy ecology.

5.4.3 Application of Results

Results of this study will be used to refine the salinity envelope and to provide environmental guidelines for delivery of freshwater to the North and South Forks of the St. Lucie estuary.

5.4.4 Methodological Approach

The estuary will be divided spatially into several zones. At present the following collections in each zone are anticipated. Collections will be on a monthly basis.

- Zooplankton (plankton net)
- Phytoplankton (plankton net)
- Benthic Macrofauna
- Juvenile Fish
- Water-column chlorophyll *a* (*in situ* fluorometry)
- Estuarine turbidity maximum (location and strength)
- Colored dissolved organic matter (CDOM fluorometry)
- Standard water quality measurements (i.e., salinity, conductivity, temperature, dissolved oxygen)

5.4.5 Progress This Year

5.4.5.1 Estuarine Turbidity Maximum

A short term preliminary study of the St. Lucie ETM was initiated in 2008. The goal of this study was to identify and evaluate the vertical and horizontal density and turbidity structure(s) with respect to DO, salinity, and/or chlorophyll *a* stratification. The results of this project can be used for the calibration of a numerical sediment transport model to evaluate light conditions in the estuary. The project also has implications in environmental operations for better management of freshwater release to improve the ecosystem health in the Low Salinity Zone and for refinement of salinity and flow envelopes.

Four sampling trips were completed (10/25/07, 11/14/07, 3/27/08, 4/3/08). ETMs occurred most often just upstream of the freshwater-saltwater interface.

5.5 Research Projects and Priority Order

Each major project (e.g. Nutrient Budget) can be broken down into several components. These components are provided in a separate table (e.g. **Table 5.2-1)**. Examination of the components of each project shows that several projects may have common components. The commonalities between components of the various projects are summarized in **Table 5.6-1**. As in the individual project tables, the source of data for each component is given (existing data, new measurements, model etc). The items funded in any given year may be prioritized according to the number of projects to which they belong.

5.6 Integrated Modeling and Assessment Framework

5.6.1 Introduction

An integrated modeling framework combining the resource-based Value Ecosystem Component approach and linked watershed and estuarine models has been proposed to meet water management objectives for protection and restoration of coastal ecosystems (Figure 3, Chapter 12 Appendix 1, SFER, 2007). Integrated or linked models are used to simulate the effects of changes in population, land use or management practices in the watershed on estuarine physics, chemistry, and ecology (Chesapeake Bay Program and IAN, 2005; Wan et al., 2002; 2006). Specifically, the watershed model estimates the quantity, timing, and quality of freshwater inflow to the estuary. The estuarine hydrodynamic, sediment transport and water quality models, in turn, simulate the estuarine conditions in terms of salinity, water quality, and sediment transport. Finally, the ecological models simulate the responses of estuarine resources and processes to the estuarine conditions. The District has been using this approach for several years in the Minimum Flows and Levels Program, and in CERP-related projects, both for feasibility studies (Indian River Lagoon South, Southwest Florida Feasibility Study) and at the project level (C-43 basin reservoir).

The modeling tools summarized here make a critical contribution to achieving the goals of the River Watershed Protection Plan through simulation of present conditions and prediction of future responses. For example, one of the primary goals of the River Watershed Protection Plan is to meet the Total Maximum Daily Load (TMDL) through nutrient load reductions. Modeling not only aids in calculating loads that presently exist but also in estimating future load reductions required to meet TMDLs or ecologically based targets. In practice the TMDL will be achieved through a combination of management measures ranging from source control BMP's for urban and agricultural lands to large filter marshes and reservoirs. Models can help formulate and evaluate various combinations of these measures to arrive at a preferred plan. Other modeling tools presented here will be used to optimize operation of reservoirs and other facilities. The contribution of models to the adaptive management process is also critical. Here models can be used to synthesize information and generate testable hypotheses that will refine the TMDL and the plan to achieve it.

Table 5.6-1. Major research projects in the St. Lucie Estuary and Watershed: their components and commonality.

Research Component	Research Projects			Source
	Nutrient Budget	**D.O. Dynamics**	**Low Salinity Zone**	
INPUTS				
Canal Loads (C23,C24,C25)	√	√	√	Monitoring
Ungauged				
Surface Flow	√	√	√	
Ground Water	√	√	√	From Ground Water Model to be developed
	√	√	√	Analysis of Data
Ocean Input	√	√		Concentration from Literature/Flow from model
Atmospheric Input	√			Literature/ Data Search
INTERNAL CYCLING				
Primary Productivity/Water Column Resp	√	√	√	New Measurements
Organic Matter Decomp/ Incl. DON	√	√		New Measurements
Benthic Flux	√	√		New Measurements
D.O. Time Series		√	√	New Contract In-house
OUTPUTS				
Export to Ocean	√			Model
Denitrification	√			Benthic Flux Project
North and South Fork Narrows:				
Larval /Juvenile fish (Species, size, number and gut content)				
Adult fish (movement and spawning				
Zooplankton (species, stage, and reproductive state)			√	New Measurements
Benthos (species, feeding type, number)				
Phytoplankton (species and size)				

Over the past several years, numerous modeling efforts were conducted for the St. Lucie Estuary and its watershed. The intent of this section is not to go over the details of the theory and numerical coding of each model developed in the area. Instead, an overview of the existing models and an assessment of data and modeling needs for future applications are given. This overview and assessment covers both hydrology/hydrodynamic and water quality aspects of modeling for the watershed and the receiving waterbody. In the future, a comprehensive modeling framework for the Northern Everglade domain (Kissimmee River and Watershed, Lake Okeechobee and watershed, integrated with the St. Lucie River estuary and its watershed) will be evaluated and developed.

5.6.2 The St. Lucie Watershed Hydrology and Water Quality Models

5.6.2.1 The St. Lucie Watershed Hydrology and Water Quality Model (WaSh)

5.6.2.1.1 Hydrology component

The development of the St. Lucie Watershed Model (WaSh) was initiated several years ago with the aim to integrate District early work on HSPF (Hydrologic Simulation Program Fortran) with advanced modeling schemes to simulate the complex canal network and flat terrain in south Florida (Wan et al., 2003). The SLE WaSh model uses HSPF to simulate surface water hydrology, a 2-Dimensional groundwater model to represent the surficial aquifer, and a full dynamic channel routing model to simulate structure operation and the canal network. An irrigation routine is also built in the model to allow for simulation of the irrigation demand. The fundamental time step for the model is one day, and output from the model is provided in daily increments. However, certain model algorithms operate at shorter time steps (30 minutes to one hour) to provide accurate representations of physical processes and provide numerical stability. Simulation results can be provided at one-half hour intervals if desired.

The domain of the SLE WaSh model covers the entire St. Lucie River watershed. Measured data collected at major flow structures such as S-49, S-48, and S-90 and selected monitoring stations in the watershed were used for model calibration and validation. The model is calibrated with data from 1990 to 2000. The period of simulation is from 1965 to 2005. The model has been applied by the District in several initiatives including the C-44 Reservoir Project.

5.6.2.1.2 Water Quality component

The water quality component of WaSh is adopted from the WASP (Water Quality Analysis Simulation Program) model non-linear DO and EUTRO modules. The model consists of simulating the production, transport and in-stream processes for dissolved oxygen, carbonaceous oxygen demand, ammonia, nitrate, organic nitrogen, organic phosphorus and soluble phosphorus. Production of nutrients from the land element uses an event mean concentration approach specific to land use types. The water quality model has been calibrated for the period of 1995 to 2005 and FDEP has selected this model in the SLE TMDL development to simulate DO and nutrient dynamics in canals and nutrient loadings into the estuary. The capability of the St. Lucie WaSh model is summarized in **Table 5.7-1**.

Table 5.7-1. The capability of the SLE WaSh model

Hydrology	Water Quality
1. Simulate daily surface and subsurface flow/stage, water budget, and structure operation in canals, sub-basins, and cells. 2. Simulate agricultural irrigation demand and supply. 3. Provide boundary conditions/input data for estuarine models, the OPTI model, and the NERSM model.	1. Simulate nutrient production from various land use types. 2. In-stream eutrophication processes including nutrient cycling and DO dynamics 3. Provide nutrient loading estimation for estuarine models.

5.6.2.1.3 The Northern Everglades Regional Simulation Model (NERSM)

5.6.2.1.3.1 Hydrology component

The Northern Everglades Regional Simulation Model (NERSM) is a basin budget/link node implementation of the Regional Simulation Model (RSM) developed by the District. The NERSM uses a lumped hydrologic approach to model water levels. It assumes that water in each water body is distributed in level pools. Local-scale features within a watershed, e.g. stages at specific gauging stations and flows across specific transects are not simulated. The model domain captures all of the Northern Everglades including the Lake Okeechobee Watershed, the Caloosahatchee Watershed, and the St Lucie Watershed. These watersheds have been sub-divided into modeling sub-watersheds as follows

- Lake Okeechobee Watershed (Upper Kissimmee, Lower Kissimmee, Lake Istokpoga, Fisheating Creek, and Taylor Creek/Nubbin Slough)
- Caloosahatchee Watershed (East and West Caloosahatchee)
- St. Lucie Watershed (C-44, C-24, C-23, Ten Mile Creek, North Fork/South Fork/Basins 4,5, and 6)

The period of simulation is 1970 to 2005 using a 1-day time step. For the St. Lucie River Watershed, basic hydrology, runoff and supplemental irrigation requirements were obtained from the WaSh model. Alternatives were evaluated by comparing model output to pre-established performance measures. The OPTI6 model (described below) provided operation criteria and simulation targets for the IRL-South preferred alternative. Violations in the high discharge criteria (2,000 cfs and 3,000 cfs mean monthly flow) and the salinity envelope criteria are the two main performance measures used to evaluate alternative scenarios.

5.6.2.1.4 The St. Lucie Reservoir Optimization Model (OPTI)

The St. Lucie Reservoir Optimization Model (OPTI) was developed for the Southern Indian River Lagoon Feasibility Study to optimize the size and operation of the storage reservoirs/stormwater treatment areas (STAs). The model simultaneously tries 1) to achieve the target monthly flow distribution for the protection of salinity sensitive biota in the SLE, 2) to meet the irrigation demands supplemented by the Floridan aquifer, and 3) to optimize the reservoir size. The model contains a genetic algorithm coupled with a reservoir routing model of the drainage network. The OPTI model requires reading the daily basin flows and daily irrigation demands obtained from the Watershed model (WaSh). The reservoir routing model tracks the water budget in the reservoir on a daily basis.

The current OPTI6 simulation extended the period of record from 31 years (1965 ~ 1995) to 41 years (1965 ~ 2005). The modeling result indicates that the desired frequency distribution can be closely matched under the optimized operation schedule. This simulated flow time series of freshwater inflows into the SLE serves as a target of restoration for NERSM to achieve during the alternative analyses. The capability of the OPTI model at the planning-level and the operation-level are summarized in Table **5.7.-2**.

Table 5.7-2. The capability of OPTI.

Planning-Level Applications	Operation-Level Applications
1. Optimize operation of reservoirs to meet the estuarine flow distribution requirements and supplemental irrigation needs. 2. Simulate inter-basin transfer of flows for environmental restoration. 3. Provide the optimal storage capacity of the reservoirs in the entire watershed.	1. Provided day to day operation support for reservoirs and STA in the watershed to meet the restoration target of the Natural System Model (NSM) flow distribution.

5.6.3 Estuarine Hydrodynamic and Water Quality Models

5.6.3.1 The St. Lucie Estuary 2D Hydrodynamic Model

5.6.3.1.1 Hydrodynamic/Salinity component

To simulate the influence of watershed freshwater inflow on estuarine salinity, a two-dimensional hydrodynamic/salinity model (RMA-2, 4) was developed for the SLE/IRL (Hu, 2000) in 2000. RMA-2 computes water surface elevation and horizontal flow velocity for sub critical, free-surface flow by solving the Reynolds form of the Navior-Stokes equation in a 2 dimensional flow field. RMA-4 simulates the depth-averaged salinity through the advection-diffusion processes in an aquatic environment. The RMA model was calibrated using a wide range of flow conditions with flow, elevation, and salinity data collected throughout the estuary. The model was applied in the IRL PIR by generating a family of dynamic-equilibrium solutions. These solutions were generated for steady inflows and a repeating series of tidal boundary conditions. The dynamic equilibrium simulations were used to develop a utility salinity model. This model considers the salinity transition time and allows for long-term simulation of daily average salinity. The predicted salinity agrees well with measured salinity data.

5.6.3.2 The St. Lucie Estuary 3D Hydrodynamic and Water Quality Model

5.6.3.2.1 Hydrodynamic/Salinity component

A comprehensive 3D estuary hydrodynamic and water quality modeling system has been developed recently to simulate the hydrodynamic/salinity, sediment transport and water quality based on Curvilinear Hydrodynamics 3 Dimensional (CH3D) and Environmental Fluid Dynamics Code (EFDC) frameworks. The CH3D model is a non-orthogonal grid model capable of simulating complicated hydrodynamic processes including wind-driven circulation, density-drive circulation and tidal circulation. The non-orthogonal nature of the model enables CH3D to accurately represent the complex geometry of a meandering river like the North Fork of the SLE. The model contains a robust turbulence closure model for accurate simulation of stratified flows in estuaries and lakes. Recent enhancements of the model include modeling of aquatic vegetation, modeling of moving shoreline and addition of sediment transport and water quality models. The model domain covers the entire estuary including the Southern Indian River Lagoon.

5.6.3.2.2 Sediment Transport component

The presence of fine-grained, organic-rich muck sediments the SLE is considered to have deleterious effects on benthic biological communities and on the overlying water. The fine sediment can be readily resuspended thereby increasing the turbidity of the water. Organic-rich sediments can also support massive bacteria activity which, in turn, promotes decomposition of organic matter and depletion of oxygen in sediments and in the overlying water. The sediment transport model is also necessary for the understanding of the estuary turbidity maximum (ETM), which plays an important role in the nursery function of the Low Salinity Zone in the estuary. Coupled with the hydrodynamic/salinity model, the sediment model can be used to study the location, spatial range, temporal variation of the ETM zone. A sediment transport model based on CH3D-SED is currently being developed to study the transport and fate of fine sediments. The objective of the study is to develop a multi-group, three-dimensional sediment transport model capable of predicting the fate and transport of fine sediments including the pattern and quantity of deposition of sediments carried by freshwater discharge. As a result, a sediment budget will be developed to count for sources and sinks and paths for sediments in the estuary. The transport and fate of sediments are important for issues such as turbidity, light attenuation, and the transport and fate of sediment-associated pollutants.

5.6.3.2.3 Water Quality component

The St. Lucie Estuary water quality model is based on Environmental Fluid Dynamics Code (EFDC). The initial model development by the District was started in 2000. Model calibration was conducted using two-year data collected during 1999 and 2000. Lately, the water quality model was modified to become a standalone water quality model that can be coupled with the CH3D hydrodynamic model. The model is now being extended for multiple-year simulations (1999 to 2007). New data including the observed DO time series and the recently collected current velocity data are being used to further calibrate and verify the water quality model. Since DO and nutrients dynamics are results of complex interactions between physical and chemical/biochemical processes, the model may serve as a tool to identify/confirm and explain the trends as observed by the statistical analysis of the monitoring data. The model can also provide certain terms in a nutrient budget of the estuary.

The capability and water management practice applications of St. Lucie Estuarine models are summarized in **Table 5.7-3**.

Table 5.7-3. The capability and water management practice application for SLE Estuarine models.

Hydrodynamic/Sediment Transport	Water Quality	Water Management Practices
1. Simulate circulation and stratification. 2. Simulate tidal stage and salinity in the entire St. Lucie Estuary. 3. Long-term (41 years) simulation 4. Provide input data for estuarine ecological response model.	1. Simulate nutrient cycling and eutrophication processes including sediment digenesis. 2. Simulate DO dynamics and its interaction with hydrodynamic mixing and eutrophication processes 3. Evaluate estuarine response with anticipated loading reductions.	1. Evaluation of Reservoirs and STAs operation. 2. Evaluation of loading reduction. 3. Location and efficiency of muck removal

5.6.4 Estuarine Ecologic Response Model

The eastern oyster (Crassostrea virginica) was selected as a valued ecosystem component for evaluation of the influence of watershed hydrology on estuarine ecosystem health. An oyster salinity stress model was developed based on available literature data. A hyperbolic cosine function of daily salinity along with a temperature factor is employed in the model. The model calculates oyster stress based on the magnitude and duration of low salinity events (salinity < 12 ppt) induced by freshwater discharge. An annual stress index is obtained to classify the year into one of four categories: No stress, Stress, Harm, and Death. This simple oyster stress model was used in the IRL-PIR for comparison of restoration alternatives. Recent update to this model includes salinity tolerance thresholds for each life stage of oysters i.e., eggs, larvae, spat, and adult. The larval presence from March to May follows egg development from January to April. Spat and juvenile oysters are present from April through July while year class adults are present from June to December. This update allows for evaluation of salinity stress for each of the oyster life stages. The model does not incorporate mortality from predation or increased stress from disease that are associated with low flow high salinity conditions.

5.6.5 Modeling Needs and Recommendations

An integrated modeling approach is recommended to provide the technical support for implementation and adaptive management of the St. Lucie River Watershed Protection Plan. In addition, several modeling needs have been identified to refine or update the existing models described in the previous section. This integrated modeling and resource assessment framework can be applied at different levels of complexity to provide the information required for sound, science-based management. The short term modeling needs for existing modeling tools are discussed below. In the future, a comprehensive modeling framework for the Northern Everglades domain (Kissimmee River and Watershed, Lake Okeechobee and watershed, integrated with St. Lucie and Caloosahatchee River, estuary and watershed) will be evaluated and developed.

5.6.5.1 Watershed Hydrology and Water Quality Modeling Needs

Effective management that aims to protect water quality requires a big picture view of water resources at the watershed-scale. Watershed models provide the necessary links for this purpose, particularly when it comes to understanding how nonpoint sources of pollution interact with point sources, and how these jointly affect the downstream water quality.

Regarding watershed hydrology and water quality simulation, modeling tools are needed which are capable of 1) simulating the hydrologic interaction of the St. Lucie River Watershed with other components of the Northern Everglades Program (Lake Okeechobee and Caloosahatchee River Watersheds); 2) simulating watershed loading, and; 3) optimizing operations and sizing of features. Existing tools include the NERSM, SLE WaSh model (District's version and FDEP TMDL version), and OPTI6 model. The NERSM model can serve as a regional hydrological model to simulate the hydrologic interactions across the Northern Everglades watersheds but would require additional refinements and integration with a water quality component and optimization component. In order to use the SLE WaSh model for simulating watershed loading, the current model would need to be updated to reflect the recent sub-basin delineation and inter-basin transfers. The model would also need to be refined with additional calibration to better simulate nutrient cycling and DO dynamics in major canals. Data collected by the monitoring activities described in Chapter 4 can be used for this purpose. Once these update are completed, the modeling period of record would need to be extended.

5.6.5.2 Estuary Hydrodynamic and Water Quality Modeling Needs

One of the major objectives of the St. Lucie River Watershed Research and Water Quality Monitoring Program is to identify and answer the priority science questions to reduce the uncertainties of the St. Lucie River Watershed Protection Plan. One of the science questions is how the change in the quantity, quality, timing, and distribution of watershed inflows will improve the water quality condition and aquatic habitats in the estuary. The estuary hydrodynamic, water quality and ecological models when integrated with the watershed models, will serve as a critical tool to evaluate the many hydrodynamic and water quality issues such as stratification, nutrient cycling, and DO dynamics in response to the implementation of the St. Lucie River Watershed Protection Plan.

Regarding estuary hydrodynamic and water quality simulation, modeling tools are needed which are capable of 1) simulating the impacts induced by the watershed loading; 2) estuary hydrodynamics; and, 3) estuary water quality processes. Existing tools include SLE-CH3D hydrodynamic and water quality components and a sediment transport model. The CH3D hydrodynamic/salinity model was successfully calibrated and verified with observed tidal and salinity data for the period from 1997 to 2005. The model can be further enhanced by including seasonal groundwater seepage and refining turbulence schemes to better simulate stratification and mixing in the estuary. Since wind-generated waves are considered to be important for sediment resuspension and therefore have significant impact on turbidity, the wind-generated wave impact will be investigated using the sediment transport model. In order to establish a nutrient budget and understand the different pathways of nutrients and hence the impact on ecosystems, the water quality component/model will need to be updated with newly collected data including the benthic fluxes, diurnal DO concentrations, and sediment and turbidity. Calibration and refinements on nutrient cycling process, stratification, DO dynamics need to be made when data is available.

5.6.5.3 Estuarine Ecologic Response Modeling Needs

In addition to oysters in the mid-estuary, another valued ecosystems component in St. Lucie Estuary is the seagrass growing in the Indian River Lagoon near the Inlet. It has been indicated that the seagrass in the area is sensitive to discharges of high flows. Unpublished data also suggest that there is a low flow requirement by fish larvae in the low salinity zone of the estuary. Future efforts in the estuarine ecologic response modeling should simulate the habitats for seagrass, oyster, and fish larvae to represent the entire spectrum of the valued ecosystems in the estuary. These Valued Ecosystems Components may serve as the performance measures for future environmental operation during different climatic and seasonal conditions. To achieve this goal, a set of ecological performance measures representing habitats for fish larvae in the low salinity zone, oyster in the mesohaline zone, and seagrass in the polyhaline zone will be needed by the operation model to direct operation for both the dry season and the wet season. These performance measures will also need to be integrated into an index-type model along with a graphic user interface to aid in future applications. Eventually, a community-level ecological response model should be developed to predict the ecosystem change with the anticipated improvement in the habitats.

5.7 Literature cited

Browder, J.A. and D. Moore. 1981. A New Approach to Determining the Quantitative Relationship between Fishery Production and the Flow of Fresh Water to Estuaries, pp. 403-430 in Cross, R.D. and D.L. Williams, eds. In: Proceedings of the National Symposium on Freshwater Inflow to Estuaries, Volume 1, U.S. Fish and Wildlife Service, U.S. Department of the Interior. FWS/OBS-81/04.

Chamberlain, R. and D. Hayward. 1996. Evaluation of water quality and monitoring in the St. Lucie Estuary, Florida. Water Resources Bulletin 32: 681-696.

Chesapeake Bay Program and IAN 2005. Chesapeake Bay Environmental Models.

Cornwell, J., M. Owen, T. Kana, E. Baily and W. Boynton. 2008. An Assessment of Processes Controlling Benthic Nutrient Fluxes in the Caloosahatchee River and Estuary and the St. Lucie River and Estuary. Draft Report prepared for the South Florida Water Management District. Purchase Order 4500019243. pp. 56.

Cushing, D.H. 1990. Plankton production and year class strength in fish populations: an update of the match and mismatch hypothesis. Adv. Mar. Biol. 26: 249-389.

Day, J.W., Jr., C.A.S. Hall, W.M. Kemp and A. Yanez-Arancibia. 1989. Estuarine Ecology. John Wiley and Sons, New York. 558 pp.

DiDonato, G.T., E.M. Lores, M.C. Murrell, L.M. Smith and J.M. Caffrey. 2006. Benthic Nutrient Flux in a Small Estuary in Northwestern Florida. Gulf Caribb. Res. 18(March): 15:25.

Doering, P.H. 1996. Temporal variability of water quality in the St. Lucie estuary, South Florida. Water Resources Bulletin 32: 1293-1306.

Fisher, T.R., Harding, L.W. Jr., Stanley, D.W., Ward, L.G. (1988). Phytoplankton, nutrients and turbidity in the Chesapeake, Delaware, and Hudson estuaries. Est. Coast. Shelf Sci. **27**: 61-93

Gray, J.S. 1992. Biological and ecological effects of marine pollutants and their detection. Mar. Pollut. Bull. 25: 48-50.

Holmes, R.M., B.J. Peterson, L.A. Deegan, J.E. Hughes and B. Fry. 2000 Nitrogen biogeochemistry in the oligohaline zone of a New England Estuary. Ecology 81:416-432.

Howes, B., D. Schelzinger, and R. Samimy. 2008. The Characterization and Quantification of Benthic Nutrient Fluxes in the Caloosahatchee River and Estuary. A Draft Project Summary Report Prepared for the South Florida Water Management District, Purchase Order 4500019232. pp. 51.

Livingston, R.J., X. Niu, F.G. Lewis, III and G.C. Woodsum. 1997. Freshwater Input to a Gulf Estuary: Long-Term Control of Trophic Organization. *Ecological Applications*, 7: 277-299.

Loneragan, Neil R. and S. E. Bunn 1999. River flows and estuarine ecosystems: implications for coaastal fiskeries a review and a case study of the Logan River, southeast queensland. Australian Journal of Ecology 24: 431-440.

Montagna, P.A. and R.D. Kalke. 1992. The Effect of Freshwater Inflow on Meiofaunal and Macrofaunal Populations in the Guadalupe and Nueces Estuaries, Texas. *Estuaries,* 15: 307-326.

Nixon, S.W. 1988. Physical Energy Inputs and the Comparative Ecology of Lake and Marine Ecosystems. *Limnology and Oceanography*, 33: 2: 1005-1025.

Nixon, S.W., S.L. Granger and B.L. Nowicki. 1995. An assessment of the annual mass balance of carbon, nitrogen and phosphorous in Narragansett Bay. Biogeochemistry 31: 15-61.

Nixon, S.W., C.A. Oviatt, J. Frithsen and B. Sullivan. 1986. Nutrients and the Productivity of Estuarine and Coastal Marine Ecosystems. *J. Limnol. Soc., South Africa*, 12 (1/2): 43-71.

North, E.W., E.D. Houde, 2003, Linking ETM physics, zooplankton prey, and fish early-life histories to striped bas *Morone saxatilis* and white perch *M. americana* recruitment, *Marine Ecology Progress Series*, 260, pp. 219-236.

Peebles, E.B, J.R. Hall, and S.G. Tolley, 1996, Egg production by the bay anchovy *Anchoa mitchilli* in relation to adult and larval fields, *Marine Ecology Progress Series* 131, 61-73.

Peterson, M. S. 2003. A conceptual view of environmental-habitat-productiion linkages in tidal river estuaries. Reviews in Fisheries Science 11(4): 291-313.

Roman, M., X. Zhang, C. McGilliard, W. Boicourt, 2005, Seasonal and annual variability in the spatial patterns of plankton biomass in Chesapeake Bay, Limnology and Oceanography, 50(2), pp. 480-492.

Seitzinger, S. P., Sanders, R.W. and R. Styles 2002. Bioavailability of DON from natural and anthropogenic sources to estuarine plankton. Limnol. and Oceanogr. 47: 353-366.

Smith, V. H., G. D. Tilman and J. C. Nekola 1999. Eutrophication impacts of excess nutrient inputs on freshwater, marine, and terrestrial ecosystems. Environmental Pollution 100: 1790196.

Smith, V.H., S.B. Joye and R.W. Howarth 2006. Eutrophication of freshwater and marine systems. Limnol . and Oceanogr. 51 351-355.

Turner, R.E. 2006. Will Lowering Estuarine Salinity Increase Gulf of Mexico Oyster Landings? *Estuaries and Coasts*, 29: 345-352

Wan, Y., K. Konyha and S. Sculley. 2002. An Integrated Modeling Approach for Coastal Ecosystems Restoration. Proceeding of the Second Inter-Agency Hydrologic Modeling Conference, July 28-August 1, 2002, Las Vegas, NV, p. 13.

Wan, Y., C. Reed, and E. Roaza. 2003. Modeling watersheds with high groundwater tables and dense drainage canals. Proceeding of 2003 AWRA International Congress: Watershed Management for Water Supply. June 29 - July 2, 2003, New York, p10.

Wan, Y., J.W. Labadie, K.D. Konyha and T. Conboy. 2006. Optimization of Frequency Distribution of Freshwater Inflows for Coastal Ecosystem Restoration. *ASCE J. Water Resources Planning and Management*, 132: 320-329.

Wilbur, D.H., 1992. Associations between Freshwater Inflows and Oyster Productivity in Apalachicola Bay, Florida. *Est. Coast. Shelf Science*, 35: 179-190.

APPENDIX F

PLAN OPERATIONS & MAINTENANCE, PERMITTING, AND MONITORING

1.0 PLAN OPERATIONS & MAINTENANCE, PERMITTING, AND MONITORING

1.1 Operations & Maintenance

With very few exceptions, the majority of projects features included in the Plan are likely to require some level of operation and maintenance (O&M). Consideration of operations and maintenance needs from the outset of planning is important to insuring that the project goals and objectives are achieved in the most efficient, effective, and safe manner. The term "operations and maintenance" collectively refers to the following five major elements:

- **Operations** – ongoing activities required to operate the management measure to achieve the project objectives – includes water control, fuels and materials, monitoring, etc.

- **Maintenance** – ongoing activities required to maintain system in an operable condition – includes machinery maintenance, mowing, inspections, etc.

- **Repair** – periodic repair of machinery or other structural elements as needed to restore complete operability of the management measure – includes machinery repair, filling scour holes, repairing erosion, etc.

- **Replacement** – periodic replacement of project elements that have reached or exceeded their functional life – includes pump replacement, stop-log riser replacement, etc.

- **Rehabilitation** – major rehabilitation of a project component may be required under the following circumstances:

  - When the component has exceeded its functional life and continued repair and replacement activities are no longer cost effective,
  - When there are substantive changes in conditions at the facility or associated components of the water management system that preclude meeting the project objectives or result in other undesirable impacts, or
  - Changes in design or safety standards.

Funding and labor requirements for O&M can vary dramatically, depending on the type of management measure and its physical setting. For example, a wetland restoration element that is composed of a fixed crest weir constructed in an existing stream to flood the wetland during wet conditions might require very little O&M beyond periodic inspections. On the other hand, a wetland restoration project that calls for pumped inflows to an area impounded by levees or berms with a water control structure to manage water levels might require substantial funding and labor resources for O&M.

As a result, O&M requirements cannot be fully determined until a significant level of design has been completed for elements of the Plan.

General O&M requirements for different types of project features are described below. Note that O&M requirements will have to be tailored for each individual facility based on site-specific conditions and project objectives.

1.1.1 Reservoirs O&M Requirements

Operations – Hydrologic, water quality, and meteorologic data is monitored to guide water control operations. In many cases, water control operations are performed remotely from the SFWMD headquarters. Where remote operational capability does not exist, field personnel perform gate changes and other water control activities based on guidance from SFWMD headquarters. Operational activities are required on an ongoing basis to provide proper inflows, water control in the reservoir, and discharges. This includes operation of pump stations, water control structures, and culverts. Costs include hired labor, fuel, and materials. Inflow pump stations require a particularly high level of operational activities and associated costs. Power costs for pump stations can be a large part of O&M.

Maintenance – The O&M Manual will establish preventative maintenance requirements for machinery at pump stations, water control structures, and culverts. These activities will include inspections, lubrication, cleaning, etc. Regular inspections of levees and channels are required to identify scouring or erosion problems. Periodic mowing of levees is also required.

Repair – Even with proper maintenance, occasional repairs will be necessary. The types of repairs that might be necessary for operation of a reservoir include machinery repair, levee erosion, channel scouring, etc.

Replacement – Pump motors, bearings, stop logs, etc., will require eventual replacement when the frequency and/or the nature of required repairs becomes cost prohibitive or unsafe.

Rehabilitation – Levees and canals will be designed and constructed to be functional indefinitely. Major rehabilitation to levees and canals should only be necessary if there is a significant change in design and/or safety standards, such as changes that occurred following the New Orleans levee failures caused by Hurricane Katrina. The most significant long-term requirements for major rehabilitation will be for the inflow pump stations.

1.1.2 STAs O&M Requirements

Operations – Water control operations for STAs require careful maintenance of water levels and flows to optimize TP reduction performance. Moreover, STAs are typically composed of multiple cells and/or treatment chains. Each individual STA cell will require control of water levels and flows. Monitoring of hydrologic, water quality, and meteorological data is performed to guide water control operations. In many cases, water control operations are performed remotely from the SFWMD headquarters. Where remote operational capability does not exist, field personnel perform gate changes and other water control activities based on guidance from SFWMD headquarters. Water control operations will include operation of pump stations, water control structures, and culverts. Costs include hired labor, fuel, and materials. Inflow pump stations require a particularly high level of operational activities and associated costs. Power costs for pump stations can be a large part of O&M.

Maintenance – Relative to reservoirs, the increased infrastructure (levees, canals, water control structures, culverts, etc) associated with STAs will generally require a greater level of effort for maintenance. The O&M Manual will establish preventative maintenance requirements for machinery at pump stations, water control structures, and culverts. These activities will include inspections, lubrication, cleaning, etc. Regular inspections of levees and channels are required to identify scouring or erosion problems. Periodic mowing of levees is also required. Within the STA cells, some reshaping of the bottom or levee modifications may be necessary after long periods of operation, due to the soil accretion. Soil accretion in the STAs may create non-uniform depths and flows that could reduce TP reduction efficiency. Additionally, soil accretion may require levee modifications to prevent overtopping.

Repair – Even with proper maintenance, occasional repairs will be necessary. The types of repairs that might be necessary for operation of an STA include machinery repair, levee erosion, channel shoaling or scouring, etc.

Replacement – Relative to reservoirs, the increased infrastructure (levees, canals, water control structures, culverts, etc) associated with STAs will generally require a greater level of effort for repairs. Pump motors, bearings, stop logs, etc., will require eventual replacement when the frequency and/or the nature of required repairs becomes cost prohibitive or unsafe.

Rehabilitation – Relative to reservoirs, the increased infrastructure (levees, canals, water control structures, culverts, etc) associated with STAs will generally require a greater level of effort for rehabilitation. Levees and canals will be designed and constructed to be functional indefinitely. Major rehabilitation to levees and canals is unlikely at an STA. The most significant long-term requirement for major rehabilitation will be for the inflow pump stations.

1.1.3 Wetland Restoration Project O&M Requirements

Operations – In general, wetland restoration projects are designed to be low maintenance, passive systems. A wetland restoration project that consists of simply plugging an existing drainage ditch may require virtually no operational activities beyond periodic inspections. Projects that involve berms or levees to protect adjacent land and downstream control structures will require additional operation activities. Hydrologic data would be collected and used to guide water control operations of the downstream control structure. Periodic inspections of the berms or levees would be required. For wetland restoration projects that include pump stations and conveyance canals, labor, fuel, and materials will be required for operations.

Maintenance – For passive wetland restoration projects, maintenance requirements may be negligible. However, for those projects that contain mechanical components (pumps or control structures) maintenance will be required. Mowing levees would be required.

Repair – For passive wetland restoration projects, repairs would be limited to potentially correcting erosion or scouring problems. For projects that involve mechanical components, such as pumps or control structures, there would be an increased need for repair. Erosion or sedimentation problems may be required.

Replacement – For passive wetland restoration projects, replacement requirements would be negligible. For projects that involve mechanical components, repairs will be necessary – even with proper maintenance.

Rehabilitation – For passive wetland restoration projects, there will be no need for rehabilitation. For projects that involve mechanical components such as pumps or control structures, major rehabilitation will be required.

1.1.4 O&M Requirements for BMPs

The components of BMPs are quite diverse. Some BMPs (feeding practices, fertilization, crop rotation, etc.) are entirely operational in their nature. Virtually all BMPs have some element of O&M that is required to insure that the objectives are being met. However, because the number and diversity of BMPs are so great, it is beyond the scope of this document to summarize these BMP O&M requirements.

1.1.5 O&M Requirements for Alternative Water Storage Facilities

Operations – Operational requirements for these projects will vary as a result of the variation in infrastructure required for each individual project. At one extreme, the operational requirements will be the same as a reservoir. At the other extreme, the project feature may be limited to a sheet pile weir constructed in an existing channel to retain floodwater runoff. In other cases, berms or levees or existing agricultural pump stations may require maintenance. Water control operations would be driven by onsite water elevations so that adverse flood impacts to adjacent areas would be avoided.

Maintenance – Maintenance requirements would vary with the extent of infrastructure involved in each individual project. Normal maintenance activities would involve periodic inspections of levees, ditches, and water control structures. If pumps are used, maintenance would include compliance with the O&M Manual or manufacturer's guidelines.

Repair – In most cases, repairs would be minimal. However, when pump stations are included, repairing mechanical components would be necessary.

Replacement – With the exceptions of pump stations, requirements for replacement should be negligible.

Rehabilitation – With the exception of pump stations, major rehabilitation requirements should be minimal.

1.2 Permitting

Construction and implementation of the Plan features will require a variety of permits and regulatory approvals. Types of permits and approvals needed are likely to vary with feature type and location.

Obtaining all required federal, state, and local permits for implementation and operation of a project often requires an intensive level of effort. Permitting can result in significant project delays if it is not adequately considered early in project development. However, specific permit requirements and/or issues may not be evident until a substantial level of detail has been developed during planning and design.

The types of permits and level of effort required during the permitting process may vary greatly for similar or identical measures, depending on the physical conditions that exist at the project site and surrounding area. During the PD&E process, continuing consideration will be given to the types of permits required and the potential permitting issues that must be addressed. In this way, the level of effort and time requirements can be factored into the planning and design process to minimize the potential for significant permit-related project delays.

Federal and state permits that are likely to be required for the types of project features contained in the Plan are described below. Local permit requirements will vary from site to site and will have to be addressed on a site-specific basis.

1.2.1 Federal Permits

- **Section 404 Dredge and Fill Permit –** This permit is required by the Clean Water Act of 1972, as amended, and is administered by the U.S. Army Corps of Engineers. A Section 404 Permit is required prior to discharging dredged or fill material into the waters of the United States. Waters of the United States (33 CFR Part 328) include essentially all surface waters, including all navigable waters and their tributaries, all interstate waters and their tributaries, all impoundments of these waters, all wetlands adjacent to these waters, and certain isolated wetlands.

  The term "wetlands" means those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. A number of federal requirements are addressed during the permitting process under Section 404. These include the following:

- **National Environmental Policy Act (NEPA) of 1969 –** This law requires federal agencies to study and consider the environmental impacts of their proposed actions. For actions that do not have any significant impact on the human environment, preparation of an Environmental Assessment (EA) is required. For projects that will have a significant impact, preparation of an Environmental Impact Statement (EIS) is required.

- **Coastal Zone Management Act –** The federal consistency requirement of the CZMA (Section 307) requires that federal actions (including permit approvals) that are likely to affect any land or water in the coastal zone (within 3 miles landward or seaward of the coast) must be consistent with the state's coastal management program.

- **Endangered Species Act –** The Endangered Species Act (ESA) requires that permit applicants take no action that might adversely affect certain listed species. In addition, species that are under stress may become listed species if adverse impacts continue to their population or habitat. To help ensure that permitted projects do not contribute to further endangerment of a species, it may be required to modify or condition a permit where a species of concern is present.

- **Magnuson-Stevens Fishery Management Act and Essential Fish Habitat –** This act requires that actions minimize, to the extent practicable, the adverse effects of fishing on essential fish habitat, and identify other measures to promote the conservation and enhancement of essential fish habitat. Coordination with the National Marine Fisheries Service (NMFS) is required.

- **National Historic Act –** If the proposed activity would involve any property listed or eligible for listing in the National Register of Historic Places, coordination with the State Historic Preservation Officer will be required to determine the required course of action.

- **Section 401 Certification –** Issuance of a 404 Permit requires that water quality certification (Section 401 of the Clean Water Act) be obtained by the applicant or waived by the regulatory agency. In Florida, authority for water quality certification has been delegated to the Florida Department of Environmental Protection (FDEP).

• **Section 10 Permit –** This permit is required by the Rivers and Harbors Act of 1899 and is administered by the U.S. Army Corps of Engineers. Approval of a Section 10 Permit is required prior to any work in, over, or under navigable waters of the United States, or which affects the course, location, condition or capacity of such waters. Processing Section 10 Permit applications is generally subject to the same procedures and requirements as the Section 404 Permits. Applications under Sections 10 and 404 are processed together. For the purpose of a Section 10 permit, navigable waters (33 CFR Part 329) are defined as waters that have been used in the past, are now used, or are susceptible to use as a means to transport interstate or foreign commerce up to the head of navigation.

- **Corps of Engineers Consent to Easement Permit –** A Consent to Easement Permit will be required for any action that requires access to, or modification of, Corps of Engineers' right of way for works of the Central and Southern Florida (C&SF) Project.

- **US Coast Guard Approvals –** In general, if a proposed project impacts a bridge or a navigation aide in a navigable waterway of the U.S., then Coast Guard approval will be required.

- **Federal Aviation Administration Guidelines –** Construction of Plan project features in the vicinity of public airports would potentially require compliance with two FAA guidelines:

  - Unsafe wildlife attractants near public airports, and
  - Obstructions to navigable airspace.

  Construction of facilities that might attract wildlife that would create unsafe conditions for landings and take-offs would be performed only beyond specified distances from the airport boundary. The specified distances vary based on the airport capacity. To ensure compliance with this guideline, management measure sites closer than 10,000 ft from any airport were eliminated from consideration. FAA notification of an obstruction to navigable airspace is required by law for construction that would penetrate an imaginary plane that rises 1 foot vertically for every 100 ft of horizontal distance from the runway.

1.2.2 State Permits

- **Environmental Resource Permits –** An Environmental Resource Permit (ERP) is required before beginning any construction activity that would affect wetlands, alter surface water flows, or contribute to water pollution. The permitting program is authorized by Part IV of Chapter 373, F.S. The ERP process is administered by the SFWMD. However, for an action proposed to be implemented by SFWMD, FDEP administers the permitting process. Exemptions from the requirement to obtain ERP permits are authorized for implementation of many agricultural BMPs. Environmental Resource Permits are recognized by the U.S. Army Corps of Engineers as water quality certification for Section 404 Permits. A joint ERP and 404 permit application is used, and the state and federal review processes proceed in parallel.

  The Comprehensive Everglades Restoration Plan Regulation Act (CERPRA) was enacted by the Florida legislature (Chapter 373.1502 F.S.) for the purpose of providing efficient and effective permitting of CERP project components. CERPRA permits are in lieu of all other permits required in Chapters 373 and 403, except for permits that are under any delegated authority. For elements of the Plan that are included in CERP, the CERPRA permit would take the place of the ERP.

- **National Pollution Discharge Elimination System Stormwater Permitting Program –** Federal law prohibits the point source discharge of pollutants to the waters of the United States without a National Pollution Discharge Elimination System (NPDES) Permit. The U.S. Environmental Protection Agency (USEPA) has delegated authority to FDEP to implement the NPDES stormwater permitting program in the State of Florida.

  - **Stormwater Pollution Protection Plan –** This program regulates point source discharges of stormwater runoff from large (> 5 ac) and small (between 1 and 5 ac) construction sites. The applicant must implement appropriate pollution prevention techniques to minimize erosion and sedimentation and properly manage stormwater.

- **Title V Air Quality Permit –** These permits are required by the Clean Air Act. Administration has been delegated by the USEPA to FDEP. Permits are required for construction and operation. The extent of required permitting varies with the magnitude of the impact of the proposed action.

- **Dewatering Water Use Permit –** The SFWMD manages the water use permitting process within its boundaries under authority of Chapter 373, State Statutes, 40E-20 F.A.C. A water use permit allows a user to withdraw a specified amount of water, either from the ground, a canal, a lake, or a river. The water can be used for a public water supply; to irrigate crops, nursery plants or golf courses; or for industrial processes. Short-term dewatering required during the construction of elements of the Plan would also require a water use permit. For features being constructed by the SFWMD, the permit application would be processed by FDEP.

1.2.3 Permitting Issues

Key permitting issues likely to be encountered during permitting of STA and Reservoir Plan features are described in **Table 1.2-1** below. Many of the other Plan features may encounter similar permitting issues.

Table 1.2-1 Key Permitting Issues

Land Requirements SFWMD needs to demonstrate ownership of lands prior to obtaining federal and state permits	Lands will have to be purchased prior to applying for 404 and 373.1502 permits.
Existing Permits Projects that are currently permitted within the proposed project footprints will have to be researched. Such existing permitting requirements, if any, may impact design criteria	Research existing permits for within proposed project footprints and if applicable, identify owners/operators of permitted projects.
Federally Listed Threatened & Endangered (T&E) Species	Many federally listed plant and animal species exist in the St. Lucie River Watershed and Estuary. Information on occurrence of T&E species within proposed project footprints and specific project affected regions will have to be determined. This information will help determine species that will be impacted, mitigation strategies, construction schedules, design criteria, management protocols, etc. Biological surveys will have to be conducted at all sites proposed for locating Plan features that are not already permitted.
State Listed T&E Species	Information on occurrence of T&E species within proposed project footprints will have to be determined. This information will help determine species that will be impacted, mitigation strategies, construction schedules, design criteria, management protocols, etc. Biological surveys will have to be conducted at all sites proposed for locating Plan features that are not already permitted.
Water Resources	Proposed projects that directly impact the C-44 Canal and the St. Lucie River may require U.S. Coast Guard navigation permit in accordance with ***23 CFR 650, Subpart H.***
Transportation and Other Infrastructures Coordination with agencies such as FDOT, FP&L, airports, cell towers, railroad crossings, etc. may be required.	Determine likely impact of proposed project features on existing transportation and other infrastructure. This information will be needed for design criteria, easement access, right-of-ways, etc.

Table 1.2-1 Continued

Archaeological/Historical Resources Numerous pre-Columbian and post-Columbian archaeological sites, as well as a large number of historic structures and districts, have been recorded at various locations in the St. Lucie River Watershed.	Cultural resource surveys will have to be conducted within all proposed project feature footprints. If such sites are present, it may impact design and probably also require monitoring during construction.
Wetlands/Uplands Presence of jurisdictional wetlands (JD) within proposed project footprints will have to be addressed.	Extent of jurisdictional wetlands (JD) within proposed project footprints will have to be determined. This information is needed to determine federal and state JD impacts. UMAM analysis will need to be conducted to evaluate existing functional values and determine compensatory mitigation for these impacts.
Contamination Presence of contaminants within project footprints will have to be determined and appropriately addressed.	Phase 1 assessment will be required for all proposed project footprints. This information is needed to determine potential contamination that may require corrective actions/ remediation; and, their impacts to endangered species such as the snail kite.
Geotechnical Information This information will help in understanding the soil composition within the project footprints (i.e. if soils would need to dry out prior to use for construction, if soil materials can be used or need to be hauled offsite, etc.). The information will also assist in design of the various features, determining blasting protocols for endangered species, and establishing road traffic and safety protocols	Soil profiles for seepage, embankment materials, ability to retain water, etc. will have to be developed.
Pump Type Benefits of diesel vs. electric pumps will have to be evaluated.	If a diesel pump is selected, and depending on its size, a Title V Air Permit may be required.
Water Quality	Effluent discharge will have to meet water quality standards and avoid impacts to downstream water bodies and ecological health of the natural system.

1.3 Monitoring

Monitoring is required to determine if individual project features within the plan are performing as intended. A comprehensive monitoring and information system will be utilized to provide the data necessary to measure the performance and effectiveness of planned projects in meeting restoration goals and objectives of the subject plan. SFWMD will utilize the existing water quality monitoring information, in addition to monitoring proposed in the St. Lucie River Watershed Research and Water Quality Monitoring Plan. This monitoring will provide project specific measurements needed to document the effectiveness of nutrient control efforts in meeting any future St. Lucie River Watershed TMDLs, once established, and to assure future compliance.

Monitoring requirements for individual regional projects (STA, reservoirs) are established during the permitting process to ensure that there is a water quality improvement as a result of the facility. Therefore, specific monitoring requirements (parameters, frequency, and locations) for regional Level 1 and 2 features have already been permitted and the information is available. Water quality information is not available for local Level 1 and 2 projects (stormwater retrofits, Ag and urban BMPs and permitted ERP projects) as a presumption of compliance is given based on implementation of water quality and quantity BMPs or facilities. No information is currently available for water quality monitoring associated with Level 3, 4, and 5 features. However, since the two primary objectives of the Plan are storage and water quality improvements, it can be expected that performance of all structural and non-structural project features included in the Plan will have to be monitored for flow and phosphorus and nitrogen load reductions. Project-level assessment will also focus on estimating the performances of both regional projects (i.e. STAs) and local projects (i.e. stormwater retrofits) located throughout the St. Lucie River Watershed. Results of the project-level assessment will provide important water quality reduction information including the assessment of the size of the sub-watershed vs. the size of the treatment facility, residence time/pollution removal efficiencies and will assist in evaluating specific nutrient reductions from different types of treatment systems. The overall temporal performance (life cycle) of these facilities over time will also be estimated through this effort. This information will ultimately be used in the adaptive management process to improve the overall performance of treatment facilities of various sizes (i.e. regional and local scale). In addition, safety monitoring will be required for features such as reservoirs and STAs.

To ensure the overall efficiencies of implemented BMPs, periodic inspections and monitoring will need to be conducted to determine if expected BMP performances are achieved. The Plan also recognizes and recommends a SFWMD-sponsored source control monitoring program, which is under development. At the sub-watershed level, monitoring activities associated with this new program will assess the collective success of pollutant source control BMPs, compliance with pollution reduction targets, and the need for additional BMPs or optimization of existing BMPs. At the local level, it will identify priority areas of water quality concern such as those with elevated non-point source loading (i.e. hot spots) and provide data to enhance performance of downstream treatment facilities.

Known monitoring requirements for the more common types of features included in the Plan are described below:

Reservoirs – Reservoirs that have been previously permitted in South Florida are required to monitor some or all of the following parameters: water level, discharge through spillways and outlet works, DO, nutrients, rainfall, water quality, algae blooms and vegetation changes, sediment in reservoir, downstream sediment, and concrete safety (horizontal alignment, vertical deflection, variations in foundation). The majority of the monitoring is to be conducted at locations within the reservoir and at the discharge point. Frequency of monitoring varies depending upon the parameter.

STAs – Water quality monitoring permitting required at recently permitted STAs includes parameters such as total phosphorus, mercury (total and methyl), vegetation, temperature, specific conductance, DO, pH, total nitrogen, and sulfates. Monitoring is typically conducted at inflow and outflow locations; some internal stations may also be monitored to provide data for performance optimization. Monitoring is generally conducted weekly or bi-weekly.

APPENDIX G

POTENTIAL FUNDING SOURCES

Potential Funding Sources

Program	Purpose
FEDERAL	
U.S. Army Corps of Engineers	
Comprehensive Everglades Restoration Plan	CERP Projects are eligible for 50:50 cost sharing per WRDA, 2000.
Small Navigation Projects	To provide the most practicable and economic means of fulfilling the needs of general navigation, through projects not specifically authorized by Congress.
U.S. Department of the Interior - federal land acquisition programs	
Land and Water Conservation Fund – Federal Land Acquisition	Acquisition for various federal agencies [U.S. Fish and Wildlife Service (USFWS), National Park Service, Bureau of Land Management, and Forest Service].
Migratory Bird Conservation Fund (USFWS)	Receipts in this account allow the USFWS to acquire important migratory breeding areas, migration resting places, and wintering areas. Areas acquired become part of the refuge system.
Grant programs strictly for land acquisition by non-Federal entities	
Cooperative Endangered Species Conservation Fund Act Program (USFWS)	To provide grants to states for Recovery Land Acquisition. (There is additional funding for Habitat Conservation Fund Land Acquisition Grants.)
Grant programs that may be used for land acquisition and other purposes by non-Federal agencies	
State and Tribal Wildlife Grants (USFWS)	To help states and tribes implement comprehensive wildlife conservation plans and activities.
Land and Water Conservation Fund State Grant Program (National Park Service)	To provide matching grants to states and local governments for the acquisition and development of public outdoor recreation areas and facilities.
Sport Fish Restoration – Grants to States (USFWS)	To provide funding for fisheries recreation and conservation efforts in the United States. Non-competitive apportionment-based program.
Federal Aid and Wildlife Restoration – Grants to States	This program apportions funds to states and territories for use in restoring and protecting wildlife.
Grant programs that may be used for land acquisition and other purposes by federal and non-federal agencies	
North American Wetlands Conservation Act (USFWS)	May fund the acquisition of habitat for waterfowl and migrating birds in support of the North American Waterfowl Management Plan.
Sport Fish Restoration --Coastal Wetlands Grants (USFWS)	To acquire, restore and enhance wetlands in coastal states (FDEP/Nature Conservancy used this program for a project in Hendry Creek to buffer Estero Bay).
Federal Aid Wetlands Conservation (USFWS)	May fund the acquisition of habitat for waterfowl and migrating birds in support of the North American Waterfowl Management Plan.
Other partnership programs supporting non-land acquisition conservation activities	
Private Stewardship Grants Program (USFWS)	To provide grants for on-the-ground conservation projects on private lands benefiting federally listed, threatened, endangered species or other at-risk species.

Program	Purpose
Landowner Incentive Program (USFWS)	Establish or supplement existing landowner incentive programs that provide technical or financial assistance, including habitat protection and restoration, to private landowners to benefit species at risk.
Partners for Fish and Wildlife Program (USFWS)	To provide assistance to landowners to voluntarily restore wetlands, streams, grasslands, woodlands, and other important habitat that support fish and wildlife.
Coastal Program	To work with coastal communities and other partners to focus and leverage resources on high-priority coastal habitat issues by providing important technical and financial support to our existing and new partners, including the Everglades/South Florida Ecosystem.
National Park Service Challenge Cost Share	To increase the participation of neighboring communities and qualified partners in preserving and improving the cultural, natural, and recreational resources for which the National Park Service is responsible.
USFWS Challenge Cost Share	Foster innovative and creative cooperative efforts to restore natural resources and establish or expand wildlife habitat, with an emphasis on federal lands and resources.
Bureau of Land Management Challenge Cost Share	To leverage federal dollars with private and state funding for conservation efforts, benefiting resources on Bureau of Land Management administered public lands. The program solicits partnerships and partnership funding through a variety of resource management programs, including fisheries, wildlife, threatened and endangered species, cultural resources and recreation.
U.S. Department of Transportation	
National Scenic Byways Program	To provide grants in support of eligible projects, including protection of natural resources in an area adjacent to a scenic byway.
Federal Lands Highway Program	To provide funds for eligible projects to include acquisition of necessary scenic easements and scenic or historic sites.
High Priority Projects	To support member priority projects.
Transportation Enhancements	To provide reimbursement for 12 eligible activities that enhance the transportation experience, including acquisition of scenic easements and sites.
U.S. Department of Agriculture	
Conservation Reserve Enhancement Program	To remove marginal agricultural lands from production and establish conservation practices to improve water quality and create wildlife habitat.
Conservation Innovation Grant	Conservation Innovation Grant (CIG) is a voluntary program intended to stimulate the development and adoption of innovative conservation approaches and technologies while leveraging federal investment in environmental enhancement and protection, in conjunction with agricultural production. Under CIG, Environmental Quality Incentives Program funds are used to award competitive grants to non-Federal governmental or non-governmental organizations, Tribes, or individuals. CIG enables Natural Resources Conservation Service (NRCS) to work with other public and private entities to accelerate technology transfer and adoption of promising technologies and approaches to address some of the nation's most pressing natural resource concerns. CIG will benefit agricultural producers by providing more options for

Program	Purpose
	environmental enhancement and compliance with federal, state, and local regulations. NRCS administers CIG.
Forest Legacy Program	To help states acquire fees or easements for perpetual forest preservation.
Wetlands Reserve Program	To assist landowners in restoring wetlands and wetland functions.
Farm and Ranch Lands Protection Program	To purchase easements on farm and ranch lands that will remain in agricultural production.
Wildlife Habitat Incentives Program	To encourage the creation of high quality wildlife habitats that support wildlife populations on wetland, riparian, upland and aquatic habitat on agricultural lands.
Federal Agriculture Improvement and Reform Act of 1996 (Farm Bill) Section 390	To provide $200 million to the Secretary of the Interior to conduct restoration activities in the Everglades ecosystem in South Florida, including the acquisition of real property.
National Oceanic and Atmospheric Administration	
Coastal and Estuarine Land Conservation Program (CELCP)	To provide matching funds to states to acquire land or easements to protect or restore coastal areas that have considerable conservation, recreation, ecological, or economic value and are threatened by conversion from their natural state to other uses or could be managed or restored to effectively conserve, enhance or restore ecological function.
Other	
Agricultural Water Enhancement Program (AWEP – formally RWEP)	Allows cooperative agreements between Secretary of Agriculture and partners on AWEP activities. Broadens list of eligible activities to include practices to mitigate the effects of drought, including the building of on-farm ponds and reservoirs. Removes priority consideration for projects that include multiple partners and that are most likely to improve the water quantity or quality issue of concern. Does not explicitly include non-governmental organizations (NGOs) as eligible partners. Allows monitoring, but does not require it to be a component of an AWEP project; no priority areas.
STATE	
Florida Forever Program/Board of Trustees (FDEP)	To fund the acquisition and restoration of environmentally sensitive lands and lands to protect water resource development and supply. To increase public access, public lands management and maintenance, and protection of land by acquisition of conservation easements. Florida Forever is the umbrella funding source for the state programs listed below.
Florida Forever Program Water Management Districts (FDEP)	To fund the acquisition of lands and capital project expenditures necessary to implement the water management districts' priority lists; $25 million of the annual Florida Forever allocation to the SFWMD is to be used exclusively for the acquisition of land needed to implement the CERP.
Florida Communities Trust (Department of Community Affairs)	To fund the state's land acquisition grant program for local governments and non-profits to acquire lands that promote outdoor recreation and natural resource protection needs identified in local government comprehensive plans.
Florida Forever Program In-holdings and Additions Programs (FDEP)	To acquire in-holdings and additions to existing conservation lands.

Program	**Purpose**
Florida Greenways and Trails (FDEP)	To fund the statewide initiative to create a system of greenways and trails connecting communities and conservation areas.
Florida Recreation Development Assistance Program (FDEP)	To fund the acquisition or development of land for public outdoor recreation and the acquisition of in-holdings and additions for state parks.
Save Our Everglades Trust Fund (FDEP)	To implement CERP.
Florida's Rural Land Stewardship Program (Department of Community Affairs)	The intent of the program is to direct development of rural lands to preserve agriculture and protect the environment. Local governments designate stewardship areas within their Comprehensive Plans and credits are allocated to individual parcels, based on environmental and other values. The credits are recorded as a covenant or restrictive easement.
Florida Coastal Management Program (FDEP)	To implement 23 statutes that protect and enhance the state's natural, cultural and economic coastal resources, and to coordinate local, state and federal agency activities using existing laws to ensure that Florida's coast is as valuable to future generations as it is today.
Matching Aid to Restore States' Habitat Program (Florida Fish and Wildlife Conservation Commission)	Provides funding to acquire and enhance habitat for waterfowl.
Save Our Rivers (SFWMD)	Enables water management districts to acquire lands necessary for water management, water supply, and the conservation and protection of water resources.
TMDL Water Quality Restoration Grants (FDEP)	The Department receives documentary stamp funding for the implementation of projects (primarily stormwater retrofitting projects undertaken by local governments) to reduce urban non-point source pollution discharged to impaired waters. These funds are restricted to projects that reduce pollutant loadings to waterbodies on the state's verified list of impaired waters or to waterbodies with a FDEP proposed or adopted TMDL.
Florida Section 319 Grant Work Plans and Project Summaries (FDEP)	The Non-point Source Management Section administers grant money it receives from USEPA through Section 319(h) of the Federal Clean Water Act. These grant funds can be used to implement projects or programs that will help to reduce non-point sources of pollution. Projects or programs must be conducted within the state's NPS priority watersheds, which are the state's SWIM watersheds and National Estuary Program waters. All projects must include at least a 40% nonfederal match.
COUNTIES	
Martin County Land Acquisition Program	In November of 2006, Martin County residents approved a ½-cent sales tax to fund future purchases of conservation lands and for improvements to the county parks system. It is estimated that $60 million will be raised over the next five years through the tax, with $30 million going toward land conservation purchases. With agricultural land prices selling at tens of

Program	**Purpose**
	thousands of dollars an acre, even with 50% matching funds from other sources, the ½-cent sales tax dollars can only purchase roughly 2000-2500 acres of land, at best.
St. Lucie County Environmental Lands Program	The St. Lucie County Environmental Lands Program began in 1994 with the passage of a $20 million local bond program and seeks to preserve, protect and restore eco-systems in their natural state while providing compatible public use. As of June 2008, over 7,355 acres have been acquired and more land identified for protection through public acquisition. Funds provided from the $20 million bond are often utilized as a match for federal or state grants.
NON-GOVERNMENTAL ORGANIZATIONS	
National Fish and Wildlife Foundation	To award challenge grants that address priority actions promoting fish and wildlife conservation and the habitats on which they depend; work proactively to involve other conservation and community interests; leverage available funding; and evaluate project outcomes.
The Conservation Fund	To forge partnerships to preserve our nation's outdoor heritage, American's legacy of wildlife habitat, working landscapes and community open space.
The Nature Conservancy (TNC)	To preserve plants, animals and natural communities representing the diversity of life on Earth. TNC works to increase public funding at the local, state and federal level and works with landowners to craft innovative land protection projects.
Trust for Public Lands (TPL)	To help agencies and communities create a vision for conservation, raise funds for conservation and complete conservation real estate transactions. TPL raises public as well as private funds and packages projects to funders and agencies.
Bureau of Land Management Challenge Cost Share	To leverage federal dollars with private and state funding for conservation efforts, benefiting resources on Bureau of Land Management administered public lands. The program solicits partnerships and partnership funding through a variety of resource management programs, including fisheries, wildlife, threatened and endangered species, cultural resources and recreation.

APPENDIX H

AGENCY AND PUBLIC COMMENTS AND RESPONSES

AGENCY AND PUBLIC COMMENTS

Consolidated Citrus, LP

Memo

To: Temperince Morgan

From: Mitch Hutchcraft

CC: Jeff Krieger

Date: October 31, 2008

Re: St. Lucie Watershed Protection Plan – Public Comments on Draft Plan

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It was a pleasure to meet you at the Caloosahatchee River Watershed Protection Plan Public Meeting. As I shared with you at the meeting, my direct concern is related to the SLRWPP, as our company is a significant land owner within the SLRWPP area, and more specifically, the C-44 basin.

I have briefly reviewed the October 2008 DRAFT Plan for the SLRWPP, and would like to submit the following questions/comments:

Lines 32 – 40 of Chapter 1: The plan states, "Achievement of the Preferred Plan benefits is contingent upon implementation of those existing and planned programs and projects that were incorporated."

CC-1

Has the potential impact of the acquisition of the US Sugar property been evaluated against the viability of, and/or timing for the existing and planned programs and projects?

CC-2

It would seem to me that if the Districts' bonding capacity is significantly reduced, those critical projects may be shelved, or at a minimum, significantly delayed. If this is the case, have alternative strategies (potentially including land owner incentives, public private partnerships, payments for environmental services, etc) been considered and identified?

Line 67 – 71 of Chapter 1.2: The plan states, "the St. Lucie watershed has been highly altered since pre-drainage times."

CC-3

Given that much of the area has been highly altered, and that much of that alteration is permanent, we are concerned with the establishment of the new Storm water standards that will require restoration to "pre-development" standards. This requirement seems to be unachievable, un-measurable, and financially prohibitive. Further, it would seem that it would create dramatically different standards for similarly situated projects. For instance, a property that was developed in the 1970s adjacent to a wetland, and its adjacent property that is currently undeveloped. The treatment required for the vacant property to develop would be dramatically different than the treatment required of the already impacted project, even though the one developed in the 1970's is more than likely generating a much greater impact on the environment.

In addition, how can you establish "pre-development" standards, when a.) it is remarkably difficult to determine what those standards were, and b.) it may be physically impossible to restore to those standards as a result of dramatic alterations in flow and water elevation resulting from major man-made impacts like the excavation of the C-44 canal? **CC-3 (cont.)**

Line 116 – 121 of Chp. 1.4: **CC-4**

The plan identifies management measures used to formulate alternatives. Is there a specific list of construction projects, beyond the C-44, that were evaluated for construction within each basin? From reading the available data, I could not determine that the plan identified a need for "X" type of treatment in "Y" basin. This level of information would seem to be very critical not only in developing a future work plan, but for assisting land owners in determining whether this is an opportunity to help collaboratively achieve some of the targeted goals.

Line 81 of Chp. 1.2 **CC-5**

The table illustrates that moderating the "pulses" and pollutant load (particularly nitrogen and phosphorous) are some of the key objectives of the Plan.

Did the plan evaluate "incentive based" solutions for land owners to participate in activities that would result in greater storage during peak flows, or assist in uptake of nutrients? Specifically, has the District evaluated the impact of working with land owners to store more water in currently permitted reservoirs, ditches or on site canals?

If you have, have you evaluated the District's regulatory and permitting standards that currently preclude these types of partnerships, and would either require modification by the District, or open land owners to significant exposure resulting from opening up ERP or CUP permits for modifications, or requiring new permits?

Specifically, a land owner may be willing to install new irrigation systems to increase conservation, reduce runoff and minimize nutrient discharges, however, the District's current regulations would treat this as a permit modification, and may result in the land owner being held to a higher water quality standard, or potentially having their water allocations re-evaluated and re-distributed to meet LOSA MFLs or other reservations. The net result is that unless the District identifies opportunities to achieve incremental enhancements without regulatory penalties, the risk to a land owner may be too great to consider collaborative solutions.

Chapter 1.4.3 **CC-6**

The Plan demonstrates that, while progress is achieved, the targeted goals have not been met in reducing flow occurrences between 2,000 and 3,000 cfs, flow occurrences in excess of 3,000 cfs, and the desired nitrogen levels.

Given that these targets are still not met, and that lack of funding to implement other "considered" projects may result a greater delta between realized results and desired results; has the District evaluated alternative strategies, funding methodologies, collaborative partnerships (projects or private mitigation banks), or other project types that would help bridge the gap?

Line 303 – 307 of Chp. 1.5: **CC-7**

The plan repeatedly emphasizes the importance of BMP in achieving the targeted goals established by the plan. Historically, funding of BMPs has been a challenge, and without adequate funding of BMPs, the success of the plan may be jeopardized. Has the district prioritized the funding of the plan, and ensured that the BMP funding will be secured?

Line 262-263 of Chp. 1.4.4: The plan states, “The major focus of management measures implemented for nutrient reductions in the watershed is phosphorus treatment.” A significant tool in reducing nutrient loading, as well as managing discharge, is the use of Low Impact Design (LID). However, many of these techniques are not given credited by the District as a project goes through permitting. Has the District considered how the LID techniques will be incentivized during the permitting process so that developers will be more willing to implement them as part of their project design? **CC-8**

From: GRAY, Paul [mailto:pgray@audubon.org]
Sent: Friday, October 31, 2008 3:15 PM
To: Balci, Pinar
Cc: Unsell, David; Gray, Susan; DRAPER, Eric; WEISBLUM, Jacqueline
Subject: St. Lucie plan comment

Dear Pinar,

It was nice talking with you at the WFF FRESP field day.

AUD-1

As you know, I was not closely involved in the draft St. Lucie Watershed Protection Plan and cannot submit detailed comments on it, but I'm submitting one thought that is related to an outstanding concern Audubon had with the IRL-S CERP component, that to my knowledge is not addressed in this draft St. Lucie Plan.

Basically, the IRL-S project projected flowing about 17 metric tons of phosphorus into Lake Okeechobee from the C-44 watershed, through the S-308 structure. This constitutes about 16% of Lake Okeechobee's entire TMDL load. Even though the recently-adopted Lake Okeechobee Operating Permit allows this amount, our concern is that this is more phosphorus than this watershed should have, by proportion.

Table 2-1 from the 2002 Lake Okeechobee SWIM Plan shows the lake receiving an average of 1,995,291 acre-feet of total inflow between 1990-94, with 89,043 acre-feet from the S-308 structure. Thus the C-44 basin contributed 4.4% of total inflows. Similarly, Table 2-2 shows the lake receiving an average of 2,292,870 acre-feet from 1995-2000, with S-308 contributing 34,134 acre-feet, 1.5% of total inflows.

Therefore we have a basin that puts about 1.5 to 4.5 % of total inflows to the lake (depending on which period of record and what lake operating schedule is used), but is allocated 16% of the TMDL. Other basins now will have to be held to stricter standards because of this inequity in allocation, and P control responsibility. Audubon recommended that more STAs, or similar treatment capabilities, be placed along the C-44 to clean the water to a more proportional level of P input.

Audubon requests that this issue be specifically identified in your report as an issue to receive further attention, and hopefully correction, as more refined plans are made in future of St. Lucie restoration efforts (i.e., the procedural progression on page 1-19 of the St. Lucie report could include this issue).

Thank you for considering this request and I look forward to working with you on these issues in the future.

Paul

PS And if this was addressed in your plan and I did not find it, please let me know…thanks

Paul N. Gray, Ph.D., Science Coordinator
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10/31/08

ST. LUCIE WATERSHED PLAN, 10-28-08,

- Overall a fine presentation.

MQ-1
- Left me feeling that the original CERP expectations are now being lowered. Help from U.S. Sugar buy might off-set?

MQ-2
- The sudden introduction of schedule WSE in Results Cont. needs elucidation. As does the implication that 7500 cfs Lake discharges to the river might be cut a mere 50%

MQ-3
- We need a picture of our river as it might look in 2018 plus. Unfortunately we have no historic prototype for comparison. Lake releases to the river started in 1926, and were intensified by the Corps' project of 1948-78. The C-23 and C-24 canals started adding volume in 1960. There was talk a while ago of the Peace River (?) as a model - relevant now?

- Sorry that this telegraphic handwritten prose at the last minute may sound harsh. My intention is constructive.

Max Q.

Temperince Morgan. FAX 561-242-5499

LEWIS, LONGMAN & WALKER, P.A.
ATTORNEYS AT LAW

Reply to: *West Palm Beach*

November 18, 2008

VIA ELECTRONIC MAIL
and REGULAR U.S. MAIL

Pinar Balci,
c/o SFWMD, MS 7640
3301 Gun Club Road
West Palm Beach, Florida 33406

RE Comments Regarding the Caloosahatchee River (and St. Lucie River) Watershed Protection Plans, October 2008 Draft

Dear Ms. Balci:

Please accept these comments into the record, submitted on behalf of Consolidated Citrus/King Ranch ("CCKR") regarding the Caloosahatchee River Watershed Protection Plan ("CRWPP") and St. Lucie River Watershed Protection Plans ("SLRWPP") or collectively ("WPPs").

CCKR is a significant stakeholder in the implementation of both of these WPPs due to the size and location of its significant land holdings across the State. The water supply for these lands includes surface water withdrawals from both of the Caloosahatchee and St. Lucie basins, as well as the Lake Okeechobee Service Area, among other sources. Land holdings of CCKR are either within, or proximate to, the various nutrient reduction load areas as identified in the WPPs. Land holdings of CCKR could also be impacted by the construction of the various projects in the WPPs. Implementation of these Plans on some level will impact the water supply or the water quality regulatory requirements for the CCKR land holdings.

The WPPs have three major components in regard to substance: Construction, Pollution Control, and Research and Water Quality Monitoring. Construction includes structural and non-structural options. Pollution Control is tied in large part to the pending total maximum daily load ("TMDL") process. Research and Water Quality Monitoring draws on the work already done, and attempts to identify and fill gaps in existing programs. Modeling is a key component of the WPPs and it provides transparency into the evaluation and priority setting effort. Modeling also provides an analytical tool by which success of the WPPs can be measured.

CRWPP: The preferred alternative (Alternative 4), upon which the CRWPP is based, depicts the need for 400,000 more acre-feet of water storage, proposes a reduction of approximately 40% in nitrogen and phosphorus discharges, and has an expected Phase I cost of up to $971 million for construction, $813 million in water quality improvements and an additional $5 million in monitoring.

SLRWPP: The preferred alternative (Alternative 4), upon which the SLRWPP is based, depicts the need for 200,000 more acre-feet of water storage, proposes an approximately 55% reduction in nitrogen and phosphorous discharges, and has an expected Phase 1 cost of up to $709 million for construction, $481 million in water quality improvements and an additional $2.7 million in monitoring.

Water storage / water quality treatment lands. It appears as though the WPPs primarily build upon storage projects that are already planned or in the approval process. What additional water storage lands might be needed to implement the WPPs beyond C-43 West Reservoir, C-44, Indian River Lagoon South Natural Storage and Water quality Areas, and C-43 BOMA project? The WPPs should make the distinction between existing, planned projects or new water storage and water quality projects to achieve the requisite 400,000 and 200,000 acre-feet of storage targets. Where would these new water storage and water quality projects be located? CCKR - 1

Flows needed to make the plan a success. Where will the water flows come from that are planned to be captured by the water storage projects (combined 600,000 acre-feet of water storage for the WPPs)? Are these flows excess discharges that originate from the watershed basin and Lake Okeechobee? How will the capture of these flows affect water supply for users and will some of that captured water be available for agricultural consumptive use? Has there been any modeling of this plan for its impact on water supply? CCKR - 2

"River of Grass" initiative. Overall coordination between the WPPs and the River of Grass initiative must occur from both a cost and planning perspective. CCKR - 3

Water Quality Requirements. It appears as though most of the WPP waterbodies are impaired for total nitrogen, total phosphorous or biochemical oxygen demand. The reductions in nitrogen and phosphorous loading (for both WPPs) show improvement, but the loading CCKR - 4 performance will be "revisited" once the TMDL is adopted. Does this mean that the WPPs will be revised and if so, how and when? CCKR - 4 continued

Operations, implementation and further planning. CCKR is concerned that the WPPs, do not have an "operational" component. Specifically, this operational component needs to include information such as which agency is responsible for what structures/facilities and how those will be operated. The WPPs provide very generic statements that could be replaced with operational plans. Given that the WPPs had a specific due date for submission to the Florida Legislature, the CCKR understands that these operational issues will likely be developed in the Process Development and Engineering phase. However, an operational plan is still needed sooner rather than later. (CCKR - 5) The WPPs also need a strong Implementation Plan addressing the specific of what will be constructed and when. Are Draft WPPs submitted to the Legislature in January 2009 or are those plans considered final? It appears as though most of the details of the WPPs (including operations and implementation) will be borne out in the Process Development and Engineering Phase which is slated to begin next year. These planning efforts must include the public, and in particular, landowners directly impacted by the further development of these WPPs. (CCKR - 6)

Rulemaking. There are several rulemaking efforts underway currently which will be included within the WPPs and will impact the implementation of the WPPs including:

- Rule 62-306.100, F.A.C. which will establish the procedures for water quality credit trading, including the process to determine how credits are generated, quantified, and validated; the process for tracking credits, trades, and prices paid; limitations on the use of credits, including eligible pollutants, minimum water quality requirements, and any adjustments for uncertainty or location; the timing, duration, and transfer of credits; and the mechanisms for determining compliance with trade provisions. The WPPs will need to be revised to incorporate this strategy into its implementation. (CCKR - 7)

- The Lake Okeechobee and Estuary Basin rule and Unified Statewide Stormwater rule: These two Rule processes will now be more coordinated, but depending on the final form of these rules, what changes may need to occur in the WPPs pursuant to their implementation? (CCKR - 8)

- What changes to the WPPs may be required after the TMDLs are finalized? (CCKR - 9)

Finally, CCKR is keenly aware of the legislative requirements driving the development and implementation of the WPPs. We do remain concerned, however, about the load reduction requirements and the actual location of some of the projects. The location of some of these features of the WPPs is not defined or subject to change. The SFWMD should be providing more certainty to landowners whose lands may be significantly affected by the WPPs about the location of project features and future revisions. We look forward to working with you in the (CCKR - 10) future on the implementation of the WPPs. For any additional questions regarding these comments, please do not hesitate to call.

Sincerely,

Stephen A. Walker

SAW/ELD:kaa
cc: Mr. Mitch Hutchcraft
Mr. Paul Grose

RESPONSES TO AGENCY AND PUBLIC COMMENTS

Comment No.	Response
CC-1	LOP2TP identified need for 1.3 million acre/ft to manage Lake Okeechobee stage and discharge. The River of Grass initiative will evaluate the relationship between storage needs and siting north and south of the Lake. It has yet to be determined the impact of the potential River of Grass land acquisition on rate of funding and implementation.
CC-2	A variety of implementation and funding strategies will be used to move the Preferred Plan projects forward. Many of these projects are already included in other planning or restoration efforts (e.g., Comprehensive Everglades Restoration Project) and it is recognized that there may be other alternative funding strategies for these projects. The coordinating agencies will continue to maximize opportunities for federal and local government cost-sharing programs and opportunities for partnerships with the private sector and local government. For example, the Preferred Plan minimizes real estate acquisition requirements by promoting involvement of private landowners as partners in the restoration program (best management practices, Florida Ranchlands Environmental Services Project, Alternative Water Storage/Disposal projects) and emphasizing the use of state-owned lands. By reducing the amount of land that needs to be purchased and developing partnerships with local landowners, the potential for delayed implementation of the restoration projects can be minimized.
CC-3	The issue of how to address sites with altered hydrology has been raised by FDEP and SFWMD staff and the Technical Advisory Committee that are working on the statewide stormwater treatment rule. We are not requiring hydrologic restoration to pre-development conditions. The issue is still being discussed and no final resolution has been derived yet. As for your example of differing treatment standards, that already exists under current regulations. A parcel developed in the 1970's would not have any stormwater treatment while the vacant parcel would have to meet current regulations when it was developed. Additionally, the level of stormwater treatment would depend on where the vacant and the developed parcel were located. If they are located within an "urbanized area where redevelopment was occurring", then the predevelopment condition for the developed parcel is not "natural landscape" and the level of treatment has yet to be determined. One of the goals of the statewide stormwater treatment rule is to encourage urban redevelopment and to reduce urban sprawl. As we proceed with rulemaking, we encourage you to be an active participant in the process to assist us in ensuring that issues such as these are satisfactorily resolved

Comment No.	Response
CC-4	Performance measures and performance indicators provide a means to evaluate how well each alternative achieves the project goals. Alternative plans were specifically formulated to achieve the targets set for each of the performance measures (e.g., flow ranges, limits, and distribution). Each alternative was then evaluated on how efficiently and effectively it meets such performance measure targets. Alternative 1 consists of the "common elements" that are included in all subsequent alternatives. All CERP Indian River Lagoon – South projects and source control management measures are included in Alternative 1. Subsequent alternatives built upon Alternative 1 and added both water quality and quantity features that were needed to move toward the project targets. The most significant of these is the addition of the C-23/24 Water Quality Treatment Project that was added to Alternative 3 to further reduce total phosphorus loads towards the project's WQ target. Chapter 6 of the SLRWPP includes additional detailed of the plan formulation and evaluation process.
CC-5	The SFWMD is a collaborative partner to develop a "pay for environmental services" (storage & treatment) program under the Northern Everglades and Estuary Protection Program. The Florida Ranchlands Environmental Services Program (LO 87) includes eight pilot projects on private lands; seven projects have been constructed and data collection and evaluation is on-going. Results from this incentive based program including potential streamlined, protective regulatory processes will be available for consideration at the end of the pilot project phase. Cooperative private landowner projects were also implemented under the SFWMD's Alternative Water Storage/Disposal (LO 12) initiative. Landowners were encouraged to submit project concepts that would store/dispose of excess stormwater on their properties to benefit natural systems including Lake Okeechobee and the estuaries. Environmental Resource and Consumptive Use permitting varied for these projects but the regulatory process recognized the cooperative nature and the environmental benefits that would be achieved. SFWMD managers and the Governing Board will be providing guidance on the future level of effort of continuing these landowner based collaborative efforts.

Comment No.	Response
CC-6	It is important to note that the SLRWPP is only attempting to address the watershed contribution to the estuary. Lake Okeechobee discharges were addressed in the LOP2TP. Focusing on the St. Lucie River Watershed contribution only, the occurrences of discharges between 2,000 and 3,000 cfs from only the watershed with the alternatives were 17 which is four occurrences below the target of 21. Also with the alternatives, the occurrences of discharges from the watershed greater than 3,000 cfs were 7 to 8 representing one to two occurrences above the target of six. In addition, the total nitrogen load reduction for the watershed only was 40% which is better than the CERP Indian River Lagoon – South of 30%. The strategy to overcome any funding challenges is described in the response to CC-2
CC-7	There is a dedicated funding source (documentary stamp taxes) for the Everglades Forever Trust Fund. FDACS and SFWMD are committed to funding BMP cost-share programs to the extent funds are made available annually.
CC-8	Low Impact Development (LID) is a major component of the proposed Statewide Stormwater Management Rule. The rule proposes to allow credit for reductions to total phosphorus and total nitrogen through the use of LID features such as pervious pavement, green roofs, and cisterns. Additional credits will be allowed from the use of other BMPs. A treatment train approach is encouraged through the availability of credit for utilizing that approach. Credit will also be offered for stormwater recycling.
AUD-1	With the Lake Okeechobee Phase II Technical Plan and St Lucie River Watershed Protection Plan projects in place, future loading from the C-44 basin to Lake Okeechobee is anticipated to be approximately 4 mt/yr. We concur that the allocations identified in the Lake Okeechobee Operating Permit should be revised to reflect a more appropriate apportionment across the 4 regions and have had some initial discussions with FDEP regarding this issue. We plan to continue those discussions next year during the Lake Okeechobee Protection Plan update process. In addition, The River of Grass initiative planning process will take into consideration the objectives of the Northern Everglades Program, as well as the projects that have been recommended by the LOTP and CRWPP, to determine the potential opportunities provided by the proposed acquisition.

Comment No.	Response
MQ-1	The SLRWPP does not in any way lower original CERP expectations. As a matter of fact, the SLRWPP reaffirms the need for the CERP IRL-S project. This plan independently evaluated storage and water quality needs for the watershed and found that the CERP IRL-S project did a great job of identifying the storage necessary to manage local watershed flows and made significant progress in addressing water quality issues. Therefore, the SLRWPP states that the amount of regional storage identified in the CERP IRL-S project is sufficient to manage local runoff; however it needs to be supplemented with additional storage in the Lake Okeechobee watershed to manage Lake Okeechobee flows and that additional water quality improvement for phosphorus is needed within the St. Lucie Watershed (plan recommends additional BMPs, regulatory programs, and regional phosphorus treatment projects). The River of Grass initiative planning process will take into consideration the objectives of the Northern Everglades Program, as well as the projects that have been recommended by the LOP2TP and SLRWPP, to determine the potential opportunities provided by the proposed acquisition.
MQ-2	The WSE Lake Okeechobee Regulation Schedule was utilized during formulation of the LOP2TP, CRWPP, and SLRWPP, as WSE was the approved lake operating schedule when the Northern Everglades analysis began. Since that time, the USACE has adopted a new Lake Okeechobee regulation schedule called LORS 2008. Future plan updates will use updated Lake Okeechobee regulation schedules and other applicable operational changes. However, please note that LORS was developed as an interim schedule and will need adjustments to be compatible with additional storage features as they come online. Based on modeling conducted during the SLRWPP plan formulation process, it is anticipated that undesirable discharges to the estuary between 2,000 and 3,000 cfs would be reduced by 75% and undesirable discharges greater than 3,000 cfs would be reduced by 50%. Additional discussion of these results can be found in Section 6.5.

Comment No.	Response
MQ-3	The plan acknowledges that historical drainage patterns within the St. Lucie River Watershed have been highly altered since pre-drainage times. Loss of natural habitat from riverfront and coastal development, increased urban development, construction of drainage canals, and agricultural activities have affected the timing, quantity, quality, and distribution of runoff to the estuary. Wet season flows have increased due to additional runoff from land clearing and impervious areas; and dry season flows have decreased due to increased water supply demand for agricultural and urban development. The goals utilized in this planning process was to maximize nutrient load reductions in an effort to move towards the estimated natural background concentrations of total phosphorus and total nitrogen as developed by the Restoration Coordination and Verification Program for the Comprehensive Everglades Restoration Program (2005) as well as work by the Coastal Ecosystems scientists. These research efforts included the development a natural watershed flow distribution using “natural” flow scenarios which included selected measured flow data for the Peace River, Florida watershed that has similar topography and rainfall patterns to the SLE watershed and does not have major drainage conveyance systems.
CCKR-1	A variety of implementation and funding strategies will be used to move the Preferred Plan projects forward. Many of these projects are already included in other planning or restoration efforts (e.g., Comprehensive Everglades Restoration Project) and it is recognized that there may be other alternative funding strategies for these projects. The coordinating agencies will continue to maximize opportunities for federal and local government cost-sharing programs and opportunities for partnerships with the private sector and local government. For example, the Preferred Plan minimizes real estate acquisition requirements by promoting involvement of private landowners as partners in the restoration program (best management practices, Florida Ranchlands Environmental Services Project, Alternative Water Storage/Disposal projects) and emphasizing the use of state-owned lands. By reducing the amount of land that needs to be purchased and developing partnerships with local landowners, the potential for delayed implementation of the restoration projects can be minimized. Some of the management measures have not been geographically located in the SLRWPP due to the need to complete the Process Engineering and Development Phase for each of the proposed reservoirs or water quality treatment facilities. Additional feasibility studies will be completed for each new management measure and each of those will be coordinated with those landowners that may be impacted.

Comment No.	Response
CCKR-2	The "excess" flows from the St. Lucie watershed will be captured in the water storage projects. Those "excess" flows will then be released to supplement low flows if needed. When assessing the four alternatives in the SLRWPP, existing LOSA water supply demands were considered and modeled as a constraint to ensure that those permitted existing users were not impacted. See Section 6.5 for more details and results.
CCKR-3	The River of Grass initiative planning process will take into consideration the objectives of the Northern Everglades Program, as well as the projects that have been recommended by the LOTP and SLRWPP, to determine the potential opportunities provided by the proposed acquisition.
CCKR-4	The SLRWPP will be updated on a three year revision cycle. Any impacts of the adoption of TMDLs and the associated Basin Management Action Plans will be incorporated during the three year revision cycle. See Chapter 9 for more details regarding the plan update and revisions process.
CCKR-5	The Implementation Strategy includes a phased approach as described in Chapter 9. More detailed information regarding lead partners and timetables for individual project implementation will be developed during program implementation and during the Basin Management Action Plan process. As developed, these details will be included in future annual reports and three-year plan updates. Specific project timelines will be dependent on funding, permitting, and other issues. Potential funding sources are discussed in Chapter 9 and Appendix G. Implementation challenges are discussed in Section 9.4. More detailed information will be included in future plan updates. A System-Wide Operating Manual will be developed that will identify many of the structures/facilities throughout the South Florida water management system (including C&SF project, CERP and other State projects) and will describe regulation schedules, water control and operating criteria; and will reflect operating criteria used in the identification of the appropriate quality, timing and distribution of water dedicated and managed for the natural system.

Comment No.	Response
CCKR-6	The submittal to the Florida Legislature on January 1, 2009 will be the final 2009 SLRWPP. As discussed in Section 9.4, there will be annual reports and three year plan updates which will be subject to a public process. The Implementation Strategy includes a phased approach. More detailed information regarding lead partners and timetables for individual project implementation will be developed during program implementation and during the Basin Management Action Plan process. As developed, these details will be included in future annual reports and three-year plan updates. Specific project timelines will be dependent on funding, permitting, and other issues. Potential funding sources are discussed in Chapter 9 and Appendix G. Implementation challenges are discussed in Section 9.4. More detailed information will be included in future plan updates.
CCKR-7	The SLRWPP will be updated on a three year revisions cycle. Any rule revisions that impact the Plans will be incorporated during the three year revision cycle. There will be a number of forums for coordination regarding implementation of the SLRWPP including the Northern Everglades Interagency Team, Lake Okeechobee Committee of the WRAC, WRAC, Governing Board, public meetings, and specific project working teams. Additional forums can be created if deemed necessary. In addition, the Basin Management Action Plan development process will also provide a forum for coordination regarding program and project coordination and will require involvement of all implementation agencies/entities, functional providers, etc.
CCKR-8	FDEP has initiated rule development on a Statewide Stormwater Rule. This rule currently proposes that discharges of TP and TN from new development be equal to or less than that discharged from a pre-developed natural condition. SFWMD also has proposed a special ERP basin rule pertaining to water quantity for Lake Okeechobee and the St. Lucie and Caloosahatchee Estuaries that would ensure that there are no increases in discharge volumes. Currently applicants are required to demonstrate that their proposed projects will not contribute to the impairment of the water body.
CCKR-9	See Section 6.4 for a discussion regarding this issue.

Comment No.	Response
CCKR-10	A variety of implementation and funding strategies will be used to move the Preferred Plan projects forward. Many of these projects are already included in other planning or restoration efforts (e.g., Comprehensive Everglades Restoration Project) and it is recognized that there may be other alternative funding strategies for these projects. The coordinating agencies will continue to maximize opportunities for federal and local government cost-sharing programs and opportunities for partnerships with the private sector and local government. For example, the Preferred Plan minimizes real estate acquisition requirements by promoting involvement of private landowners as partners in the restoration program (best management practices, Florida Ranchlands Environmental Services Project, Alternative Water Storage/Disposal projects) and emphasizing the use of state-owned lands. By reducing the amount of land that needs to be purchased and developing partnerships with local landowners, the potential for delayed implementation of the restoration projects can be minimized. Also see response to CCKR-1