APPENDIX B

NORTHERN EVERGLADES REGIONAL SIMULATION MODEL

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

List of Tables

List of Figures

TABLE OF CONTENTS (CONTINUED)

List of Figures (continued)

B1.0 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 Phase II Technical Plan (P2TP) planning 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.

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 (H&H) 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 (FV) 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.

When implemented in a study area that can be conceptualized as a lumped system, as in the case of NERSM, RSM can be used as a node-link model. It produces complete water budgets given appropriate boundary conditions and simplified operating rules. Initial usage of RSM for the LOWCP Phase II is a water budget model. 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.

To support the P2TP planning process, RSM was applied to create a customized hydrologic model called the Northern Everglades Regional Simulation Model (NERSM) which is used to simulate hydrologic conditions in the LOW under varying scenarios such as current base, future base, and alternative plans. It is the initial hydrologic simulation tool developed for the Phase II Technical Plan to facilitate the evaluation of water-resource management options within the P2TP study area (**Figure B-1**).

B1.1 Spatial Representation

The model area covers Lake Okeechobee and five sub-watersheds north of the lake referred to as 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 basin (C-43) basin through S-77 and the St. Lucie basin (C-44) through S-308.

The study area is represented in NERSM by a series of links and nodes (**Figure B-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 Upper Kissimmee (KUB) and Lower Kissimmee (LKB) are represented using multiple links and nodes. Others, like Taylor Creek/Nubbin Slough (TCNS), Lake Istokpoga (LI), and Fisheating Creek (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 B-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.

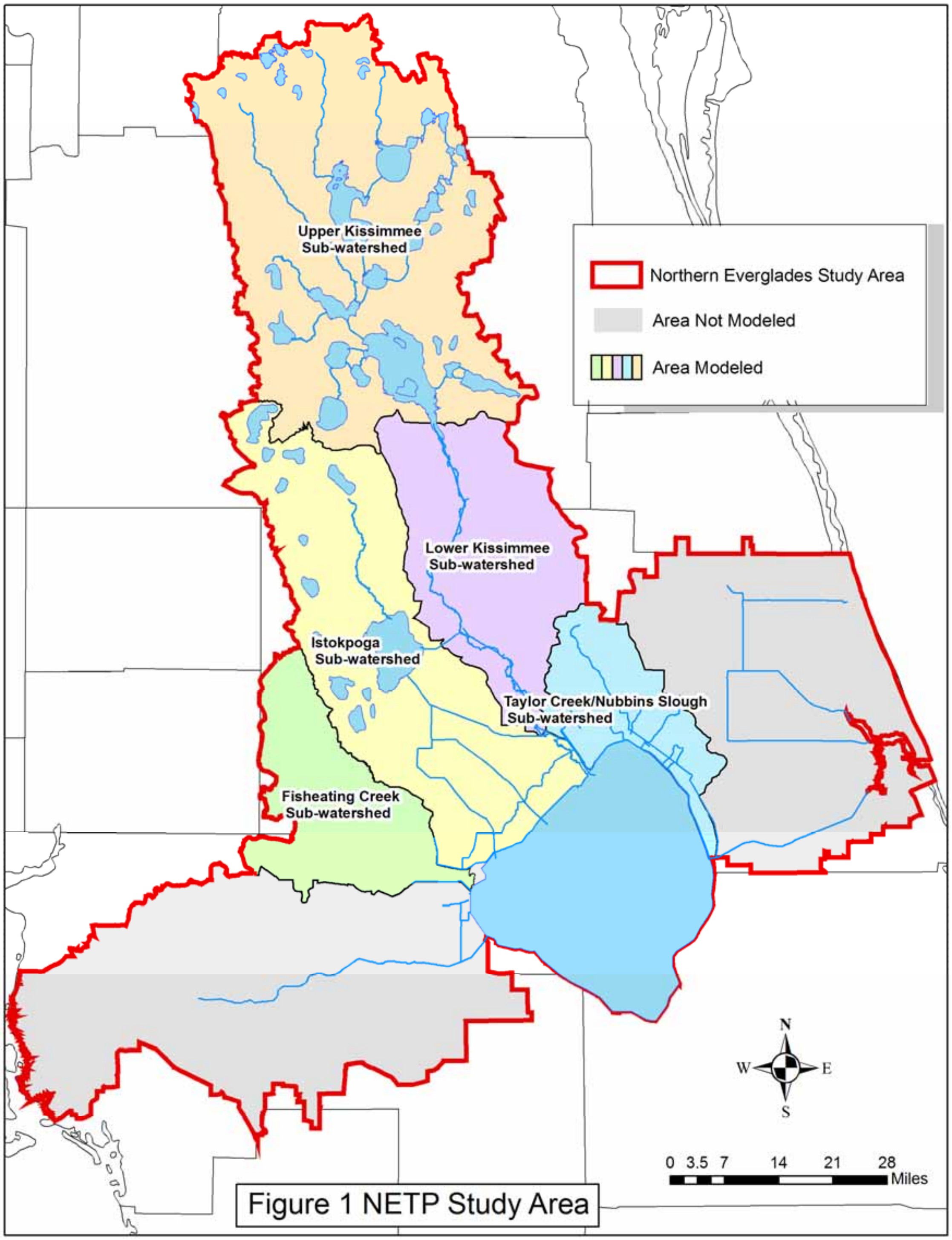


Figure B-1. Sub-watersheds modeled in the Northern Everglades Regional Simulation Model (NERSM).

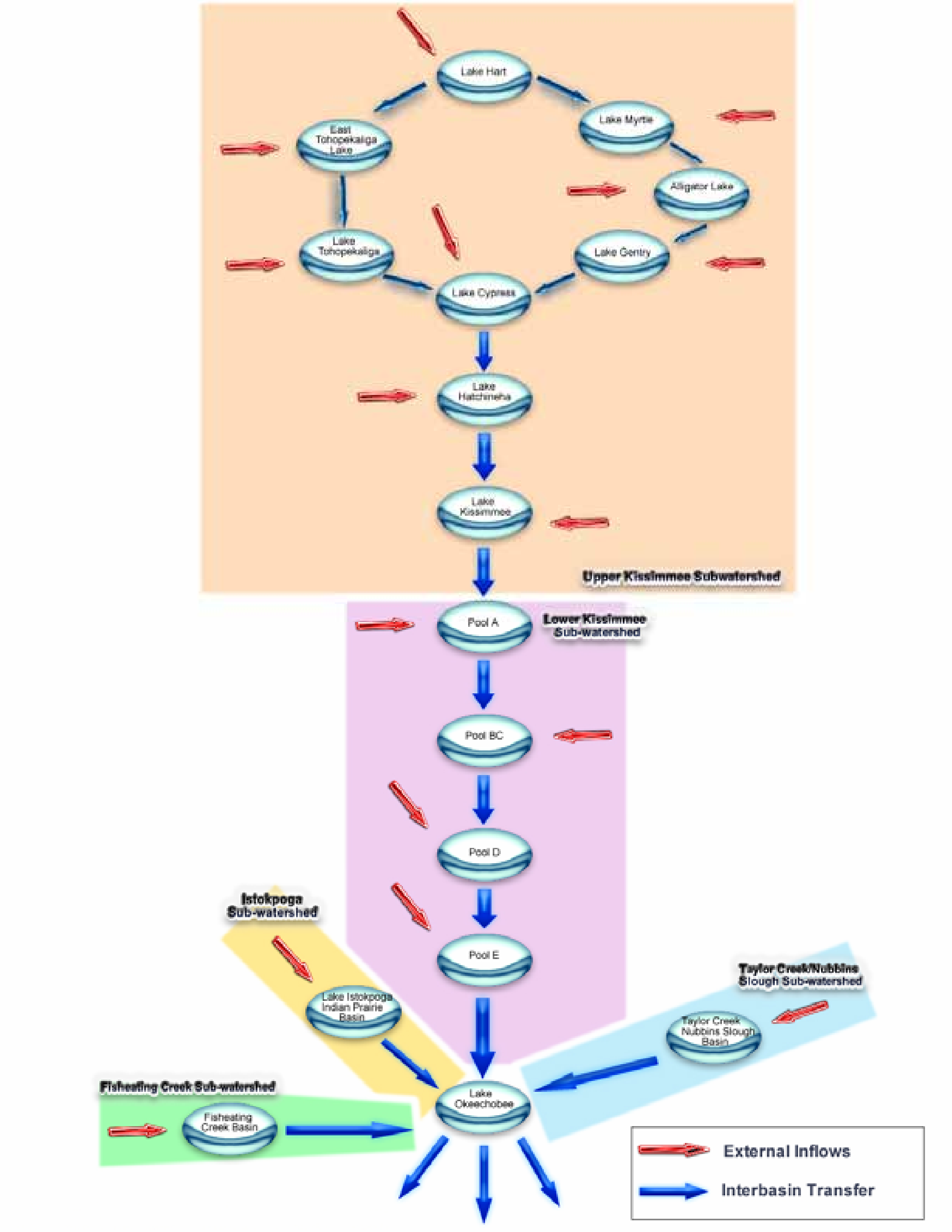


Figure B-2. Node-link diagram representation of NERSM.

B1.2 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.

B1.3 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 P2TP 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 1-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 P2TP 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 flow patterns from the TCNS, LI and FEC sub-watersheds into Lake Okeechobee are assumed to be preserved while simulating management measures. Rainfall-runoff relationships and drainage/routing characteristics within a sub-watershed are assumed not to change from before to after management measures are operational. The volume of divertible runoff is equal to the total historical sub-watershed outflow reduced by the ratio of the total footprint of the management measures and total area of the sub-watershed. This simplified approach is referred to as the "flow pass-through" method.

- 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 such as reservoirs and stormwater treatment areas (STAs). It is assumed that the historical sub-watershed inflow discharged to LOK 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 management measures considered in the future base and alternative scenarios, it is assumed that there are no other changes in land use or land cover within the LOW.
- No flow-regulation structures exist in the Fisheating Creek Sub-watershed. The creek has an open connection with Lake Okeechobee (LOK). The link between the sub-watershed and LOK 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.
- 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.

B1.4 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 historic flow records collected at control structures and hydrometeorologic data. Boundary conditions for watersheds simulated using the flow pass-through method are based on daily historic 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 and SFWMM which consider discrete components of the hydrologic cycle such as evapotranspiration, 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 evapotranspiration 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.

B1.5 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, evapotranspiration, and flow releases. Post processing is used to generate information for quantifying specific performance measures designated for the various project management measures (**Table B-1)**.

B1.6 Model Validation

To ensure that the NERSM was performing as intended, current base and future base conditions were also simulated using the South Florida Water Management Model (SFWMM or 2x2) 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 2x2 output for the same regions. NERSM output for the Lower Kissimmee sub-watershed was compared to UKISSWIN output.

B1.6.1 South Florida Water Management Model (SFWMM)

The South Florida Water Management Model has been extensively used in previous District modeling efforts. The major operational components of Lake Okeechobee that are common to both SFWMM and NERSM are the WSE schedule and 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 B-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 and duration – criteria exceeded
Caloosahatchee Estuary (CE)	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)
St. Lucie Estuary (STE)	Number of times high discharge criteria exceeded (between 2,000 and 3,000 cfs)
	Number of times 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

B1.6.2 UKISS 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 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.

B1.6.3 Validation Results

NERSM performance was shown to match 2x2 (**Figure B-3)** and UKISSWIN (**Figures B-4** and **B-5**). The NERSM was therefore considered suitable for making planning level decisions.

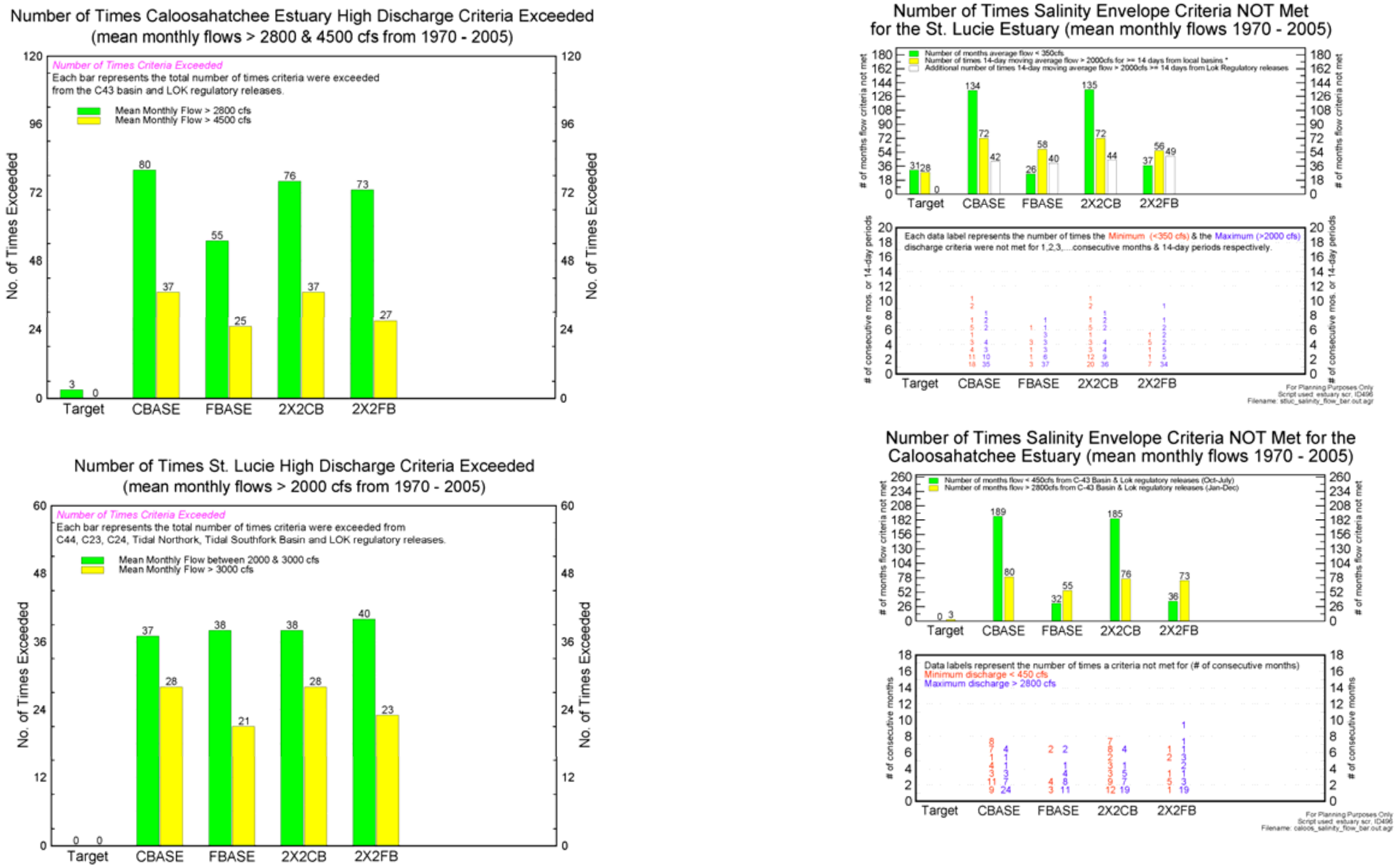


Figure B-3. Comparison of NERSM and 2x2 Model Outputs for selected performance measures.

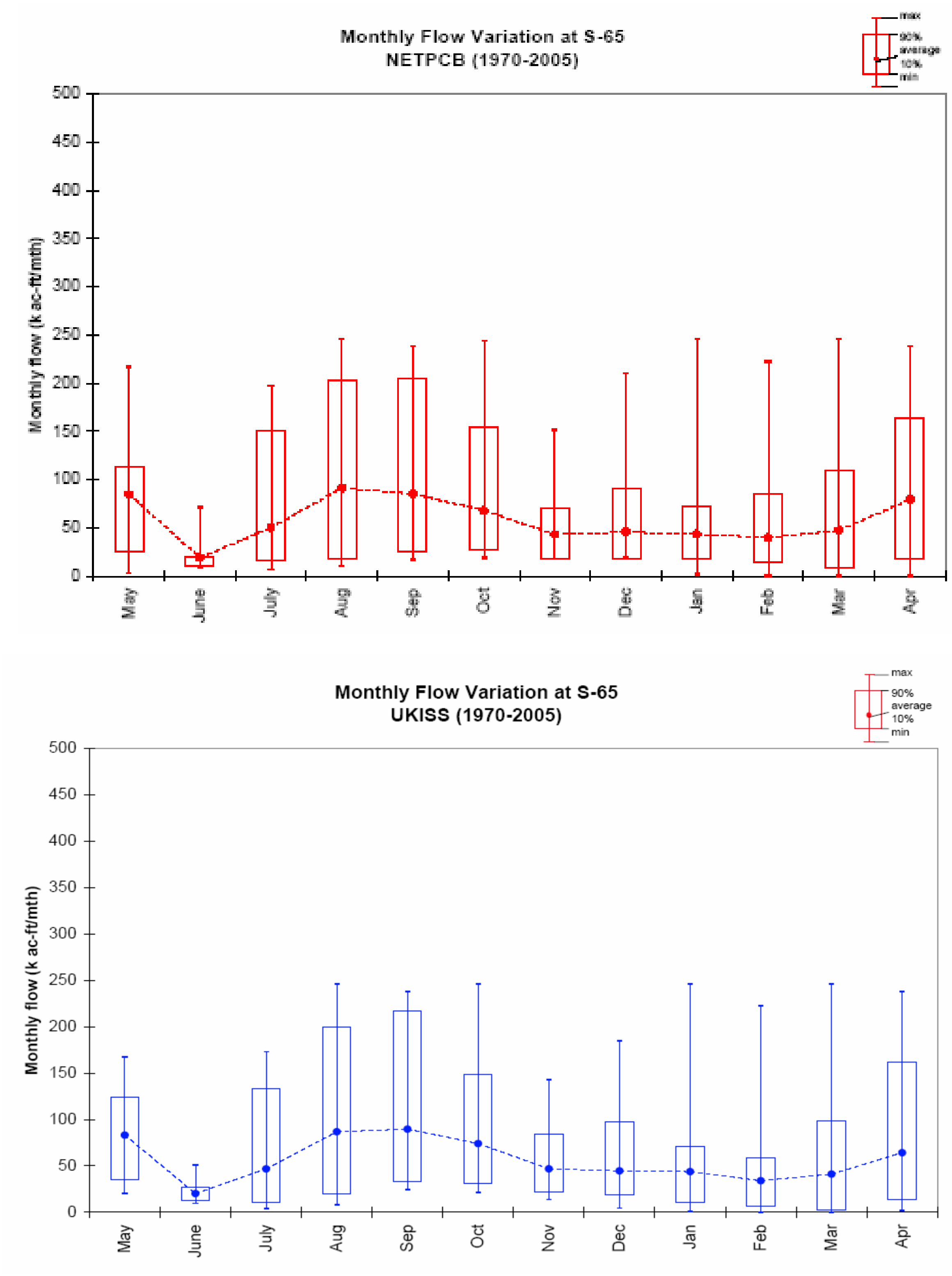


Figure B-4a and b. Monthly flow variation at S-65 in NERSM and UKISSWIN model for Current Base.

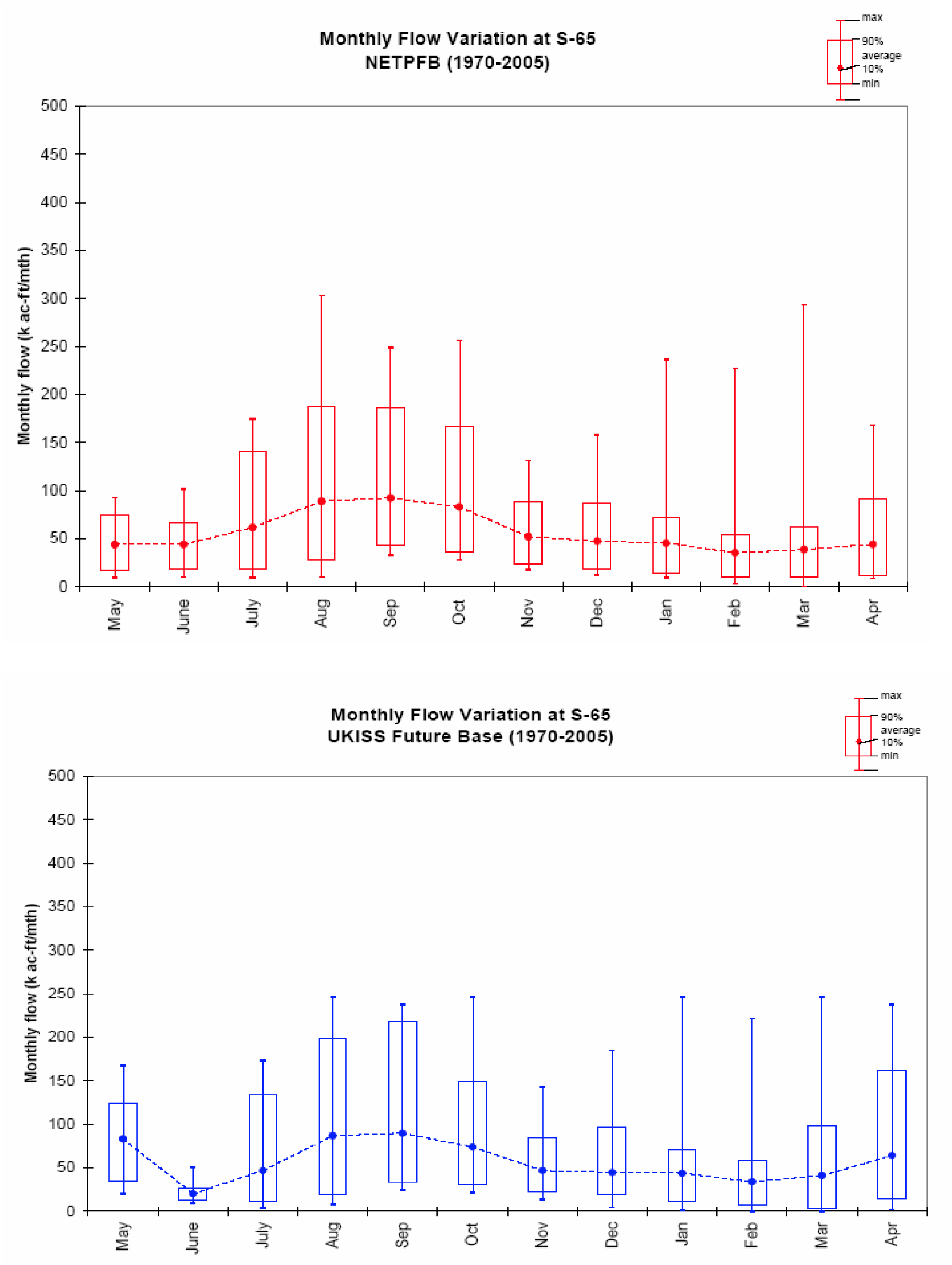


Figure B-5a and b. Monthly flow variation at S-65 in NERSM and UKISSWIN model for Future Base

B2.0 NERSM APPLICATION

B2.1 Modeling Scenarios

The following scenarios were evaluated using the NERSM:

- **Current Base** – This scenario represents sub-watershed and management conditions that existed in the LOW 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 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.

- **Future Base** – This scenario represents the current base scenario plus planned conditions likely to exist in the LOW following the implementation of three Acceler8 (A8) projects and two Kissimmee River water-resources projects. The following projects were included in the future base scenario:

    - **A8 Projects**: C-43 (Caloosahatchee River) Reservoir, C-44 (St. Lucie Canal) Reservoir and STA, and A-1 (Everglades Agricultural Area Reservoir A-1).

    - **Kissimmee Projects**: Kissimmee River Restoration Project and the Kissimmee River Headwaters Revitalization

  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 Water Conservation Areas (WCAs) are simulated based on the WSE Regulation Schedule consistent with the SFWMM 2010A8 run. The C-43 reservoir is simulated with operations very similar to the SFWMM, except for the fact that basin demand is no longer being met by the reservoir. This change is more in line with the intent of the C-43 reservoir as defined in the PIR. The C-44 reservoir, on the other hand, is not explicitly simulated, however the C-44 reservoir releases calculated using SFWMM are combined with NERSM-calculated releases from LOK to evaluate the total impact on the St. Lucie Estuary.

- **P2TP Alternative Plans** – The P2TP planning process formulated and evaluated four Alternative Plans for achieving project goals and objectives. Each scenario represents the future base scenario plus a variety of management measures from three general categories – reservoirs, stormwater treatment areas (STAs), and Aquifer Storage and Recovery (ASR). Management measures meeting the following criteria were selected to be included in the model:

1. The management measure should have water quantity benefits to the regional system. The impacts on the regional system by some management measures, like on-site treatment, are too small to be included in the model.

2. A conceptual design should exist for the management measure. 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 management measures are summarized in **Tables B-2** through **B-5** and described in other sections of the report. The Alternative Plans are summarized as follows:

- **Alternative 1 – Common Elements:** The primary objective of this alternative is the reduction of total phosphorus (TP) loadings to Lake Okeechobee and an increase in storage that would be provided by the construction and implementation of measures that have either been completed since 2005, are imminent, or would become imminent pending resolution of certain issues. The 13 management measures considered in Alternative 1 are common to the other three Alternative Plans. Three of the five original A8 LOER Fast-Track (LOFT) projects (Taylor Creek Reservoir, Lakeside Ranch STA, and Nubbin Slough STA Expansion) are included in this alternative.

  The other two original LOFT projects (Re-routing of S-133 Basin Runoff and Re-routing of S-154 Basin Runoff) recently have been reported (LOFT BODR Report, CDM 2007) to provide limited net benefit relative to the substantial costs. In addition to the three A8 projects, Alternative 1 includes four additional STAs (3 in TCNS and 1 in LI Sub-watersheds), four ASR projects (1 in TCNS, 2 in LKB, and 1 in LI), and two additional reservoirs (in LKB and LI).

  The water quantity benefits of Alternative 1 are quantified by the combined capacities of reservoir storage, STA storage and ASR capacity which total 265,000 acre feet (ac-ft), 19,000 ac-ft and 66 million gallons per day (MGD), respectively.

- **Alternative 2 – Maximize Storage:** The primary objective of this alternative is to maximize the storage capacity. In addition to management measures included in Alternative 1, Alternative 2 provides a substantial increase in acreage for additional and enlarged reservoirs. It also explores the potential of treating Lake Okeechobee water by diverting it into the adjacent reservoirs in the FEC Sub-watershed, LI and LKB Sub-watersheds when Lake stage is above the stage envelope.

  Alternative 2 considers all of the management measures associated with Alternative 1 (hence current base and future base scenarios) plus four additional reservoirs. Reservoirs are added to the LKB, LI, and FEC Sub-watersheds. The combined additional capacity associated with these reservoirs totals 1,050,000 ac-ft which increases the total simulated reservoir storage capacity to 1,315,000 ac-ft.

- **Alternative 3 – Maximize Water Quality Improvements:** The primary objective of this alternative is to maximize the reduction of TP loadings to Lake Okeechobee. Alternative 3 includes all of the management measures associated with Alternative 1. Six additional management measures are simulated in Alternative 3 including one ASR in TCNS, two reservoirs (in LI and FEC), and three STAs (two in LI and one in FEC).

  This alternative focuses on significantly improving treatment capacity by increasing the acreage allocated for STAs: from 19,000 ac-ft in Alternative 1 to 41,000 ac-ft in Alternative 3. A slight increase in above-ground storage results from this alternative as RASTAs (reservoir assisted STAs) are proposed in the LI and FEC Sub-watersheds: from 265,000 ac-ft to 334,000 ac-ft. The reservoirs just upstream of the STAs are meant to provide a steady stream of water into the STAs, providing some attenuation of basin runoff which tend to be flashy (large and intermittent) in the two sub-watersheds mentioned. S-154 deep well injection in TCNS Sub-watershed is also included in this alternative. The combined capacities of reservoir storage, STA storage and ASR capacity associated with Alternative 3 total 334,000 ac-ft, 41,000 ac-ft and 66 MGD, respectively.

- **Alternative 4 – Optimize Storage and Water Quality Improvements:** Alternative 4 is a hybrid of Alternative Plans 2 and 3 and addresses the objectives of maximizing storage capacity and reduction of TP loadings to Lake Okeechobee. It considers all of the management measures associated with Alternative 1 with the exception that Taylor Creek Reservoir is converted to an STA. Six additional management measures are simulated in Alternative 4 including four reservoirs in LKB (two in LKB and one each in LI and FEC) and two STAs in LI. The combined capacities of reservoir storage, STA storage and ASR capacity associated with Alternative 3 total 914,000 ac-ft, 54,000 ac-ft and 66 MGD, respectively.

  A reduced capacity for reservoir storage as modeled in Alternative 2 (from 1,315,000 ac-ft to 914,000 ac-ft) is replaced by additional treatment as modeled in Alternative 3 (from 41,000 ac-ft to 54,000 ac-ft). Cross-sub-watershed basin flow is also incorporated in this alternative to fully utilize the treatment capacities of the enlarged STAs. The Istokpoga Canal RASTA is replaced with a RASTA that can be used to treat LKB Sub-watershed runoff. Likewise, the Taylor Creek reservoir is converted into an STA such that portions of basin runoff generated in Pool E of the LKB Sub-watershed can be treated prior to being released into Lake Okeechobee. Connections of the reservoirs adjacent to the Lake are assumed in this alternative as in Alternative 2.

Table B-2. Summary of management measures simulated in NERSM Alternative 1.

Sub-Watershed	Management Measure		Reservoir			STA		ASR / Deep Well Injection	
	MM ID #	**MM ID**	**Effective Area (acres)**	**Capacity (ac-ft)**	**Inflow / Outflow Capacity (cfs)**	**Effective Area (acres)**	**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)	
	19	Taylor Creek ASR							6/ 6
	23	Taylor Creek Reservoir (LOFT)	1,600	24,000	300 / 300				
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
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]	
FEC		None							

Note:

1. MM ID Numbers are cross referenced against Table C-1 in Appendix C.
2. MMs in ALT 1 are common elements across all alternatives.

Table B-3. Summary of management measures simulated in NERSM Alternative 2.

	Management Measure		Reservoir			STA			ASR / Deep Well Injection
Sub-Watershed	**MM ID #**	**MM ID**	**Effective Area (acres)**	**Capacity (ac-ft)**	**Inflow / Outflow Capacity (cfs)**	**Effective Area (acres)**	**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)	
	19	Taylor Creek ASR							6/6
	23	Taylor Creek Reservoir (LOFT)	1,600	24,000	300/300				
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 / 2,500				
	108	Istokpoga/Kissimmee Reservoir	18,750	300,000	1,000 and 1,500[c] / 2,500				
LI	18	[1]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]	
	108	Istokpoga/Kissimmee Reservoir	18,750	300,000	750 and 1,500[c] / 2,500				
FEC	109	Fisheating Creek Reservoir	15,625	250,000	500 and 1,500[c] / 2,500				

Table B-4. Summary of management measures simulated in NERSM Alternative 3.

Sub-Watershed	Management Measure		Reservoir			STA			ASR / Deep Well Injection
	MM ID #	**MM ID**	**Effective Area (acres)**	**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]**	
	19	Taylor Creek ASR							6/ 6
	54	S154 Deep Injection Well							68/ 0
	23	Taylor Creek Reservoir (LOFT)	1,600	24,000	300/300				
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
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]	
	112	Istokpoga Canal RASTA: Reservoir	1,800	28,000	300 / 500				
	112	Istokpoga Canal RASTA: STA				4,500	6,750	500 / ~500[b]	
FEC	 61 77	Reservoirs: FEC RASTA I FEC RASTA II	3,915	41,580	650/ 600				
	 61 77	STAs: FEC RASTA I FEC RASTA II				8,505	12,758	600 / ~600[b]	

Table B-5. Summary of management measures simulated in NERSM Alternative 4.

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 and 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] and 2,500[g]				
	114	Istokpoga/Kissimmee RASTA	8,100	129,600	1,000 and 1,500[c] / 1,500[h] and 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 and 750[c] / 1,500				
	114	Istokpoga/Kissimmee RASTA: STA				7,200	10,800	1,500 and 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 and 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

B2.2 Model Setup

B2.2.1 Upper Kissimmee Basin (KUB) Sub-watershed

The Upper Kissimmee Basin (KUB) Sub-watershed model covers nine interconnected lakes or Lake Management Areas (LMA) as shown in **Figure B-6**. The lakes are Alligator, Myrtle, Hart, Gentry, East Tohopekaliga, Tohopekaliga, Cypress, Hatchineha and Kissimmee. 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 the District (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 B-6)**. The lakes are shallow and range in depth from 8 ft in Lake Kissimmee to 13 ft in Lake Alligator. The lakes cut into the surficial aquifer which has a thickness ranging from 50 to 100 ft. 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 6 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 the District'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 B-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 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 implemented in the model as regulation schedules, gate operation criteria, and rules of operation of the water control structures.

B2.2.2 Lower Kissimmee Basin (LKB) Sub-watershed

The current base setup for the Lower Kissimmee Basin Sub-watershed reflects conditions post-Phase I of the Kissimmee River Restoration (KRR) project. The sub-watershed is partitioned into 4 major basins separated by water control structures. **Figure B-7** illustrates the node-link diagram for the Lower Kissimmee Basin 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 Lower Kissimmee Basin 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 boundary condition to each level-pool.

For the future base and alternative scenarios, S-65C is removed as part of the full Kissimmee River Restoration (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).

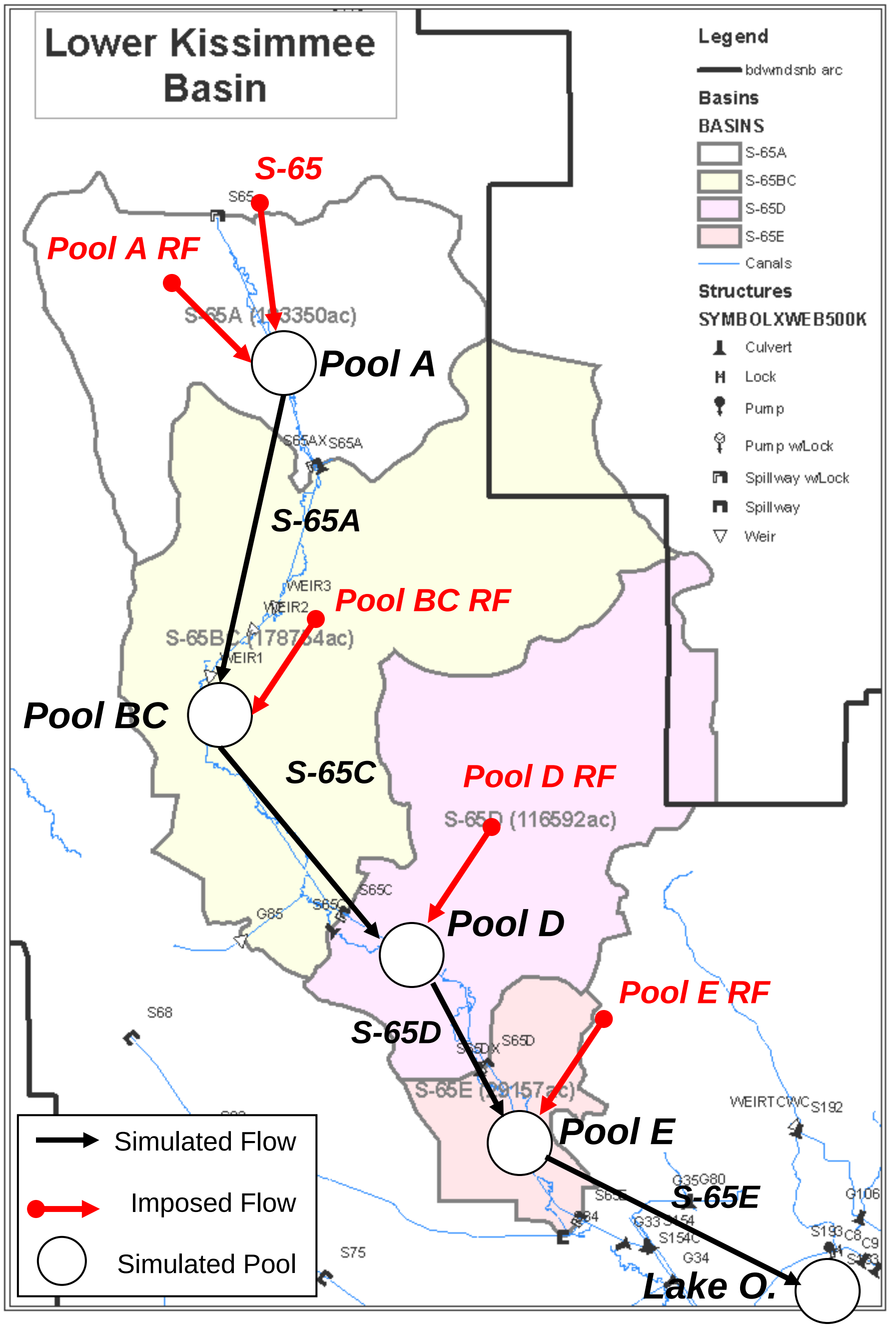


Figure B-7. Node-link diagram representation of Current Base Condition for Lower Kissimmee Sub-watershed in NERSM.

B2.2.2.1 Lower Kissimmee Sub-watershed Configuration for Alternatives 1 and 3

Figure B-8 is a schematic showing how management measures in the Lower Kissimmee Sub-watershed were simulated in Alternatives 1 and 3. Descriptions of how Lower Kissimmee management measures and basin flows were simulated Alternatives 1 and 3 are provided below:

#26: 10 Well ASR System (Paradise Run ASR)

- Inlet: capacity: 50 MGD (77.5 cfs), source: C-38 Pool E
- Outlet: capacity: 50 MGD (77.5 cfs), destination: C-38 Pool E
- Operation:
  - When Lake Okeechobee (LOK) is above the high envelope stage ***and*** Pool E has excess (i.e. Pool E is above its optimum of 21.0 ft as defined in the future base simulation), water will be sent to Paradise Run ASR first (subject to capacity), and any remaining excess will be sent downstream thru S-65E (subject to capacity).
  - When LOK is below the low envelope stage, water will be sent from Paradise Run ASR to Pool E (subject to capacity), where it will be discharged by S-65E (subject to capacity) once Pool E exceeds its optimum of 21.0 ft.
  - During times when LOK is within the stage envelope, S-65E will move local excess plus any inflows coming from upstream (subject to capacity).
- Efficiency loss: 30 percent (70 percent recovery rate)

Dummy Node

- 3 outlet structures: 1) structure into Kissimmee Reservoir; 2) Structure into Kissimmee River ASR; and 3) Bypass to LOK
- When LOK 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 Kissimmee River ASR Pilot (subject to capacity), and any remaining water will be sent downstream to LOK.
- When LOK is below the low envelope stage, water will be sent from both the Kissimmee Reservoir (subject to capacity) and the Kissimmee River ASR Pilot (subject to capacity) downstream to LOK.
- An emergency flood control operation is added to discharge water from Kissimmee Reservoir regardless of LOK stage to ensure the Kissimmee Reservoir does not exceed 16.5 ft depth (which corresponds to its maximum depth plus a buffer). Note that inflows to Kissimmee Reservoir are cutoff once it reaches its maximum depth of 16 ft; however, rainfall may bring it above 16 ft.
- Regardless of LOK stage, any water remaining in the dummy node that is not diverted to either project feature will be sent directly to LOK.

#29: Kissimmee Reservoir

- Location: Indian Prairie/Istokpoga Sub-watershed
- Storage capacity: 161,263 ac-ft
- Footprint: 10,281 acres

- Effective storage area: 10,079 acres = 161,263 ac-ft / 16 ft
- Approximate bottom elevation: 33 ft NGVD29
- Maximum depth: 16 ft (49 ft NGVD29)
- Emergency discharge when depth reaches 16.5 ft
- Inlet: capacity: 1,500 cfs pump, source: Downstream of S-65E
- Outlet: Modeled as a 1,500 cfs pump.
- Will receive ET and 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)

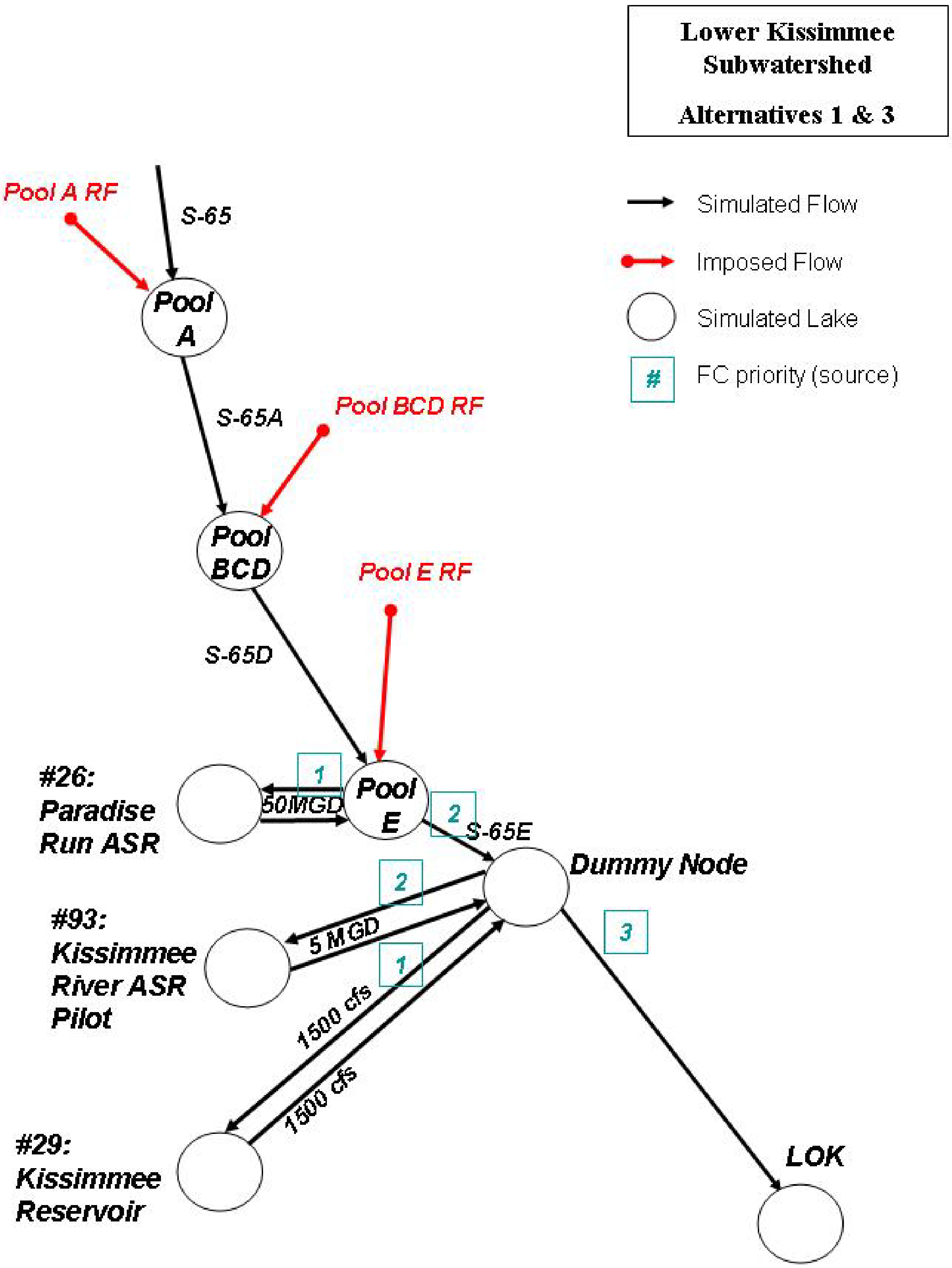


Figure B-8. Lower Kissimmee Sub-watershed simulation configuration for Alternatives 1 and 3.

B2.2.2.2 Lower Kissimmee Sub-watershed Configuration for Alternative 2

Figure B-9 is a schematic showing how management measures in the Lower Kissimmee Sub-watershed were simulated in Alternative 2. Descriptions of how Lower Kissimmee management measures and basin flows were simulated in Alternative 2 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 (LOK) is above the high envelope stage and Pool E has excess (i.e. Pool E is above its optimum of 21.0 ft 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 LOK is below the low envelope stage, water will be sent from both Kissimmee Reservoir East and Paradise Run ASR to Pool E (subject to capacity), where it will be discharged by S-65E (subject to capacity) once Pool E exceeds its optimum of 21.0 ft.
- An emergency flood control operation is added to discharge water from Kissimmee Reservoir East regardless of LOK stage to ensure that the reservoir depth does not exceed 16.5 ft (which corresponds to its maximum depth plus a buffer).
- During times when LOK is within the stage envelope, S-65E will move local excess plus any inflows coming from upstream (subject to capacity).

Dummy Node

- Enables the interception of S-65E flows before they reach LOK
- 4 outlet structures: 1) Structure to Kissimmee Reservoir; 2) Structure to Istokpoga/Kissimmee Reservoir; 3) Structure to Kissimmee River ASR Pilot; and 4) Bypass to LOK
- When LOK 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 LOK.
- When LOK is above the high envelope stage, water may also be sent directly from Lake Okeechobee into the Istokpoga/Kissimmee Reservoir. Flows from LOK 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 LOK water).
- When LOK is below the low envelope stage, water will be sent from the Istokpoga/Kissimmee Reservoir; subject to capacity) and the Kissimmee River ASR Pilot (subject to capacity) downstream to LOK.
- An emergency flood control operation is added to discharge water from the Istokpoga/Kissimmee Reservoir regardless of LOK stage to ensure the Kissimmee Reservoir does not exceed 16.5 ft depth (which corresponds to its maximum depth plus a buffer). Note

that inflows to Kissimmee Reservoir are cutoff once it reaches its maximum depth of 16 ft; however, rainfall may bring it above 16 ft.
- Regardless of LOK stage, any water remaining in the dummy node that is not diverted to either project feature will be sent directly to LOK.

#26: 10 Well ASR System (Paradise Run ASR)

- Inlet: capacity: 50 MGD (77.5 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 ac-ft
- Footprint: 14,000 acres
- Effective storage area: 12,500 acres = 200,000 ac-ft / 16 ft
- Maximum depth: 16 ft
- Emergency discharge when depth reaches 16.5 ft
- Inlet: capacity: 1,000 cfs pump, source: Upstream of S-65E (Pool E)
- Outlet: capacity: 2,500 cfs pump, destination: Upstream of S-65E (Pool E)
- Will receive ET and rainfall representative of Pool E
- No seepage loss assumed

#29: Kissimmee Reservoir

- Location: Indian Prairie/Istokpoga Sub-watershed
- Storage capacity: 161,263 ac-ft
- Footprint: 10,281 acres
- Effective storage area: 10,079 acres = 161,263 ac-ft / 16 ft
- Approximate bottom elevation: 33 ft NGVD29
- Maximum depth: 16 ft (49 ft NGVD29)
- Emergency discharge when depth reaches 16.5 ft
- Inlet: capacity: 1,500 cfs pump, source: Downstream of S-65E
- Outlet: Modeled as a 1,500 cfs pump.
- Will receive ET and rainfall representative of Indian Prairie/Istokpoga Sub-watershed
- No seepage loss assumed

#108: Istokpoga/Kissimmee Reservoir

- Location: Indian Prairie/Istokpoga Sub-watershed
- Storage capacity: 300,000 ac-ft
- Footprint: 21,000 acres
- Effective storage area: 18,750 acres = 300,000 ac-ft / 16 ft
- Maximum depth: 16 ft

- Emergency discharge when depth reaches 16.5 ft
- Inlet: capacity: 1,000 cfs pump, source: Downstream of S-65E (1st priority for inflow into Istokpoga/Kissimmee Reservoir)
- Inlet: capacity: 1,500 cfs pump, source: Lake Okeechobee (2nd priority for inflow into Istokpoga/Kissimmee Reservoir)
- Outlet: capacity: 2,500 cfs pump, destination: Downstream of S-65E
- Will receive ET and 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)

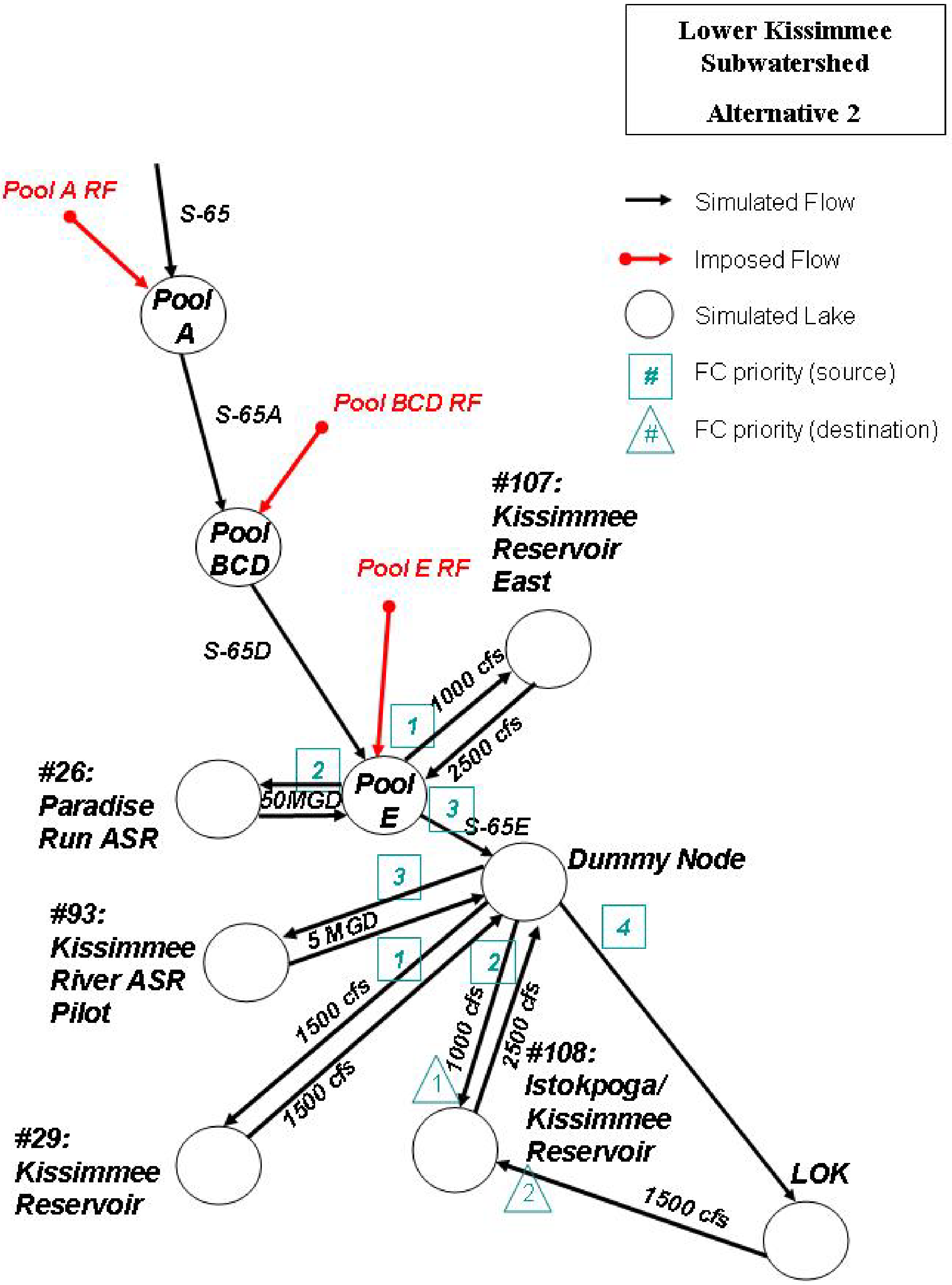


Figure B-9. Lower Kissimmee Sub-watershed simulation configuration for Alternative 2.

B2.2.2.3 Lower Kissimmee Sub-watershed Configuration for Alternative 4

Figure B-10 is a schematic showing how management measures in the Lower Kissimmee Sub-watershed were simulated in Alternative 4. Descriptions of how Lower Kissimmee management measures and basin flows were simulated for Alternative 4 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 (LOK) is above the high envelope stage and Pool E has excess (i.e. Pool E is above its optimum of 21.0 ft 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 LOK is below the low envelope stage, water will be sent from Kissimmee Reservoir East to LOK through Taylor Creek STA (subject to capacity) as first priority, and back to Pool E as second priority (subject to capacity). When LOK 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 ft.
- An emergency flood control operation is added to discharge water from Kissimmee Reservoir East regardless of LOK stage to ensure that the reservoir depth does not exceed 16.5 ft depth (which corresponds to its maximum depth plus a buffer).
- During times when LOK is within the stage envelope, S-65E will move local excess plus any inflows coming from upstream (subject to capacity).

Dummy Node

- 4 outlet structures: 1) Structure to Kissimmee Reservoir; 2) Structure to Istokpoga/ Kissimmee Reservoir; 3) Structure to Kissimmee River ASR Pilot; and 4) Bypass to LOK
- When LOK 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 LOK.
- When LOK is above the high envelope stage, water may also be sent directly from Lake Okeechobee into the Istokpoga/Kissimmee Reservoir. Flows from LOK 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 LOK water).
- When LOK 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 LOK as second priority (subject to capacity). When LOK 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 LOK.

- An emergency flood control operation is added to discharge water from the Kissimmee and the Istokpoga/Kissimmee Reservoirs regardless of LOK stage to ensure that the reservoirs do not exceed 16.5 ft depth (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 ft; however, rainfall may bring it above 16 ft.
- Regardless of LOK stage, any water remaining in the dummy node that is not diverted to either project feature, will be sent directly to LOK

#26: 10 Well ASR System (Paradise Run ASR)

- Inlet: capacity: 50 MGD (77.5 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 ac-ft
- Footprint: 14,000 acres
- Effective storage area: 12,500 acres = 200,000 ac-ft / 16 ft
- Maximum depth: 16 ft
- Emergency discharge when depth reaches 16.5 ft
- 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 and rainfall representative of Pool E
- No seepage loss assumed

#29: Kissimmee Reservoir

- Location: Indian Prairie/Istokpoga Sub-watershed
- Storage capacity: 161,263 ac-ft
- Footprint: 10,281 acres
- Effective storage area: 10,079 acres = 161,263 ac-ft / 16 ft
- Approximate bottom elevation: 33 ft NGVD29
- Maximum depth: 16 ft (49 ft NGVD29)
- Emergency discharge when depth reaches 16.5 ft
- Inlet: capacity: 1,500 cfs pump, source: Downstream of S-65E
- Outlet: Modeled as a 1,500 cfs pump.
- Will receive ET and 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 ac-ft
- Footprint: 9,000 acres
- Effective storage area: 8,100 acres = 129,600 ac-ft / 16 ft
- Maximum depth: 16 ft
- Emergency discharge when depth reaches 16.5 ft
- 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 and 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)

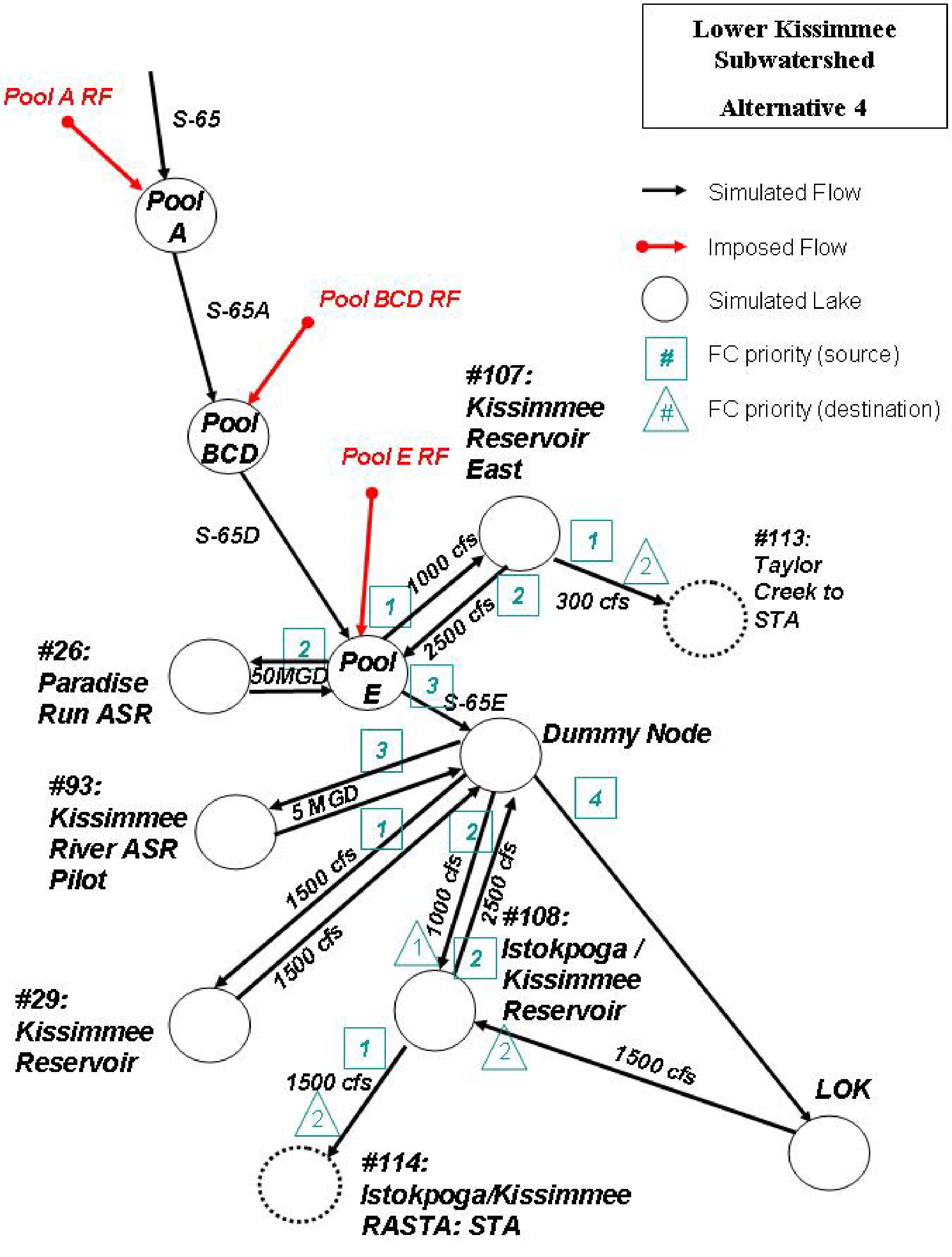


Figure B-10. Lower Kissimmee Sub-watershed simulation configuration for Alternative 4.

B2.2.2.4 Taylor Creek/Nubbin Slough (TCNS) Sub-watershed

It is assumed that the runoff from Taylor Creek/Nubbin Slough 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 LOK in current and future base scenarios.

An alternative scenario is formed by combining different management measures into the future base condition. 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 management measures before reaching Lake Okeechobee (LOK). Rainfall and evapotranspiration 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 management measures and LOK.

B2.2.2.5 Taylor Creek/Nubbin Slough Configuration for Alternatives 1 and 2

Figure B-11 is a schematic showing how management measures in the Taylor Creek/Nubbin Slough Sub-watershed were simulated in Alternatives 1 and 2. Descriptions of how Taylor Creek/Nubbin Slough management measures and basin flows were simulated in Alternatives 1 and 2 are provided below:

#23: Taylor Creek Reservoir (LOFT)

- Location: Taylor Creek and Nubbin Slough Sub-watershed (North of City of Okeechobee)
- Trigger: LOK stage envelope.
- Storage capacity: 24,000 ac-ft
- Footprint: 1,600 acres
- Approximate bottom elevation: 35.5 ft NGVD29
- Maximum depth: 15 ft (50.5 ft NGVD29)
- Inlet: capacity: 300 cfs pump, source: TCNS Basin
- Outlet: capacity: 300 cfs pump, destination: TCNS Basin
- Operation:
  - When LOK 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 LOK.
- Will receive ET and rainfall representative of Taylor Creek and Nubbin Slough Sub-watershed
- Seepage loss: 1cfs (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

- Simulated as a single aggregated STA
- Location: Taylor Creek and Nubbin Slough Sub-watershed

- Brady Ranch STA in western Martin County between the Beeline Highway and Lake OK immediately east of Lakeside Ranch; 2430 ac-ft; 1800 acres; 1.5 ft
- Taylor Creek STA in Grassy Island Ranch; 147 ac-ft;118 acres;1.25 ft; 29.1 ft NGVD 29
- Nubbin Slough STA in New Palm/Newcomer Dairy; 1,546 ac-ft;773 acres; 2 ft; 21.9 ft NGVD 29
- Lemkin Creek STA in Southwest of the city of Okeechobee. 500 ac-ft; 240 acres; 3 ft.
- Storage capacity: 3,240 + 2,430 + 147 + 1,546 + 500 = 7,863 ac-ft
- Footprint: 1,600 + 2,160 + 1,600 + 118 + 773 + 205 = 4,856 acres
- Approximate bottom elevation: 24.0 ft NGVD29
- Maximum depth: 4 ft. At 2.5ft, stops getting inflow; at 1.5ft, start outflow
- Inlet: capacity: 300 + 200 + 24 + 120 + 100 =744 cfs pump, source: TCNS basin
- Outlet: weir width 250ft, weir height 1.5. crest elevation at 25.5 ft NGVD29 (starts releasing at 1.5 ft) destination: Lake LOK – seepage water sent to LOK via special water mover
- Will receive ET and rainfall representative of Taylor Creek and Nubbin Slough Sub-watershed
- seepage loss: [{ (4856-205)/ 2160 }* 7] =15.1 cfs (to LOK)

#19: Taylor Creek ASR

- Location: Taylor Creek and Nubbin Slough Sub-watershed (adjacent to L63N canal in Okeechobee)
- Inlet: capacity: 6 MGD (9.3 cfs), source: Dummy node 1
- Outlet: capacity: 6 MGD (9.3 cfs), destination: LOK
- Efficiency loss: 30 percent (70 percent recovery rate)
- Operation:
  - When LOK is above the low envelope stage, 100 percent water will be sent to recharge Floridian aquifer well
  - When LOK is below the low envelope stage, 70 percent of water will be sent from the Tailor creek ASR to LOK

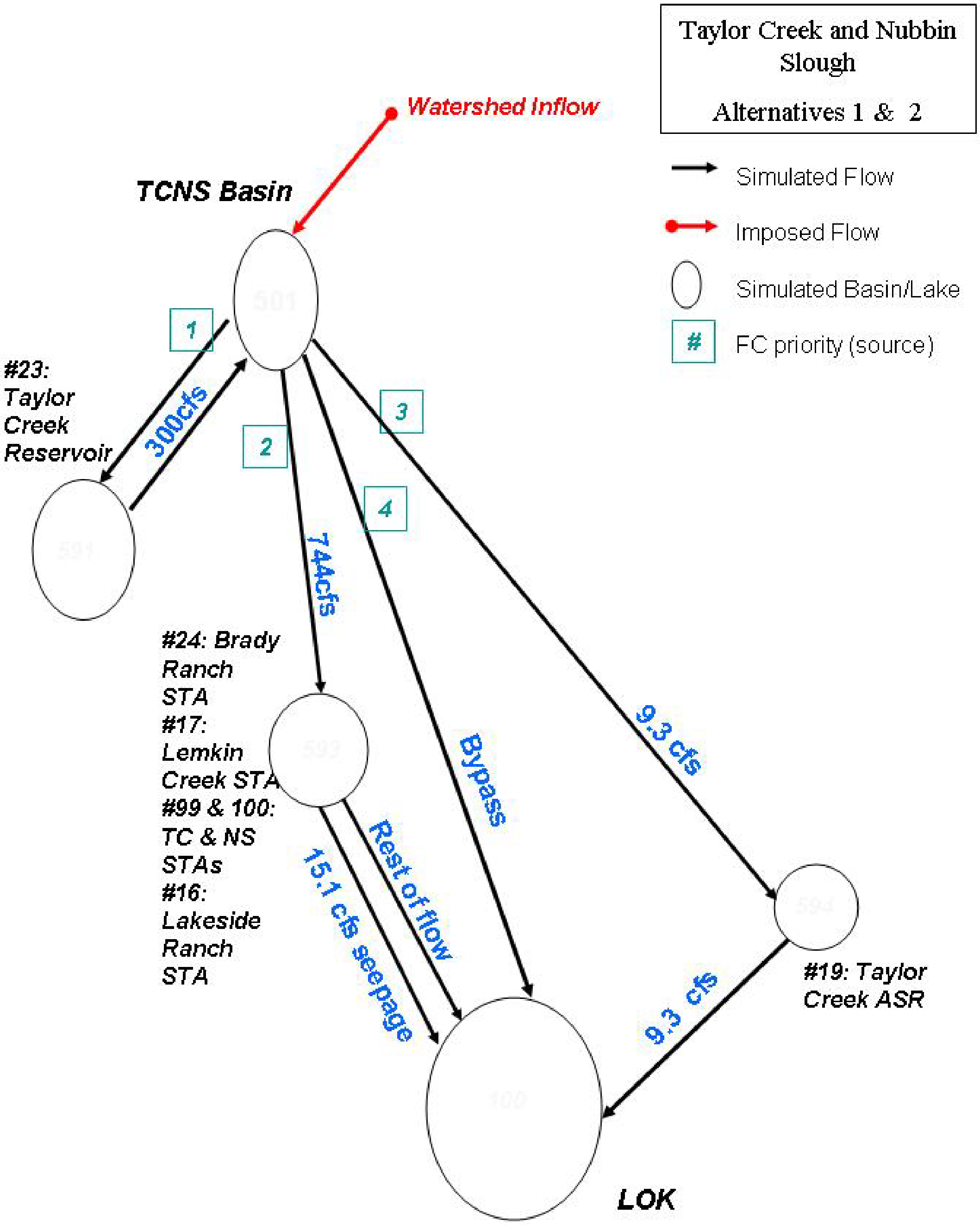


Figure B-11. Taylor Creek/Nubbin Slough Sub-watershed simulation configuration for Alternatives 1 and 2.

B2.2.2.6 Taylor Creek/Nubbin Slough Sub-watershed Configuration for Alternative 3

Figure B-12 is a schematic showing how management measures in the Taylor Creek/Nubbin Slough Sub-watershed were simulated in Alternative 3. Descriptions of how Taylor Creek/Nubbin Slough management measures and basin flows are simulated in Alternative 3 are provided below:

#23: Taylor Creek Reservoir (LOFT)

- Location: Taylor Creek and Nubbin Slough Sub-watershed (North of City of Okeechobee)
- Trigger: LOK stage envelope.
- Storage capacity: 24,000 ac-ft
- Footprint: 1600 acres
- Approximate bottom elevation: 35.5 ft NGVD29
- Maximum depth: 15 ft (50.5 ft NGVD29)
- Inlet: capacity: 300 cfs pump, source: TCNS Basin
- Outlet: capacity: 300 cfs pump, destination: TCNS Basin
- Operation:
  - When LOK is above the high envelope stage, water will be sent from the TCNS basin to Tailor creek Reservoir first (subject to capacity)
  - When LOK 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 LOK
- Will receive ET and rainfall representative of Taylor Creek and Nubbin Slough Sub-watershed
- seepage loss: 1cfs (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: Taylor Creek and Nubbin Slough Sub-watershed
- Brady Ranch STA in western Martin County between the Beeline Highway and Lake OK immediately east of Lakeside Ranch; 2,430 ac-ft; 1,800 acres; 1.5 ft
- Taylor Creek STA in Grassy Island Ranch; 147 ac-ft;118 acres; 1.25 ft; 29.1 ft NGVD 29
- Nubbin Slough STA in New Palm/Newcomer Dairy; 1,546 ac-ft;773 acres; 2 ft; 21.9 ft NGVD 29
- Lemkin Creek STA in Southwest of the city of Okeechobee. 500 ac-ft; 240 acres; 3ft.
- Storage capacity: 3,240 + 2,430 + 147 + 1,546 + 500 = 7,863 ac-ft
- Footprint: 1,600 + 2,160 + 1,600 + 118 + 773 + 205 = 4,856 acres
- Approximate bottom elevation: 24.0 ft NGVD29
- Maximum depth: 4 ft. At 2.5 ft, stops getting inflow; at 1.5 ft, start outflow
- Inlet: capacity: 300 + 200 + 24 + 120 + 100 =744 cfs pump, source: TCNS basin
- Outlet: weir width 250 ft, weir height 1.5. crest elevation at 25.5 ft NGVD 29 (starts releasing at 1.5 ft) destination: Lake LOK – seepage water to LOK via special water mover

- Will receive ET and rainfall representative of Taylor Creek and Nubbin Slough Sub-watershed
- seepage loss: [{ (4856-205)/ 2160 }* 7] =15.1 cfs (to LOK)

#19: Taylor Creek ASR

- Location: Taylor Creek and Nubbin Slough 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: LOK
- Operation:
  - When LOK is above the low envelope stage, 100 percent water will be sent to recharge Floridian aquifer well
  - When LOK is below the low envelope stage, 70 percent of water will be sent from the Tailor creek ASR to LOK
- Efficiency loss: 30 percent (70 percent recovery rate)

#54: S154 Deep Injection Well

- 4 x 17 (68) MGD wells (105 cfs)
- Assumed to operate only during the wet season when LOK stage is above envelope.

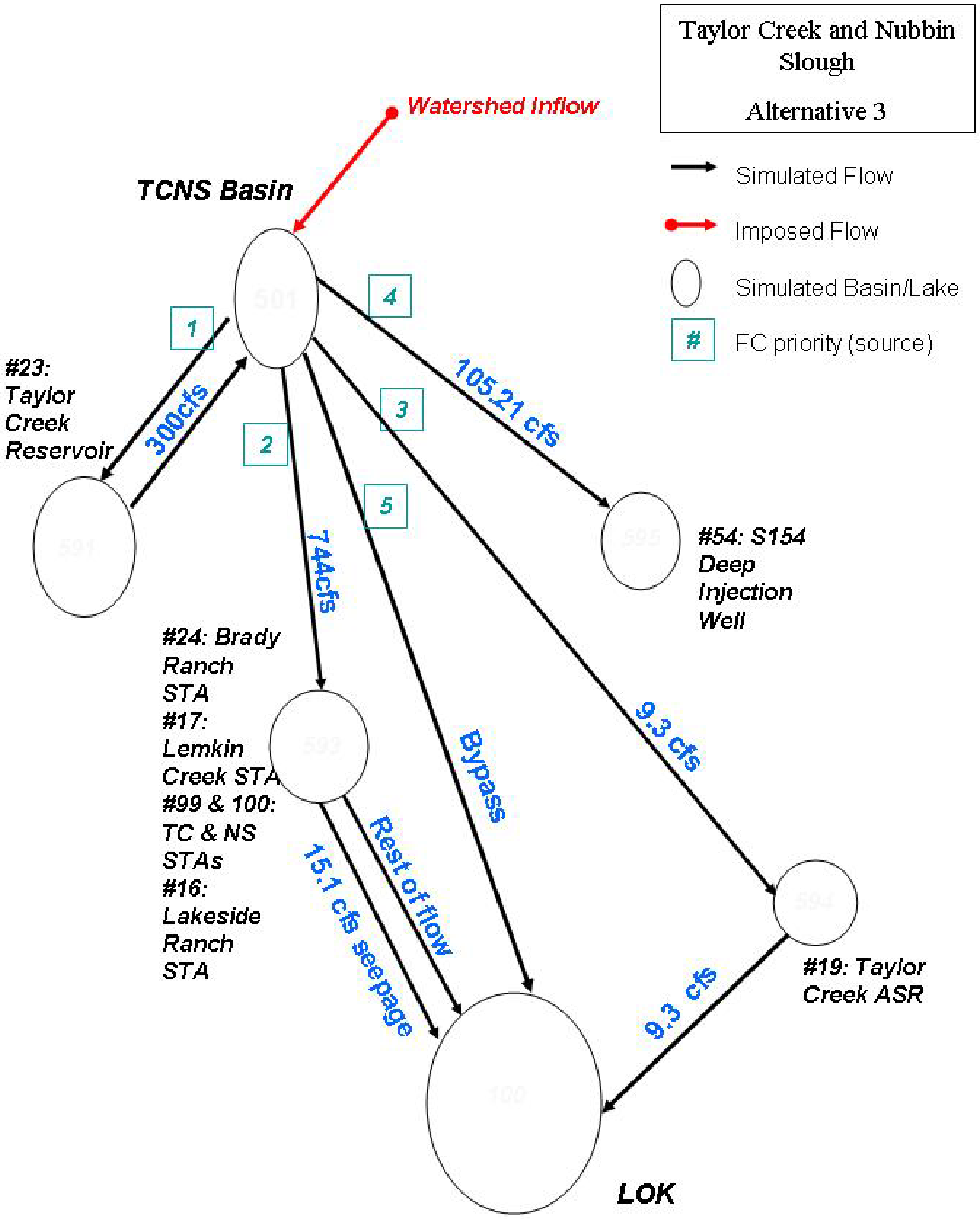


Figure B-12. Taylor Creek/Nubbin Slough Sub-watershed simulation configuration for Alternative 3.

B2.2.2.7 Taylor Creek/Nubbin Slough Sub-watershed Configuration for Alternative 4

Figure B-13 is a schematic showing how management measures in the Taylor Creek/Nubbin Slough Sub-watershed were simulated in Alternative 4. Descriptions of how Taylor Creek/Nubbin Slough management measures and basin flows were simulated in Alternative 4 are provided below:

#113: Taylor Creek STA

- Location: Taylor Creek and Nubbin Slough Sub-watershed (North of City of Okeechobee)
- Trigger: LOK stage envelope.
- Storage capacity: 24,00 ac-ft
- Footprint: 1600 acres
- Approximate bottom elevation: 35.5 ft NGVD29
- Maximum depth: 15 ft (50.5 ft NGVD29)
- Inlet 1: capacity: 300 cfs pump, source: TCNS Basin;
- Inlet 2: capacity: 300 cfs pump, source: Kissimmee Reservoir East
- Outlet: weir width 200ft, starts releasing at 1.5ft depth; destination: LOK.
- Operation:
  - When LOK is above the high envelope stage, water will be sent from the TCNS basin to Tailor creek Reservoir first (subject to capacity)
  - When LOK 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 LOK
- Will receive ET and rainfall representative of Taylor Creek and Nubbin Slough Sub-watershed
- seepage loss: 1cfs (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: Taylor Creek and Nubbin Slough Sub-watershed
- Brady Ranch STA in western Martin County between the Beeline Highway and Lake OK immediately east of Lakeside Ranch; 2,430 ac-ft; 1,800 acres; 1.5 ft
- Taylor Creek STA in Grassy Island Ranch; 147 ac-ft;118 acres; 1.25 ft; 29.1 ft NGVD 29
- Nubbin Slough STA in New Palm/Newcomer Dairy; 1,546 ac-ft;773 acres; 2 ft; 21.9 ft NGVD 29
- Lemkin Creek STA in Southwest of the city of Okeechobee. 500 ac-ft; 240 acres; 3 ft.
- Storage capacity: 3,240 + 2,430 +147+1,546+500 = 7,863 ac-ft
- Footprint: 1,600 + 2,160 + 1600 + 118 + 773 + 205 = 4,856 acres
- Approximate bottom elevation: 24.0 ft NGVD29
- Maximum depth: 4 ft. At 2.5 ft, stops getting inflow; at 1.5 ft, start outflow
- Inlet: capacity: 300 + 200 + 24 + 120 + 100 =744 cfs pump, source: TCNS Sub-watershed
- Outlet: weir width 250ft, weir height 1.5. crest elevation at 25.5 ft NGVD29 (starts releasing at 1.5 ft) destination: Lake LOK – seepage will be sent to LOK via special water mover

- Will receive ET and rainfall representative of Taylor Creek and Nubbin Slough Sub-watershed
- seepage loss: [{ (4856-205)/ 2160 }* 7] =15.1 cfs (to LOK)

#19: Taylor Creek ASR

- Location: Taylor Creek and Nubbin Slough 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: LOK
- Operation:
  - When LOK is above the low envelope stage, 100 percent water will be sent to recharge Floridian aquifer well
  - When LOK is below the low envelope stage, 70 percent of water will be sent from the Tailor creek ASR to LOK
- Efficiency loss: 30 percent (70 percent recovery rate)

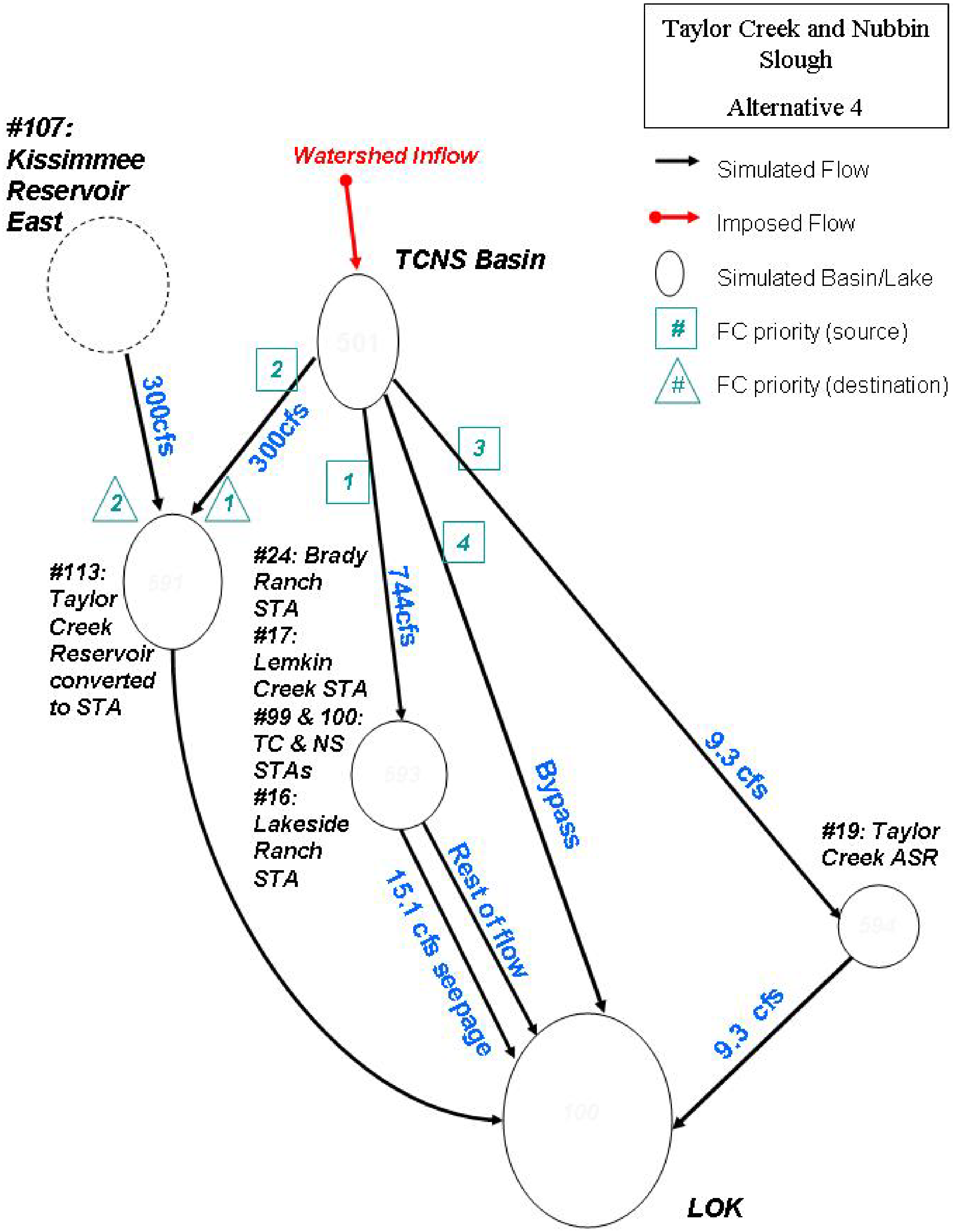


Figure B-13. Taylor Creek/Nubbin Slough Sub-watershed simulation configuration for Alternative 4.

B2.2.3 Lake Istokpoga (LI) Sub-watershed

The Lake Istokpoga 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 the District 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 management measures such as reservoirs, STAs and ASRs in the alternative scenarios, the outflow (runoff) to LOK 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 water bodies exhibit the same amount of net rainfall as the corresponding runoff generated during pre-management measure.

B2.2.3.1 Lake Istokpoga Sub-watershed Configuration for Alternative 1

Figure B-14 is a schematic showing how management measures in the Istokpoga Sub-watershed were simulated in Alternative 1. Descriptions of how Istokpoga management measures and basin flows were simulated in Alternative 1 are provided below:

Istokpoga flows

- Flows will pass through 1) Istokpoga Reservoir; 2) Brighton Reservation ASR; and 3) Istokpoga STA – subject to feature capacity and LOK envelope
- When LOK is below the low envelope stage, the Istokpoga Reservoir will have the first priority – subject to capacity
- The second priority will be for the Istokpoga STA (subject to capacity) and the third priority will be the Brighton Reservation ASR when LOK is below the low envelope stage
- Water not utilized by any of the 3 projects will be bypassed to LOK irrespective of 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: Istokpoga Sub-watershed (C-40A/C-41A basins)
- Storage capacity: 79,560 ac-ft
- Effective area: 5,416 acres
- Approximate bottom elevation: 29 ft NGVD29
- Maximum depth: 16 ft
- 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: Istokpoga Sub-watershed (L-49 basins)
- Storage capacity: 10,860 ac-ft
- Effective area: 7,240 acres
- Approximate bottom elevation: 17 ft NGVD29
- Maximum depth: 1.5 ft
- Inlet: capacity: 2,000 cfs pump, source: C-41 canal downstream of S-71
- Outlet: 2 Weirs with outflow capacity of 1000 cfs each, invert elevation 18.5 ft NGVD
- No seepage loss assumed

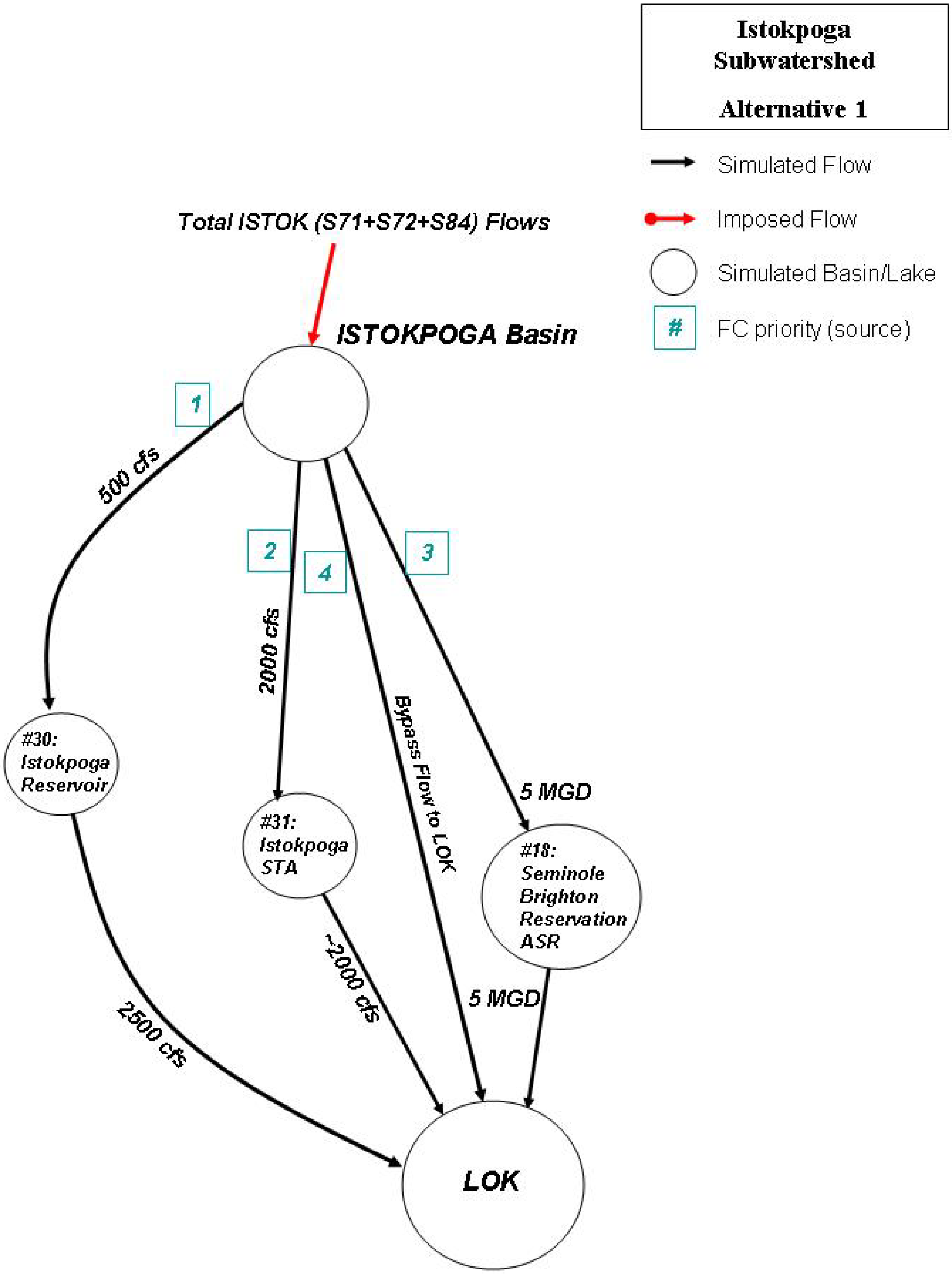


Figure B-14. Istokpoga Sub-watershed simulation configuration for Alternative 1.

B2.2.3.2 Istokpoga Sub-watershed Configuration for Alternative 2

Figure B-15 is a schematic showing how management measures in the Istokpoga Sub-watershed were simulated in Alternative 2. Descriptions of how Istokpoga management measures and basin flows were simulated in Alternative 2 are provided below:

Istokpoga Flows

- Flows will pass through 1) Istokpoga Reservoir; 2) Brighton Reservation ASR; and 3) Istokpoga STA – subject to feature capacity and LOK envelope
- When LOK is below the low envelope stage, the Istokpoga Reservoir will have the first priority – subject to capacity
- The second priority will be the Istokpoga Reservoir Complex, the third priority will be the Istokpoga STA, and fourth priority will be the Brighton Reservation ASR.
- If LOK is above the high envelope stage and there is capacity in the Istokpoga Reservoir Complex, water from LOK will be back pumped into the Reservoir complex.
- Water not utilized by any of the 4 projects will be bypassed to LOK irrespective of the lake stage.
- Istokpoga STA releases water to LOK 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: Istokpoga Sub-watershed (C-40A/C-41A basins)
- Storage capacity: 79,560 ac-ft
- Effective area: 5,416 acres
- Approximate bottom elevation: 29 ft NGVD29
- Maximum depth: 16 ft
- 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: Istokpoga Sub-watershed (L-49 basins)
- Storage capacity: 10,860 ac-ft
- Effective area: 7,240 acres
- Approximate bottom elevation: 17 ft NGVD29
- Maximum depth: 1.5 ft
- Inlet: capacity: 2,000 cfs pump, source: C-41 canal downstream of S-71

- Outlet: 2 Weirs with outflow capacity of 1000 cfs each, invert elevation 18.5 ft NGVD
- No seepage loss assumed

#108: Istokpoga/Kissimmee Reservoir

- Location: Indian Prairie/Istokpoga Sub-watershed
- Storage capacity: 300,000 ac-ft
- Footprint: 21,000 acres
- Effective area: 18,750 (90 percent of 21,000)
- Maximum depth: 16 ft
- Inlet: capacity: 750 cfs pump, source: C-41A canal downstream of S-83 (1st priority for inflow)
- Inlet: capacity: 1,500 cfs pump, source: Lake Okeechobee (2nd priority for inflow)
- Outlet: Pump with outflow capacity of 2,500 cfs
- No seepage loss assumed

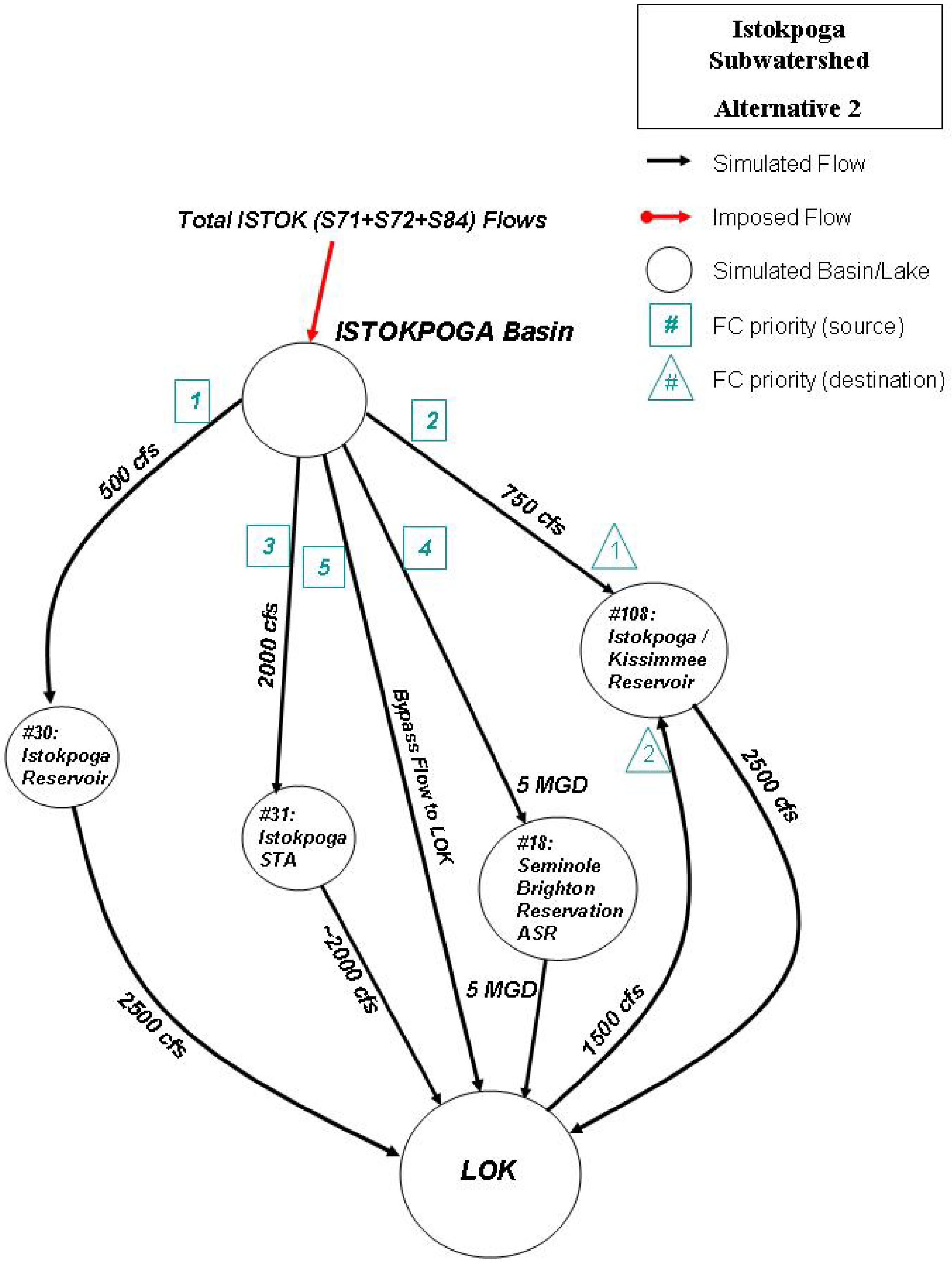


Figure B-15. Istokpoga Sub-watershed simulation configuration for Alternative 2.

B2.2.3.3 Istokpoga Sub-watershed Configuration for Alternative 3

Figure B-16 is a schematic showing how management measures in the Istokpoga Sub-watershed were simulated in Alternative 3. Descriptions of how Istokpoga management measures and basin flows were simulated in Alternative 3 are provided below:

Istokpoga Flows

- The total Istokpoga flows will pass through the Alt 3 features with the following priorities 1) Istokpoga Canal RASTA: Reservoir, 2) S-68 STA, 3) Istokpoga reservoir, 4) Istokpoga STA, and 5) Seminole Brighton Reservation ASR, subject to feature capacity and LOK stage envelope.
- The downstream Istokpoga Canal RASTA will receive flows from the Istokpoga Canal Reservoir, and flows not utilized by the Alt 3 projects will by bypass to LOK as priority 6.
- Water not utilized by any of the 6 projects will be bypassed to LOK 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: Istokpoga Sub-watershed (C-40A/C-41A basins)
- Storage capacity: 79,560 ac-ft
- Effective area: 5,416 acres
- Approximate bottom elevation: 29 ft NGVD29
- Maximum depth: 16 ft
- Inlet: capacity: 500 cfs pump, source: C-41A canal downstream of S-83
- Outlet: Pump with outflow capacity of 2,500 cfs
- No seepage loss assumed

#31: Istokpoga STA

- Location: Istokpoga Sub-watershed (L-49 basins)
- Storage capacity: 10,860 ac-ft
- Effective area: 7,240 acres
- Approximate bottom elevation: 17 ft NGVD29
- Maximum depth: 1.5 ft
- Inlet: capacity: 2,000 cfs pump, source: C-41 canal downstream of S-71
- Outlet: 2 Weirs with outflow capacity of 1,000 cfs each, invert elevation 18.5 ft NGVD
- No seepage loss assumed

#111: S68 STA

- Location: Istokpoga Sub-watershed (L-49 basins)
- Storage capacity: 3,240 ac-ft
- Effective area: 2,400 acres
- Approximate bottom elevation: 17 ft NGVD29
- Maximum depth: 1.35 ft
- Inlet: capacity: 250 cfs pump, source: C-41 canal downstream of S-68
- Outlet: 1 Weir with outflow capacity of 250 cfs each, invert elevation 18.35 ft NGVD
- No seepage loss assumed

#112: Istokpoga Canal RASTA: Reservoir

- Location: Istokpoga Sub-watershed
- Storage capacity: 28,800 ac-ft
- Effective area: 1,800 acres
- Approximate bottom elevation: 29 ft NGVD29
- Maximum depth: 16 ft
- Inlet: capacity: 300 cfs pump, source: C-41A canal
- Outlet: Pump with outflow capacity of 500 cfs
- No seepage loss assumed

#112: Istokpoga Canal RASTA: STA

- Location: Istokpoga Sub-watershed
- Storage capacity: 6,750 ac-ft
- Effective area: 4,500 acres
- Approximate bottom elevation: 17 ft NGVD29
- Maximum depth: 1.5 ft
- Inlet: capacity: 500 cfs pump, source: Istokpoga Canal Reservoir
- Outlet: 2 Weirs with outflow capacity of 250 cfs each, invert elevation 18.5 ft NGVD
- No seepage loss assumed

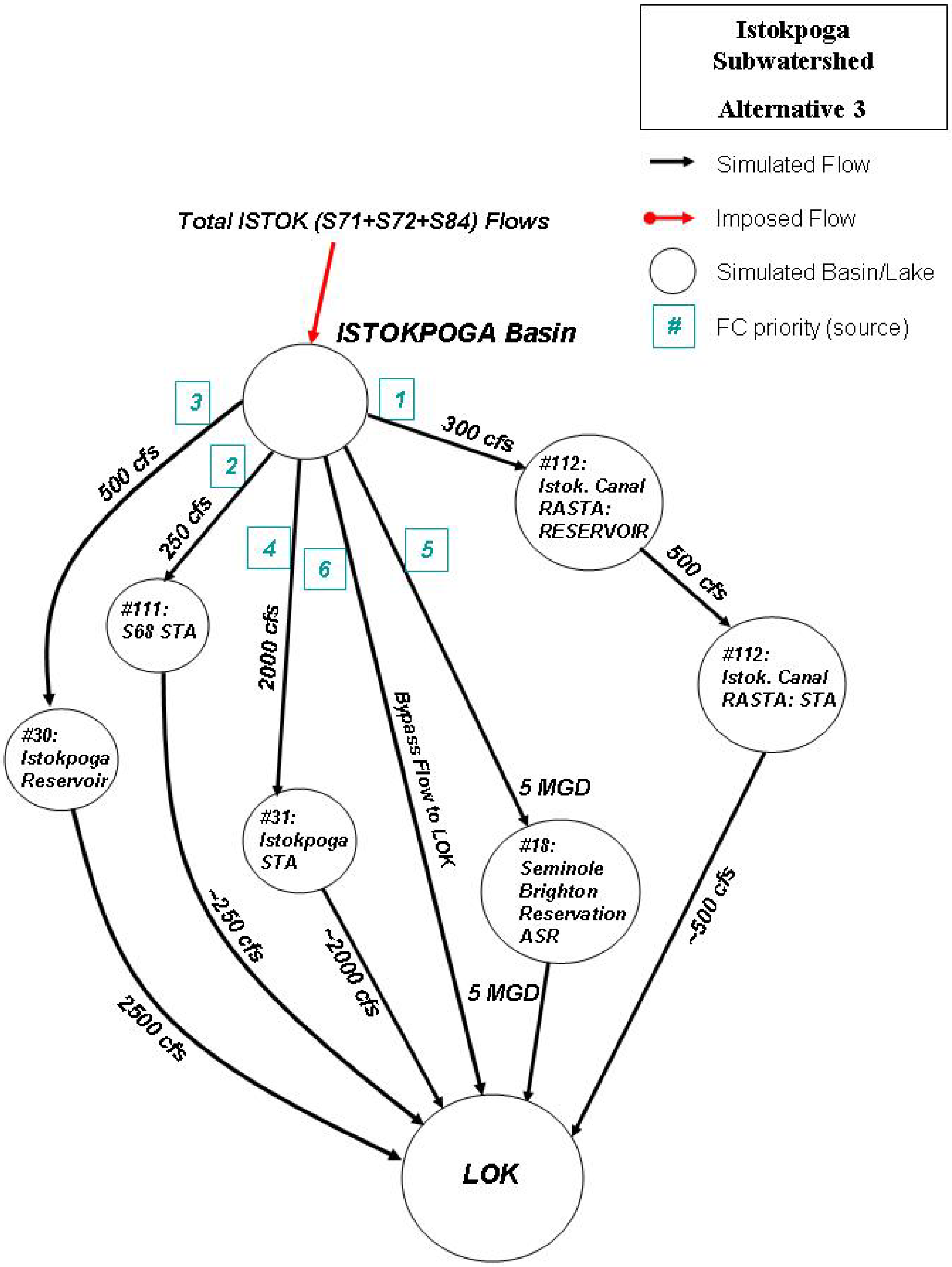


Figure B-16. Istokpoga Sub-watershed simulation configuration for Alternative 3.

B2.2.3.4 Istokpoga Sub-watershed Configuration for Alternative 4

Figure B-17 is a schematic showing how management measures in the Istokpoga Sub-watershed were simulated in Alternative 4. Descriptions of how Istokpoga management measures and basin flows were simulated in Alternative 4 are provided below:

Istokpoga Flows

- The total Istokpoga flows will pass through the Alt 3 features 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 LOK 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 LOK is above the high envelope stage and there is capacity in the Istokpoga Reservoir Complex, water from LOK will be back pumped into the Istokpoga/Kissimmee RASTA.
- Flows not utilized by the Alt 3 projects will by bypass to LOK as priority 6 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: Istokpoga Sub-watershed (C-40A/C-41A basins)
- Storage capacity: 79,560 ac-ft
- Effective area: 5,416 acres
- Approximate bottom elevation: 29 ft NGVD29
- Maximum depth: 16 ft
- Inlet: capacity: 500 cfs pump, source: C-41A canal downstream of S-83
- Outlet: Pump with outflow capacity of 2,500 cfs
- No seepage loss assumed

#31: Istokpoga STA

- Location: Istokpoga Sub-watershed (L-49 basins)
- Storage capacity: 10,860 ac-ft
- Effective area: 7,240 acres
- Approximate bottom elevation: 17 ft NGVD29
- Maximum depth: 1.5 ft
- Inlet: capacity: 2,000 cfs pump, source: C-41 canal downstream of S-71
- Outlet: 2 Weirs with outflow capacity of 1,000 cfs each, invert elevation 18.5 ft NGVD
- No seepage loss assumed

#111: S68 STA

- Location: Istokpoga Sub-watershed (L-49 basins)
- Storage capacity: 3,240 ac-ft
- Effective area: 2,400 acres
- Approximate bottom elevation: 17 ft NGVD29
- Maximum depth: 1.35 ft
- Inlet: capacity: 250 cfs pump, source: C-41 canal downstream of S-68
- Outlet: 1 Weir with outflow capacity of 250 cfs each, invert elevation 18.35 ft NGVD
- No seepage loss assumed

#114: Istokpoga/Kissimmee RASTA: Reservoir

- Location: Indian Prairie/Istokpoga Sub-watershed
- Storage capacity: 144,000 ac-ft
- Footprint: 10,000 acres
- Effective area: 9,000 (90 percent of 10,000)
- Maximum depth: 16 ft
- 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: Istokpoga Sub-watershed
- Storage capacity: 10,800 ac-ft
- Effective area: 7,200 acres
- Approximate bottom elevation: 17 ft NGVD29
- Maximum depth: 1.5 ft
- Inlet 1: capacity: 1,500 cfs pump, source: Istokpoga/Kissimmee RASTA
- Inlet 2: capacity 1,500 cfs pump, source: Istokpoga/Kissimmee RASTA
- Outlet: 3 Weirs with outflow capacity of 1,000 cfs each, invert elevation 18.5 ft NGVD
- No seepage loss assumed

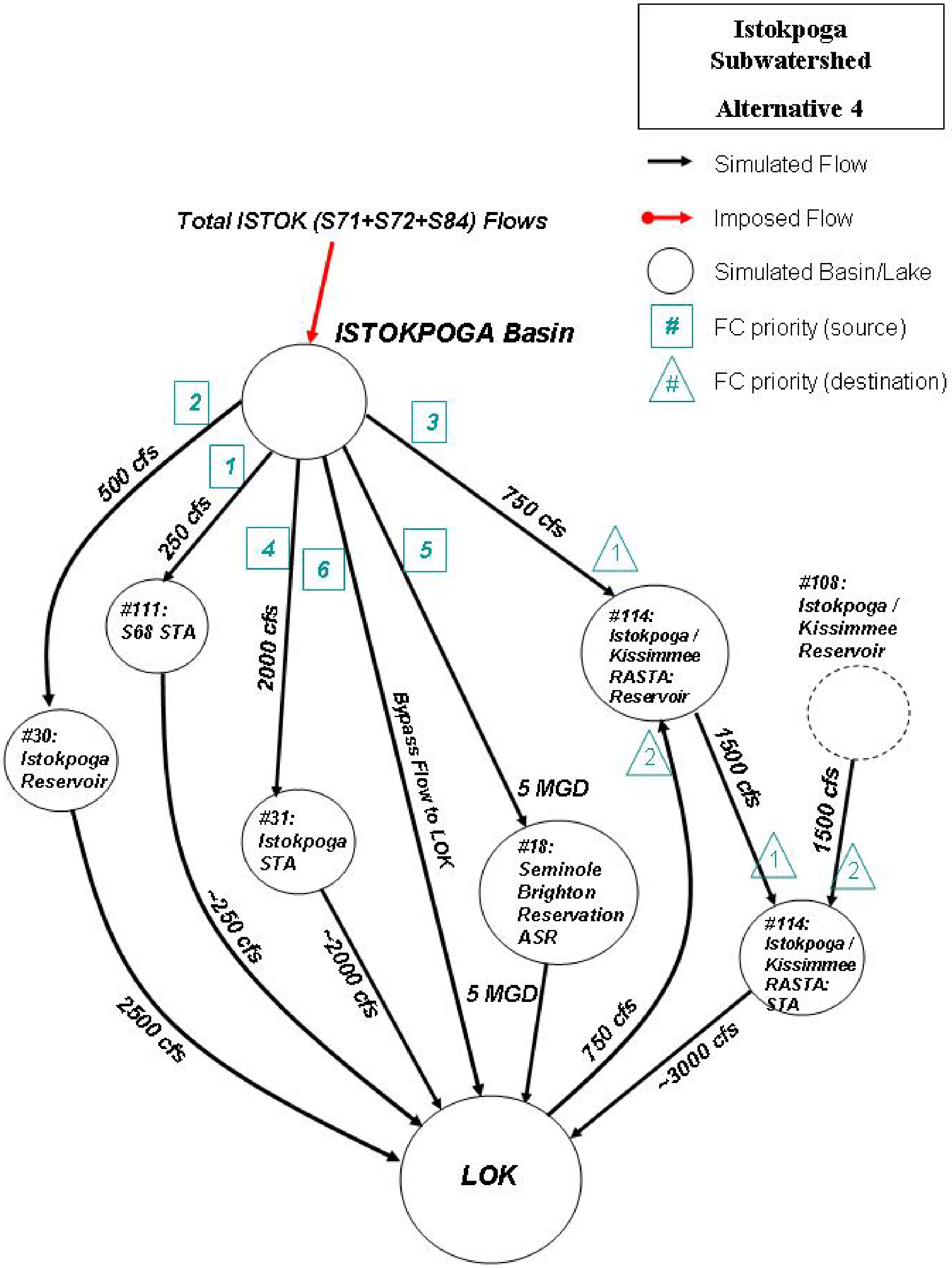


Figure B-17. Istokpoga Sub-watershed simulation configuration for Alternative 4.

B2.2.4 Fisheating Creek (FEC) Sub-watershed

The Fisheating Creek 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 Fisheating Creek 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 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. This station is the most downstream "natural" station which is located on the upper Fisheating Creek basin, several miles upstream of the confluence of the creek to the Lake Okeechobee. The assumption is the Lake Okeechobee inflows downstream of Palmdale are included in MDS term.

There are no management measures included in the FEC Sub-watershed as part of Alternative 1.

B2.2.4.1 Fisheating Creek Sub-watershed Configuration for Alternative 2

Figure B-18 is a schematic showing how management measures in the Fisheating Creek Sub-watershed were simulated in Alternative 2. Descriptions are provided below of how Fisheating Creek basin flows and management measures are simulated in Alternative 2:

#109: FEC Reservoir

- Storage capacity: 250,000 ac-ft
- Effective Area: 15,625 acres (~90 percent of footprint = 17,500 acres)
- Maximum elev.: (Bottom Elevation + 16.0) ft NGVD29
- Emergency discharge when elev. Reaches: (Bottom Elevation +16.0 + 0.5) ft NGVD29
- Inlets:
  500 cfs pump, source: FEC Basin and 1,500 cfs pump, source: LOK
- Outlet: 2,500 cfs pump, destination: LOK
- Operation:
  - Water from FEC basin is sent to the FEC reservoir first when LOK is above envelope subject to capacity (500 cfs) and available storage below maximum depth. Any remaining water is sent downstream to LOK.
  - Water from LOK basin is sent to the FEC reservoir next when LOK is above envelope subject to capacity (15,000 cfs) and available storage below maximum depth.
  - Water from the FEC reservoir is sent to LOK (subject to capacity of the structure) when LOK is below envelope; emergency discharge occurs when reservoir is above 16.5 ft depth
- Receives ET and rainfall representative of FEC Sub-watershed
- No seepage loss assumed

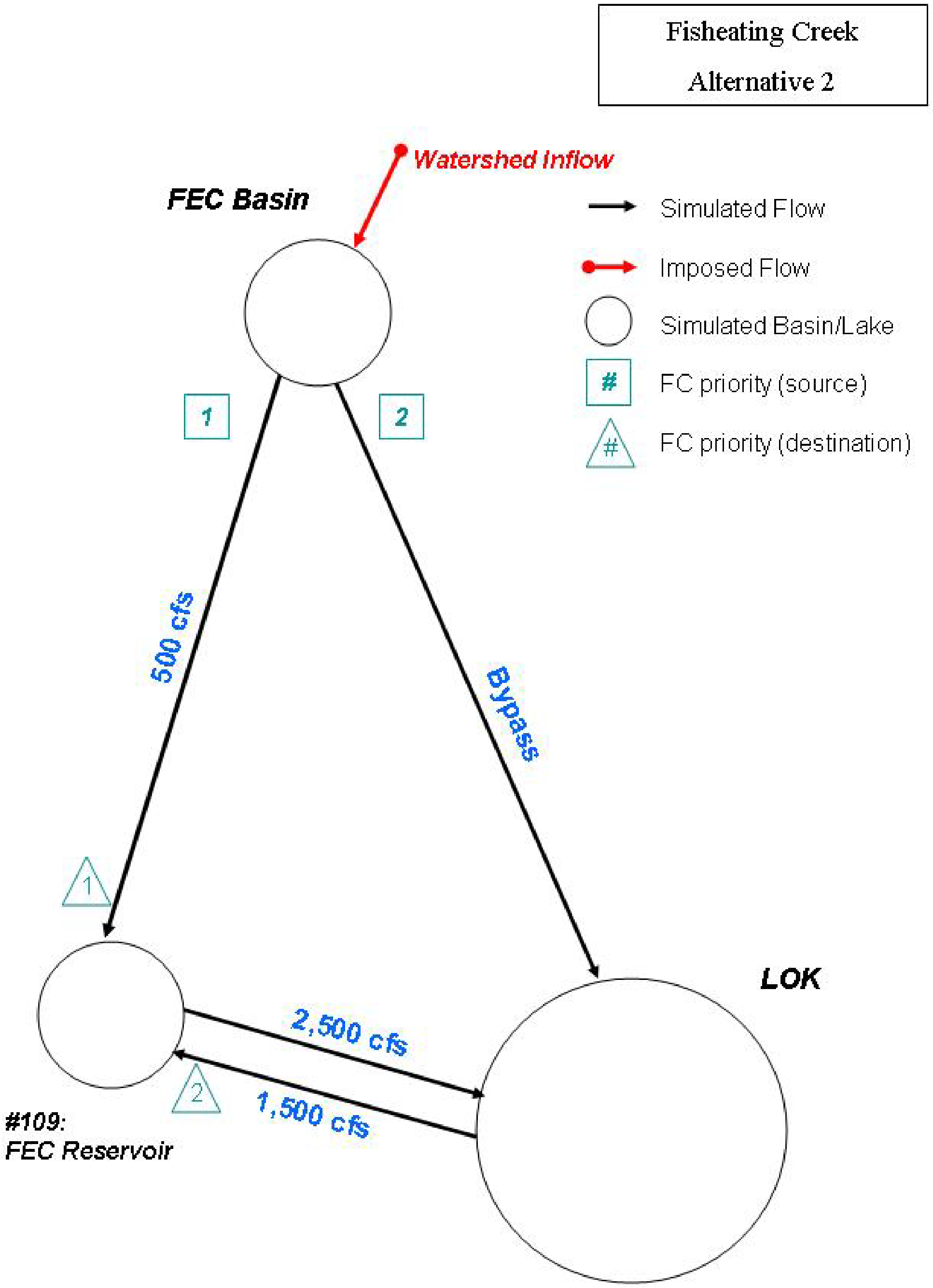


Figure B-18. Fisheating Creek Sub-watershed simulation configuration for Alternative 2.

B2.2.4.2 Fisheating Creek Sub-watershed Configuration for Alternative 3

Figure B-19 is a schematic showing management measures in the Fisheating Creek Sub-watershed as simulated in Alternative 3. Descriptions are provided below of how Fisheating Creek basin flows and management measures are simulated in Alternative 3:

#61: FEC RASTA I, #77: FEC RASTA II: Reservoirs

- Location: Upper reaches of the FEC Sub-watershed
- Storage capacity: 27,000 + 14,580 = 41,580 ac-ft
- Footprint: 3,000 + 1,350 = 4,350 acres (90 percent of footprint = 3,915 ac)
- Maximum depth: [10 ft (F-05) and 12 ft (I-33)] , 41580/3915 = 10.62 ft; (Bottom Elevation +10.62) ft NGVD 29
- Emergency discharge when depth reaches. Bottom Elev+10.62 + 0.5 ft NGVD29
- Inlet: capacity: 450+200 = 650 cfs pump, source: FEC Basin
- Outlet: capacity: 500 +100 = 600 cfs pump, destination: STA
- Operation:
    - Water from FEC basin is sent to the Reservoir first (subject to capacity and available storage below maximum depth), and any remaining water is sent downstream to LOK.
    - Water from the Reservoir is sent downstream to STA (subject to capacity of the structure and 2.5 ft of maximum depth).
- Receives ET and rainfall representative of FEC Sub-watershed
- No seepage loss assumed

#61: FEC RASTA I, #77: FEC RASTA II: STAs

- Location: Upper reaches of the FEC Sub-watershed in association with the respective reservoirs
- Storage capacity: 12,150 + 608 = 12,758 ac-ft
- Footprint: 9,000+450 acres (90 percent of footprint = 8,505 acres)
- Maximum depth: 12,758 / 8505 = 1.5 ft;
- Inlet: capacity: 600 cfs pump, (2.5 ft+ Bottom Elevation NGVD) when reservoir stops releasing, source: FEC RASTA I and II Reservoirs
- Outlet: weir with crest length calculated based on inflow and 1 foot head difference - crest elevation at (1.5 ft + bottom Elevation) NGVD 29; destination: Lake OK when STA water level is above weir elevation
- Receives ET and rainfall representative of FEC Sub-watershed
- No seepage loss assumed

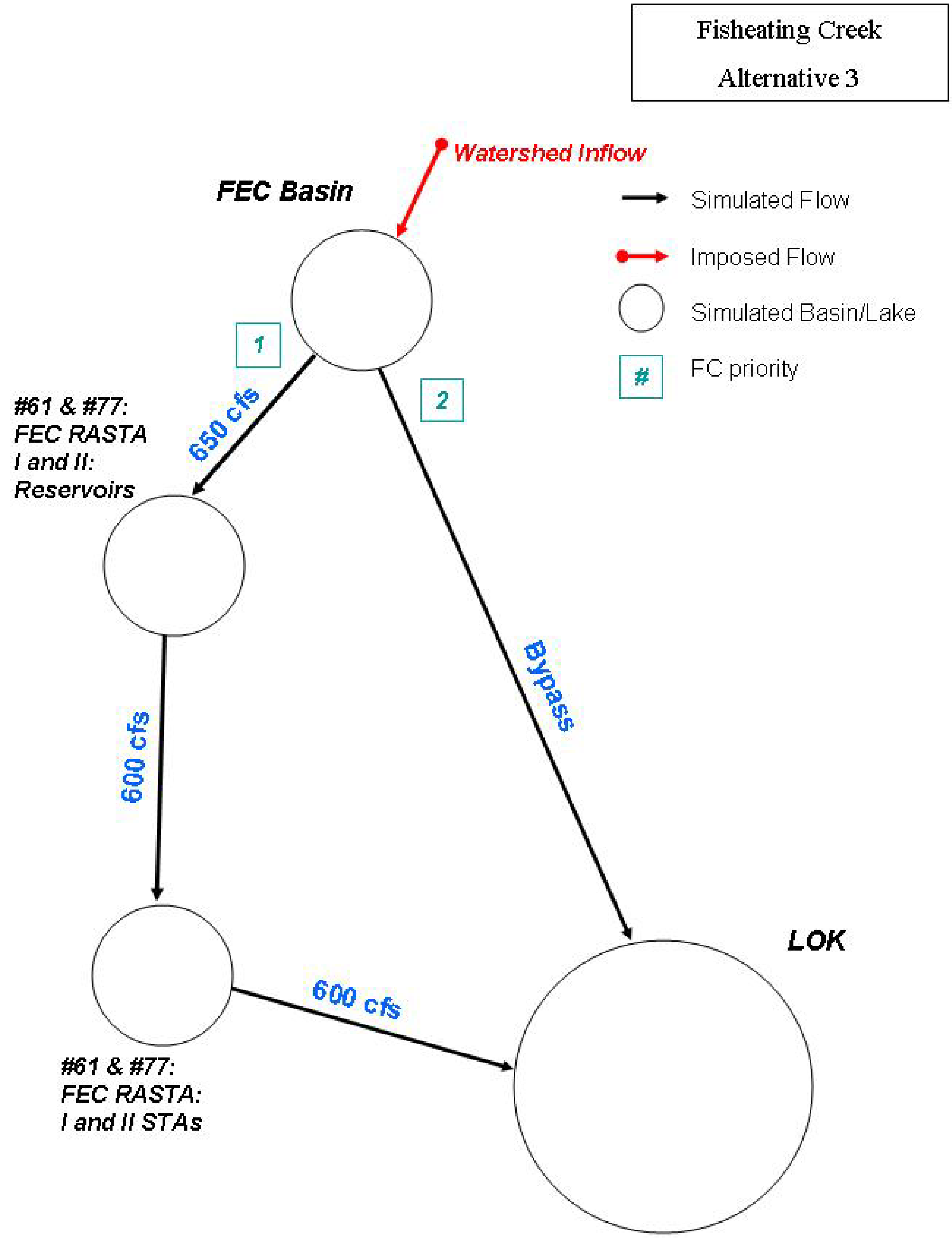


Figure B-19. Fisheating Creek Sub-watershed simulation configuration for Alternative 3.

B2.2.4.3 Fisheating Creek Sub-watershed Configuration for Alternative 4

Figure B-20 is a schematic showing how management measures in the Fisheating Creek Sub-watershed were simulated in Alternative 4. Descriptions are provided below of how Fisheating Creek basin flows and management measures are simulated in Alternative 4:

#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 ac-ft
- Footprint: 3,000 + 1,350 + 11,000 = 15,350 acres (90 percent of footprint =13,815 acres)
- Maximum depth: [10 ft (F-05); 12 ft (I-33); 16ft [F-01]] , 199,980 / 13,815 = 14.5 ft; (Bottom Elevation + 14.5 ft) NGVD 29
- Emergency discharge when depth reaches. Bottom Elevation + 14.5 + 0.5 ft NGVD29
- Inlets:
  450 + 200 + 1,800 = 2,450 cfs pump for first source: FEC Basin; and
  1,500 cfs pump from second source: LOK
- Outlet: capacity: 500 + 100 + 500 = 1,100 cfs pump, destination: STA
- Operation:
  - When LOK 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 LOK through bypass – first priority
  - When LOK is above high envelope stage, water is sent from LOK to the reservoir (subject to capacity and available storage below maximum depth) – second priority
  - When LOK is below high envelope stage, water is sent directly from FEC basin to LOK through bypass.
  - When LOK is below the low envelope stage, water is sent from reservoir to the STA (subject to capacity and available storage below 2.5 ft maximum depth).
- Receives ET and 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 ac-ft
- Footprint: 9,000 + 450 + 6,500 = 15,950 acres (90 percent of footprint = 14,355 acres)
- Maximum depth: 21,533 / 14,355 = 1.5 ft;
- Inlet: capacity: 500 + 100 + 500 = 1,100 cfs pump, (2.5 ft + 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 1ft head difference), crest elevation at (1.5 ft + bottom Elevation) NGVD 29; destination: LOK; Outflow occurs when STA water level is above outlet weir elevation.
- Receives ET and rainfall representative of FEC Sub-watershed
- No seepage loss assumed

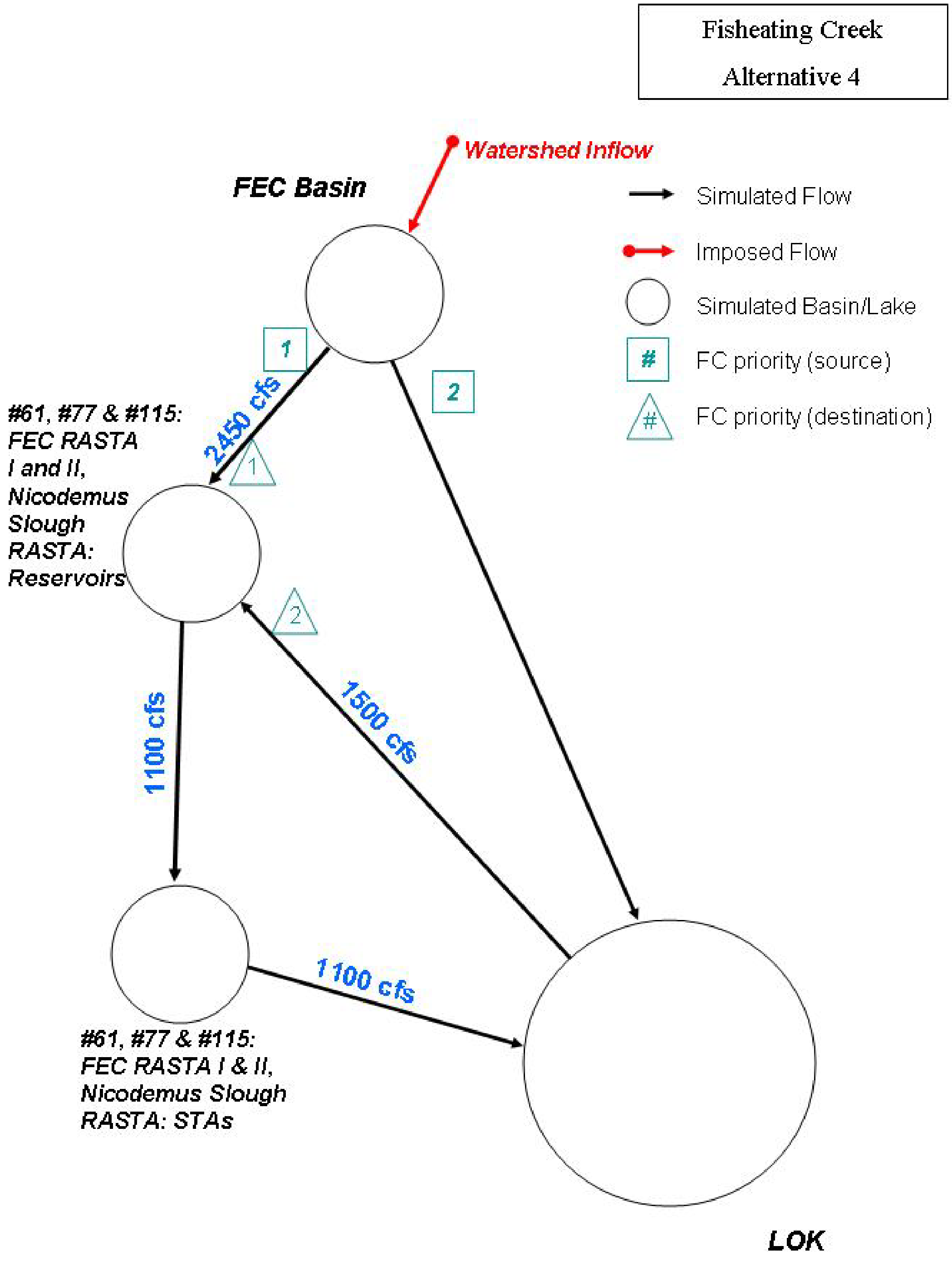


Figure B-20. Fisheating Creek Sub-watershed simulation configuration for Alternative 4.

B2.2.5 Lake Okeechobee (LOK) Sub-watershed

Several features from NERSM were developed, or adopted from SFWMM in order to meet modeling requirements established during the alternative formulation and analysis phase of the project. A brief description of primary components that comprise the LOK water balance and computational algorithms that were incorporated in the model is given next.

LOK 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. Evapotranspiration 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. Historic sub-watershed flows are adjusted in select Alternative Scenarios as needed to account for the "footprint" of management measures considered in a particular scenario. NERSM calculated flows from the LKB Sub-watershed are another tributary inflow to LOK.

Backflows coming from the EAA in areas east, west, and south of LOK as simulated in SFWMM are input as a boundary condition for the NERSM.

In the future base and Alternative Scenarios, the C-43 reservoir is modeled in the NERSM as a special package which interacts with Lake Okeechobee and the Caloosahatchee estuary. The performance of C-43 reservoir and its ability to meet C-43 estuary demands are affected by LOK stages. The footprint for the C-43 reservoir was obtained from modeling obtained during 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 (e-mail 2007).

The C-44 reservoir receives water only from local basin runoff, hence it is not explicitly simulated in NERSM. However, NERSM calculated releases are combined with the contribution of the C-44 project as simulated in SFWMM to evaluate the total impact on St. Lucie Estuary.

B2.2.6 Lake Okeechobee Operations

The Water Supply and Environmental (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 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 based in the current base Scenario on the WSE schedule implemented in SFWMM 2005 base run. Releases for the same purpose are simulated in the future base and Alternative Scenarios based on the WSE schedule as implemented in the SFWMM 2010A8 run.

Based on the WSE schedule, discharges to the Caloosahatchee River (C-43) through S-77 and discharges to the St Lucie Canal (C-44) through S-308 are simulated. 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), to WCA 3A (S-351 to North New River canal and S-354 to Miami Canal).

Instead of meeting local basin demand as well as 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 inline 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 LOK 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.

The C-44 reservoir receives water only from local basin runoff, hence it is not explicitly simulated in NERSM. However a release rule is implemented in NERSM to address environmental requirements of the St. Lucie Estuary. NERSM calculated releases are combined with the contribution of the C-44 project as simulated in SFWMM 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 future base and Alternative Plans scenarios, regulatory releases south are zero except through C-10A.

Non-regulatory releases are sent to areas of the system for a myriad of purposes including irrigation, saltwater intrusion control, domestic water supply and environmental enhancement. Additionally, in the future, Lake Okeechobee discharges will be made to the proposed above-ground reservoirs to be constructed in the Everglades Agricultural Area (EAA).

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 Lake Okeechobee Water Shortage Management (LOWSM) methodology described below is implemented in NERSM.

All other non-regulatory releases such as environmental water supply releases to the Water Conservation Areas and Everglades National Park, urban water supply releases to the Lower East Coast (LEC) and discharges to the EAA reservoir were obtained from the SFWMM and input as boundary condition flows.

B2.2.7 MDS and LOWSM Algorithms

The modified-delta-storage (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. One begins with the historic 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.

The Lake Okeechobee Water Shortage Management (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 Lake Okeechobee Service Area (LOSA) demands to be met. The weekly demands, based on a 1-in-10-year drought condition, were obtained from the South Florida Water Management Model (SFWMM).

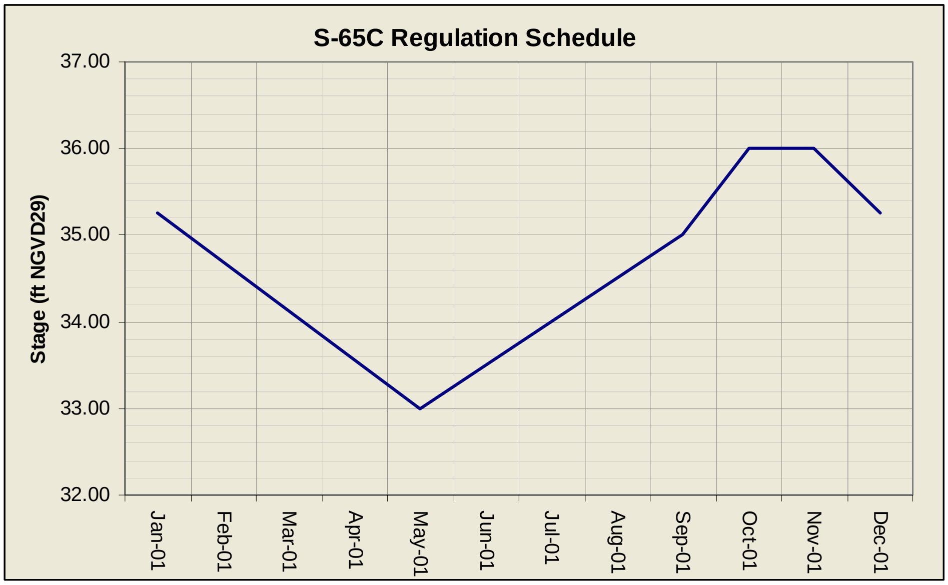
B2.3 Sub-watershed Specific Assumptions and Specifications

B2.3.1 Current Base (2005) Assumptions

Table B-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 ft, 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 (LMA). 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 and 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 6 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 – 2,000 cfs S-63 – 700 cfs S-65 – 4,000 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 the Phase I of the Kissimmee River Restoration 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 District Technical Publication 86-5, and are similar to the District'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 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 outlined in the technical publication.
	Lower Kissimmee Sub-watershed (LKB)
General	• Model reflects conditions post-Phase I of the Kissimmee River Restoration (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, BC, D 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, 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 B-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 2,000 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.

	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 LOK is imposed as flow boundary condition. Then the flow would pass through the sub-watershed and outlet directly into LOK.
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 LOK 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 LOK 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.
Lake Istokpoga Sub-watershed	

General	• A flow pass-through method is implemented for this area. The historical flow from this area into LOK is imposed as flow boundary condition. Then the flow would pass through the sub-watershed and outlet directly into LOK. The sub-watershed is assumed to be cutoff 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 setup 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 LOK 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 LOK is imposed as an inflow to the sub-watershed as a boundary condition and allowed to flow into LOK.
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 LOK, 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 LOK. The assumption is 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 LOK.
Operations	• For flow pass-through method, the structures are assumed to have been operated to pass historical outflow.
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 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 B-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 and M. J. Chen)]

In the table, the flow equation coefficients for the Kissimmee River spillways are shown.

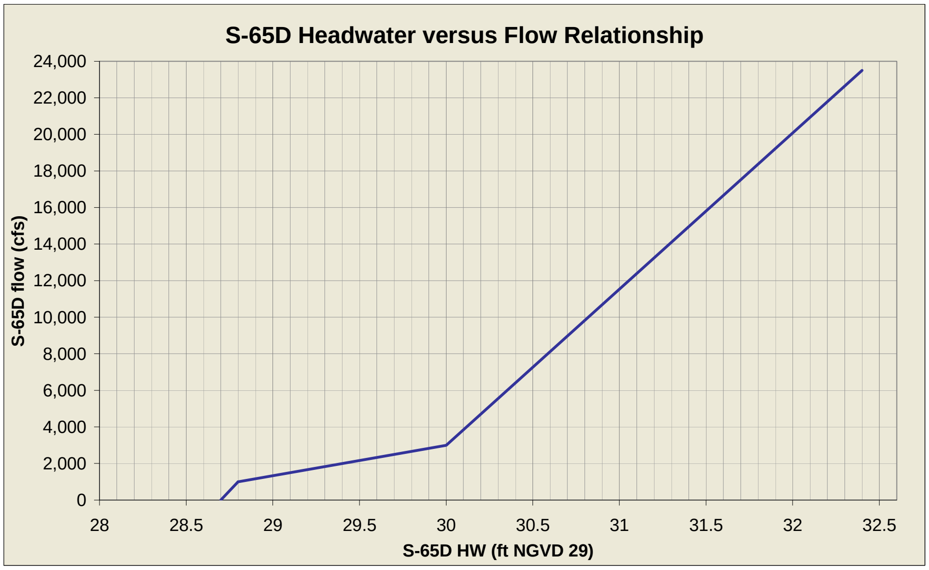
H: head water above CEL (ft) = HW-CEL;
h: tail water above CEL (ft) = TW-CEL;
g: gravitational acceleration, 32.2 ft^2/s;
G_o: gate opening (ft);
L: spillway width (ft);
y_c: critical depth (ft); and
Q: computed discharge (cfs).

Note: Coefficients a and b only apply to Kissimmee River gated spillways.

B2.3.2 Future Base (2015) Assumptions

Table B-8. Summary of primary characteristics of Future Base Condition and alternative plan models.

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 Kissimmee River Restoration 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 ft 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 Kissimmee River Restoration (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. • 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 B-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 lookup 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-	• Same as in current base.

Area Relationships	
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.
Structure Capacity	• Same as in SFWMM
Operations	• Regulatory releases to the estuaries are simulated based on the WSE 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. • Due to interaction between the C-43 reservoir and Lake Okeechobee, the C-43 reservoir will be simulated with similar operations as in the SFWMM. • The C-44 reservoir will not be explicitly simulated but the contribution of the C-44 project as simulated in another model, the SFWMM, will be incorporated. The time series of C-44 reservoir releases (as simulated in SFWMM) and the RSM-simulated Lake Okeechobee releases will be combined to evaluate the total impact on St. Lucie Estuary. • Individual LOSA basin demands are boundary conditions. Water management cutback scheme 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.

B3.0 WATER BUDGET COMPONENTS

B3.1 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 7 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 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 B-9 shows average monthly and annual rainfall values for key individual sub-watersheds within the LOW. 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 B-9**, rainfall values for the highest monthly and annual rainfalls (generally in portion of the Sub-Watershed (St Lucie drainage area) on the east coast) 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 B-9. Average monthly and annual rainfall depths (inches) for Lake Okeechobee sub-watersheds (1971 – 2000).

Sub-Watershed	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Dec	Dec	Annual
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 (min)	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 (max)	2.51	2.31	3.14	3.13	4.99	8.10	6.57	6.7	8.18	6.73	3.07	2.15	57.58

B3.2 Evapotranspiration

Evapotranspiration (ET) is the total evaporation plus transpiration by vegetation. Potential evapotranspiration 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 evapotranspiration will be less than potential evapotranspiration.

District-wide average annual evapotranspiration is estimated to be 51.2 inches (130.1 cm) although there is geographic variation. Temporal variation in annual potential evapotranspiration 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 evapotranspiration 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 1965 through 2005 was 55.4 inches. **Figure B-21** shows the variation in average monthly PET values for Lake Okeechobee.

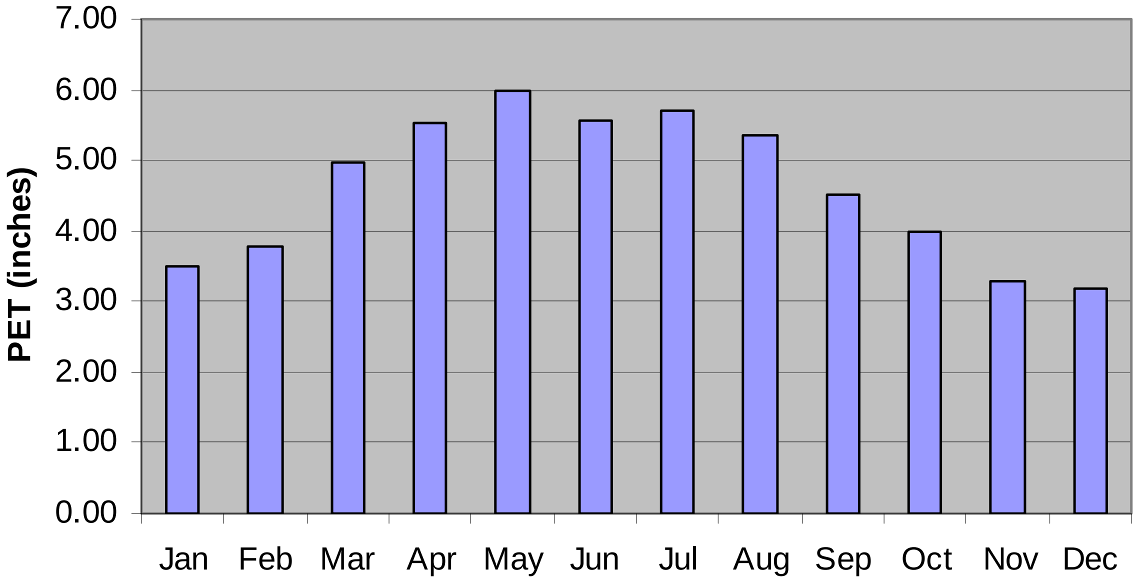


Figure B-21. Average monthly potential evapotranspiration rates at Lake Okeechobee (1965 through 2005).

B3.3 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 LOW 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.

B3.3.1 Existing Conditions Flows

Table B-10 shows the recorded average annual flows to Lake Okeechobee contributed by each of the sub-watersheds recorded for the period of record from 1991 to 2005. Upper Kissimmee Sub-watershed flows were measured at S-65. The source of Lower Kissimmee Sub-watershed flows is the drainage area between Lake Kissimmee and Lake Okeechobee. The Lake Okeechobee Sub-watershed flows are the sum of flows from the Caloosahatchee Basin, EAA, and St Lucie Basin. Data indicates that three sub-watersheds (Upper Kissimmee, Lower Kissimmee, and Lake Istokpoga) contributed nearly three-quarters of the flow (73 percent) to Lake Okeechobee.

Table B-10. Average annual inflows (ac-ft) from sub-watersheds to Lake Okeechobee.

Sub-Watershed	Average Annual Flows (ac-ft)	Percent total flow
Upper Kissimmee	954,204	37
Lower Kissimmee	378,836	15
Taylor Creek/Nubbin Slough	187,583	7
Lake Istokpoga	548,831	21
Fisheating Creek	224,368	9
Lake Okeechobee	264,457	10
Total	**2,558,279**	**100**

Average annual inflows from the three basins that compose the Lake Okeechobee Sub-watershed are described below:

- Flows from the Caloosahatchee Basin represent less that 0.5 percent of the total Lake Okeechobee average annual inflow. Such flows occur during periods of extremely low stages in Lake Okeechobee. Under such conditions, flows to the lake help minimize the duration when lake stages are below the desirable seasonal stage envelope and potentially reduce water supply demands not met in the Lake Okeechobee Service Area.

- Flows from the EAA Basins represent about 6 percent of the average annual inflow to Lake Okeechobee. Backpumping from the EAA is only performed when it is necessary to avoid local flooding. Diversions of the Chapter 298 District flood discharges and construction of the EAA Storage Reservoir will substantially reduce the volume and frequency of discharges from the EAA to Lake Okeechobee under the future base condition.

- Flows from the St Lucie Basin represent about 4 percent of the average annual inflows to Lake Okeechobee. These flows occur when Lake Okeechobee stages fall below 14.5 ft, NGVD (the upper operating range of C-44). Under such conditions, flows to the lake help minimize the duration when lake stages are below the desirable seasonal envelope and potentially reduce water supply demands not met in the Lake Okeechobee Service Area.

Additionally, the construction and operation of the C-44 Reservoir Project is expected to reduce the volume of flows to Lake Okeechobee from C-44.

B3.3.2 Future Base Condition Flows

Flow characteristics for individual sub-watersheds under *future base* scenario, as projected by NERSM simulations, are described below. Discharge exceedance curves are used in the following discussions to describe significant flow characteristics. These curves were developed based on RSM simulations of the future base condition for each of the sub-watersheds for the period of record from 1970 through 2005. The curves depict the percentage of time during the period of record when flows for the sub-watershed were more than a given rate.

- **Upper and Lower Kissimmee Sub-watersheds** – A discharge exceedance curve for the combined Kissimmee sub-watersheds (**Figure B-22**) indicates that 10 percent of the daily flows are greater than 3,103 cfs. Approximately 36 percent of the total flow volume occurs when flows are greater than 3,103 cfs and 23 percent of the total flow volume occurs when flows are greater than 4,629 cfs (5 percent exceedance).

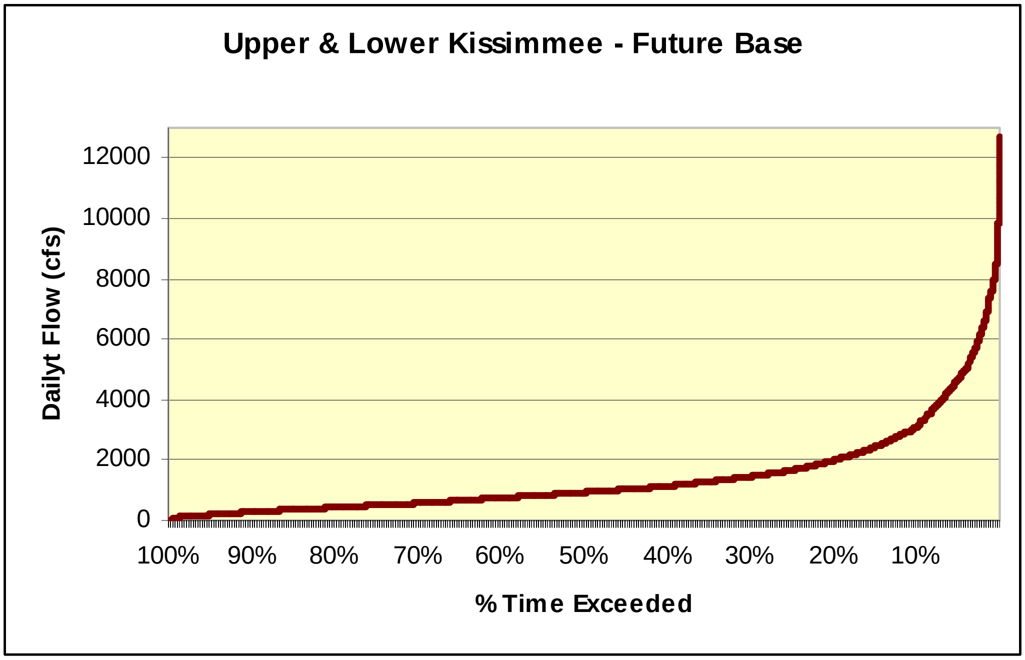


Figure B-22. Discharge exceedance curve for the combined Upper and Lower Kissimmee Sub-watersheds.

- **Taylor Creek/Nubbin Slough Sub-watershed** – A discharge exceedance curve for the Taylor Creek/Nubbin Slough Sub-watershed (**Figure B-23**) indicates that approximately 10 percent of the daily flows are greater than 486 cfs and that more than half of the total flow volume (56 percent) occurs when flows are greater than 486 cfs. Approximately 39 percent of the total flow volume occurs when discharges are greater than 762 cfs (5 percent exceedance).

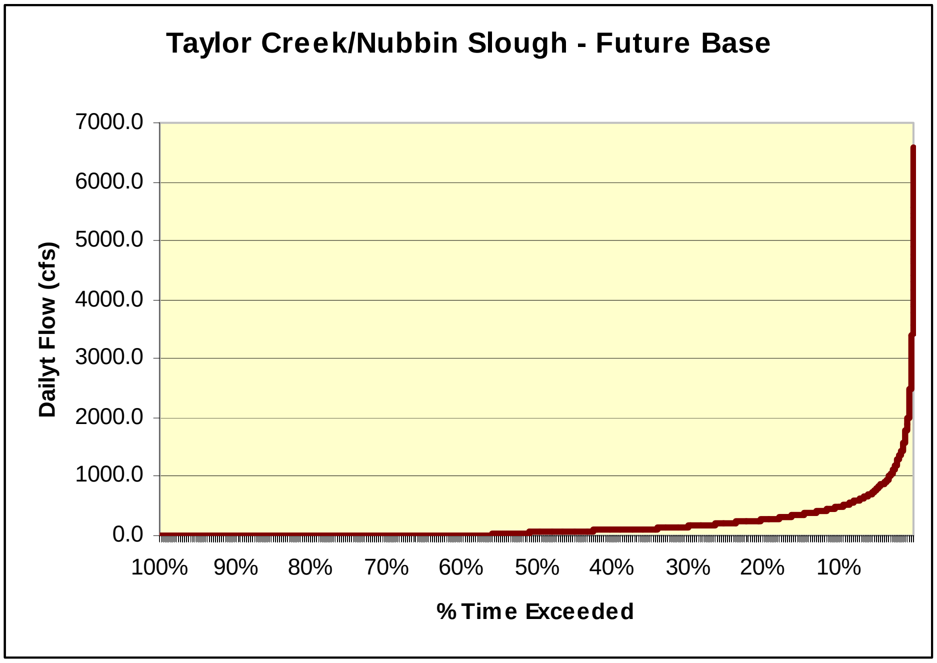


Figure B-23. Discharge exceedance curve for the Taylor Creek/Nubbin Slough Sub-watershed.

- **Lake Istokpoga Sub-watershed** – **Figure B-24** shows a discharge exceedance curve for the Istokpoga Sub-watershed. It shows that 10 percent of the daily flows are greater than 1,577 cfs and that more than one-half (54 percent) of the total flow volume occurs when flows are greater than 1,577 cfs. Approximately 36 percent of the total flow volume for the period of record occurred when flows are greater than 2,384 cfs (5 percent exceedance). In conclusion, there are infrequent flows but they are very heavy when they occur.

- **Fisheating Creek Sub-watershed** – Fisheating Creek is the only free flowing tributary to Lake Okeechobee. This sub-watershed is characterized by long periods of little or no flow during normal or dry conditions (**Figure B-25**) and very high peak discharges typically occur over very short periods of time. Approximately 10 percent of the daily flows are greater than 760 cfs and 60 percent of the total flow volume occurs when flows are greater than 760 cfs. Approximately 42 percent of the total flow volume occurs when flows are greater than 1,160 cfs (5 percent exceedance).

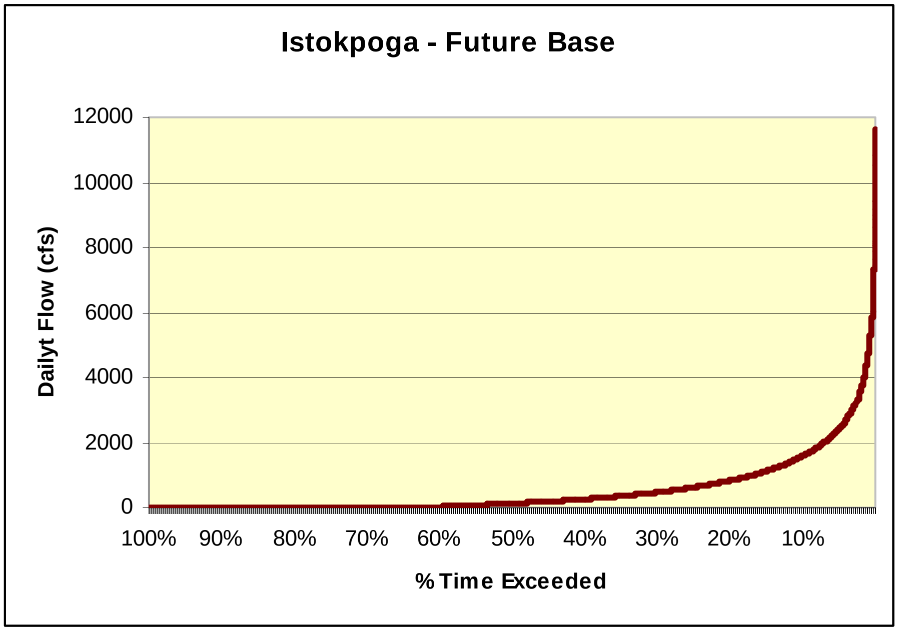


Figure B-24. Discharge exceedance curve for the Lake Istokpoga Sub-watershed.

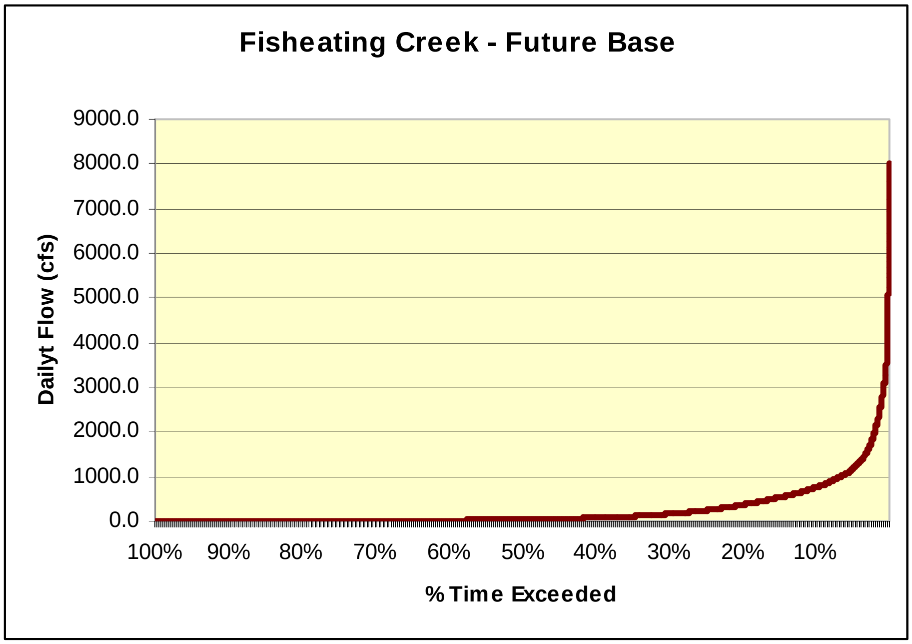


Figure B-25. Discharge exceedance curve for the Fisheating Sub-watershed.

B4.0 ANNUAL AND SEASONAL SUB-WATERSHEDS WATER BUDGETS

A simple graphic was developed during the course of creating the various models representing current and future base Conditions and Alternative Plans 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, evapotranspiration, model-calculated flows, imposed flows (i.e. historic 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.

B4.1 Annual Sub-watershed Water Budget Components

Average annual volumes for primary sub-watershed water budget components are illustrated in **Figures B-26 through B-30** for the six simulation scenarios. The net change in LOK storage (ΔS) in all scenarios is less than 1 percent of the total inflows or outflows from the lake. This is an important check of model integrity and indicates that the various sinks and sources of water to LOK are being properly accounted for.

B4.2 Dry Season Sub-watershed Water Budget Components

Average dry season volumes for the primary sub-watershed water budget components are illustrated in **Figures B-31 through B-35**. The negative value for LOK storage change indicates a net loss of water from storage in LOK during the 7 month dry period. A negative change in storage is associated with falling lake levels. The effects of management measures associated with the additional storage capacity considered in Alternatives 2 and 4 is indicated by the arrows labeled LOK withdrawals that lead from LOK back into the LI, TCNS and FEC Sub-watersheds.

B4.3 Wet Season Sub-watershed Water Budget Components

Average wet season volumes for the primary sub-watershed water budget components are illustrated in **Figures B-36 through B-40**. The positive value for LOK storage change indicates a net gain of water in LOK storage during the 5 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 LOK for discharge in upland storage facilities is greater during the wet season.

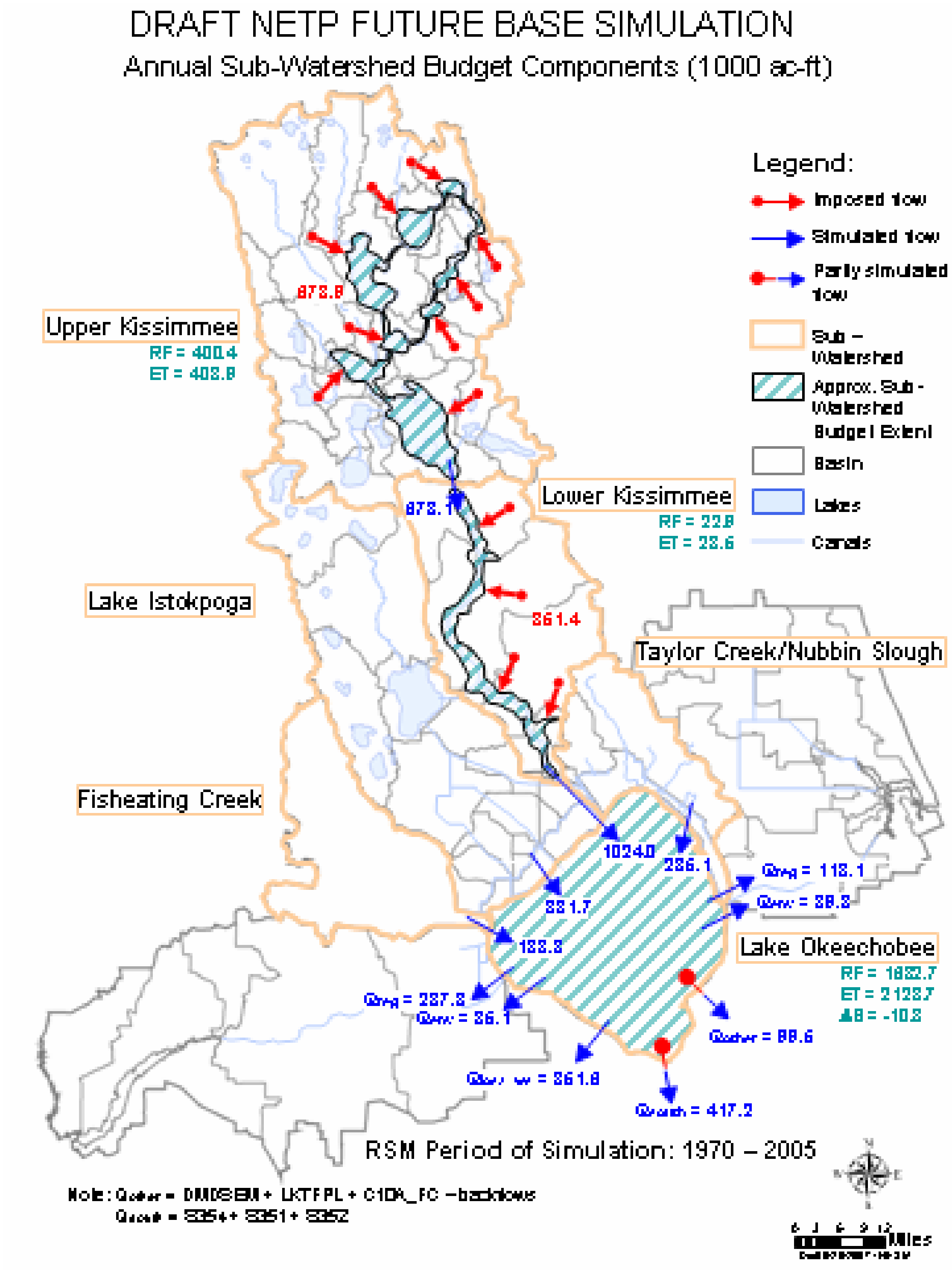


Figure B-26. NERSM calculated annual sub-watershed water budget components Future Base.

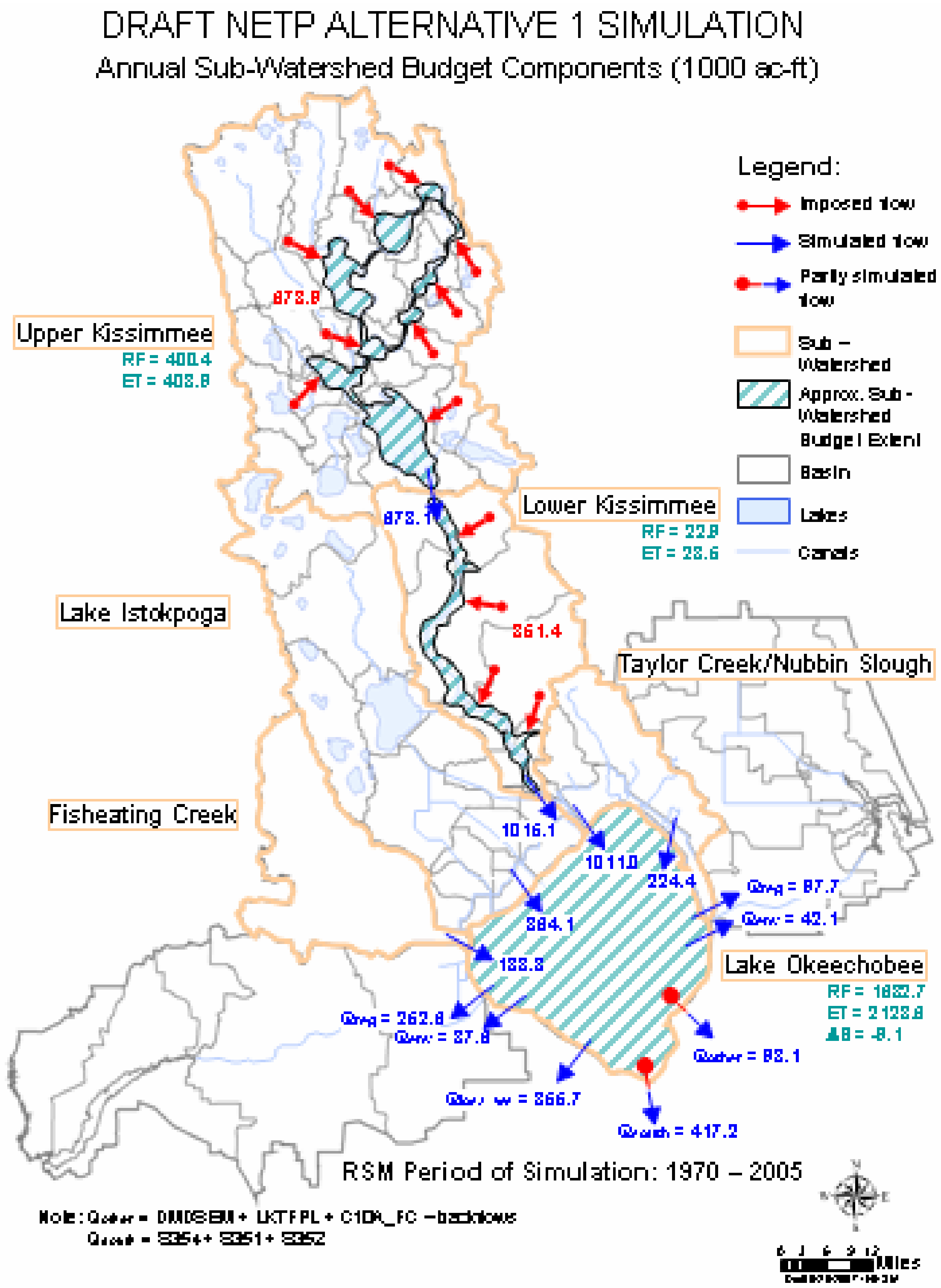


Figure B-27. NERSM calculated annual sub-watershed water budget components Alternative 1.

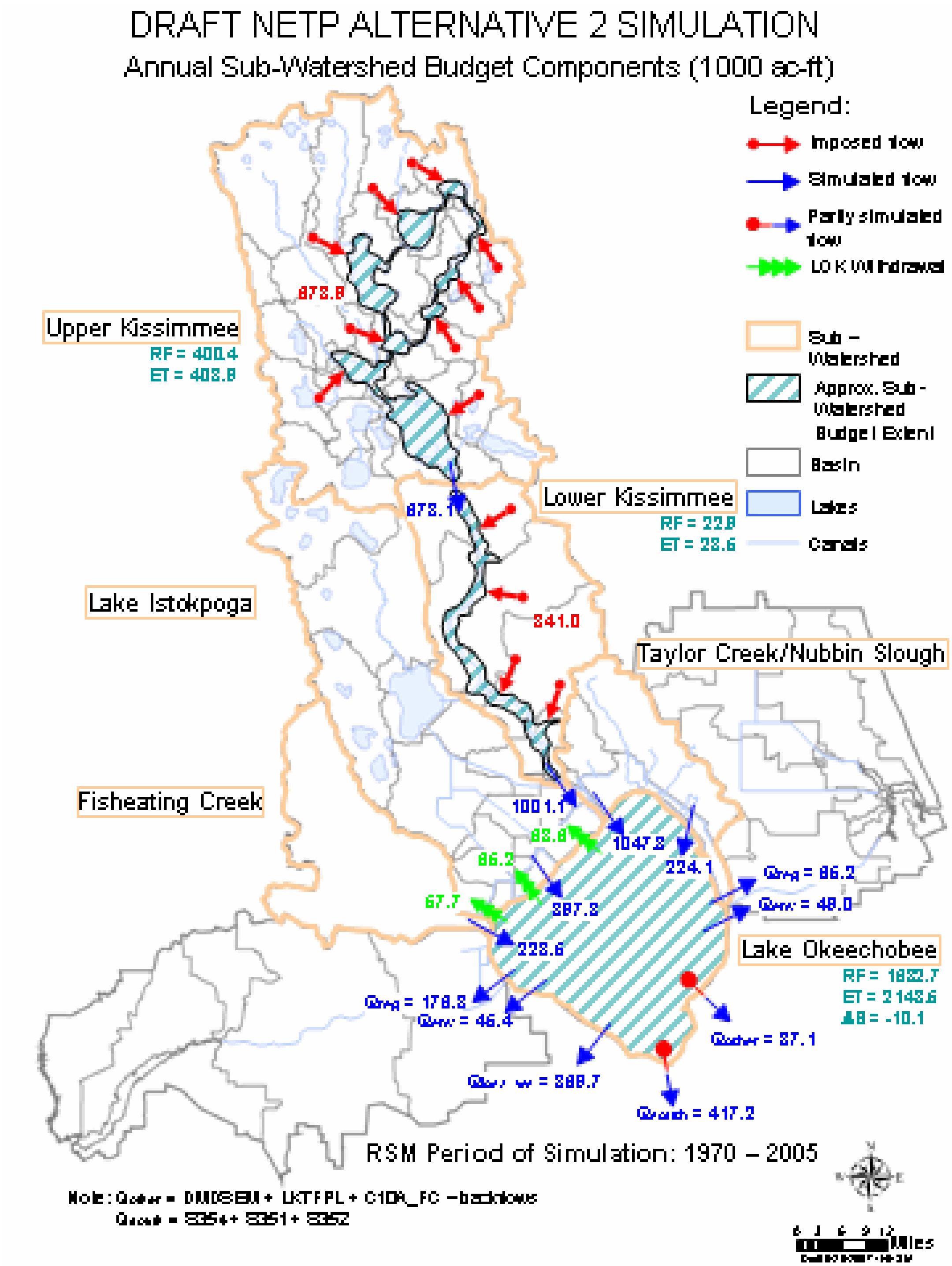


Figure B-28. NERSM calculated annual sub-watershed water budget components Alternative 2.

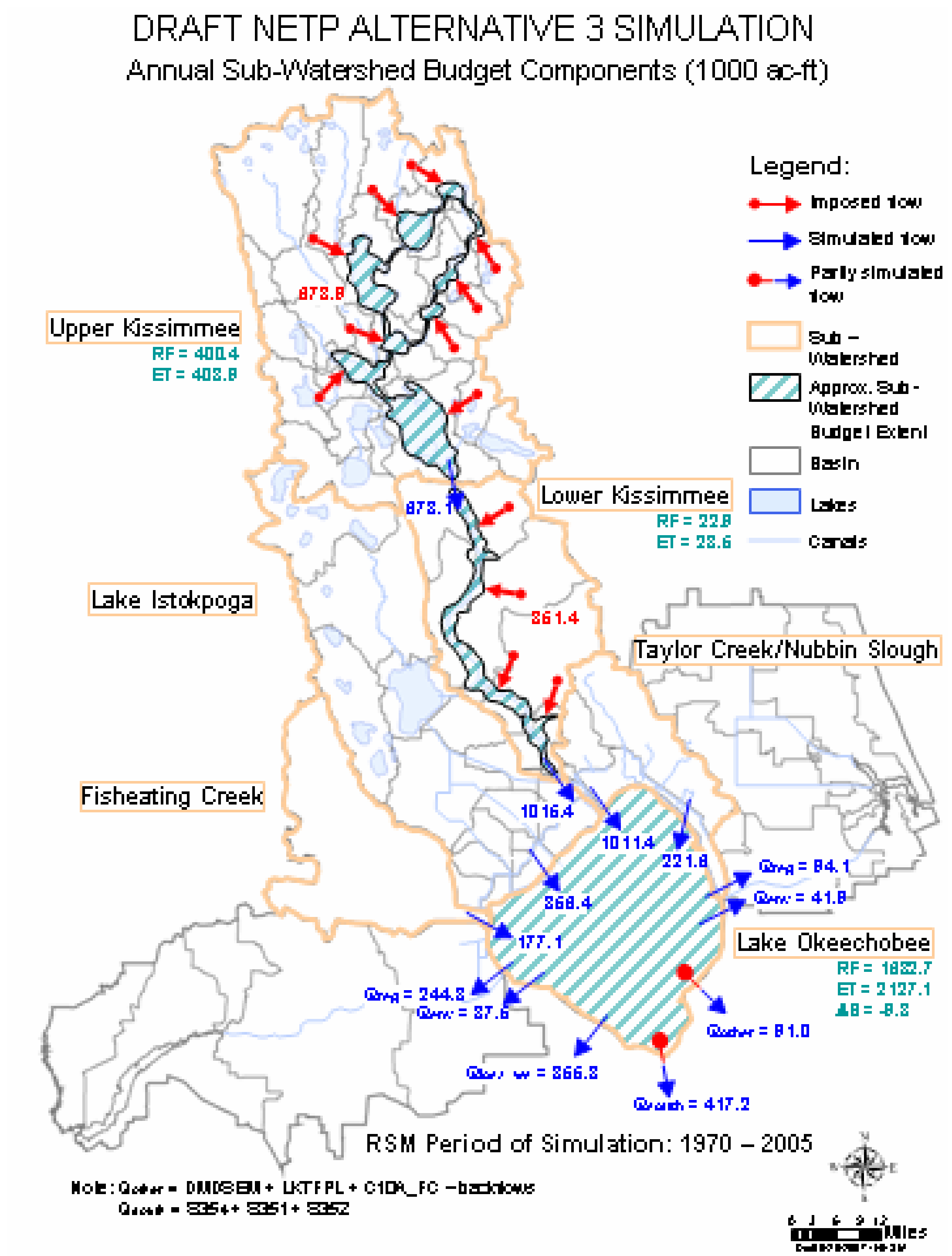


Figure B-29. NERSM calculated annual sub-watershed water budget components Alternative 3.

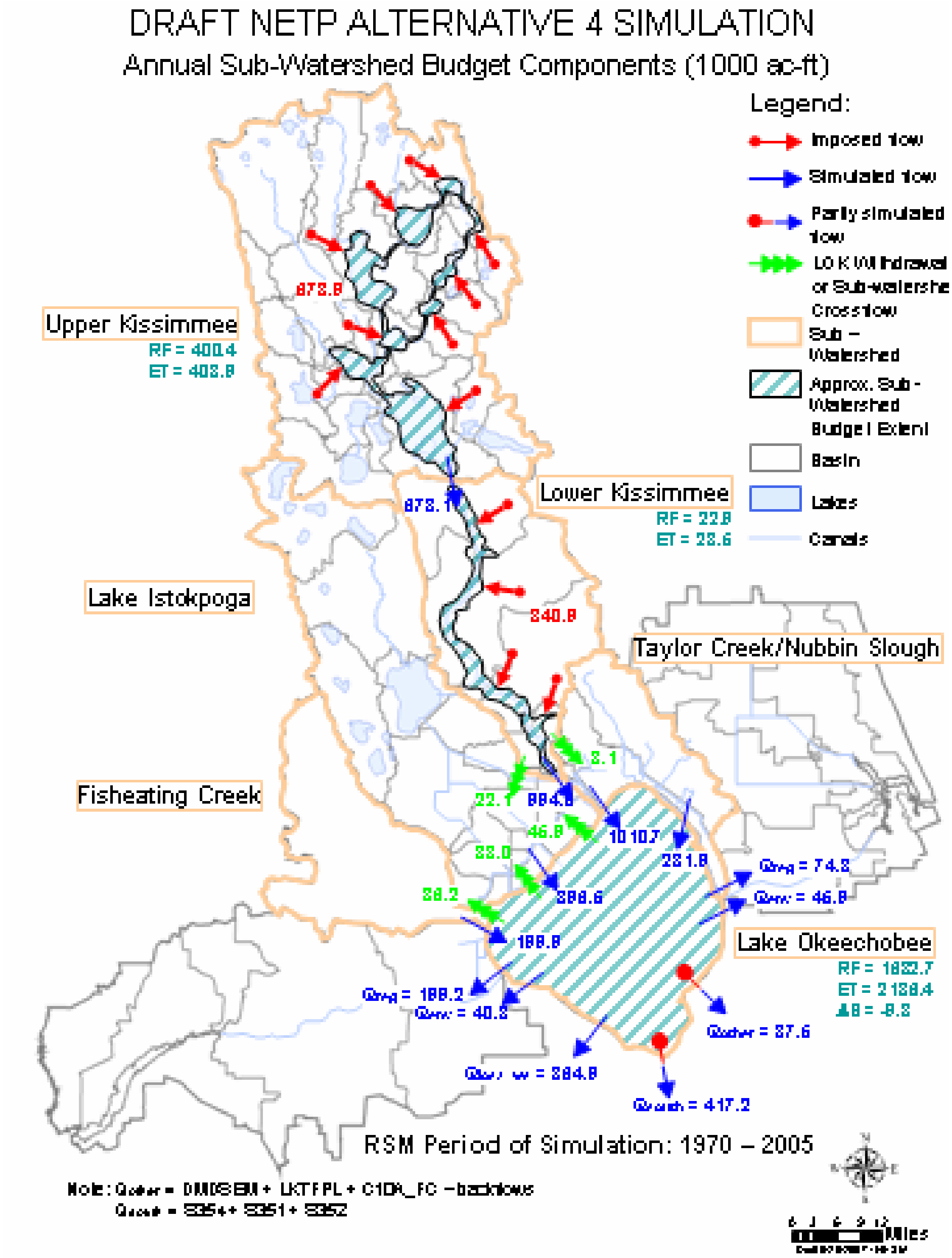


Figure B-30. NERSM calculated annual sub-watershed water budget components Alternative 4.

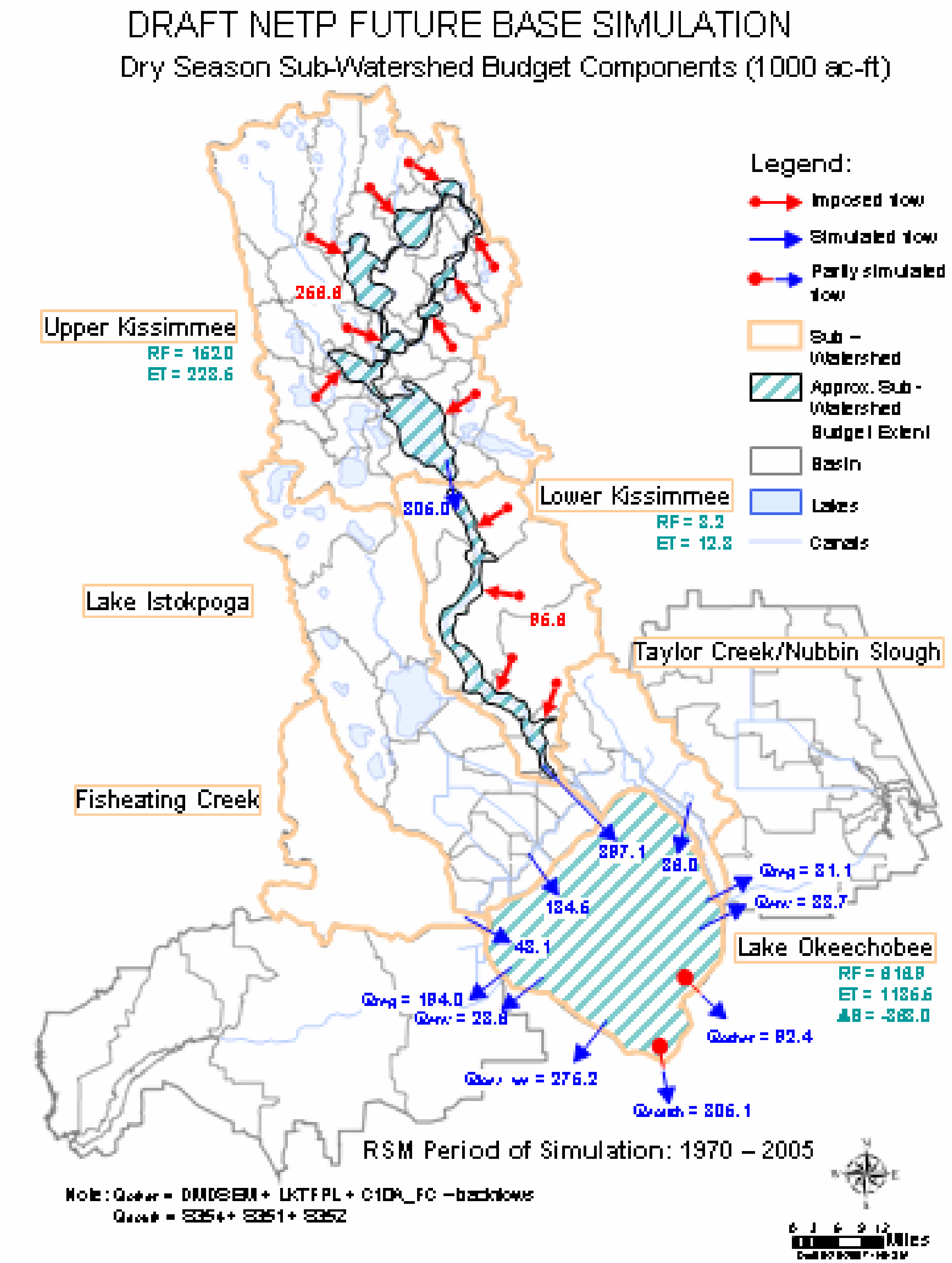


Figure B-31. NERSM calculated dry season sub-watershed water budget components, Future Base.

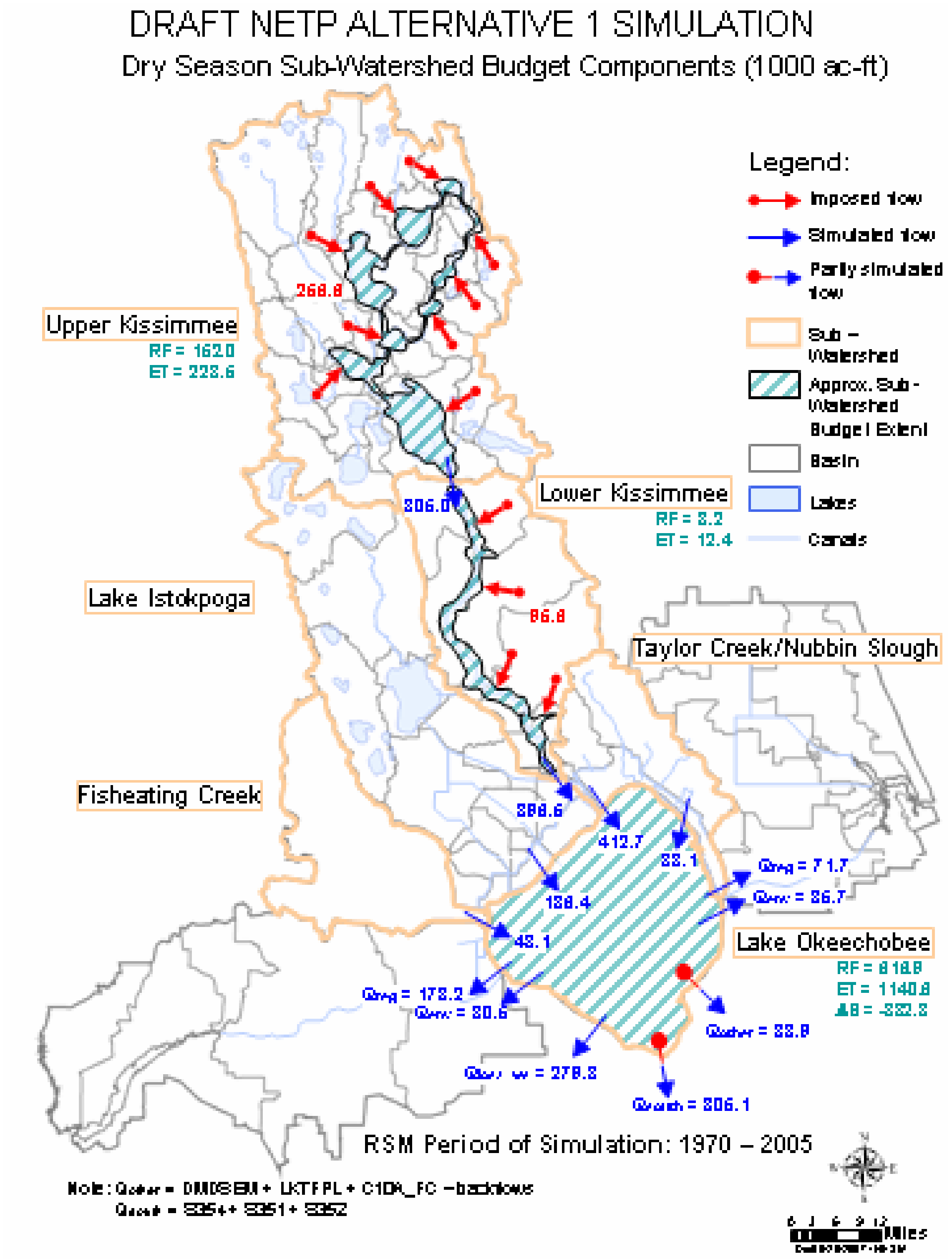


Figure B-32. NERSM calculated dry season sub-watershed water budget components, Alternative 1.

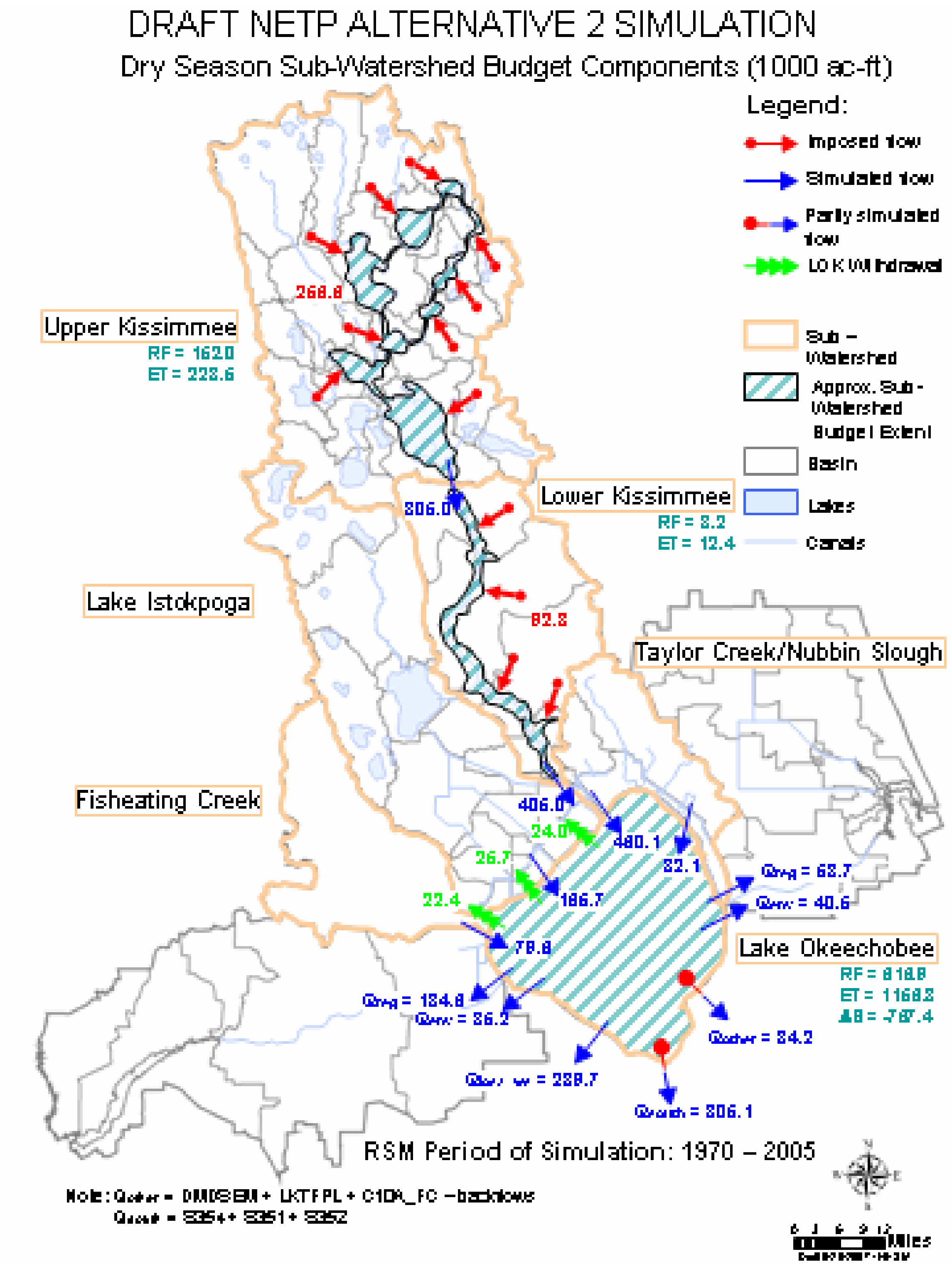


Figure B-33. NERSM calculated dry season sub-watershed water budget components, Alternative 2.

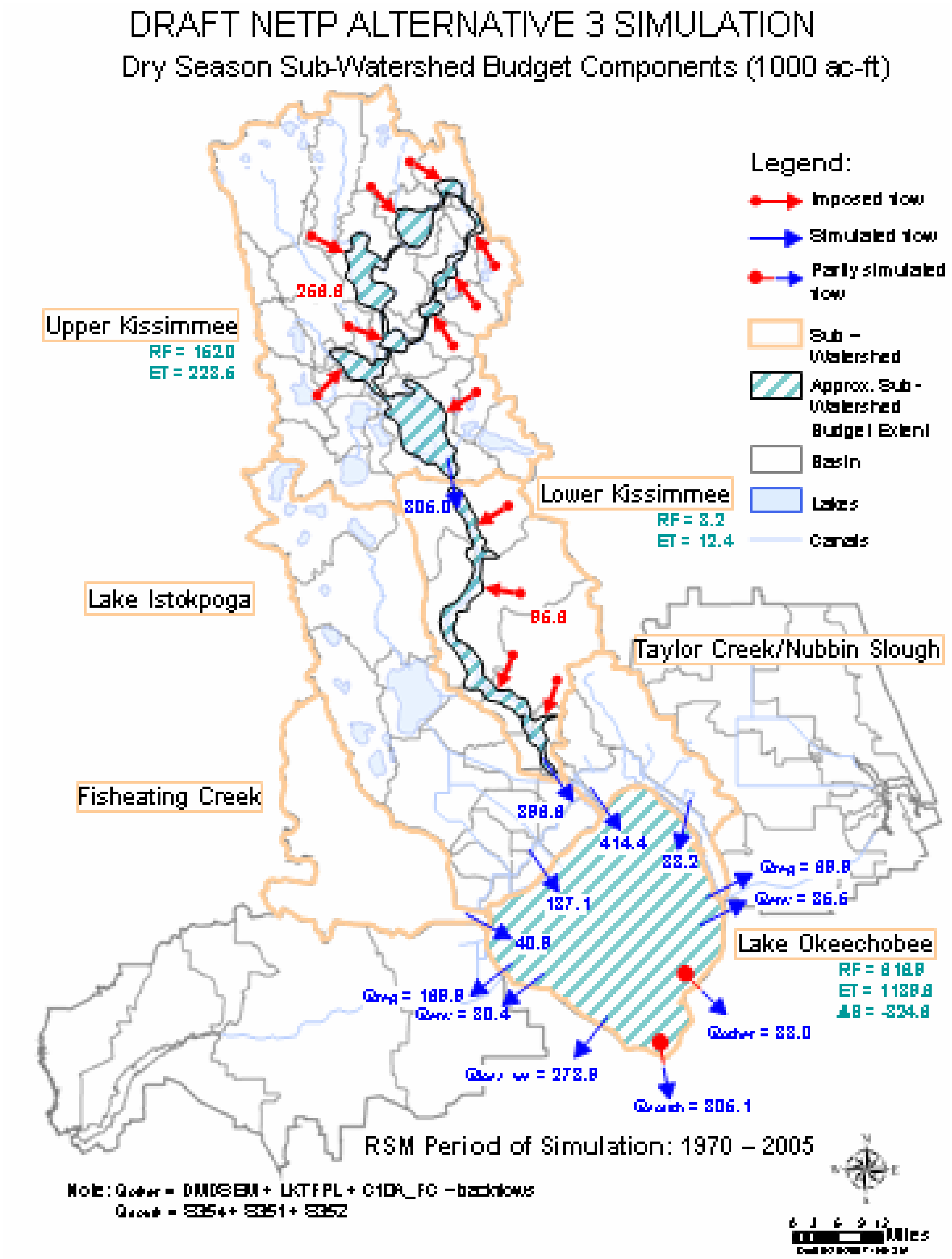


Figure B-34. NERSM calculated dry season sub-watershed water budget components, Alternative 3.

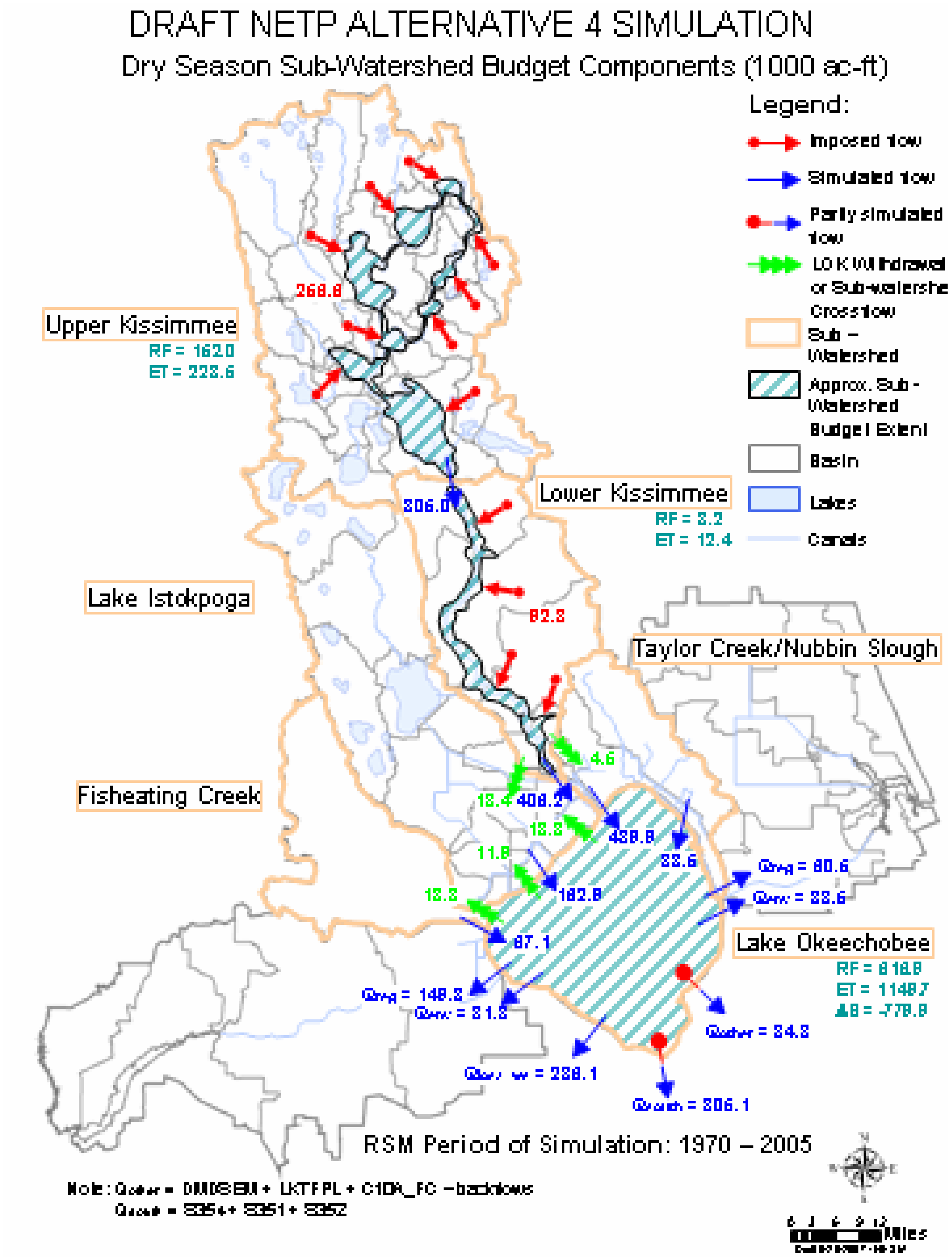


Figure B-35. NERSM calculated dry season sub-watershed water budget components, Alternative 4.

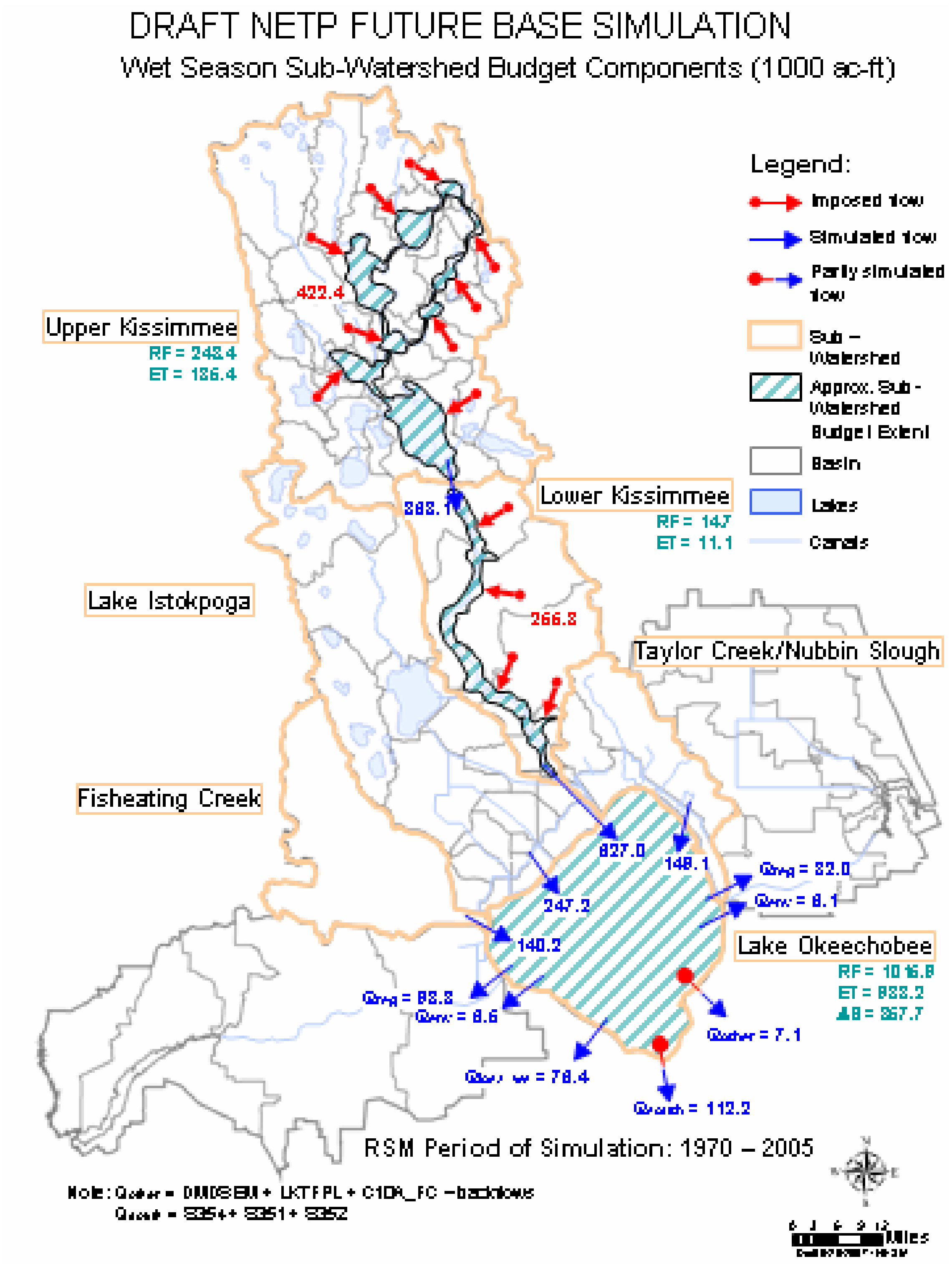


Figure B-36. NERSM calculated wet season sub-watershed water budget components, Future Base.

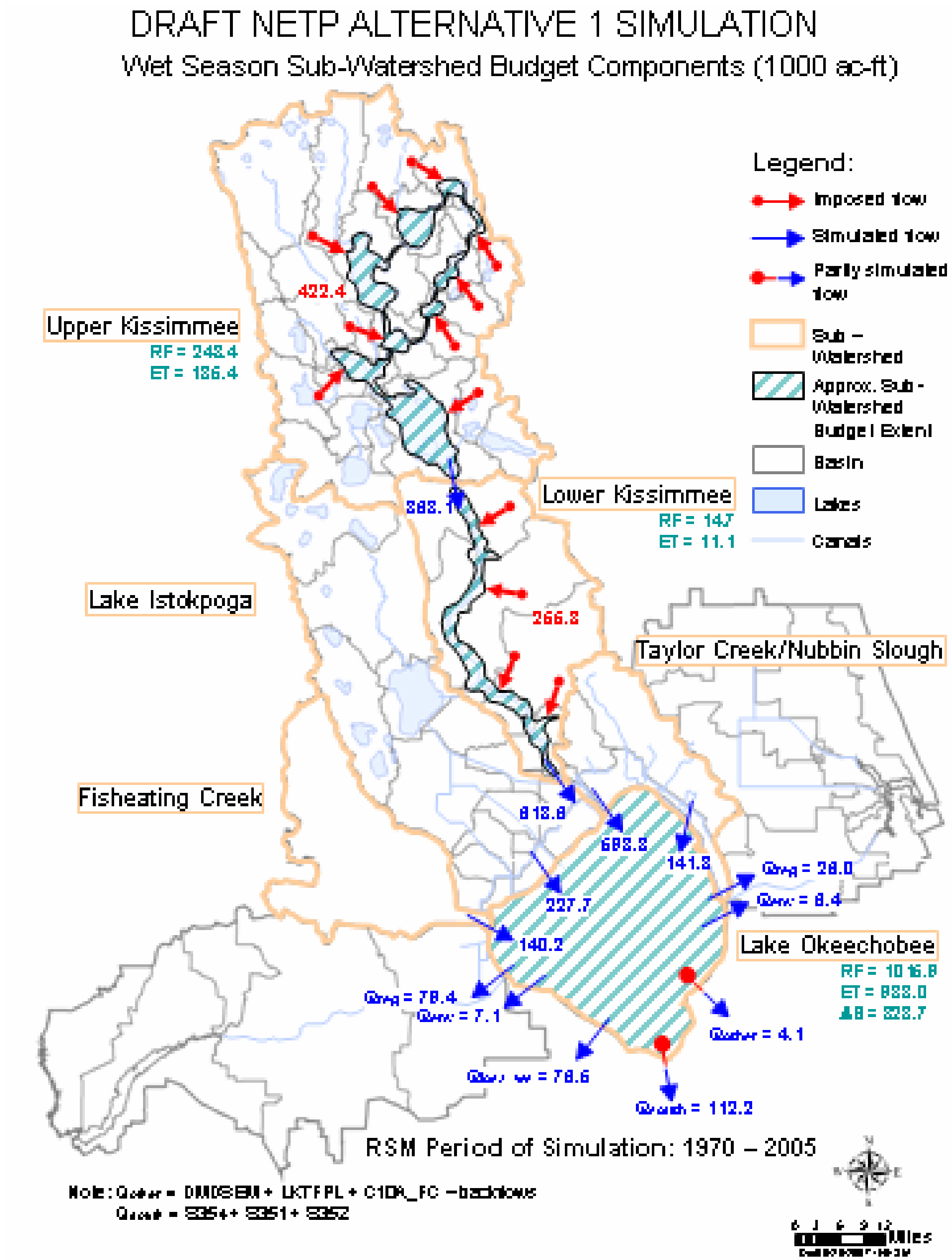


Figure B-37. NERSM calculated wet season sub-watershed water budget components, Alternative 1.

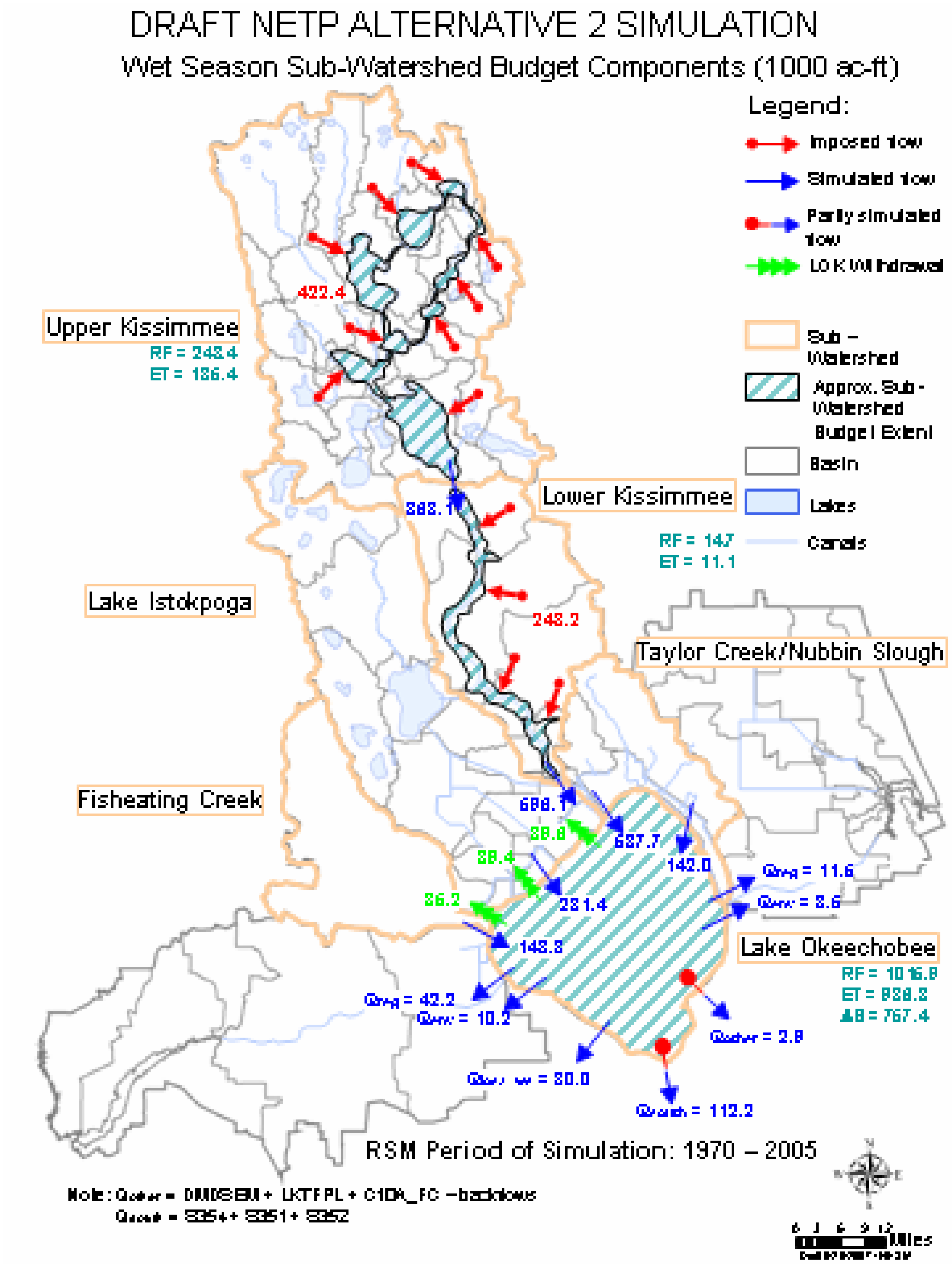


Figure B-38. NERSM calculated wet season sub-watershed water budget components, Alternative 2.

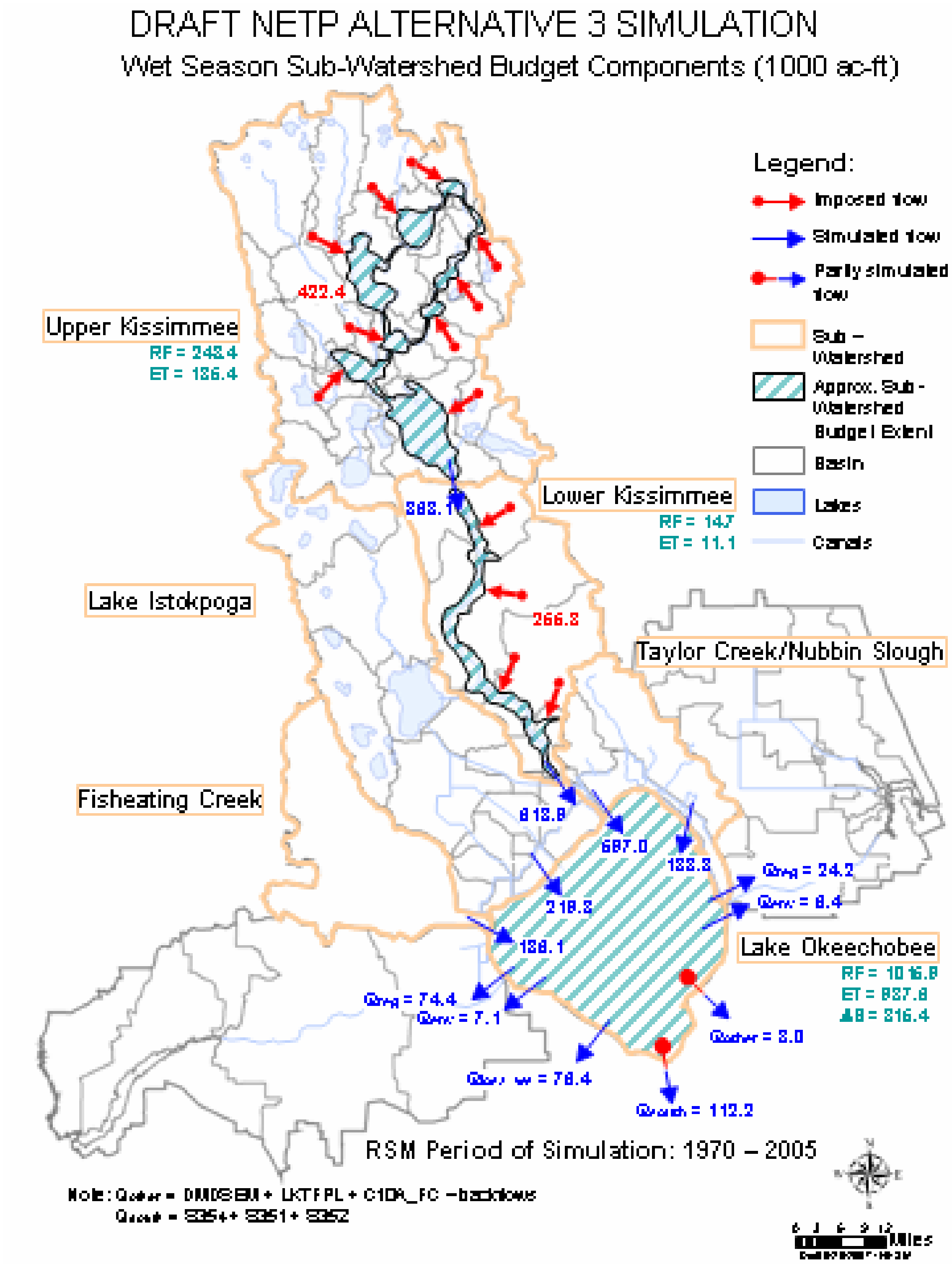


Figure B-39. NERSM calculated wet season sub-watershed water budget components, Alternative 3.

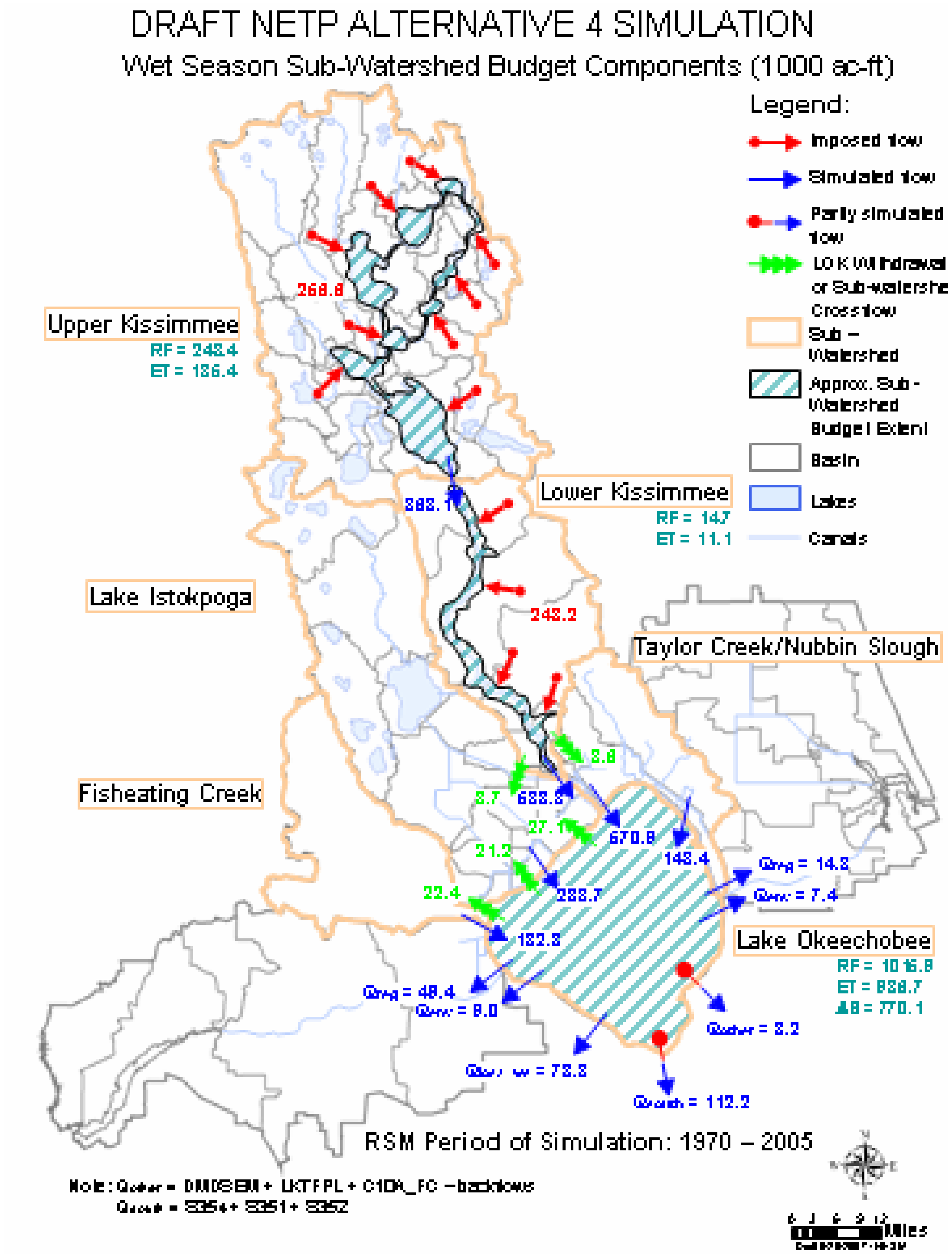


Figure B-40. NERSM calculated wet season sub-watershed water budget components, Alternative 4.

B5.0 QUANTIFICATION OF WATER AVAILABLE IN THE WATERSHED

The Florida legislation enacting the development of the P2TP identifies the need to determine the volume of water in storage in the Northern Everglades required to achieve the environmental performance measures prescribed for Lake Okeechobee and the Caloosahatchee and St. Lucie Estuaries. The ability to divert runoff from the many sub-watersheds and basins that contribute flows to Lake Okeechobee is a key planning component. Large volumes of water sent to Lake Okeechobee from tributary sub-watersheds can contribute to the occurrence of high stage conditions in LOK which can, in turn, result in increased discharges to the Caloosahatchee and St. Lucie Estuaries. A screening level spreadsheet tool was developed to facilitate the evaluation of various storage alternatives to meet the performance measures defined for LOK and estuaries.

B5.1 Objectives

An effort to define the need for additional storage upstream or adjacent to Lake Okeechobee must consider the desired performance measures associated with the both LOK and the downstream Caloosahatchee and St. Lucie Estuaries. The following primary performance measures were defined for the purposes of the storage evaluation:

1. Lake Okeechobee Stage Envelope: It is desirable for lake stage to vary between the lower and upper limits of a pattern annual stage hydrograph (**Figure B-41**) termed an “envelope.” A standard scoring methodology has been developed by the Restoration Coordination and Verification (RECOVER) arm of the Comprehensive Everglades Restoration Plan (CERP) project. The scoring system returns a value between 0 and 100 representing an aggregated damaging deviation outside (i.e. above and below) the desired envelope for the 36-year period of analysis. As scores approach a value of 100, conditions approach the desired ecological target response for Lake Okeechobee.

2. Extreme Lake Okeechobee Stages: The occurrence of extreme high lake stages above 17 ft NGVD or extreme low stages below 10 ft should not occur. RECOVER established a standard scoring methodology in which a standard score of 100 represents the desired condition in which neither extreme is exceeded.

3. Northern Estuary High Discharge: RECOVER defined the following high flow thresholds: 2,800 cfs for Caloosahatchee Estuary and 2,000 for St. Lucie Estuary. Flows above these thresholds begin to adversely impact estuary salinity as well as estuarine habitat and biota.

4. Northern Estuary Daily Desired Targets: An alternate means of defining desired estuary performance is to rely on daily time-series of flows into the estuaries as developed through various prior modeling efforts to meet salinity, habitat and biological objectives. For Caloosahatchee Estuary, matching the “EST05” target time-series, developed using the LIN-RES model, would achieve desired inflow conditions to the estuary. Desired targets for the St. Lucie Estuary are based on the performance associated with the Indian River Lagoon project as modeled using the WASH and IRL-routing models.

While not all considerations for the multi-purpose objectives of Lake Okeechobee management were explicitly used in this analysis, the use of the above measures serves to provide reasonable certainty that the needs of other objectives will be achieved. For example, it can be safely assumed that should performance of a defined scenario result in a 100 percent standard score for the Lake Okeechobee stage-envelope metric, there should not be concerns related to flood protection criteria for the dike. Similarly but for low stages should a 100 percent standard score for the Lake Okeechobee stage-envelope metric be obtained, it is reasonable to assert that water supply objectives for downstream locations such as LOSA would not be adversely impacted and that the likelihood of introducing additional exceedances of LOK minimum flows and levels criteria is small.

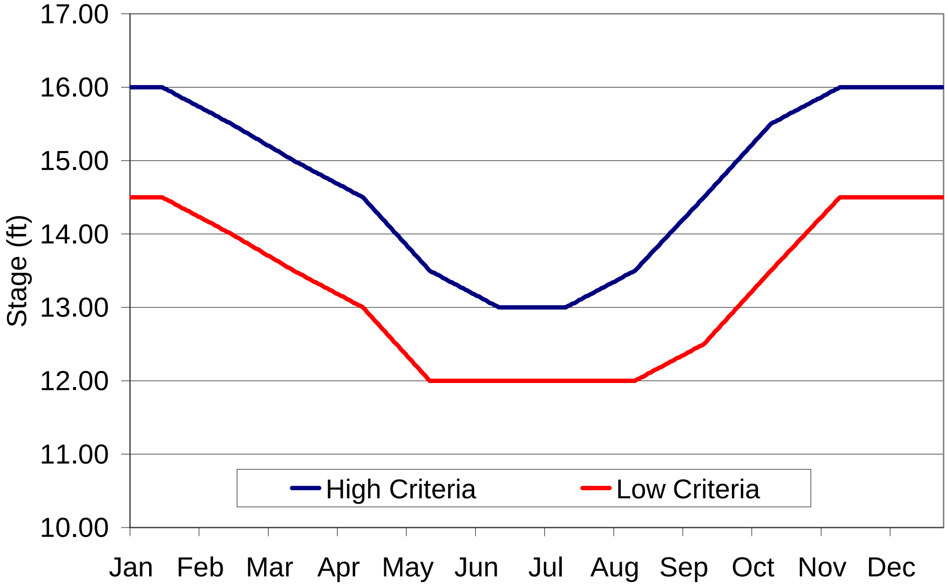


Figure B-41. Lake Okeechobee desired stage envelope.

B5.2 Methodology

Output from the NERSM future base scenario was utilized to develop the underlying framework for a screening level spreadsheet application. The spreadsheet application provides a means for examining a number of scenarios aimed at achieving the Lake Okeechobee and Caloosahatchee / St. Lucie Estuary performance measures defined above. It performs water budget transformations using daily time series data for stages and discharge volumes calculated by NERSM based on a number of user-prescribed options and subject to the following order of operations:

1. The volume of water released from Lake Okeechobee towards the estuaries in excess of the defined high-flow thresholds or daily targets is returned to the LOK control volume.
2. The excess volume of water within the LOK control volume is diverted to offline storage when needed, such as when the lake stage is above the stage envelope.
3. The volume of water in offline storage is returned to the LOK control volume when needed, such as when the lake stage is below the stage envelope.

The offline storage component of the spreadsheet application simultaneously simulates above-ground storage subject to rainfall and evaporation processes as well as below-ground (ASR) storage subject to a user-defined efficiency loss. The maximum capacity of the above-ground storage is calculated as the product of the user-prescribed effective footprint area of the reservoir and an assumed depth of 16 ft. The volume of the ASR storage bubble is not limited. Inflow and outflow structure capacities for both above- and below-ground storage features are user defined and limit the total transfer rate of water between the offline storage and LOK control volume. By utilizing various combinations of footprint areas, structure capacities and efficiency losses, a user of the spreadsheet application can simulate various combinations of storage associated with surface reservoir, ASR, and deep well injection systems. The application also calculates an adjustment to LOK inflow volumes to account for the reduction in contributing drainage area associated with the reservoir footprint and for changes in Lake ET associated with revised stage estimations.

It is important to emphasize the distinction that the spreadsheet application was developed to assist in screening level analysis and to aid in evaluating a water storage goal for the P2TP. The spreadsheet application does not explicitly simulate LOK operational protocols, but rather it applies mathematical adjustments to LOK release volumes in order to achieve designated performance measures, with the difference term remaining in Lake Okeechobee.

The application utilizes perfect knowledge of downstream estuary targets to prevent LOK releases toward the estuaries regardless of current approved operations (e.g. WSE regulation schedule). Many releases that would be affected by changes in simulated lake stage due to the presence of water in storage (e.g. water shortage allocations) are not adjusted. It is not believed that the simplifying assumptions used in the spreadsheet application significantly affect the accuracy of its results for planning purposes. However any in-depth analysis of anticipated project effects should be undertaken with a more comprehensive simulation model such as the NERSM.

B5.3 Quantification of Divertible Volume

In order to determine a numerical quantification of divertible volume on an event-by-event basis, the spreadsheet application was run assuming ASR systems are 100 percent efficient and have an unlimited inflow/outflow capacity. Divertible volume is composed of the volume within Lake Okeechobee during high stage events and as releases from LOK to the estuaries. An event is defined as a period of continuous release from LOK to offline storage without an interruption of greater than 30 consecutive days. The results of this analysis are illustrated for various assumptions associated with releases to the Caloosahatchee and St. Lucie Estuaries.

Figure B-42 illustrates the frequency distribution of event volumes when releases to the northern estuaries are unmodified and as such represents a quantification of divertible volume within only Lake Okeechobee. **Figures B-43 and B-44** illustrate the frequency distributions of event volumes considering performance measures related to estuary high discharge and desired target criteria, respectively.

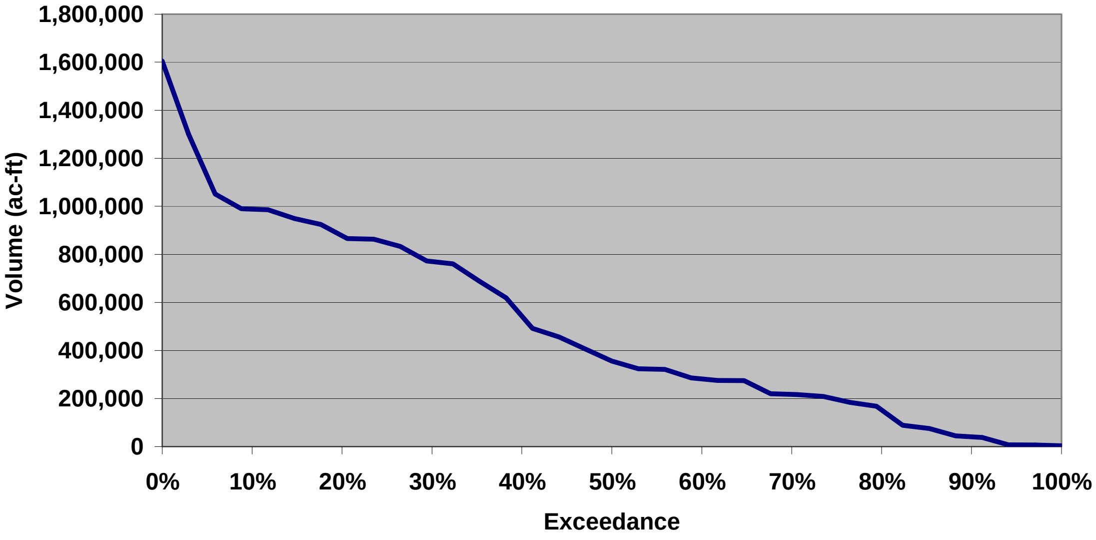


Figure B-42. Frequency distribution of Lake Okeechobee divertible volume events (1970-2005).

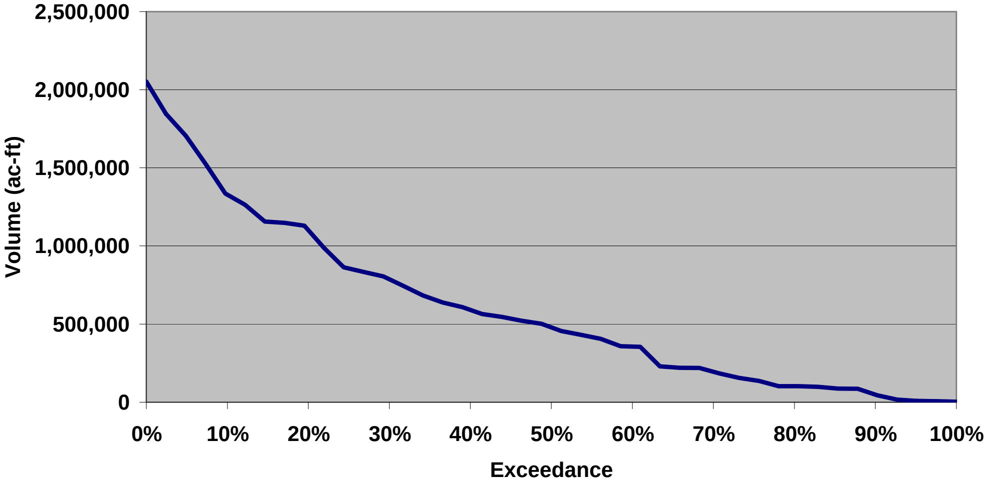


Figure B-43. Frequency distribution of Lake Okeechobee and estuary high discharge divertible volume events (1970-2005).

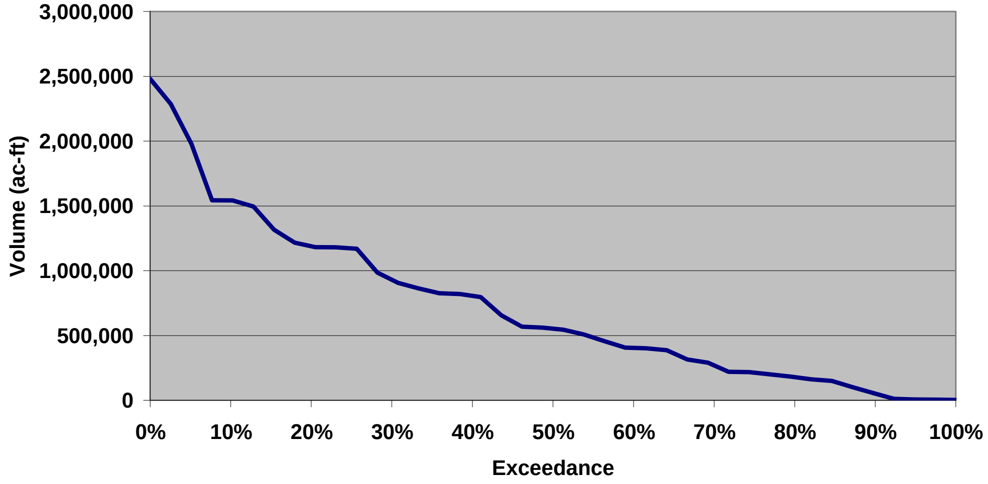


Figure B-44. Frequency distribution of Lake Okeechobee and estuary target divertible volume events (1970-2005).

Examination of the above figures indicates that the frequency distributions of divertible volume events are nearly exponential in shape with the most extreme divertible volume events displaying significantly higher volumes. This observation is mirrored in **Table B-11** which indicates that the peak event is four times the magnitude of median events and one half to two thirds larger than the 10 percent exceedance events.

Table B-11. Characteristics of divertible volume events calculated for the period 1970-2005.

Scenario	Peak Event (ac-ft)	10 Percent Exceedance Event (ac-ft)	Median Event (ac-ft)
Lake high stages only	1,605,000	989,000	356,000
Lake highs + Estuary high discharge criteria	2,053,000	1,328,000	479,000
Lake highs + Estuary targets	2,481,000	1,543,000	553,000

B6.0 SENSITIVITY ANALYSES FOR STORAGE CAPACITY SCENARIOS

As described in Section 7.2.1, a storage capacity between 900,000 and 1,300,000 ac-ft was utilized as a target during plan formulation. Alternative 2 was formulated to provide 1,300,000 ac-ft of storage capacity – the upper limit of the targeted range. A sensitivity analysis was performed to corroborate the reasonableness of the storage target range. This analysis was based on an evaluation of additional benefits that might be achieved by scenarios that contained storage capacities greater than the targeted range. Implementation issues such as cost, real estate availability, etc were not addressed.

B6.1 Methodology

The results of simulations of Alternatives 1 through 4 were supplemented with the evaluation of five additional storage scenarios. These scenarios were based on Alternative 2 and included larger quantities of storage than any of the four original alternatives. NERSM simulations of these scenarios provided a comparison of potential benefits that could be achieved with a broad range of storage capacities.

B6.1.1 Alternatives 1 to 4

Alternatives 1 through 4 were each formulated to achieve specific goals. As a result, a different storage capacity (and water quality treatment capacity) was included in each alternative (see Section 7.5 for a detailed discussion). Storage contained with Alternatives 1 to 4 ranged from 265,000 ac-ft to 1.3 million ac-ft. **Table B-12** provides a summary of the goals and storage capacities associated with Alternatives 1 through 4.

Table B-12. Goals and storage capacities for Alternatives 1 through 4.

Alternative	Goal	Storage Capacity (ac-ft)
Alternative 1	Current, on-going, and planned projects	265,000
Alternative 2	Maximizes storage capacity	1,315,000
Alternative 3	Maximizes phosphorus load reduction	330,000
Alternative 4	Integrates the most efficient and effective combination of storage capacity and phosphorus load reduction	900,000

Since the purpose of the storage scenarios was to evaluate potential benefit resulting from large storage options, five scenarios were created by enlarging Alternative 2. The five scenarios included storage ranging from 1,500,000 ac-ft to 4,012,000 ac-ft. The performance of Alternative 2 and each of the five storage scenarios was compared to assess the potential benefits that might be attained with additional storage.

The storage capacity contained in Alternative 2 was incrementally increased from Scenarios 2A (1.5 million ac-ft) through scenario 2E (4 million ac-ft). The following reservoirs remained constant in all five scenarios:

- Taylor Creek Reservoir (24,000 ac-ft),

- Kissimmee Reservoir (161,000 ac-ft),
- Kissimmee East Reservoir (200,000 ac-ft),
- Istokpoga Reservoir (80,000 ac-ft), and
- Fisheating Creek Reservoir (250,000 ac-ft).

The Istokpoga/Kissimmee Reservoir capacity was incrementally increased from 300,000 ac-ft in Alternative 2 to 1,649,000 ac-ft in Scenario 2E. **Table B-13** shows the storage capacities that were simulated in Alternative 2 and the other storage scenarios.

Table B-13. Storage capacities (in ac-ft) for Alternatives 2 through 2E by sub-watershed.

Sub-watershed	Alt 2	Scenario 2A	Scenario 2B	Scenario 2C	Scenario 2D	Scenario 2E
Total	1,315,000	1,507,000	1,766,000	2,011,000	2,515,000	4,012,000

B6.2 Results

These storage scenarios were simulated using the NERSM for the 36-year period of record from 1970 through 2005. The performance of each scenario was evaluated using the same set of RECOVER performance measures that were used in the evaluation of the four original alternatives. Based on the results of these simulations, scenarios with storage capacities beyond 1,300,000 ac-ft produced relatively small impacts on Lake Okeechobee water levels (**Figures B-45 and B-46)**

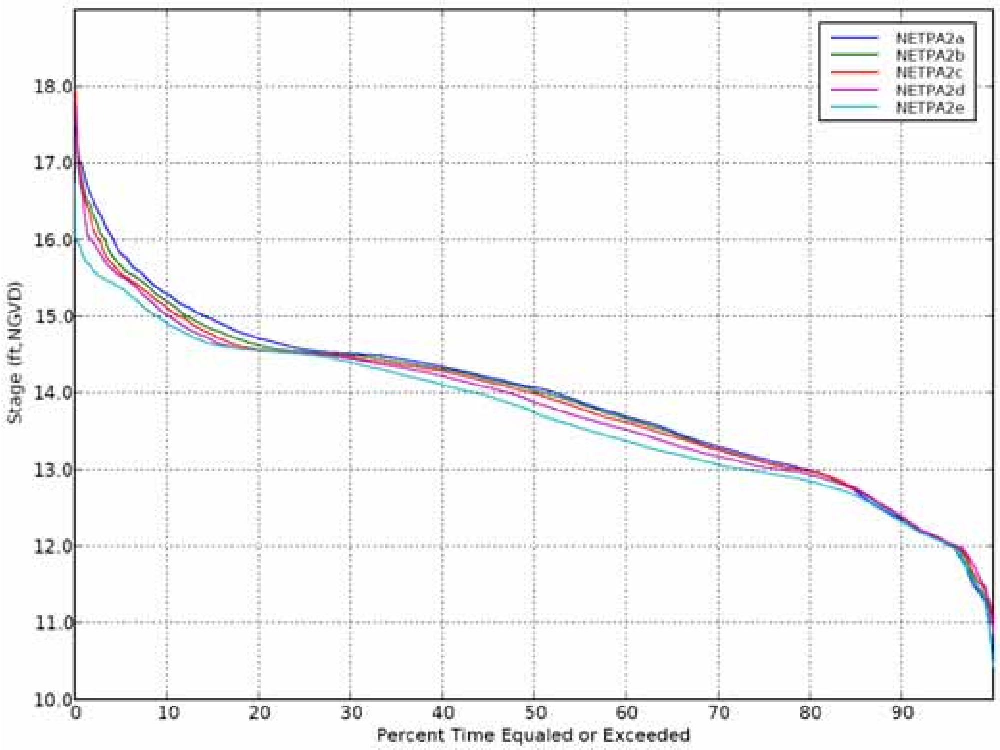


Figure B-45. Lake Okeechobee stage exceedance curves for Alternative 2 and Scenarios 2A through 2E.

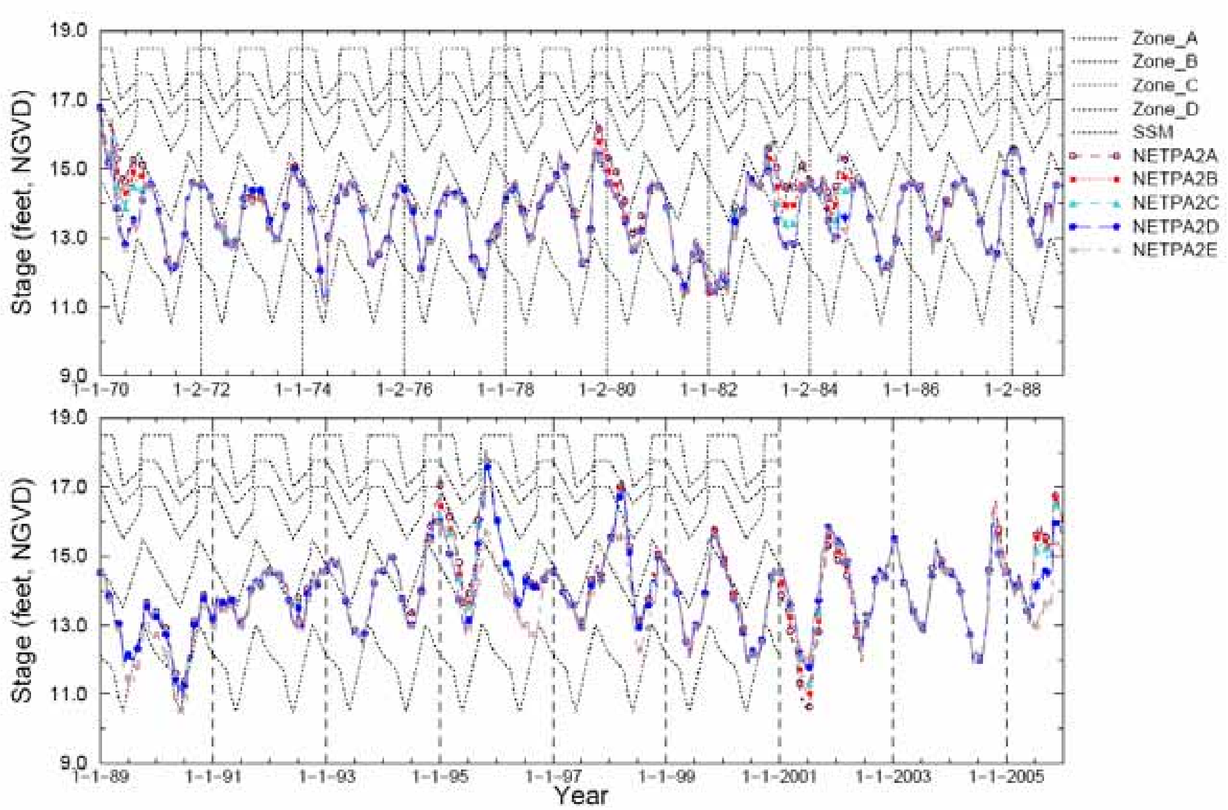


Figure B-46. Lake Okeechobee stage hydrographs for Alternative 2 and Scenarios 2A through 2E.

The performance results for Alternative 2 and Scenarios 2A through 2E are shown in **Table B-14**. The performance results for Alternatives 1 through 4 were previously shown in Section 8, **Table 8-4**.

Discussions of the potential benefits of adding storage capacity beyond the 1,300,000 ac-ft target are described below for Lake Okeechobee, Caloosahatchee Estuary, St Lucie Estuary, and Water Supply.

B6.2.1 Lake Okeechobee

For performance measures related to avoiding extreme low water levels and violations of the minimum water level and duration criterion, all scenarios with storage capacities of 1,300,000 ac-ft or more achieve the maximum score. There would be no benefit to providing more than 1,300,000 ac-ft of storage to avoid extreme low water levels. Similarly, there is essentially no benefit to additional storage beyond 1,300,000 ac-ft of storage in reducing the number of weeks with lake stages below the desirable envelope.

Table B-14. Comparison of performance of Scenarios 2 through 2E based on RECOVER performance measures.

Performance Measure/Indicator	Target	Alt 2	Scenario 2A	Scenario 2B	Scenario 2C	Scenario 2D	Scenario 2E
Storage capacity (1,000 ac-ft)	--	1,315	1,507	1,766	2,011	2,515	4,012
Lake Okeechobee							
Extreme Low Lake Stage*	100	100	100	100	100	100	100
Extreme High Lake Stage*	100	96.46	97.22	97.23	97.99	98.23	100
Below Envelope - Weekly Average*	100	99.10	100	100	100	100	100
Above Envelope - Weekly Average*	100	83.36	85.55	89.25	91.85	95.62	99.27
Minimum Water Level and Duration **	< 6	0	0	0	0	0	0
Caloosahatchee Estuary							
High Discharge Exceeded							
Mean Monthly Flow > 2,800 cfs**	3	43	43	42	41	37	35
Mean Monthly Flow > 4,500 cfs**	0	15	14	13	12	11	7
Number of months Lake Okeechobee regulatory releases >2,800 cfs**	0	9	6	6	2	2	0
Salinity Envelope							
Mean Monthly Flow < 450 cfs**	0	11	8	8	7	8	9
Mean Monthly Flow >2,800 cfs**	3	43	43	42	41	37	35
St. Lucie Estuary							
High Discharge Exceeded							
2,000 cfs < Mean Monthly Flow < 3,000 cfs**	0	34	35	34	32	*31*	30
Mean Monthly Flow > 3,000 cfs**	0	16	14	14	14	13	12
Salinity Envelope							
Mean Monthly Flow < 350 cfs**	31	10	7	6	4	5	7
14-day (MAF) > 2,000 cfs from Lake Okeechobee Regulatory Releases**	0	20	17	13	12	8	3
Water Supply							
Everglades Agricultural Area Mean Annual Percent Demand not Met (%)	0	1.5	1.3	1.2	1.1	1.1	1.3
Lake Okeechobee Service Area Mean Annual Percent Demand not Met (%)	0	0.7	0.6	0.6	0.6	0.6	0.6

*Standard Score
**Frequency

Figure B-47 shows a plot of the extreme high lake stage performance measure scores and the storage capacities for the scenarios that were evaluated. A strong correlation was found between the score for this performance measure and storage capacity. Additional storage capacity (beyond 1,300,000 ac-ft) could increase benefits related to avoiding extreme high water levels in Lake Okeechobee. However, improvements in the performance measure scores for scenarios with more than 900,000 to 1,300,000 ac-ft storage capacity require disproportionate increases in capacity. In other words, incremental increases in storage capacity beyond 1,300,000 ac-ft provide diminishing incremental improvements in performance.

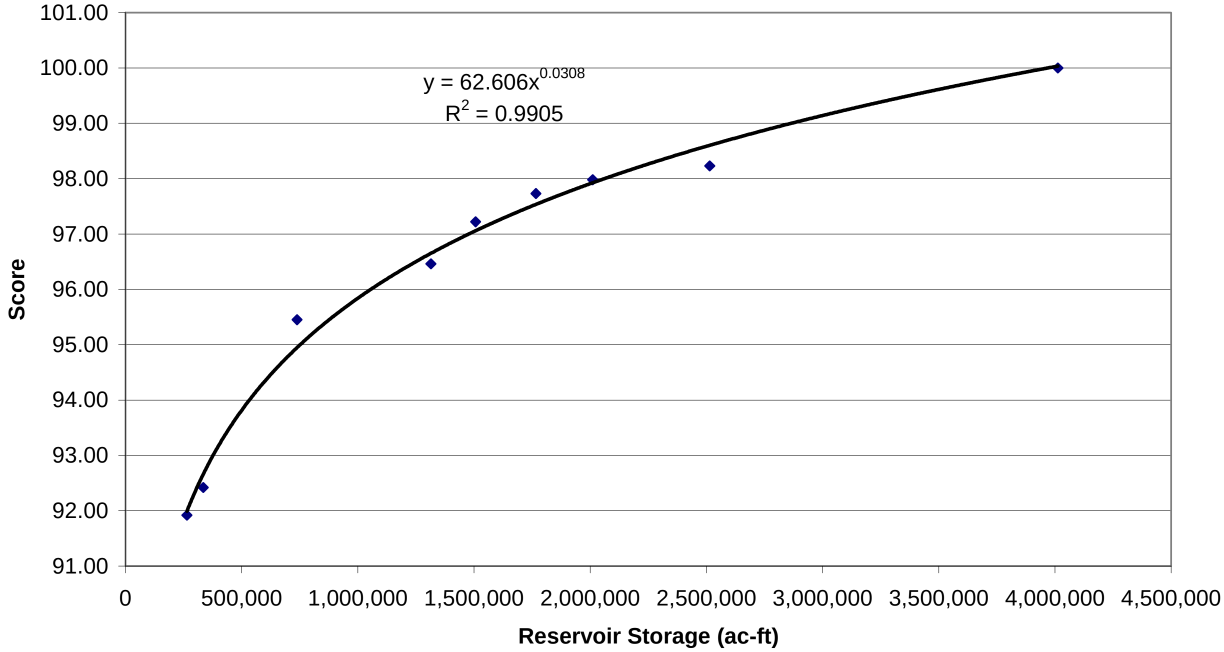


Figure B-47. Correlation between scenarios' storage capacity for the extreme high lake stage performance measure.

Figure B-48 shows a plot of Lake Okeechobee stage envelope (above) performance measure scores and the storage capacities for the scenarios that were evaluated. A strong correlation was found between the score for this performance measure and storage capacity. There is a more linear relationship between increases in scenarios' performance for the performance measure and storage capacity up to about 2,000,000 ac-ft. Additional storage beyond 1,300,000 ac-ft would produce additional benefits for preventing weekly lake stages above the lake stage envelope. However, even Scenario 2E, which includes 4,012,000 ac-ft of storage, still does not quite achieve the maximum score for this performance measure.

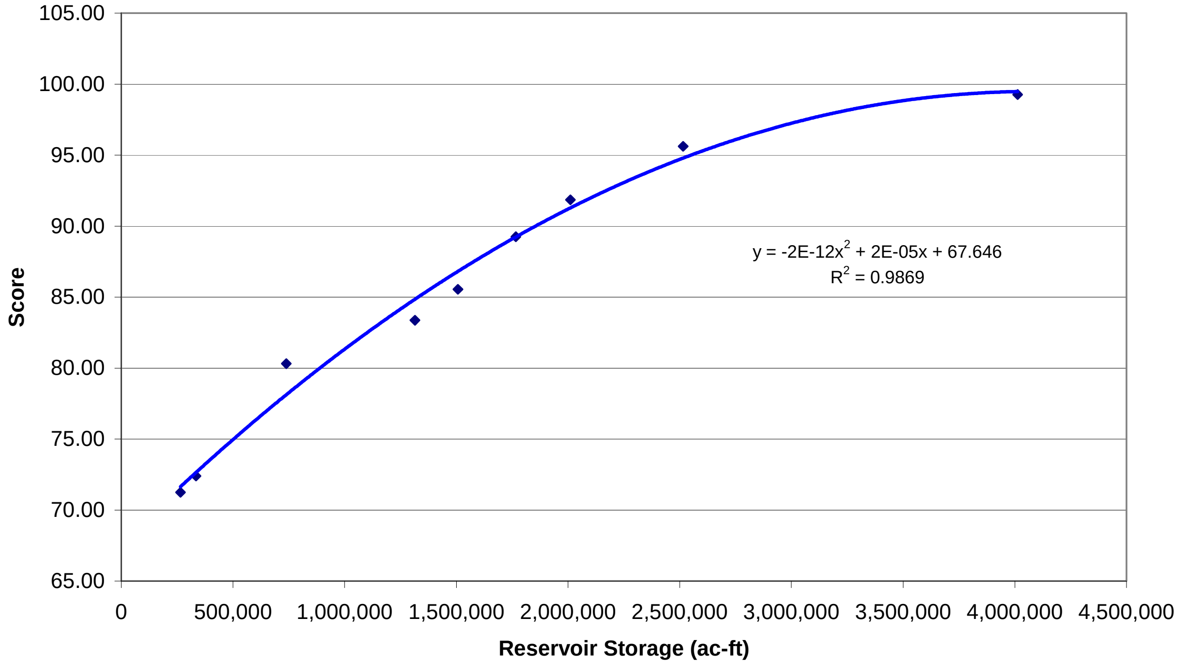


Figure B-48. Correlation between scenarios' storage capacity and score for the Lake Okeechobee stage envelope (above).

B6.2.2 Caloosahatchee Estuary

Scenarios with storage capacities greater than 1,300,000 ac-ft continue to produce additional benefits for performance measures addressing high flows (>2,800 cfs and >4,500 cfs) to the Caloosahatchee Estuary. These flow events include regulatory discharges from Lake Okeechobee in addition to local runoff from the Caloosahatchee Basin. This plan addresses Lake Okeechobee flows and includes no components intended to capture local C-43 Basin runoff.

For this analysis, it is more informative to evaluate the number of events when Lake Okeechobee regulatory discharges exceed the 2,800 cfs threshold**. Figure B-49** shows the a plot of the storage capacity for the scenarios that were evaluated and number of months with Lake Okeechobee regulatory releases to C-43 greater than 2,800 cfs and the storage capacities for the scenarios that were evaluated. A strong correlation was found between the performance measure results and storage capacity. For scenarios with storage capacities greater than 900,000 to 1,300,000 ac-ft, there is diminishing incremental benefit for each incremental of additional storage capacity.

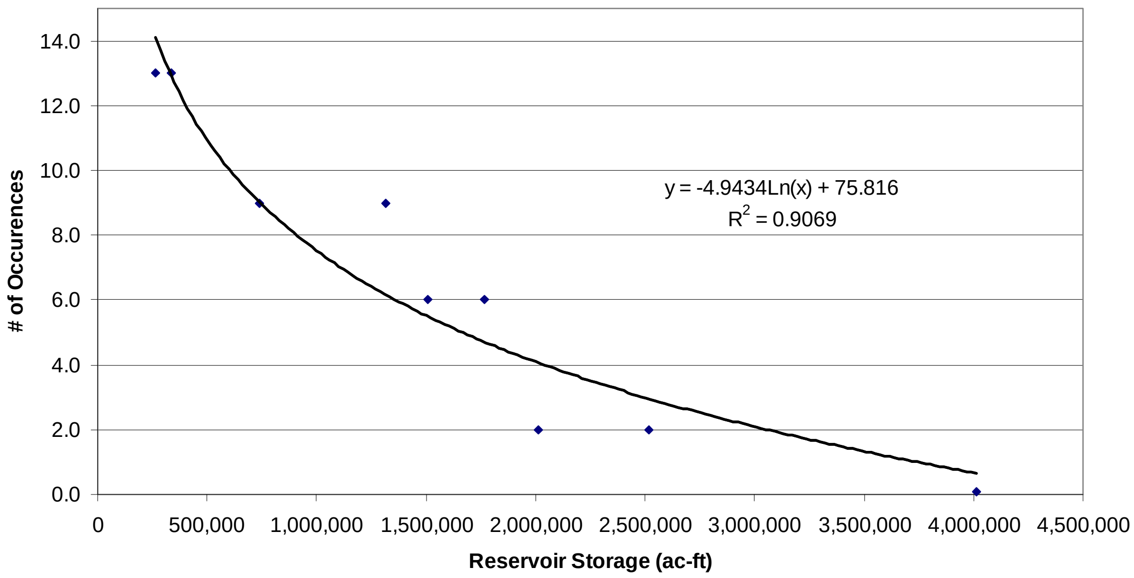


Figure B-49. Correlation between the scenarios' storage capacity and number of months with Lake Okeechobee regulatory discharges greater than 2,800 cfs.

Figure B-50 shows a plot of the storage capacities for the scenarios that were evaluated and the number of months with discharges to the Caloosahatchee Estuary were less than 450 cfs and the storage capacities for the scenarios that were evaluated. A strong correlation was found between the performance measure results and storage capacity. For the C-43 low discharge performance measure, the incremental benefits provided by storage greater than 900,000 to 1,300,000 ac-ft also diminish with each increment of additional storage capacity.

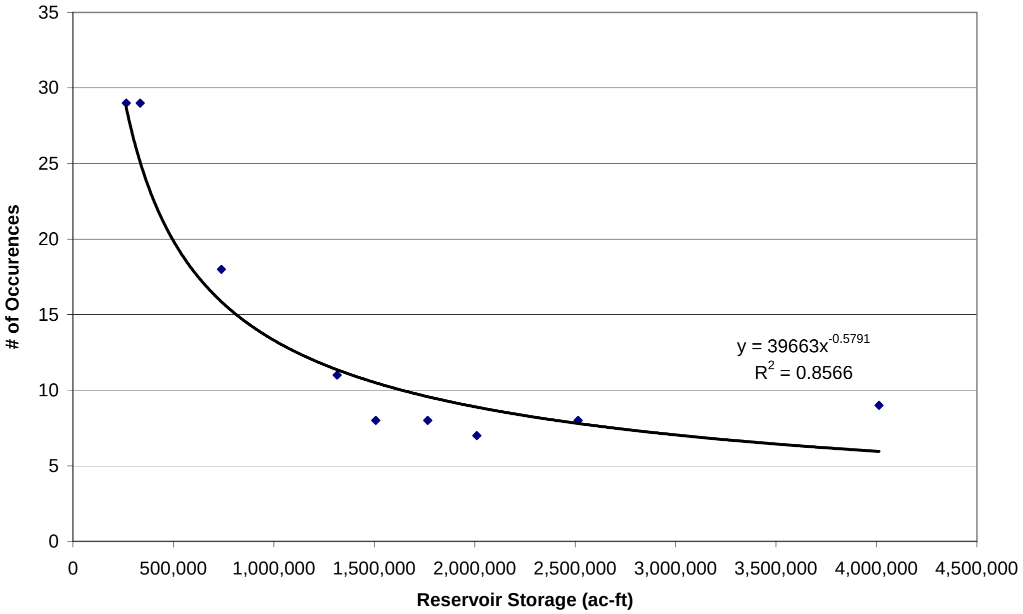


Figure B-50. Correlation between the scenarios' storage capacities and the number of events when C-43 discharges to the Caloosahatchee Estuary are less than 450 cfs.

B6.2.3 St Lucie Estuary

The results of the performance measure for mean monthly flows to the St Lucie Estuary between 2,000 and 3,000 cfs are difficult to interpret. The target is to avoid any occurrences of such events. A scenario could reduce the magnitude of one or more mean monthly flow events from greater than 3,000 cfs to events between 2,000 and 3,000 cfs. This would be a benefit – however, the performance measure for mean monthly flows between 2,000 and 3,000 cfs would indicate a deterioration in performance for the scenario. There is a relatively poor correlation between the number of mean monthly flow events between 2,000 and 3,000 cfs and storage capacity for these reasons. It should be noted that this performance measure evaluates the combination of flows to the estuary from Lake Okeechobee and the local runoff from the St Lucie Basin.

Analysis of the performance measure for mean monthly flows greater than 3,000 cfs provides a clear comparison of scenarios' performance. This performance measure also evaluates the combination of flows to the estuary from Lake Okeechobee and the local runoff from the St Lucie Basin.

Figure B-51 shows the a plot of the storage capacities for the scenarios that were evaluated and number of mean monthly flows to the St Lucie Estuary greater than 3,000 cfs and the storage capacities for the scenarios that were evaluated. A strong correlation was found between the performance measure results and storage capacity. Beyond a range of about 900,000 and 1,300,000 cfs, there is diminishing incremental benefit for each increment of additional storage capacity.

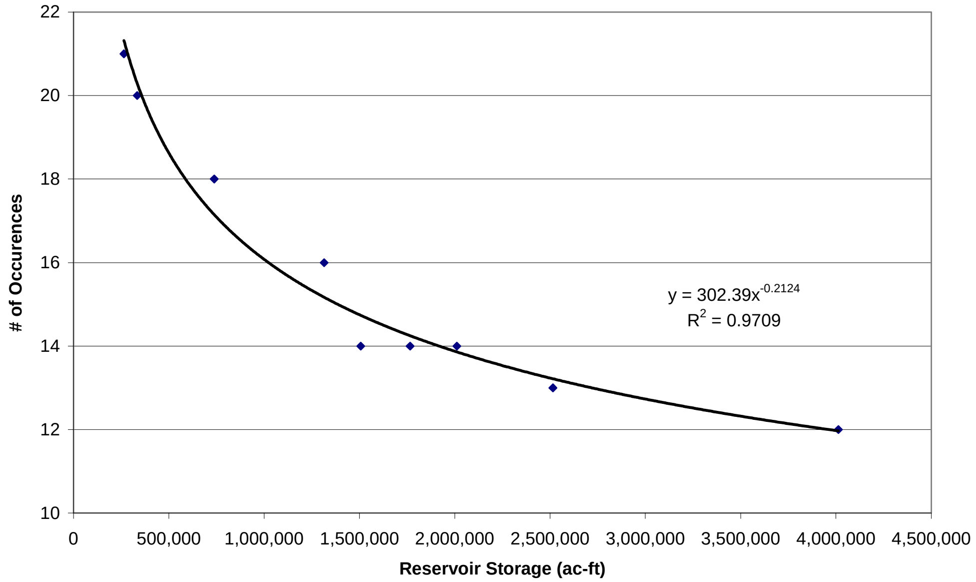


Figure B-51. Correlation between the scenarios' storage capacities and the number of events when mean monthly C-44 discharges to the St Lucie Estuary are greater than 3,000 cfs.

There is a similar breakpoint in the correlation between the storage capacity and the performance measure for C-44 discharges to the St Lucie Estuary less than 350 cfs as shown in **Figure B-52**. There are diminishing benefits for each additional increment of storage capacity beyond a range of about 900,000 and 1,300,000 ac-ft.

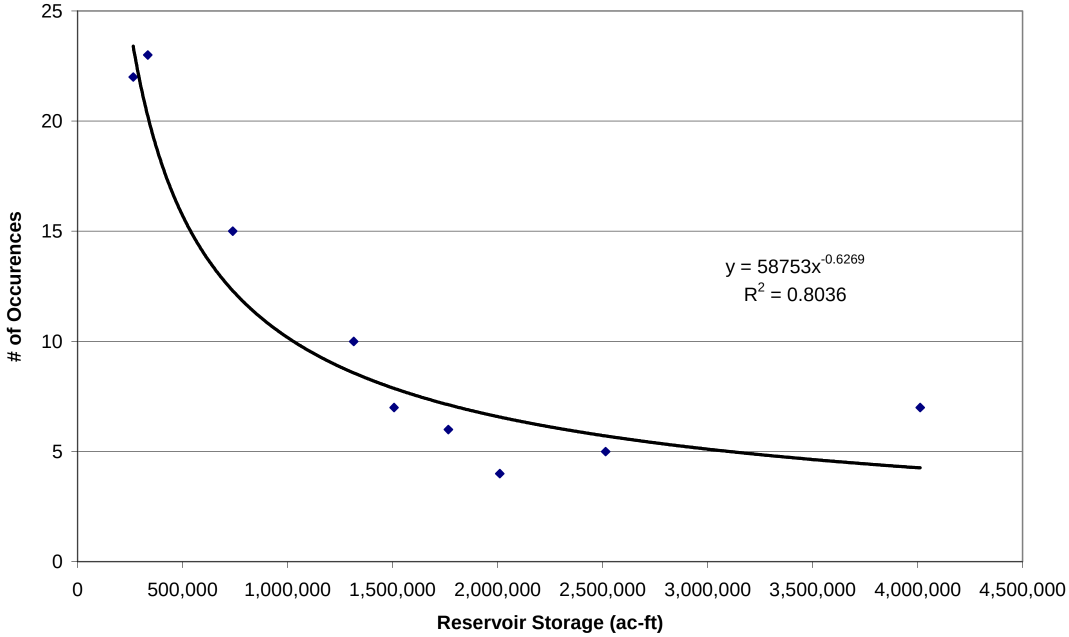


Figure B-52. Correlation between the scenarios storage capacities and the number of events when mean monthly C-44 discharges to the St Lucie Estuary are less than 300 cfs.

Figure B-53 shows the correlation between the scenarios' storage capacities and the number of events with the 14-moving average Lake Okeechobee discharges to C-44 are greater than 2,000 cfs. This performance measure does not address the impacts of local C-43 Basin runoff. There is no clear breakpoint in the relationship until storage capacities exceed about 3,000,000 ac-ft. The target for this performance measure is to avoid any events when the 14-day moving average discharge is greater than 2,000 cfs. However, even Scenario 2E (4,012,000 ac-ft of storage capacity) does not achieve the target for this performance measure.

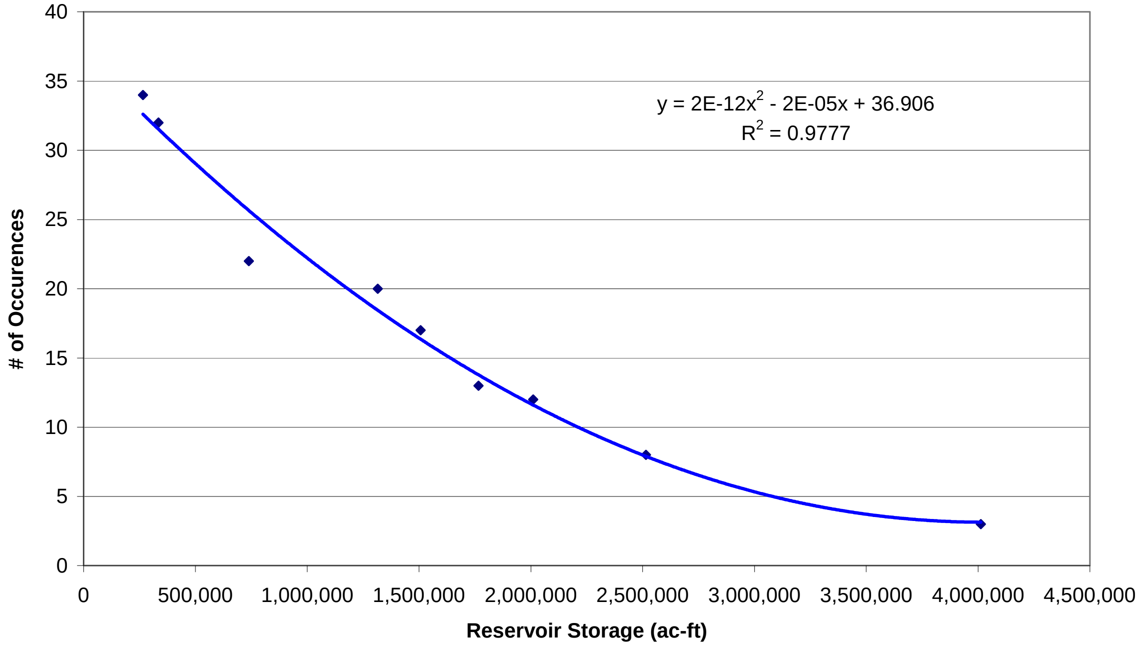


Figure B-53. Correlation between the scenarios' storage capacities and the number of events when the 14-day moving average Lake Okeechobee discharge to C-44 is greater than 2,000 cfs.

B6.2.4 Water Supply

Improving the level of service for agricultural and urban water supply is not a project goal. However, scenarios with water storage capabilities will increase the availability of water supply. **Figures B-54** and **B-55** show the correlations between scenarios' storage capacities and water supply demands not met for the Everglades Agricultural Area and the Lake Okeechobee Service Area. In both cases, there are diminishing incremental improvements in water supply with each additional increment of storage greater than about 900,000 to 1,300,000 ac-ft.

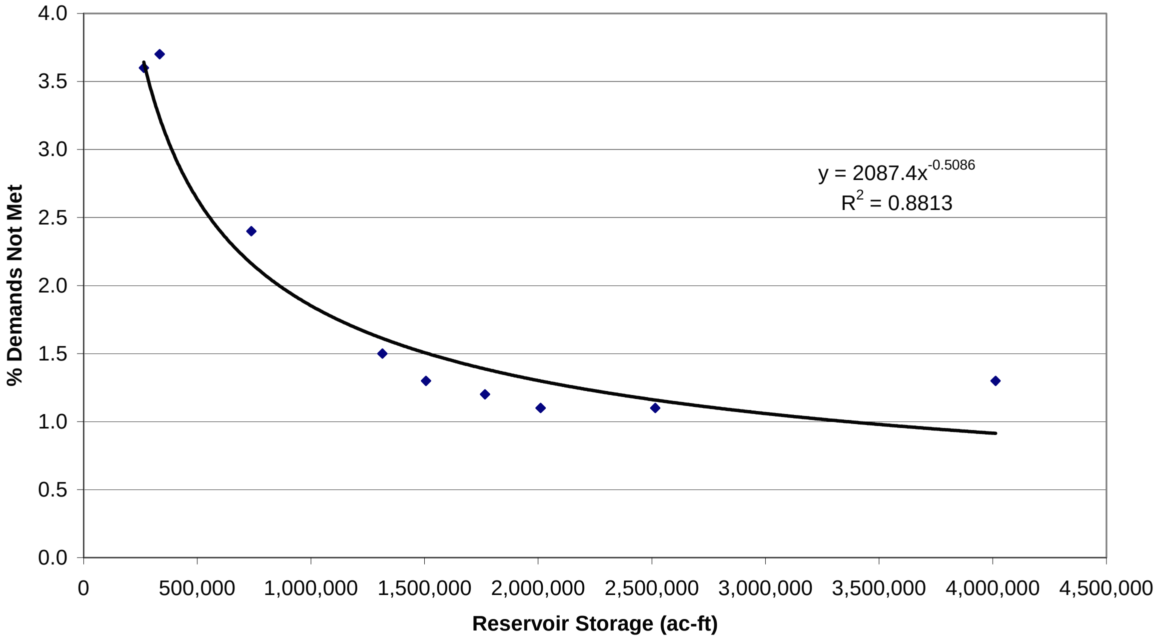


Figure B-54. Correlation between scenarios' storage capacities and Everglades Agricultural Area water supply demands NOT met.

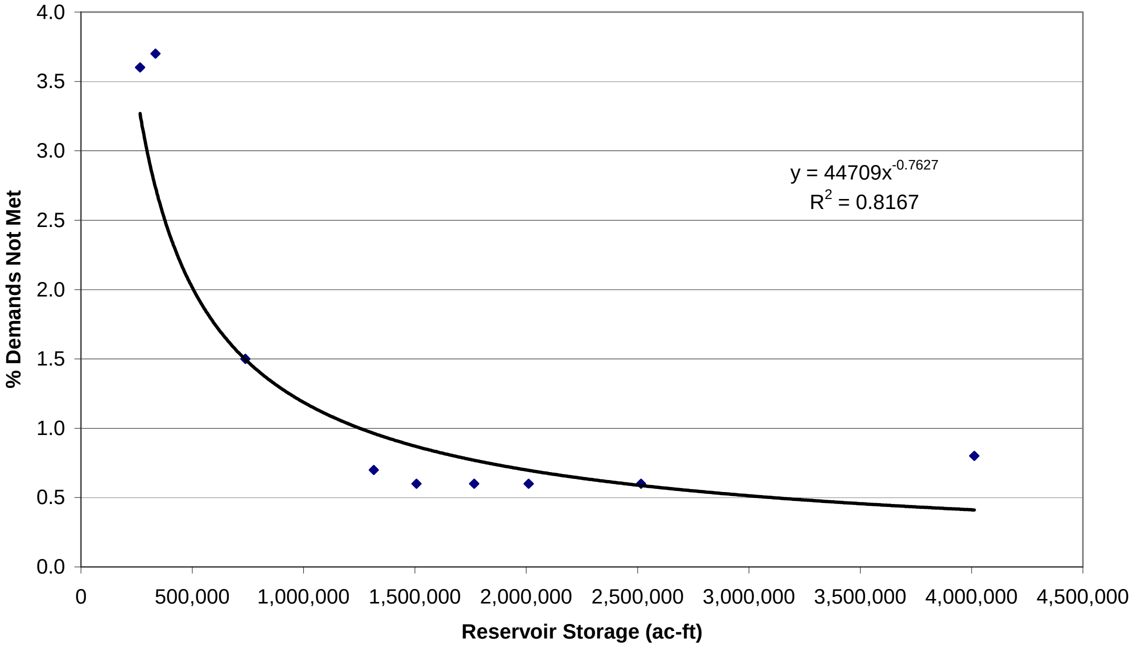


Figure B-55. Correlation between scenarios' storage capacities and Everglades Agricultural Area water supply demands NOT met.

B6.3 Conclusions

- Alternative 2 achieves the targets for performance measures related to the following performance measures - there no additional benefits to be gained by scenarios with greater storage capacity:
  - Extreme low Lake Okeechobee stages,
  - Weekly stages below the Lake Okeechobee stage envelope, and
  - Minimum Lake Okeechobee water levels and duration.

- Incremental improvements in the performance of scenarios for the following performance measures diminish with each incremental increase in storage capacity greater than 1,300,000 ac-ft.
  - Extreme high Lake Okeechobee stages,
  - Number of months with Lake Okeechobee regulatory releases to C-43 are greater than 2,800 cfs,
  - Mean monthly flows to the Caloosahatchee Estuary less than 450 cfs,
  - Mean monthly discharges to the St Lucie Estuary greater than 3,000 cfs,
  - Mean monthly flows to the St Lucie Estuary less than 450 cfs,
  - Everglades Agricultural Area water supply demands not met, and
  - Lake Okeechobee Service Area water supply demands not met.

- Scenarios with storage capacities greater than 1,300,000 provide increasing benefits for the following performance measures:
  - Weekly stages above the Lake Okeechobee stage envelope and
  - 14-day moving average Lake Okeechobee regulatory discharges to C-44.

  Only Scenario 2E, the largest storage capacity evaluated, came close to the target for the performance measure for weekly stages above the Lake Okeechobee stage envelope. Even Scenario 2E fell short of the target for the 14-day moving average Lake Okeechobee regulatory discharge to C-44 performance measure.

- The storage goal of 900,000 to 1,300,000 ac-ft provides substantial benefits and the addition of additional increments of storage capacity would produce diminishing incremental benefits. Since cost of a scenario is proportionate to its storage capacity, this analysis indicates that the storage target utilized would be cost effective.

B7.0 REFERENCES

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