OKISS Model Development and History Matching Report

(Deliverable 2.1.3.2.5.2)

Kissimmee Basin Modeling and Operations Study

(Contract No. 4600000933-W002)

Prepared for:

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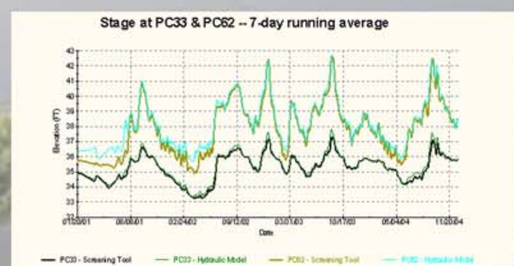

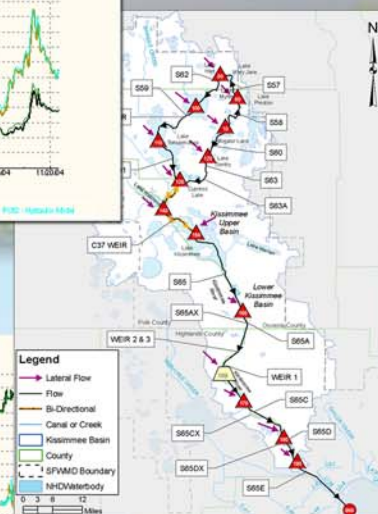

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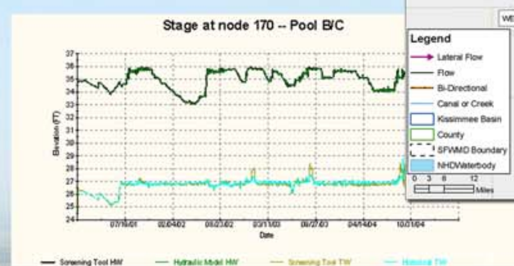

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HYDROLOGICS

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1 INTRODUCTION

1.1 Background

The goal of the Kissimmee Basin Modeling and Operations Study (KBMOS) is to assess whether existing operating criteria for the water control structures in the Kissimmee Basin (KB) can be modified to achieve a more acceptable balance among flood control, water supply, aquatic plant management and natural resource water management objectives. Natural resource objectives are outlined in the Kissimmee River Restoration (KRR) Project and the Kissimmee Chain of Lakes Long Term Management Plan (KCOL LTMP).

The KBMOS Work Plan identifies the need to develop a suite of modeling tools to use in the evaluation of possible operating criteria that would help to achieve the project objectives captured in a series of hydrologic performance measures and indicators. The modeling strategy proposed in the work plan introduced the use of a Screening Tool to allow the modeling team to begin the process of screening and evaluating alternative plans concurrent with the development of the KB Alternative Formulation Evaluation Tool (AFET or Hydraulic Model and AFET-W) (Earth Tech, 2007a and Earth Tech | AECOM, 2008. respectively). This approach allows significant progress in the evaluation of operating criteria with a tool that runs in much less time than the detailed tool. The KBMOS Team selected the Operational Analysis and Simulation of Integrated Systems (OASIS) computer program, from Hydrologics, Inc., as the Study Screening Tool. OASIS is a water resource system model that simulates routing decisions through LP (Hydrologics, Inc. 2006).

A Proof of Concept that compared the current South Florida Water Management District (SFWMD) model, the Upper Kissimmee Chain of Lakes Routing Model (UKISS) and OASIS, supported the selection of OASIS as the KBMOS Screening Tool. The Proof of Concept followed the guidelines described in a Test Plan put together by the KBMOS Team (Earth Tech, 2005). Since OASIS offered the flexibility and capability required to screen alternative plans in the KBMOS and taking into account that the SFWMD has gained confidence in the results obtained by UKISS, the Proof of Concept was designed as a comparison of OASIS with UKISS to demonstrate that OASIS was able to duplicate the results obtained by UKISS. For the purpose of the Proof of Concept, an OASIS model was developed for the same model domain covered by UKISS, which corresponds to the Kissimmee Chain of Lakes (KCOL). The OASIS model created for the KCOL was named O-KCOL. The development of O-KCOL was documented in the OASIS KCOL Model Report (Earth Tech, 2006a). O-KCOL was then updated to include the Lower Kissimmee Basin (LKB) (Earth Tech, 2006a), creating OKISS, which is the name used for the OASIS model for the KB. OKISS was developed following the guidelines established in the Screening Tool Technical Design Document (TDD) (Earth Tech, 2006b). The development of OKISS was based on the O-KCOL model (Earth Tech, 2006c). OKISS included the expansion of O-KCOL to incorporate storage and routing for the Kissimmee River and the C-38 channel.

A history matching exercise was performed to verify the results produced by OKISS by comparing historic operations to results from the Hydraulic Model. This exercise is documented in Earth Tech, 2007b. The version of OKISS used in the 2006 history matching was updated using information obtained from the calibration of the KBMOS AFET (Earth Tech, 2007c). An additional history matching exercise was performed to validate the refined version of OKISS to be used in the KBMOS alternative screening.

The purpose of this OKISS Model Development and History Matching Report is to document the process used to develop and verify the KBMOS Screening Tool.

1.2 Overview of OASIS

OASIS by Hydrologics, Inc. was the computer program used to build the KBMOS Screening Tool (OKISS). OASIS with Operational Control Language™ (OCL) is a generalized program for modeling the operations of water resources systems. OASIS simulates the routing of water through a system represented by nodes and arcs. This routing accounts for both human control and physical constraints on the system.

OASIS contains both arcs and nodes. Arcs represent conveyance from one node to another, while a node represents a point of interest in the system. There are three node types:

- **Junction Nodes**: Junction nodes are used to model a point in the system where inflow (or outflow) occurs, a point where there is a water-quality boundary condition, or a point where conveyance features (represented by arcs) meet. Junction nodes are not automatically associated with any special operating rules.
- **Reservoir Nodes**: Reservoir nodes are nodes at which water can be stored. OASIS computes the storage at the end of every time-step, which then becomes the storage at the beginning of the next time-step. Reservoir nodes are generally associated with operating rules.
- **Demand Nodes**: Demand nodes are nodes to which water is delivered.

With the exception of the terminal node (which is a junction node) all nodes in the OKISS model are reservoir nodes. In some cases, a single reservoir node is used to denote a group of lakes or a reach of the Kissimmee River. Note that OASIS does not differentiate between "reservoirs" and "lakes;" reservoir nodes are used for anything that can store water. Nodes are connected by water conveying arcs. Arcs cannot store water. Canals interconnecting the Kissimmee Upper Basin lakes are modeled as arcs, therefore they do not have an associated storage volume. Storage available in those canals is assumed included in the storage tables of the downstream lake.

Unlike other reservoir management models that simultaneously solve a series of equations imposed by flow continuity and operational rules to find a solution, which includes the flow through each arc, OASIS simulates decisions about routing water by solving a linear program (LP). The LP contains linear equality and inequality relationships between the **decision** variables of the system. The decision variables are the average flow of the time-step in each system arc and the end-of-period storage for the time-step in each system reservoir node. The modeler can define new decision variables that are linear expressions of flow and storage. By solving the LP each time-step, OASIS obtains a simultaneous solution of all decision variables.

The LP contains two types of rules including operating goals (also referred to as operating objectives in this report) and operating constraints. Operating constraints are rules that cannot be violated (i.e. conservation of mass). Operating goals are rules that OASIS attempts to satisfy. Operating goals are, however, in competition with each other by their very nature. Therefore, a specific operating goal may not be satisfied due to constraints or conflict with other goals. Goals and constraints are expressed as linear relationships between decision variables. Alternative plan components are “translated” to operating goals during the implementation of those alternative plans to OASIS. Therefore, in KBMOS, operating goals are specific instructions with their associated priority.

When solving the LP, OASIS always finds a system operation that maximizes the number of “points,” although in some cases there may be more than one such solution. For determining “points,” each operating goal is assigned a **weight or a priority**. The weight associated with an operating goal is expressed as the number of points per unit (in most cases acre-ft.) of water that OASIS gets for satisfying that goal. To maximize the number of points earned, OASIS routes water to satisfy goals with higher weight in preference over goals with lower weight. The word **“penalty”** simply denotes a weight of negative value. While the units of the terms in a target do not have to be the same, by converting everything to acre-feet the weights can be directly compared.

At each time-step, OASIS re-evaluates the goals and constraints before solving the LP. Prior to a solution, all decision variables are treated as unknowns. Goals and constraints can only be expressed as linear relationships between the unknown decision variables. In other words, it is not possible to simulate a non-linear relationship between decision variables such as storage and flow. If there is a non-linear relationship that must be simulated, it is often possible to approximate the relationship with a piecewise-linear approximation. When using piecewise-linear approximations, OASIS automatically ensures that the segments of the function enter in the correct order. This is accomplished by automatically defining the necessary integer variables and additional constraints.

It is important to clarify that the LP solver does not optimize operating criteria for the long term. The solver is used on a daily basis to meet the operating criteria on that day. It generates a solution that meets all constraints for the day and provides the highest number of “points” using the operating criteria specified by the user. By doing so, OASIS guaranties that the priorities associated to each alternative plan component (operating goal) are respected. The weights that generate the points usually indicate which use, flow, or storage is more important on that day, or that storage or shortages should be balanced to the extent possible on that day. The user must specify the operation criteria used by the solver for day to day optimization. It is the operating criteria that determine the long term performance of the system and the values of the performance measures. OASIS does not optimize the operating criteria, and is therefore a simulation, rather that an optimization model. To obtain more detail information about OASIS, the reader is to refer to the OASIS User Manual (Hydrologics, Inc., 2006).

Operations in the screening tool model are directed by weights on operating objectives or goals. The weights are generally hierarchical, because if OASIS must decide between two goals (such as to store water or release it downstream), it will choose the goal with the higher weight. The weights assigned to each operating goal will depend entirely on the operating criteria being analyzed. An analogy to a decision-tree type of management model (which is based on IF-THEN-ELSE statements) would be that the weights in OASIS let the program know the order in which the decision-tree branches will be evaluated or which condition is going to be checked (or satisfied) first.

OKISS uses weights and targets to specify the physical conditions and operations in the Kissimmee Basin. For example, a target aimed at having a lake follow a regulation schedule will cause OKISS to release the amount of water necessary to bring the stage back to its schedule (subject to other constraints and targets with higher weights in the model). OKISS includes high penalties if the flow exceeds the maximum flow (the flow that would occur at the maximum allowable gate opening); therefore, the releases made each day in OKISS will be less than the flow through the structure when the gates are at their maximum allowable opening. While OKISS does not specify a gate opening, the gate opening which yields the simulated flow is within the range of allowable openings. In practice, operators choose appropriate gate openings to bring the stage down to the regulation schedule. OKISS calculates necessary flows to do the same.

OASIS uses its LP solver to route water through the system based on the specified operations, it is not used to optimize the rule itself. Simulated operations are known before their implementation in the model, thus the operating rules do not need to be extracted from model results. The ease with which the operations can be implemented in practice is a function of the rule itself, not its OASIS implementation. Rules can be implemented in OASIS with or without results from MIKE SHE/MIKE 11.

When using an LP solver, it is possible to have alternate optima, or multiple solutions for water routing, in a single day which provide equal objective function values. Weights are staggered in OKISS in order to avoid this.

1.3 Version of OKISS

The version of OKISS described in this report represents the conditions of the KB at the end of Phase I of the KRR Project. This condition includes a restored floodplain in Pools B and C, which are joined in a single pool since the S-65B Structure was demolished as part of activities associated with Phase I of the KRR Project. Therefore, this model represents the same conditions used for the calibration of the AFET.

1.4 Future Activities Related to the Development and Use of OKISS in KBMOS

The model described in this report was used to develop the Screening Tool, corresponding to the Base Conditions that are defined in the Summary of Base Conditions Report (Earth Tech, 2007d). The following activities were executed before the use of the model in the alternative selection process:

- **Development of the "With Project" base condition Model**. The Screening Tool for the "With Project" base condition was built using information obtained from the configuration of With Project base in the Hydraulic Model. The required modifications included an update of the Operating Criteria according to the definition of "With Project" base condition included in the Summary of Base Conditions Report and an update of the restored portion of the river. The "With Project" base condition Model includes a single pool to represent Pools B, C and D. The methodology used to represent the floodplain in the "With Project" base condition Model was the same methodology used to include Pools B and C in the Post-Phase I KRR Project Model, as described in Section 3.1.2. The "With Project" base condition Model is documented in the Evaluation of "With Project" Base Conditions Report (AECOM, 2009)

- **Development of the Heuristic Wrapper**. The Screening Tool was linked with a heuristic wrapper to be used in an iterative process during the alternative screening process. The purpose of the heuristic wrapper is to refine operating parameters in the proposed alternative plan components identifying the parameter values for each component that result in a better performance of the proposed alternative. An alternative component parameter is a value within the definition of an alternative plan (minimum water elevation, maximum water elevation, threshold value that triggers certain operations, etc.) that can be changed to improve the performance metrics that result from an alternative plan. Alternative plan performance metrics were measured with the Performance Measure Evaluation (PME) Tool (Earth Tech, 2007e).
- **Validation of Model Tools by comparing PME Tool Results.** Model output obtained with the study modeling tools for the "With Project" base condition was run through the PME Tool. A comparison of the PME Tool results, in terms of performance measure scores, was made to verify that the evaluation of a given alternative, in either of the study tools, results in similar scores.
- **Sensitivity Analysis.** Most of the model uncertainty comes either from the hydrologic calculations done in AFET-W or from the hydraulic representation of the floodplain, also in AFET-W. Based on this and considering the Screening Tool was tuned to match AFET-W results, the Study Team did not consider it necessary to evaluate of the uncertainty of this particular tool. Furthermore, AFET-W is the model which is being used to develop the final evaluations of the alternative plans that will be used by the study team to generate the decision package, which will be sent to the Governing Board. Therefore, a robust sensitivity analysis that was planned for KBMOS only focused on the AFET-W results.

Although this model may be used in the future for other applications, the activities performed to-date and those that are planned for the immediate future, are intended to address the use of OKISS as the Screening Tool for the KBMOS. The Study Team recognizes that additional work and evaluations may be required prior to the application of OKISS for other applications

1.5 Report Structure

As described above, an OASIS model is comprised of nodes and arcs. Section 2 summarizes the nomenclatures used in the development of the OKISS model. Within OKISS, nodes were used to represent the lakes of the Kissimmee Upper Basin (KUB) and the pools (including the river channel and floodplain or the C-38 Canal) in the LKB. The physical characteristics, constraints and the assumptions and procedures used to represent OKISS nodes are described in Section 3. Arcs represent the spillways, culverts and conveyance canals in the KUB and only the structures in the LKB. Physical characteristics, constraints and the assumptions and procedures used to represent OKISS arcs are described in Section 4. Section 5 describes the basic assumptions and procedures used by OKISS to simulate the operations in the KB. The current operating criteria are used in that section to describe OKISS operations. Section 6 summarizes the various verification or history matching exercises performed to guarantee that the use of OKISS as the KBMOS Screening Tool resulted in accurate evaluations of the operating criteria being tested with the tool.

2 OKISS NOMENCLATURE

Figure 2-1 shows the node-arc diagram used to build the OKISS model. The red triangles represent each lake management area in the upper basin and pools in the Kissimee River. For Pool B/C two nodes are used (179, 180). A yellow trapezoid was used for node 179 to distinguish it from other nodes. In essence this node serves as storage within that reach of the Kissimmee River. Both the red triangles and yellow trapezoid are standard OASIS reservoir nodes. The arcs are the lines between the nodes. The black lines show one way arcs, while the orange lines show canals (C36, C37) that allow two way flow. The purple arrows mark locations where lateral inflows (runoff and tributary inflow) enter the model.

Table 2-1 relates each model node number with its corresponding Water Control Unit (WCU). This table also includes the list of lakes included in each WCU.

Performance measures are evaluated for each lake management area in the upper basin (Node 010 to 150) as well as flow through structure S-65 and S-65E (arcs 150.160 and 190.999). Stages at Cross Sections 5 and 9, located within Pool B/C, are calculated from structure S-65A releases (arc 160.179) and lateral inflows to Pool B/C.

Table 2-1: OKISS Nomenclature – Post Phase I – KRR Project

Water Control Units	Lakes Included	OKISS Node
Alligator	Alligator, Brick, Lizzie, Center, Trout, Coon	10
Myrtle	Myrtle, Joel, Preston	60
Hart	Hart, Mary Jane	80
Gentry	Gentry	120
East Tohopekaliga	East Tohopekaliga, Fells Cove	100
Toho	Tohopekaliga	110
Cypress	Cypress	130
Hatchineha	Hatchineha	140
Kissimmee	Kissimmee	150
Pool A	Pool A	160
Pool B/C	Pools B and C - “Floodplain Storage”	169
Pool B/C-2	Pools B and C - “Structure or Backwater Storage”	170
Pool D	Pool D	180
Pool E	Pool E	190
Terminal Node	Lake Okeechobee – S65E Tailwater	999

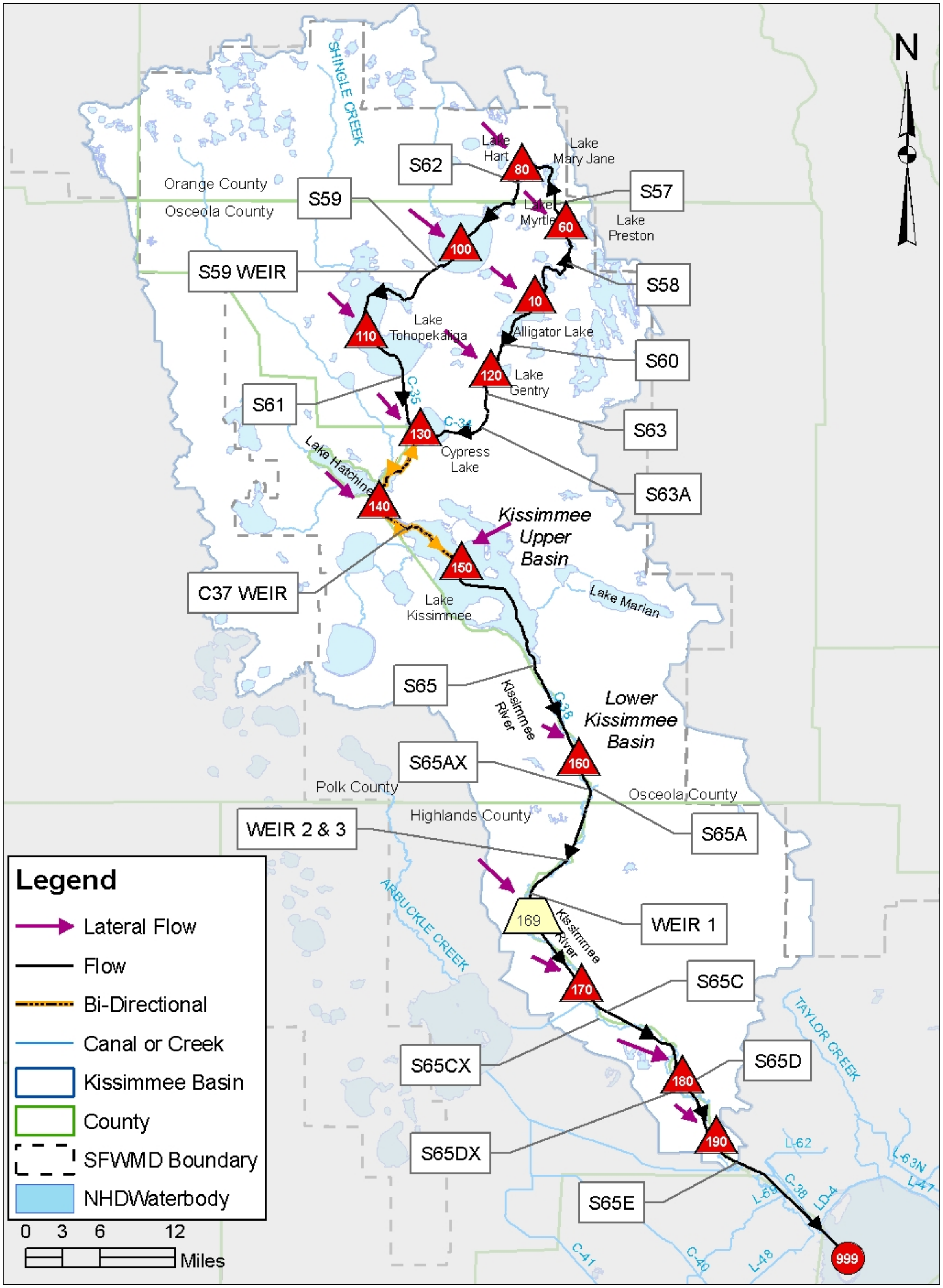

Figure 2-1: OKISS Schematic of the Kissimmee Basin for Post – Phase I KRR Project Conditions

3 OKISS NODES

3.1 Storage Volume and Stages

In any lake or reservoir, the amount of water in storage determines the water-surface elevation and the water-surface area. OKISS handles the storage calculation in the KUB using the traditional "Storage-Area-Elevation" (SAE) Tables. The LKB storage is handled by adding a flow component to the SAE Tables. The following sections describe the process and the data used to derive the storage information included in OKISS.

3.1.1 Storage Volume and Stages in the KUB (SAE Tables)

The SAE tables were obtained from the Digital Elevation Model (DEM) developed within the KBMOS Study (Earth Tech, 2006d). This DEM incorporated topographic information from the United States Geological Survey (USGS) with bathymetric data obtained from the United States Army Corps of Engineers (USACE). Storage areas were obtained for each lake, at different elevations, using the procedure described in Appendix A.

3.1.2 Storage Volume and Stages in the LKB

In the LKB, the storage and surface area are a function of flow, in addition to elevation. Because not only the pool surfaces are tilted, but also the water surface profile is a function of the flow, storage must be determined from functional relationships. To calculate and simulate the storage capacity for the pools of the LKB, several computer model runs were made using the calibrated version of the MIKE 11 portion of the AFET-W (Kissimmee River Floodplain Hydraulic Model), which represents the Post- Phase I KRR Project conditions. The MIKE 11 model was subdivided into four sub-models. Consequently, each pool was analyzed individually.

A schematic of the Pool A model is shown in Figure 3-1. The model was run for various flows ($Q_{S\text{-}65}$) to steady state. Model output of flow ($Q_{S\text{-}65}$), pool storage (S), pool headwater ($HW_{Pool\ A}$), and pool tailwater ($TW_{Pool\ A}$) was used to develop regression equations relating these four variables. These data and equations are found in "LKB_hydraulics_WPB.ocl" and Appendix B. It is important to note that the nomenclature for HW and TW in Appendix B is different from that used in OKISS and elsewhere in this document. This is because the exercise done in MIKE 11 analyzed only the reaches or pools independently (hence the naming convention that refers to the pool only) while OKISS uses the structures as the focal point. The HW of a pool is the TW of the structure located at the upstream end of the pool and vice versa. The TW of the pool corresponds to the HW of the structure located at the downstream end of the pool.

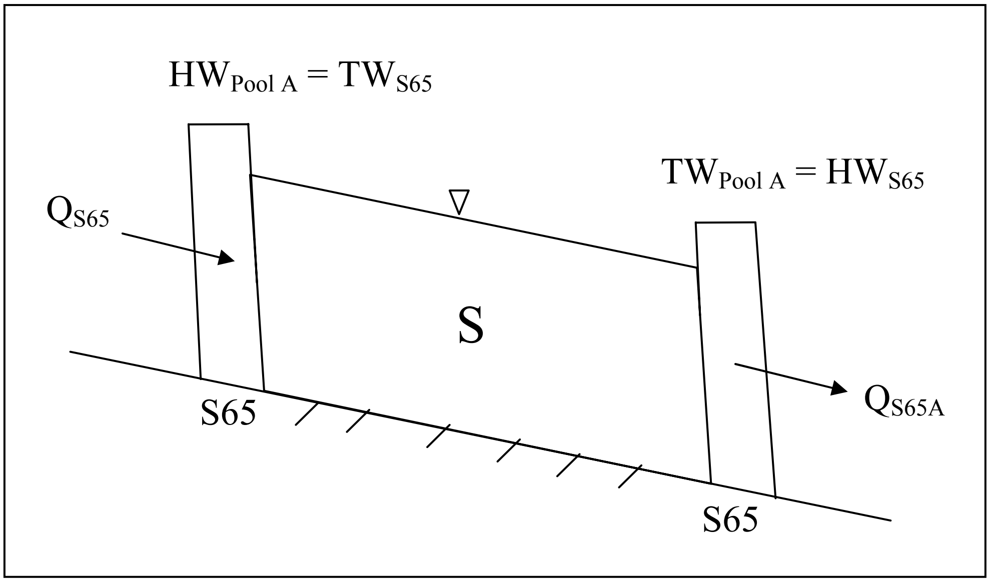

Figure 3-1: Schematic of MIKE 11 model for Pool A

A similar analysis was performed to build the OKISS model representing the "With Project" base condition, in which case the "With Project" base condition MIKE 11 network were used to extract the functional relationships.

Note that Pool B/C's bathymetry is significantly different than that of the other pools and is therefore treated separately.

Linearization of Headwater-Tailwater-Flow (HW-TW-Q) Relationships
Tables included in Appendix B directly relate pool HW stages with TW and flow. These tables were used to obtain the HW stages for each pool as described below.

3.1.2.1.1 Pool B/C – Post Phase I KRR Project

Pool B/C, in the Post-Phase 1 (After 2001 conditions) Model, has a very different functional relationship from the other pools and therefore, is treated separately. The bathymetry of restored Pool B/C is radically different from the other canals. The restored Pool B/C does not have a large conveyance element like the C-38 Canal. The thalweg of the restored river is at least 10 ft. higher than the invert elevation of the C-38 Canal and the conveyance of the restored river is less than the conveyance of the C-38 Canal. As a result, the hydraulic gradient of the restored Pool B/C is much steeper than that of the other pools. The stages are therefore more dependent on the hydraulic conditions in the river, which are controlled by the flow. Therefore, variables like storage volume and TW stage are also more dependent on flow values and storage in the restored Pool B/C, increasing dramatically with flow.

At the same time, flow is independent of HW in restored Pool B/C, within the historic range of HW, TW and flows. In fact, the HW would have to exceed the maximum for structural stability before the pool would extend to the upstream structure (S-65A), causing HW to affect flow. Instead, flow is simply a function of TW at the upstream pool (or HW of S-65A).

For its application in OKISS, this function was linearized in segments, based on the data in Appendix B. The flow is segmented at increments to closely approximate the data.

3.1.2.1.2 Pools A, D and E – Post Phase I KRR Project

MIKE 11 model results used to calculate the tailwater at the upstream structure (structure S-65 in the case of Pool A, for example). Unlike the storage calculation (see below), there are three decision variables in this case, S-65_TW, S-65A_HW, and S-65 release for Pool A, so the linearization process is more complex.

The HW-TW relationship is linear, with the slope and intercept of the line varying with flow (Q). Figure 3-2 shows stage HW-TW-Q curves for a generic pool. Say that the solution on a hypothetical day is given by the red circle in Figure 3-2. To specify that point, start at the lowest data point in the bottom left—data point for lowest HW, TW, and flow. A function, f_1 was developed to account for the actual flow on the day in question. However, as seen in Figure 3-2, f_1 overshoots the solution because the slope of the lowest flow line is less steep than the actual flow line (red dashed line).

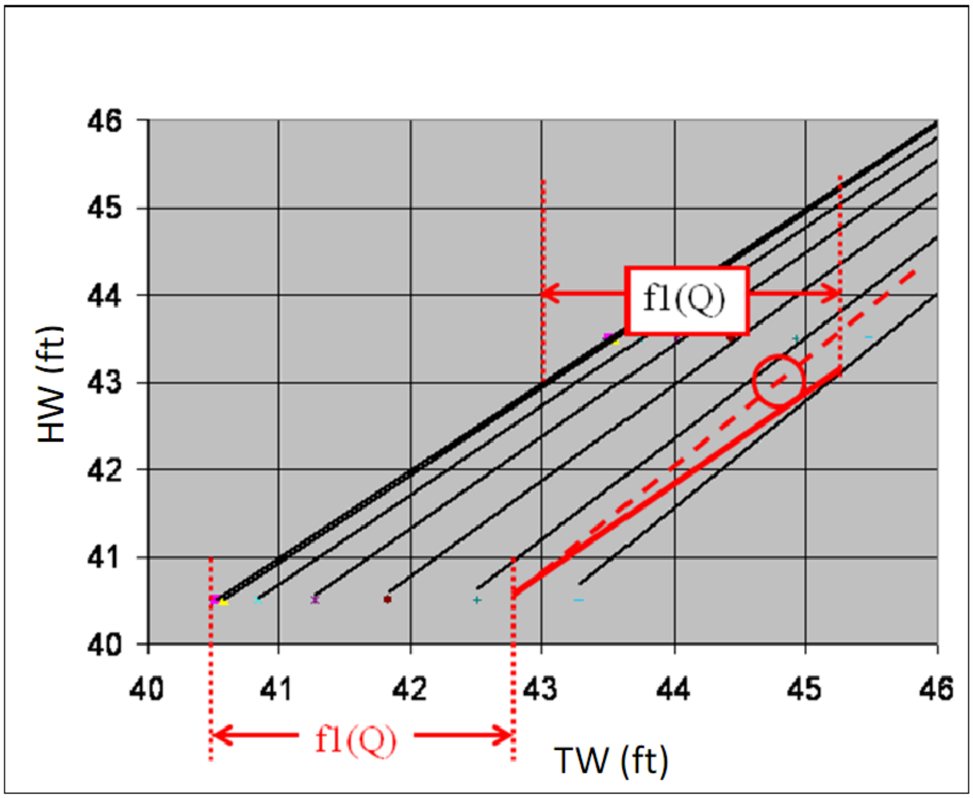

Figure 3-2: Stage HW-TW-Q curves for a generic pool

Therefore, a second function, f2, is needed to correct for this difference in slope.

Figure 3-3 and Figure 3-4 show the development of that function based on the geometry of the dashed red (HW-TW relationship at actual flow) and solid red (HW-TW relationship at lowest Q) lines in Figure 3-2.

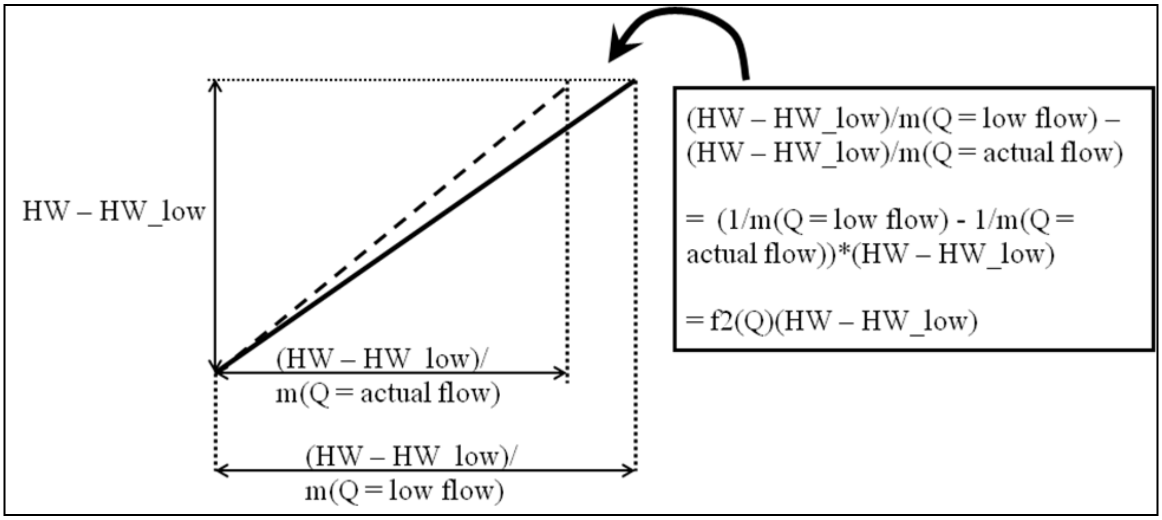

Figure 3-3: Formulation used in calculating f2

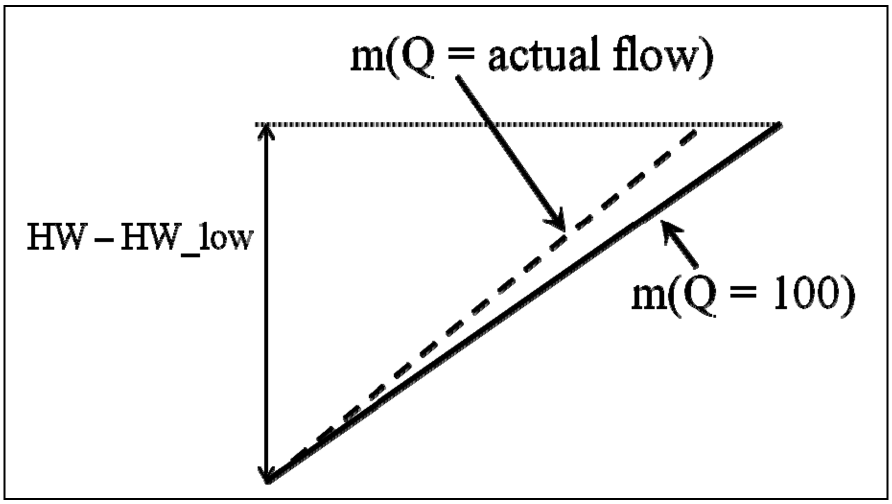

Figure 3-4: Geometry used in calculating f_2

The resulting equation for tailwaters is:

TW_upstream_node = HW + f_1(Q) - f_2(Q)(HW - HW_low) ....Equation 1

Where f_1(Q) represents the effect of Q on TW (under the assumed conditions HW = low historic) and is calculated as the difference between TW at Q = low flow cfs and Q = the actual flow at the lowest HW on historic record (given in *l_basin_substitutes.ocl*):

$$f_1(Q) = TW_{actual} - TW_{low}$$

Where TW_{actual} = Tailwater from table when HW = HW_low and Q = actual Q and
TW_{low} = Tailwater from table when HW = HW_low and Q = low Q

f_2(Q) then accounts for the fact that the HW may be different than HW_low. The f_1(Q) correction will overshoot the data for other HWs. This function is the difference of the slopes (m) of the HW-TW line for Q = low flow and for Q = the actual flow:

$$f_2\,(Q) = 1/m_{\,(\text{for } Q = \text{low flow})} - 1/m_{(\text{for } Q = \text{actual flow})}$$

where:

$$m = (TW2 - TW1)/(HW2 - HW1).$$

The last term in Equation 1 (f_2(Q)(HW - HW_low)) is nonlinear with respect to f_2(Q) and HW. In OKISS, this term is approximated as the sum of two linear terms by using the beginning of period (t) HW and the flow estimated for that pool as follows:

$$f_2(Q)(HW_{t+1} - HW\_low) = f_2(Q)(HW_t - HW\_low) + f_2(Q\_est)(HW_{t+1} - HW_t)$$

This equation provides a close approximation, since the pools are operated to maintain a constant and any error that does occur from a change in HW is corrected for in the final term. To approximate the data closely, f_1 and f_2 were carefully segmented. The ability of these equations to approximate the data was assessed by comparing model results to three-dimensional non-linear regression equations fit to the data. This exercise, included in Appendix D, shows the average of the absolute value of the difference between the calculated (regression equation) and simulated HW to be 0.3, 0.2, 0 and 0.2 feet for each structure respectively. The difference for all of the pools is always less than 0.5 feet, with the exception of seven occurrences, at times when the flow into the node was less than the storage.

HW-Flow-Storage Relationships

Tables included in Appendix B also directly relate pool storage volume with TW and flow. These tables were used to estimate the storage being used at each pool as described below.

3.1.2.1.3 Pool B/C

During the development of OKISS, it became evident that Pool B/C did not reach steady-state conditions in a single day. Hence, the direct use of the tables in Appendix B, which assumed steady-state conditions, was not possible for this pool. Instead, a function was needed that conserved mass, provided a time-lag between the arcflows into and out of Pool C comparable to that seen in the flow data and approached the steady-state solution over time. The adopted approach meets these three criteria, as explained below.

Storage in Pool B/C is a strong function of flow and a weak function of HW. Each of these function relationships are treated separately by separating Pool B/C into floodplain storage (Node 169) and structure or backwater storage (Node 170, see Figure 2-1). A function relating structure storage and HW was developed from the tables in Appendix B.

However, the floodplain storage-flow function (Stor(Q)) cannot be used directly because floodplain storage does not reach steady-state in a single day. Instead, the inverse of the storage-flow function is used with the storage from *previous* time-steps. This provides the needed time lag and converges to the steady-state solution at times when the flow into floodplain storage is stable. Figure 3-5 illustrates Pool B/C formulation in OKISS.

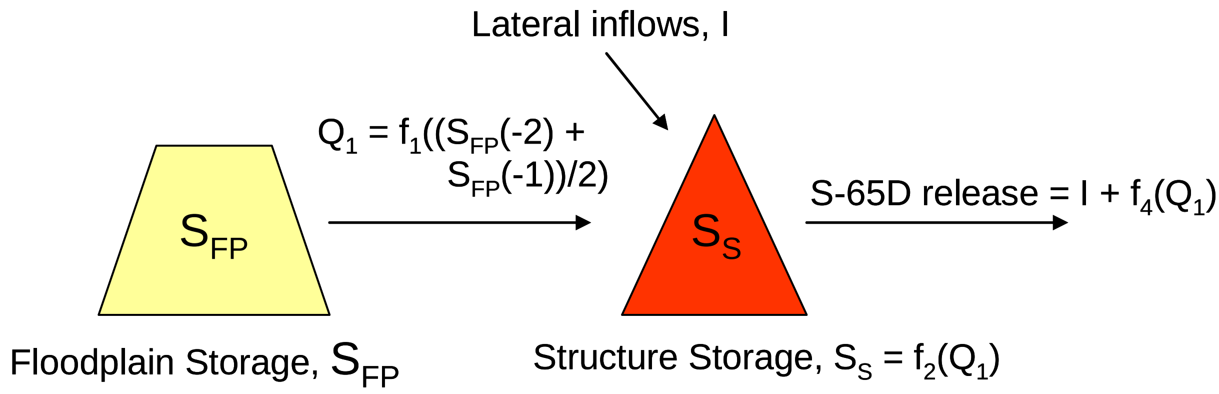

Figure 3-5: Pool B/C formulation in the OKISS model

This approach was tuned to historical flow data in two ways. First, the average of the two previous days' floodplain storage was used to set the arcflow *out* of floodplain storage (arcflow169.170), as this eliminated erroneous spikes in Pool B/C's outflow. Next, the lateral inflow to Pool B/C was divided between floodplain and reach storage to give the best fit to the data.

The procedure used in OKISS to obtain an appropriate match between storage and flow in Pool B/C is described below.

Flow (arcflow) from Pool A (Node 160) is "dumped" into the floodplain (Node 169). Flow out of the floodplain (Node 169) is obtained from the tables in Appendix B by finding the flow that matches the volume stored in the previous time-step and the TW of Pool B/C (obtained from Node 170). End-of-day volume is calculated by adding the volume discharged from Node 160 and subtracting the interpolated volume from the storage of the previous day. A portion of the lateral inflows of Pool B/C is also included in this calculation.

Flow calculated in the previous step is routed through the S-65C Structure (Node 170). The remaining portion of the lateral inflows is added to the flows coming from Node 169. The volume stored at that node is obtained from the tables in Appendix B. This volume is the volume reported in the tables for the minimum flow.

Stages in Node 170 are also obtained from the minimum flow volume portion of the tables in Appendix B.

3.1.2.1.4 Pools A, D and E

Storage in Pools A, D, and E is a function of structure headwater and flow into the pool. Because storage is a weak function of flow (274 af difference between 100 cfs and 8250 cfs in Pool A, for example), an estimate of flow is used instead of the actual flow. This simplification removes one decision variable from the calculation. Storage (decision variable) is set equal to a function of structure HW (decision variable) using a constraint command. By using the estimated flow, which is known at the beginning of the time-step, the intercept and slopes for segmented linearized functions of HW and storage can be accessed in a look-up table, specifically.

Stages at Interim Locations in Pool B/C

Since some of the Evaluation Performance Measures require time-series of intermediate locations in Pool B/C, the OKISS configuration of Pool B/C described in the previous section was modified so that stages at Weir 2, Weir 1, PC62 and PC33 were calculated. The evaluation location of the river performance measures were modified after the initial development of OKISS. However, since there are no records of observed data for the new evaluation locations, the analysis presented here was based on the aforementioned stations to verify the model results against observed data. The goodness of fit obtained with OKISS for the evaluation locations finally selected is documented in the Evaluation of "With Project" Base Conditions Report (AECOM, 2009) The modifications made to Pool B/C conceptualization in OKISS were also based on tables included in Appendix B and was derived from the calibrated version of the MIKE 11 portion of AFET[1] . The OCL file is included *after* the LP is solved, meaning that the calculation of the stages at an interim location is done once the *arcflows* are calculated for each time-step. As a result, for each time-step, the flows and stages are determined throughout the basin and then the flows in Pool B/C and stages at the S-65C Structure are used to calculate the stages at the interim locations.

As described above, OKISS has three different flows associated with Pool B/C including:

- arc160.169 - flow into Pool B/C (S-65A)
- arc169.170 - flow within Pool B/C, specifically between "reach storage" and "structure storage"
- arc170.180 - flow out of Pool B/C (S-65C)

The flow at each of the interim locations was calculated as a combination of these three flows. The appropriate fraction of each flow was determined by setting flow through the S-65A Structure equal to the historical flows and fitting the resulting stages to historical stages. The resulting fits are shown in Figure 3-6 through Figure 3-8. A figure was not prepared for PC62 since this station was not in place until 2005.

The aforementioned Figure 3-8 shows that during the summer and fall of 2002 and January 2003, the stages at PC33, determined by the look-up table, are about a foot lower than historical stages. This result is consistent with the Hydraulic Model calibration run. A plug installed during this period altered the dynamics near PC33 temporarily. The close agreement after January 2003 shows that the look-up tables are capturing current dynamics well.

The temporary alteration to pool dynamics from about January 2002 to January 2003 is illustrated by the historical stage (blue line) and flow (red line) at the S-65C Structure, which are also shown in Figure 3-8 In this figure, it is observed that the historical stages at PC33 do not necessarily vary in magnitudes proportional to the flow during this period as they do the rest of

[1] During the KBMOS alternative plan selection process, AFET-W replaced AFET. AFET-W was calibrated under Pre-Phase I conditions and was used to represent the fully restored conditions of the KRR Project. However it was not adapted to represent the Post-Phase I conditions as AFET was. The AFET hydraulic calibration of the Post-Phase I conditions was not altered during the calibration of AFET-W. Therefore, volumetric calculations obtained from AFET to develop the OKISS Post-Phase I condition model are still applicable. AFET-W results were used to develop the OKISS model that contains in full the KRR Project.

the time. For example, the peak flow on 9/29/2004 is about 4000 cfs higher than that on 1/9/2003, but the PC33 peak stages are about the same.

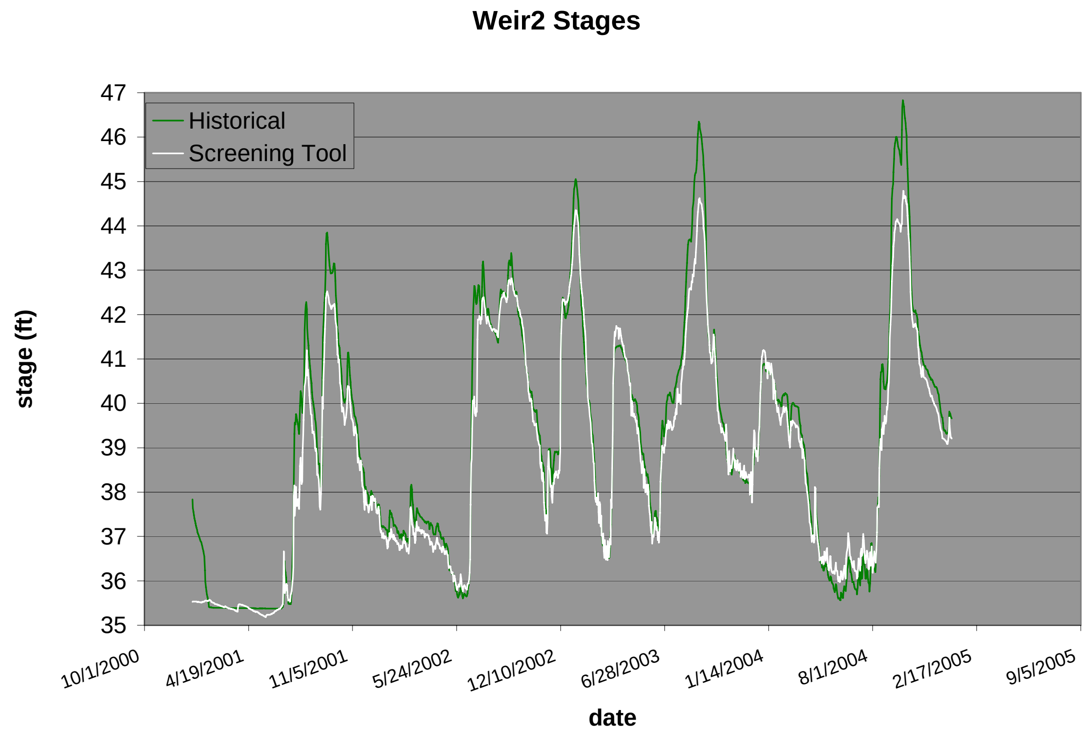

Figure 3-6: Simulated and Observed Stages at Weir 2

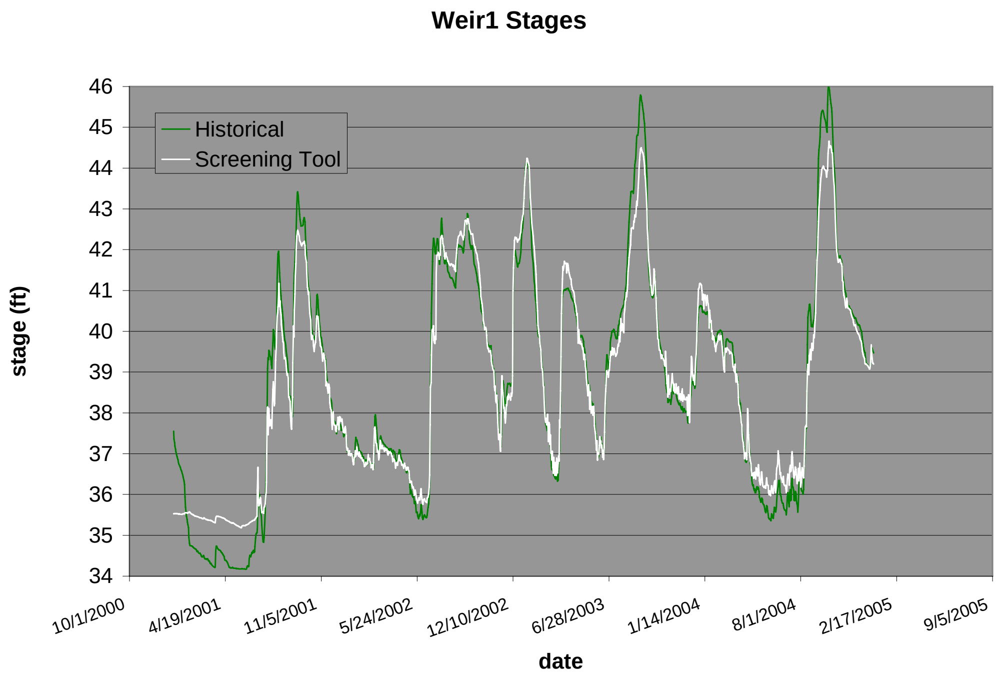

Figure 3-7: Simulated and Observed Stages at Weir 1

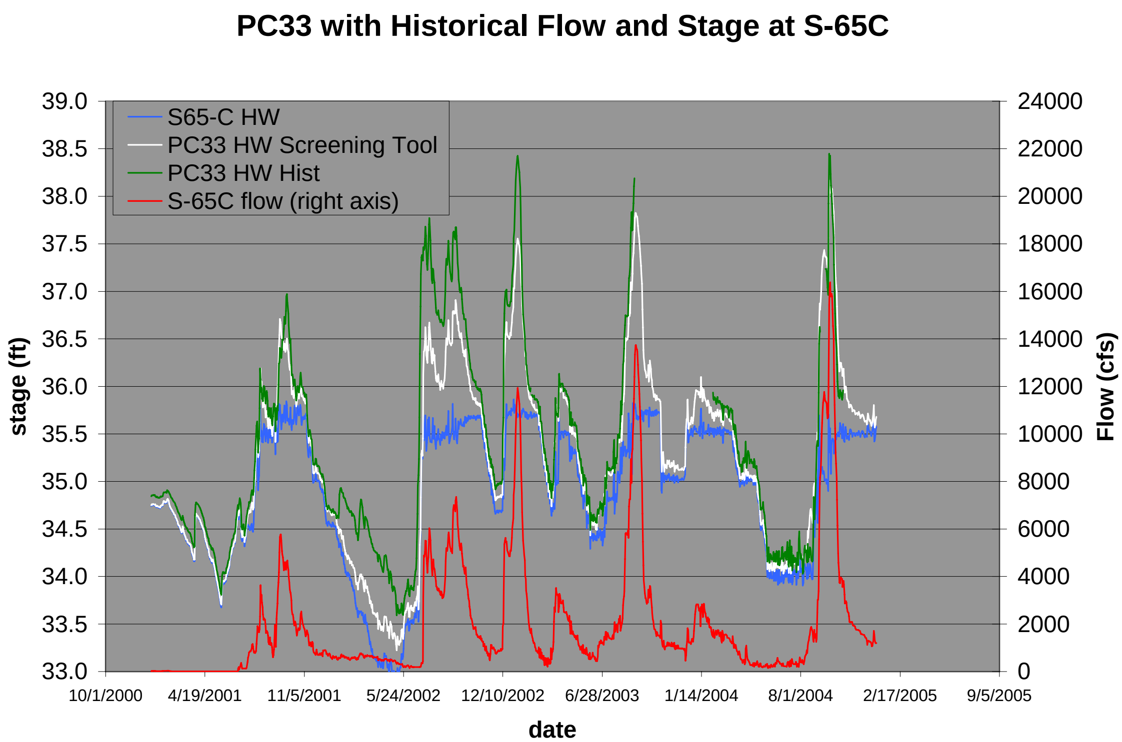

Figure 3-8: Simulated and Observed Stages at PC 33

3.2 Evaporation and Direct Precipitation

Although OASIS has the capability of simulating evapotranspiration (ET) and direct precipitation over the lakes represented by nodes, this option was not used in OKISS since these variables are already included in the set of system inflows that are transferred from the AFET during the screening process. The initial versions of OKISS have this option turned off. It can be enabled if required during the screening process. Additionally, rainfall and ET are available within the model set-up, in case they need to be referenced by the alternative plan components during the screening process. Alternatively, an internal adjustment can be included in OKISS to account for the change in lake ET and rainfall. This adjustment would be added to the alternative runs to slightly modify the sets of lateral inflows based on the surface area of each lake at each time-step. The adjustment would be calculated, at every time-step, by a ratio between the area of the lake in the base conditions run (source of lateral inflows) to the area of the lake in the alternative being modeled. This ratio would then be multiplied by the ET and rainfall values in the time-series that is currently in OKISS.

3.3 System Inflows

System inflows (A.K.A. lateral inflows) used in OKISS during the alternative screening process are obtained from the KBMOS AFET. The version of OKISS used in the latest verification process, documented in Section 6.2, included the lateral inflows obtained by AFET during the calibration process (2001-2004). These inflows were replaced by the inflows obtained for the AFET-W "With Project" base condition during the screening process.

A detailed description of the methodology used to extract the AFET lateral inflows is included in Appendix C. The appendix also includes a verification of the MIKE 11 mass balance.

4 OKISS ARCS

4.1 End-of-Day Lake and River Reach Elevations

The flow through canals and structures is computed as a function of head in the lakes. Since the flow that is needed correspond to the daily average, and the information available corresponds to end of day stages, the daily average flow can be calculated by applying the average head in the lake into the functions. However, storage in each lake at the end of each simulation day is an unknown decision variable whose value is solved simultaneously with the flows and storages in all other parts of the system. It is not possible to enter this unknown storage value into the non-linear SAE function. An alternate approach where flows instead of heads are averaged could also be possible. Flows obtained with the selected approach where successful compared with the reference data. Therefore, it was not necessary to try the alternate approach.

Thus, OKISS contains variables that represent the estimated (approximated) end-of-day lake elevation (or beginning of next day). With the variables in question represented as $Z_{L,t+1}$, the constraint used to define them is:

$$Z_{Lt+1} = Z_{L,t} + \Delta S_{L,t} / A_{L,t} \qquad \text{Equation 2}$$

where:

$Z_{L,t+1}$ = elevation at lake L at the end of the day (ft.), which is the same at the elevation of the lake at the beginning of the day t+1
Z_{Lt} = elevation at lake L at the beginning of day t(ft.)
$\Delta S_{L.t}$ = change in storage at lake L for day t (acre-ft.)
$A_{L,t}$ = surface area at lake L at the beginning of day t (ac)

ΔS_L is a linear expression of decision variables and Z_{L-0} and A_{L-0} are both known values, having been solved on the previous simulation day. Although this must be acknowledged to be a linear approximation of the end-of-day elevation, in practice, the error is very small because the change in storage in a single day is small and the curvature of the SAE line is small.

4.2 C-36 and C-37 Canal Capacities

During the development of OKISS, Hydrologic Engineering Center-River Analysis System (HEC-RAS) simulations were performed under different scenarios for the Post-Phase I KRR Project C-36 and C-37 Canals. Based on the simulation results, a Q vs. HW and TW table was constructed for each canal. A two-dimensional regression equation was developed for flow in the tables for the C-36 and C-37 Canals:

$$Q = A^* (HW\text{-}TW)^b * (HW\text{-}C)^d + e \quad \text{Equation 3}$$

where:

Q = flow through the canal for the time-step (cfs)
HW = headwater elevation at the canal (ft.)
TW = tailwater elevation at the canal (ft.)
A, b, C, D and e = constants specific to canal and given below:

	A	b	C	D	e
C-36	4.310E-10	0.3556	8.908	8.006	102.768
C-37	6.500E-04	0.272	21.678	4.713	-43.750

The fit to the data is shown in Table 4-1. For large flows, the difference between the regression equation and data is less than 15 percent. Other regression equation forms failed to fit the data as well as the one chosen. A more detailed description of the process used to develop the above-mentioned equations is included in Appendix D.

Table 4-1: Measures of fit for the regression equation of flow in the C-36 and C-37 Canals

		Deviation from Data (cfs)		Max Error as % of Flow	
	R^2	Ave	Max	All Data	Data > 6595 cfs
C-36	0.9733	85	1258	34	14
C-37	0.9692	257	1343	144	13

Equation 3 gives an instantaneous value for the flow. This must be converted to a daily value for use in OKISS. The approach taken in OKISS is to make the daily flow equal to the average of the instantaneous flows at beginning- and end-of-period. The end-of-period HW and TW are computed from the simulated end-of-day storages in the lakes, which are decision variables. Q is also a decision variable. As discussed above, a non-linear relationship between decision variables cannot be written in OASIS. Therefore, a segmented linear approximation of this function was developed.

Then, the flow for the day using beginning- and end-of-period HW_C and TW_C values was assumed to be equal to:

$Q = (Q_0 + Q_1) / 2$ .... Equation 4

where:

Q_0 = flow computed using beginning-of-day HW and TW
Q_1 = flow computed using end-of-day HW and TW

$Q_0 = A^* (HW_0\text{-}TW_0)^b * (HW_0\text{-}C)^d + e$ .... Equation 5

$Q_1 = A^* (HW_1\text{-}TW_1)^b * (HW_1\text{-}C)^d + e$ .... Equation 6

and,

TW_0 = tailwater elevation at beginning of the day (ft.)
HW_0 = headwater elevation at beginning of the day (ft.)
TW_1 = tailwater elevation at end of the day (ft.)
HW_1 = headwater elevation at end of the day (ft.)

The right-hand side of Equation 5 contains no decision variables and so it is evaluated as shown. Equation 6 contains decision variables and so it is replaced with a segmented linear approximation. However, it must be noted that Equation 6 contains three decision variables. A plot of this relationship would occupy three-dimensional space. Developing a linear approximation of such a relationship would be too complex. It was judged that the most important factor in Equation 6 is $(HW_{-1}\text{-}TW_{-1})^b$. Therefore, a linear approximation was developed for this part of the function and the factor $(HW_{-1}\text{-}C)^d$ was assumed to be equal to $(HW_0\text{-}C)^d$. The error resulting from this assumption is discussed in the O-KCOL Documentation (Earth Tech, 2006a).

4.3 Culvert and Spillway Capacities

4.3.1 Structures in the Kissimmee Upper Basin

Spillways

The following is the process used in the KUB to define the maximum capacities for the spillways structures. It is important to emphasize that the flow equations described in this section are derived from instantaneous values. However, these equations are applied in OKISS for average daily values. This is considered valid because the equations are used only to verify the maximum allowable gate openings. OKISS does not model gate operations. The decision variables in OKISS are the flows through the structures, which are calculated for each time-step (1 day).

Maximum gate openings were calculated using the equations used by the SFWMD's UKISS, which are included below. These equations were derived by the SFWMD from the USACE charts of maximum allowable gate opening included in the KB Water Control Plan.

$Go = A\,(H\text{-}h)^B\,(h)^C + D$ .... Equation 7

where:

H	=	Headwater elevation in ft.
h	=	Tailwater elevation in ft.
Go	=	Gate opening in ft.
A, B, C, D	=	Constant coefficients specific to the structure

AECOM

Once the maximum gate openings were defined, the maximum allowable flows were calculated using the flow equations proposed in (Ansar et al, 2005), included in Table 4-2 below.

The following definitions apply to Table 4-2, where the flow equations the KB spillways are shown:

- H: headwater (ft.)
- h: tailwater (ft.)
- g: gravitational acceleration, 32.2 ft./s^2
- G_o: gate opening (ft.)
- L: spillway width (ft.)
- y_c: critical depth (ft.)
- Q: computed discharge (cfs)

Table 4-2: Spillway equations based on SFWMD dimensional analysis Ansar et al (2005)

Flow Condition	Equation	Restriction	Remarks
Controlled Submerged (CS)	$Q = L\sqrt{g y_c^{\,3}}$ $y_c = aG_o\left(\frac{H-h}{G_o}\right)^b$ $a = 1.04,\ b = 0.30$	$\frac{h}{G_o} \geq 1.0$	Also known as submerged orifice
Controlled Free (CF)	$Q = L\sqrt{g y_c^{\,3}}$ $y_c = aG_o\left(\frac{H}{G_o}\right)^b$ $a = 0.86,\ b = 0.35$	$\frac{h}{G_o} < 1.0\ \&\ \frac{H}{G_o} \geq \frac{1}{K}$ $K = 2/3$	Also known as free orifice
Uncontrolled Submerged (US)	$Q = L\sqrt{g y_c^{\,3}}$ $y_c = aH(1-\frac{h}{H})^b$ $a = 0.838,\ b = 0.167$	$\frac{h}{G_o} < 1.0, \frac{H}{G_o} < \frac{1}{K}, \& \frac{h}{H} \geq K$ $K = 2/3$	Also known as submerged weir
Uncontrolled Free (UF)	$Q = L\sqrt{g y_c^{\,3}}$ $y_c = aH$ $a = 0.7$	$\frac{h}{G_o} < 1.0, \frac{H}{G_o} < \frac{1}{K}, \& \frac{h}{H} < K$ $K = 2/3$	Also known as free weir
Transitional Flow	No transition region		

The dimensions and flow equation coefficients for the structures in the KUB are included in Table 4-3 below.

Table 4-3: SFWMD Flow Equation Coefficients for KUB Structures

Structure ID	Structure Type	Number of Gates	Structure Invert (ft. NGVD)	Gate Width (ft.)	Gate Height (ft.)	a[1]	b[1]
S-57	Culvert	2	52.5	3.53	4.5	NA	NA
S-58	Culvert	2	54.5	3.53	4.5	NA	NA
S-59	Spillway	1	49.1	18	8.9	1.12/0.86 0.89/0.77	0.21/0.38/0.17/NA
S-60	Spillway	1	54.9	12.8	9.1	1.12/0.86 0.89/0.77	0.21/0.38/0.17/NA
S-61	Spillway	1	36.9	27.8	18.1	1.00/0.86 0.89/0.77	0.27/0.38/0.17/NA
S-62	Spillway	1	55.2	14.8	6.8	1.12/0.86 0.89/0.77	0.21/0.38/0.17/NA
S-63	Spillway	1	53.9	15.8	8.1	1.12/0.86 0.89/0.77	0.21/0.38/0.17/NA
S-63A	Spillway	2	49.3	15.8	7.7	1.12/0.86 0.89/0.77	0.21/0.38/0.17/NA
S-65	Spillway	5	39.2	27.8	14.2	1.04/0.838 8/0.86/0.7	0.3/0.167/0.35/NA

[1] SFWMD structure coefficients for the CS/US/CF/UF flow conditions
NA Not Applicable

In addition to the flow restrictions imposed by the maximum gate openings, a maximum flow through the structures was initially added to the spillways. These maximum flows restrictions were removed from the latest version of OKISS because they are considered part of the Operating Criteria.

Culverts

The process used to calculate the maximum flow through the culverts is described below.

A maximum flow was used to cap the flows through the S-57 and S-58 Structures. These maximum flows are:

- S-57 max flow = 230 cfs
- S-58 max flow = 110 cfs

To ensure that OKISS flows through the S-57 and S-58 Structures match the theoretical hydraulic capacity, the following equations were used (obtained from the original UKISS configuration).

Flow Type:	Open channel flow
Flow Equation:	$Q1 = (1.49/n)(AR1)(XAR)(SLOPE)^{0.5}$
Criteria:	$HW<TOP$

Flow Type:	Orifice flow
Flow Equation:	$Q2 = 0.75A[64.4(HW-TW)]^{0.5}$ *(UKISS formula. Flow is partially submerged downstream, therefore Q is also a function of TW))*
Criteria:	$HW>TOP$ and $TW<TOP$

Flow Type:	Full pipe flow
Flow Equation:	$Q3 = (1.49/n)(AR1)(SLOPE)^{0.5}$
Criteria:	$HW>TOP$ and $TW>TOP$

In the above equations:

Q1,Q2,Q3	=	Flow in cfs under three different flow conditions
TOP	=	Top elevation of pipe in msl
n	=	Manning n (0.024 for all culverts)
AR1	=	$(A)(d/4)^{0.6667}$
XAR	=	*(1.72y/d - 0.373*
y	=	Mean depth of flow in ft. = (HW – TW) /2 - Invert Elevation as used in UKISS
d	=	Diameter of pipe in ft.
A	=	Cross sectional area of pipe in sq ft.
SLOPE	=	Slope of water surface
	=	*(HW-TW)/L*
HW	=	Headwater elevation in msl
TW	=	Tailwater elevation in msl
L	=	Length of pipe in ft.

4.3.2 Structures in the Lower Kissimmee Basin

The following is the process used in the LKB to define the maximum capacities for the spillway structures:

- The maximum gate openings used to cap flow in these equations, calculated from a regression equation developed from the Maximum Allowable Gate Openings Curves (Central and Southern Florida Project, Master Water Control Manual, Kissimmee River-Lake Istokpoga Basin, USACE Jacksonville District, August 1994):

GOmax = a(HW * TW)b + cHW + dTW + e

Details on the regression equation, including the constants and R^2 values, are provided in Appendix E. Much of the time, the HW at the structures is maintained at the target value for operations. To refine the maximum gate opening at these times, the gate openings from the curves were entered into a look-up table for HW = target HW (GO_TargetHW_node). The look-up table is used in lieu of the regression equation when the HW is at its target stage. The HW-TW curve below, for which there is no restriction on gate opening, was also entered as a look-up table (GO_restrict_node).

- Maximum flows were calculated by using the maximum gate openings in the equations proposed by the SFWMD and documented in (Ansar, 2005). The forms of these equations are given in the previous section. Table 4-4 summarizes the physical characteristics of the LKB Structures.

Table 4-4: SFWMD Flow Equation Coefficients for LKB Structures

Structure ID	Structure Type	Number of Gates	Structure Invert (ft. NGVD)	Gate Width (ft.)	Gate Height (ft.)	a[1]	b[1]
S-65A	Spillway	3	34.4	27.8	13.8	1.04/0.838/0.86/0.7	0.3/0.167/0.35/NA
S-65C	Spillway	4	22.2	27.8	13.8	1.04/0.838/0.86/0.7	0.3/0.167/0.35/NA
S-65D	Spillway	4	15	27.8	13.8	1.04/0.838/0.86/0.7	0.3/0.167/0.35/NA
S-65E	Spillway	6	9.6	27.8	13.8	1.04/0.838/0.86/0.7	0.3/0.167/0.35/NA

[1] SFWMD structure coefficients for the CS/US/CF/UF flow conditions

5 OKISS OPERATIONS

OKISS is a mass balance model of the KB Hydrologic System. As such, it was designed to solve the mass balance equations while meeting operating criteria, which includes the regulatory schedules of the KB. OKISS builds a unique LP formulation for each time-period to solve the mass balance equations, while meeting operating criteria and hydraulic constraints. The mass balance equations are included as constraints in the LP and therefore, must be satisfied. The operating criteria, including the need to maintain the regulation schedules, are included in the objective function. Each carries a weight, or priority, which represents its importance relative to other program objectives. It is important to emphasize that the terminology included in the "OASIS User Manual" includes the term "operating goals" when referring to the portion of the operating criteria that is within the LP objective function. These objectives should not be confused with the KB operational goals. To avoid confusion in this report, OASIS "operating goals" are referred to as OASIS "operating objectives".

5.1 Role of Weights within OKISS

As part of the LP methodology, OKISS models the KB as a system. The model is set-up by the definition of constraints and goals. A constraint is a statement that OKISS must satisfy, including mass balance equations, maximum flow restrictions, head loss calculations, surrogate relationships, hard operational rules, etc. A goal is a rule that OKISS intends to meet. By their nature, operating objectives are in competition with each other. Some operating objectives are even in conflict with some of the constraints (i.e. lowering stages to avoid flood control will cause the release of large flows, which are constrained by a maximum gate-opening rule). Therefore, not all operating objectives can be satisfied. Any given objective can take precedence over other objectives through the use of weights. Weights are used in OKISS to assign priorities. Operations in an OKISS model are directed by weights on operating objectives or goals. The weights must be viewed as hierarchical. When OKISS must decide between two goals (such as to store water or release it downstream), it will choose the goal with the higher weight. The weights assigned to each operating goal will depend entirely on the Operating Criteria being analyzed. An analogy to a decision-tree type of management model (which is based on IF-THEN-ELSE statements) would be that the weights in OKISS let the program know the order in which the decision-tree branches will be evaluated, or which condition is going to be checked (or satisfied) first. Using the same analogy, constraints will be those set of conditions that are to be satisfied all of the time and are usually located at the end of every decision-tree branch. This will verify that the final solution is always within the space defined by the constraints.

An LP system is comprised of an Objective Function and a series of constraints, both of which are expressed in terms of the decision variables. The LP solver is run for every time-step to maximize the value of the Objective Function. The Objective Function is a linear function formed by the addition of several components, one for each operating objective. Each component is multiplied by a weight to let the LP know which component (operating objective) has priority over the rest. To make certain that the comparisons among components (operating objectives) are done under a common datum and that the weights are the only way to assign priorities to each operating objective, the components in the Objective Function must be expressed in the same units. OKISS defines the Objective Function as a volume calculation. This volume is defined in acre-ft. Having a component in units different than acre-ft. will invalidate the hierarchy intended with the weight system.

The LP maximizes the sum of the products of weights and volumes. OKISS will define weights on storage, weights on volumes of flow in arcs and weights on the difference in volume between target volume values and simulated volume values. In general, if storage is to be used to meet a given flow or demand, it is only necessary to set the storage weight lower than the demand or flow weight. How much lower is usually arbitrary. Because weights can be combined, weights for similar targets (e.g. minimum flow, demand, storage, etc.) are usually set in (well-separated) ranges. Generally, weights should not span more than four orders of magnitude for computational reasons.

In almost all cases, the actions that the weights influence are controlled in a hierarchical manner. The cardinal order of value takes precedence over the relative value. For example, if four demands take water from a single source, with weights of 35, 30, 25 and 20, all of Demand 1 will be met before any of Demand 2, all of Demand 2 will be met before any of Demand 3, etc. The same thing will happen if the weights are 53, 12, 11 and 10.

If the same demands are distributed around the system, the hierarchical order will still apply, except that other constraints may limit the amount of water that can be delivered to any of the demands. In other words, the LP solver will find all possible ways to redirect water from a demand with a lower weight that is getting water, to a water-short demand with a higher weight. If a higher weight demand is short of water, a lower weight demand will get the water only to the extent that redirection is not possible. Implementing this type of allocation policy without a system solver will require custom code (if-then or iteration) for every change of the system configuration. With LP, the solver automatically adapts to the change in configuration. Ordering the weights can serve the same function as an if-then block (e.g. if the weight on this lake is higher than the weight on that lake, keep the water in this lake as high as possible at the expense of levels in the other lake). The biggest difference is that the LP makes the ordering work system-wide, while automatically respecting all other system constraints. This can save substantial coding effort. Note that if the hierarchical order needs to change "on-the-fly," changing the order of the weights may be all, and will certainly be most, of what needs to be done to implement the change. The Condition functionality in OASIS target command specifically allows for changing the hierarchical order of weights based on the values of state variables.

The hydraulic or physical constraints, once linearized, can be included in OKISS as constraints in the LP solver or, as part of the Objective Function along with the operating objectives, they can be given very high weights so that they are always met. The LP solver (a commercial package, XA by Sunset Software) then finds a solution that satisfies all mass balance equations and produces a set of flows for the system that meet the operating criteria, essentially in the order of decreasing weights, since it meets the highest weighted operating objectives first. This technique seems to be able to meet the operating goals and respect hydraulic constraints with considerably more precision than the iteration technique used in the other programs.

5.2 Operation Criteria coded in OKISS

The current version of OKISS was complemented with the Structure Operations, defined within the Summary of "With Project" Base Conditions Report (Earth Tech | AECOM, 2008a), for the "With Project" base condition. As described in Section 1.1, the development of the current version of OKISS required a series of stages. Each one of these stages had a different set of operating criteria, according to their specific needs. Three sets of operating criteria were developed and included in the preliminary versions of OKISS:

1. **Current Operating Criteria as coded in UKISS**. This set of operating criteria was developed only for the KUB (KCOL) and intended to mimic the operating criteria coded in UKISS. It was developed as part of the Proof of Concept exercise (Earth Tech, 2005).
2. **Current Operating Criteria in the KUB and LKB**. This set of operating criteria was used in the initial verification or history matching exercise (documented in Section 6.1). It consisted of the current operating criteria as coded in UKISS for the KUB, plus the current operating schedules for the LKB.
3. **AFET Fixed Stage Operating Criteria**. This set of operating criteria was used in the final verification or history matching exercise (documented in Section 6.2), where stages produced by the Hydraulic Model were used as targets.

Out of these sets of operating criteria, the set described under Item 2 is the set that most closely resembles the set of operating criteria described in the Summary of "With Project" Base Conditions Report (Earth Tech | AECOM, 2008a). This set is simpler than the current actual operating rules in the system. For instance, rules implemented in OKISS call for maximal lake drawdown until the regulation schedule is met. The current actual operating rules call for a gradual drawdown (15 days) of lakes once they are within 0.5 ft. of the regulation schedule. The full set of operating criteria were coded in OKISS prior to the evaluation of the "With Project" base condition.

5.3 The Objective Function

The set of operating conditions currently in OKISS (similar to the With Project base conditions) are used in this section as an example of how an operating criteria must be coded in OKISS. Therefore, the weight structure described in this section corresponds to the operating schedules currently in place in the KB, unless otherwise specified.

There are 44 terms in the OKISS objective function. All of them are described below and the coefficients are shown in the tables within the same row. Penalties are negative weights, e.g. a penalty of 5000 means that the term goes into the objective function with a coefficient of -5000. The objective function is simply the sum of the products of the terms and their coefficients. All of the storage terms are end-of-period or volumes and all of the flow terms are volumes for the time-step. The two types of penalties defined by OKISS are "Penalty+" and "Penalty-". Penalty+ is applied when the value goes above the target and Penalty- is applied when the value goes below the target.

There are no conditional targets in OKISS. Therefore, the same objective function is used at every time-step. If there were conditional targets, they would be listed below and the coefficients for the differences would be taken from the first condition that was evaluated to be true for that time-step. The file named "OCL.out" would identify which condition holds at each time-step.

5.3.1 Physical Flow Equations

The very highest weights (60,000 and 50,000 points) are used to ensure that the model follows the physical flow equations. Because these weights are higher than all others, the physical flow equations will always be followed, except in the extreme cases of flooding. Note that the LKB hydraulics equations that were developed from the HW-TW-Storage-Flow relationships (see Appendix B), are entered as constraints.

The paragraphs below describe the components of the Objective Function. Annotations or descriptions for each component are also provided.

The information listed below follows this format.

TARGET	CONDITION	Penalty-	Penalty+	Priority

- Difference between flow and average of beginning of period and estimated end of period instantaneous flows for the C-36 and C-37 Canals. These are physical constraints and therefore, the penalties are very high.

C36Flow	default	60000	60000	1
C37Flow	default	60000	60000	1

- Difference between structure flow and structure capacity for the listed structures. These are all physical constraints and therefore, the penalty+ is set very high. The penalty- of 20 points on flow through the S-60 Structure directs the model to release excess Alligator Lake water through the S-60 Structure instead of through the S-58 Structure. This weight does not cause the model to release Alligator Lake water from below schedule, because the 1500 points for Alligator Lake water are greater than the 20 points for flow through the S-60 Structure.

Qmax_S59	default	0	50000	1
Qmax_S60	default	20	50000	1
Qmax_S61	default	0	50000	1
Qmax_S62	default	0	50000	1
Qmax_S63	default	0	50000	1
Qmax_S65	default	0	50000	1
Qmax_S57	default	0	50000	1
Qmax_S58	default	0	50000	1
MaxFlow_targ_160.169	default	0	50000	1
MaxFlow_targ_170.180	default	0	50000	1
MaxFlow_targ_180.190	default	0	50000	1
MaxFlow_targ_190.999	default	0	50000	1

- Difference between flow and target flow in Pool B/C. In OKISS, Pool B/C is modeled as two different nodes where one represents reaching storage and the other represents storage immediately upstream of the S-65C Structure, or backwater storage. The equation defining flow between these two nodes is an unsteady application of the steady-state Storage-TW-flow relationship developed with the Hydraulic Model (see Appendix B). The actual flow between the nodes is set to this calculated flow using a target with a very high penalty.

PoolC_reach_outflow	default	60000	60000	1

- Difference between the head (HW – TW) on LKB structures and the maximum allowable head for structural stability. Note that while still large, these weights are multiplied by a stage difference rather than a volume and therefore, their value in the objective function is lower than weights multiplied by volumes. Also, note that TW at the S-65E Structure is not currently modeled in OKISS and so, while the target for structural stability is included in the model, the weight is currently set to zero.

Struct_targ1_160	default	0	60000	1
Struct_targ1_170	default	0	60000	1
Struct_targ1_180	default	0	60000	1
Struct_targ1_190	default	0	0	1

5.3.2 Flood Control in the Upper Basin

The next highest weights are the penalties for storing water above the lake regulation schedules (7000-200 points) in the KUB. The model releases as much water as it can from above the schedules to avoid these penalties.

- Difference between lake storage and storage at lake regulation schedule for the respective lakes. Weights decrease in the downstream direction so that storage above rule in the uppermost lake is voided preferentially, per UKISS. The With Project base condition model will not follow this set of weights, since they are not part of the document's current operating conditions.

reg_sched_Alligator	default	0	7000	1
reg_sched_Myrtle	default	0	6000	1
reg_sched_Hart	default	0	5000	1
reg_sched_East_Toho	default	0	4000	1
reg_sched_Toho	default	0	3000	1
reg_sched_Gentry	default	0	2000	1
reg_sched_Kiss	default	0	850	1

The penalties for storing water above schedule are highest for the upstream lakes and decrease as one goes downstream. Because the weights for being above schedule decrease in the downstream direction, upstream lakes will release water (up to structure capacity), even if this will cause downstream lakes to rise above schedule. If it were otherwise, OKISS might choose not to release excess water from Alligator Lake because it might mean incurring a higher penalty at a downstream lake such as Cypress Lake. Because Alligator Lake has the highest penalty, the penalties on downstream lakes do not prevent releasing excess water from Alligator Lake. The same is true for every upstream lake. Depending on the operating goals and hierarchies involved in alternative operating rules, the weights will almost certainly change in production runs of the OKISS model.

5.3.3 Storing Water in the Upper Basin

Only one OKISS "zone", which is different from the regulation schedule operating rule zones defined in the current schedules, is defined. Thus, the simulated volume of storage in each of the lakes is multiplied by the corresponding coefficient from the table below. The rationale for the ordering of the weights is to keep water in the volume below the regulation schedule as high as possible in the system, thus preventing downstream lakes from pulling water out of upstream lakes. This is consistent with UKISS, but is not reflected by the current operating criteria. Hence, it will need to be adapted for the base condition runs.

The lower lakes are balanced by the canal flow targets which have very high penalties, both positive and negative. The weight order for the lower lakes is reversed for computational efficiency (convexity in the larger portion of the piecewise linearization of the canal functions), but the solution is the same regardless of weight order for these three lakes. Solution times are 2-3 times faster with this weight order. The weights on the upper lakes are higher to avoid any chance that a small imbalance in the canal equations could draw water from the upper lakes.

NODE NUMBER	Wt: A-Zone
010	1500.00
060	1450.00
080	1400.00
100	1350.00
110	1300.00
120	1450.00
130	250.00
140	300.00
150	350.00

5.3.4 S-65 Structure Releases

Releases from the S-65 Structure are made according to a release schedule where the higher the stage in Lake Kissimmee, the higher the release. The latest version of the OKISS model simulates the release schedule in current use. In the "With Project" base condition run, this schedule will be updated to use the schedule defined in the Kissimmee River Headwaters Revitalization Project.

TARGET	CONDITION	Penalty-	Penalty+	Priority
S65_ZoneB_Release	default	400	100	1

To emulate operations in the Hydraulic Model, a weight of 400 is given to matching target flows at the S-65 Structure. This weight is higher than the weights for storing water in lakes Cypress, Hatchineha and Kissimmee and lower than the weight for storing water in all other KUB lakes. Therefore, water will be taken from these three lakes only to satisfy the target releases of the S-65 Structure. The penalty for exceeding the scheduled release is sufficiently low that flood control releases from all KUB lakes will be made if necessary (above the regulation schedule).

5.3.5 Lower Basin Operations

The LKB structures are currently operated to maintain a fixed HW stage, with the exception of the S-65C Structure. This structure is operated to maintain one stage at high flows and another at low flows. The target stage at each structure is set with a single target statement. The penalties for deviation from these stages are low, relative to those in the KUB, to ensure that water is not pulled from the KUB to meet these goals. The stages are converted to volumes in the target statements and therefore, these weights are comparable to those in the KUB.

The weights are staggered from upstream to downstream, to be consistent with the KUB operations.

TARGET	CONDITION	Penalty-	Penalty+	Priority
Targ_HW_Ops160	default	9	9	1
Targ_HW_Ops170	default	8	8	1
Targ_HW_Ops180	default	7	7	1
Targ_HW_Ops190	default	6	6	1

Very small negative weights are added to storage in the LKB to reduce run time.

NODE NUMBER	Wt: A-Zone
160	-0.01
169	-0.01
170	-0.01
180	-0.01
190	-0.01

5.3.6 Summary

Table 5-1 below summarizes the weights used for the KUB.

Table 5-1: Operating Goals and Corresponding Weights – Post Phase I Conditions

Operating Goal	Weight
Do not simulate more or less than the calculated flow in canals C-36 and C-37.	60,000
Do not exceed calculated flow through spillways and culverts.	50,000
Do not store water above lake schedules.	7000 to 6 (see Table 5-2)
Release the scheduled flow through S-65.	400
Maintain water in lakes up to schedule.	1500 to 6 (see Table 5-2)
Release as much water as possible through S-60.	20
Respect structural stability requirements in LKB	60,000
Do not simulate more or less than the calculated flow between reach and structure storage in Pool B/C[2]	60,000

A different weight value is assigned to each lake, as shown in Table 5-2 below.

Table 5-2: Weight Values for Kissimmee Upper Basin Lakes – Post – Phase I Conditions

Lake	OKISS node number	Weight for storing water below schedule	Weight for storing water above schedule
Alligator	010	1500	-7000
Myrtle	060	1450	-6000
Hart	080	1400	-5000
East Tohopekaliga	100	1350	-4000
Tohopekaliga	110	1300	-3000
Gentry	120	1450	-2000
Cypress	130	250	
Hatchineha	140	300	
Kissimmee	150	350	-850

The weights for storing water below schedule are highest for the most upstream lakes and decrease as one goes downstream. Therefore, OKISS keeps the water in the upstream lakes and does not release it to downstream lakes unless it is above the regulation schedule. Because the flows between the three lowest lakes are controlled by the canal flow equations (which have much higher weights for violations), the weights on the downstream lakes are configured to increase the speed of the solution of the LP and otherwise have no relative significance.

[2] All other LKB hydraulics are constraints.

OKISS allows flows through the S-58 Structure when additional releases through the S-60 Structure would raise Lake Gentry above regulation schedule and when releases through the S-58 Structure would not cause stages over schedule in any of the lakes downstream of the S-58 Structure.

Table 5-3 includes the weights or priorities used for the LKB. The last operating goal in Table 5-1 also applies to the LKB.

Table 5-3: Weight Values for Lower Kissimmee Basin Pools – Post Phase I Conditions

Lake	OKISS node number	Weight for storing water below schedule	Weight for storing water above schedule
Pool A	160	9	-9
Pool B/C[3]	170	8	-8
Pool D	180	7	-7
Pool E	190	6	-6

[3] Node 170 (“structure storage”) only

6 OKISS VERIFICATION

6.1 OKISS ABILITY TO MODEL OPERATING CRITERIA

A model verification or history matching exercise was performed to test the ability of the OKISS model to accurately simulate operating criteria in the KB. Additionally, there was a *preliminary* review of the basic model features (storage, capacities, etc) and the surrogates used to represent the physical features of the basin canals, river and structures. The results of this verification are presented in this section. Corresponding OKISS files are included in Appendix G.

The analyses presented here (Section 6.1) were performed with a preliminary version of the OKISS model, prior to it being updated with newer information obtained from the calibrated Hydraulic Model. However, the version used in the analyses had the required elements needed to perform the intended verification. The analyses presented in Section 6.2 include the final verification that was performed using the latest version of OKISS. These analyses included a *detailed* review of the surrogates used in the model.

The history matching process encompassed runs completed using the OKISS model to simulate Post-Phase I KRR conditions. Results were compared to the data collected and QA/QC'd during the KBMOS. The history matching exercise was applied to the entire KB (including both the KUB and the LKB). The exercise focused on validating the effectiveness of the Screening Tool to model the current operating criteria.

During this history matching process, OKISS was run using the current regulation schedule to define the flow through the KBMOS structures. Resulting stages were compared with historic stages. The following procedures delimited this verification exercise:

- The history matching exercise was performed during a period of time where little or no deviations from the Operating Criteria occurred or where the operation of the Central and Southern Florida (C&SF) Project closely mimics the operation schedules. Additionally, the Period of Simulation (POS) had to fall within Post-Phase I of the KRR. A one-year period was selected meeting the requirements stated above. The selected period for this step is October 2001 to October 2002. The reasons to justify this selection are:
    - This is the only period of time within Post-Phase I restoration in which the S-65C Structure closely follows it operations schedule
    - Most of the other stations show a pattern consistent with the current operating criteria
    - Data available for this period is also consistent, without many gaps
    - Since the AFET lateral inflows were not available at the time the exercise was performed, hydrological lateral inflows were generated for the selected period (10/01 – 10/02) to drive the history matching exercise. These inflows were generated by back-calculating water budgets using historical records of stages, storage-area tables and historical records of flow through the KB structures. It is important to note that the history matching exercise documented in Section 6.2 was carried out using AFET lateral inflows.
    - OKISS was run using the current regulation schedule, assuming no deviations

- Stages and flows (*arcflows*) obtained by OKISS were compared to historic stages. Differences in stages were documented and explained.

The above-mentioned exercise concluded that OKISS successfully models the operations as stated by the target lake and pool stages throughout both the KUB and the LKB.

The primary difference between the simulated results and historical data was that OKISS adhered strictly to the regulation schedule of target stages. Simulated *arcflows* adjust to meet these targets within the confines of minimum and maximum flows. Historically, *arcflows* are kept relatively smooth, which causes stages to deviate from their targets. A secondary effect of maintaining target stages in OKISS is lower simulated stages in lakes Cypress, Hatchineha and Kissimmee. Water held upstream to meet target stages was moved to these lakes historically. This section documents differences between the OKISS simulation and historical data.

6.1.1 Testing Operations in the Kissimmee Upper Basin

Simulated and historical stages in Alligator Lake (Node 010) and Lake Myrtle (Node 060) agree closely, as shown in Figure 6-1. In the summer and fall, the model keeps the stages at their targets more closely than was done historically. This resulted in slightly different *arcflows*, as shown in Figure 6-2.

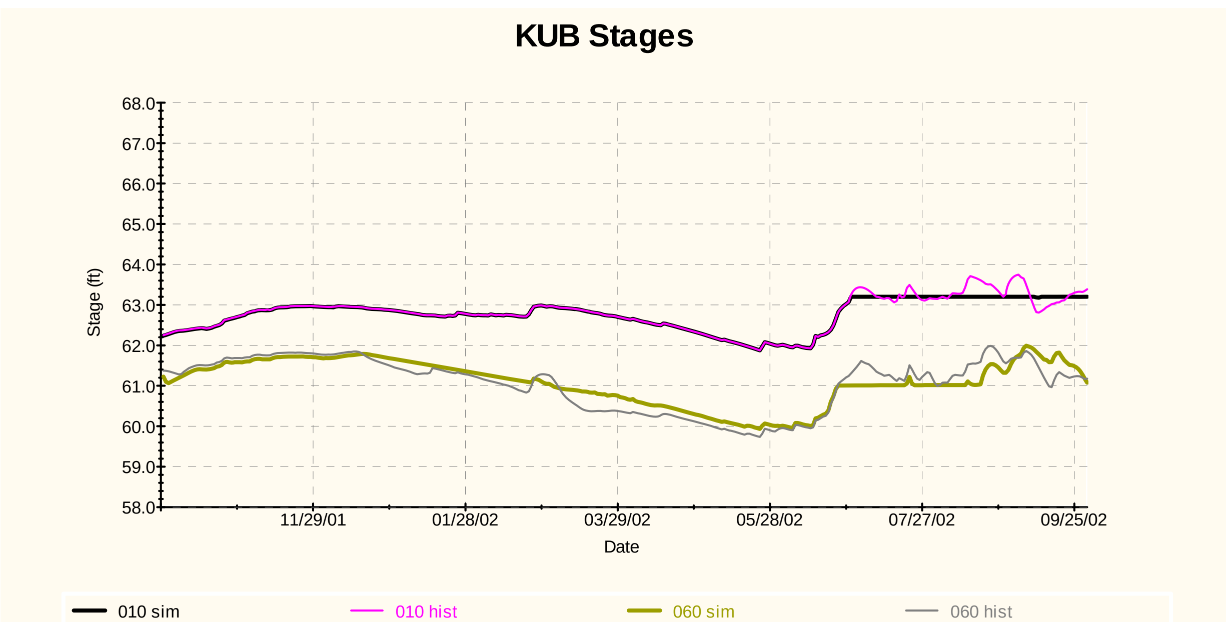

Figure 6-1: Simulated and historical stages at Nodes 010 and 060

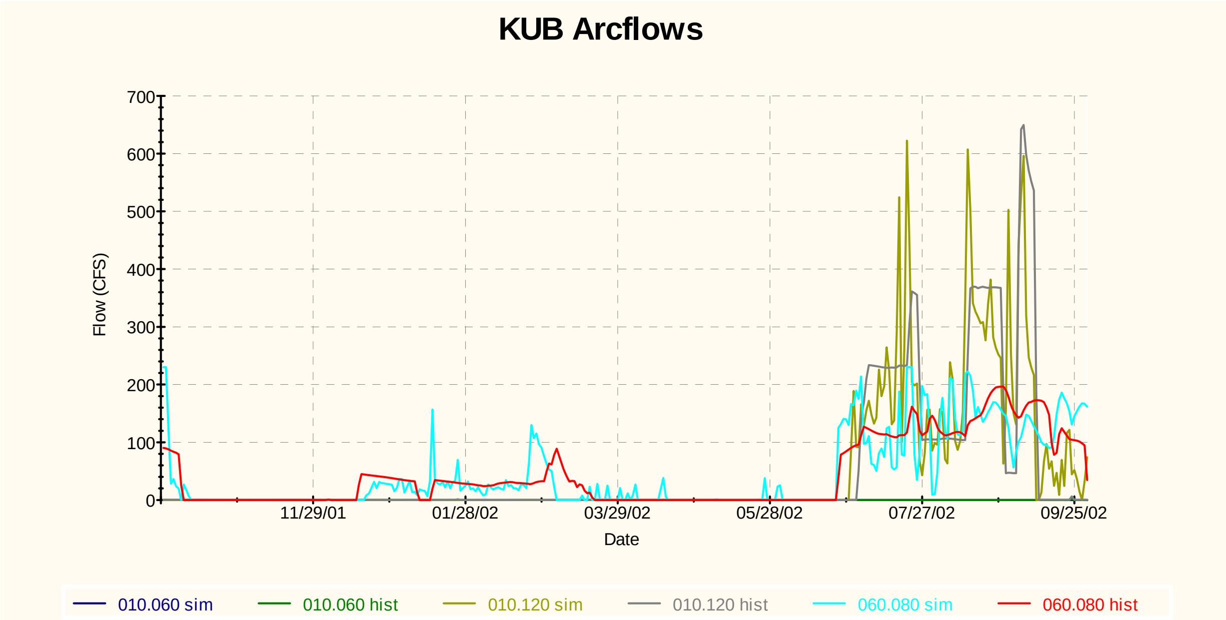

Figure 6-2: Simulated and historical arcflows in Arcs 010.060, 010.120 and 060.080

The flow through Arc 010.060 is zero over the entire time-period, both historically (green line) and when simulated (blue line). The general trend in arcflow010.120 (yellow line = simulated, gray line = historical) are the same, but more spikes of flow are seen in the simulated record to maintain the target stages. The maximum difference is 100 cfs and deviations of this magnitude are very rare. The same is true in Arc 060.080 (light blue and red lines).

The same trend is seen throughout the KUB. Simulated stages at Nodes 080 and 100, shown in Figure 6-3, follow the regulation schedule more closely than historical stages, with the exception of Node 080 in September 2002. During this period, the larger simulated flow in Arc 060.080 (see Figure 6-2**)**, to maintain the target stage in Node 060, resulted in higher simulated stages at Node 080. Simulated stages in Nodes 100 and 110 match historical stages throughout the history-matching period (Figure 6-4**),** except in the spring when the simulated stages adhere to the regulation schedule more closely than the historical data.

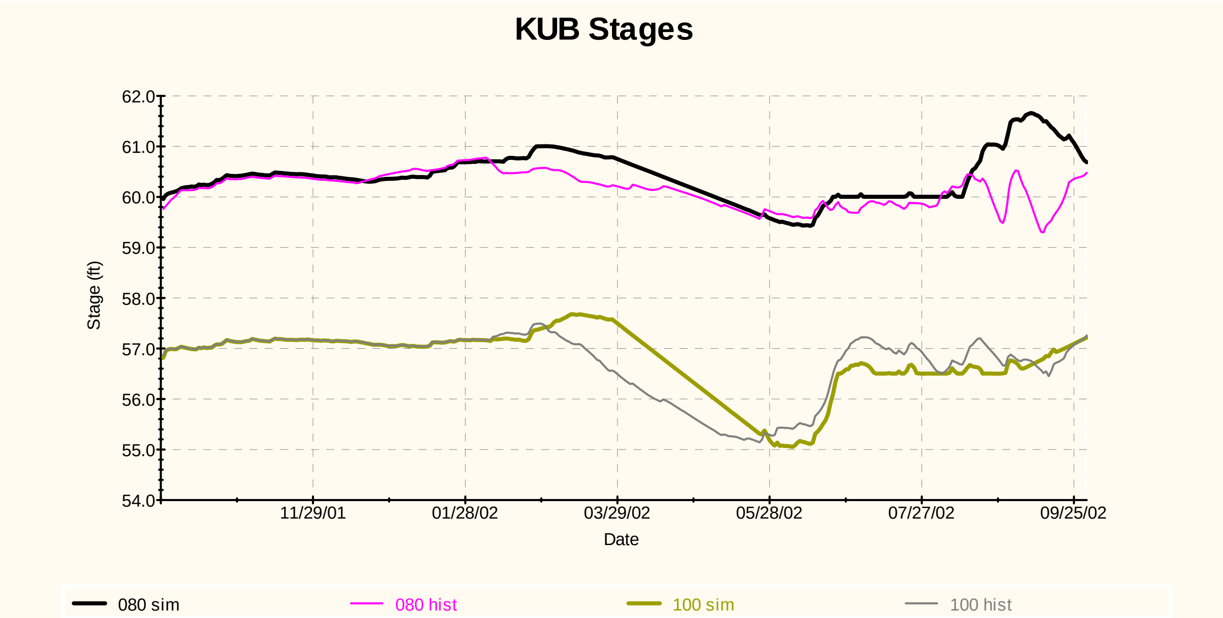

Figure 6-3: Simulated and historical stages at Nodes 080 and 100

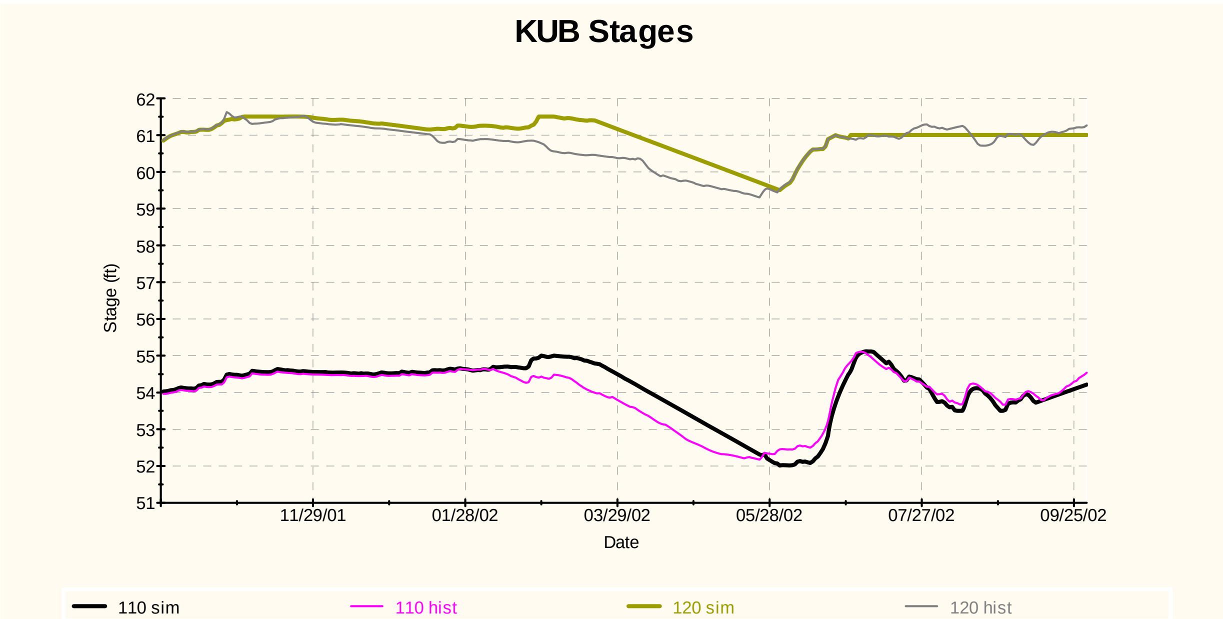

Figure 6-4: Simulated and historical stages at Nodes 110 and 120

To maintain the target stages, the *arcflows* deviate from the historical substantially, as shown in Figure 6-5 and Figure 6-6. In the summer and fall, when lateral inflows are much higher than the rest of the year, the *arcflows* agree more closely. Periods of no *arcflow* are also reproduced in the simulations.

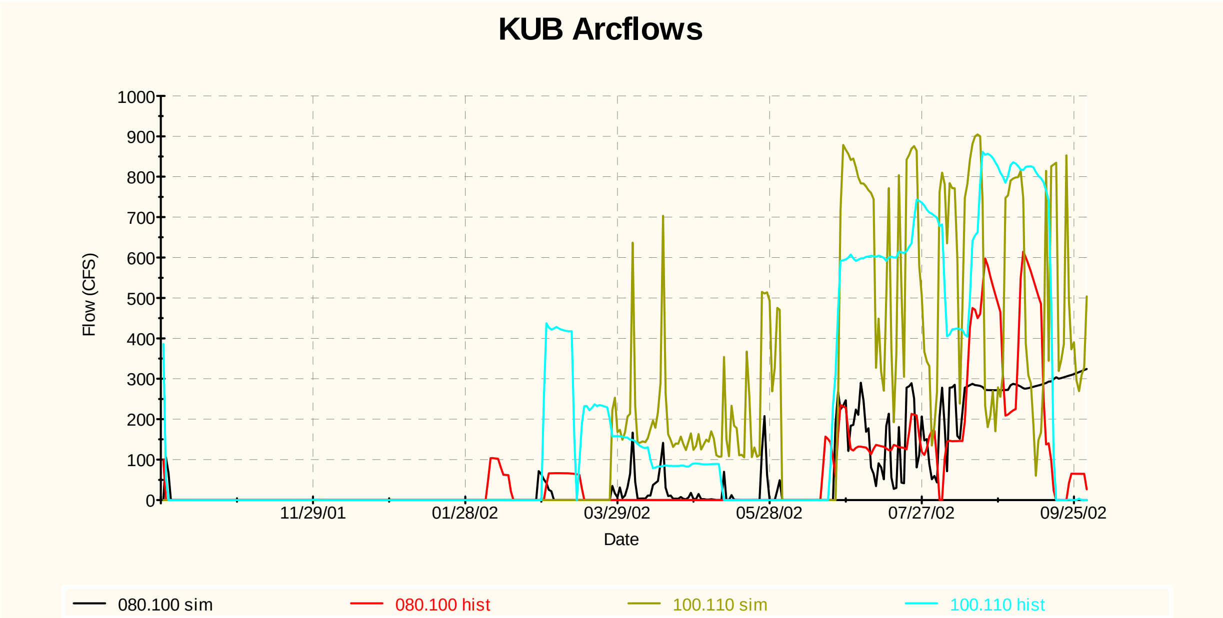

Figure 6-5: Simulated and historical flows in Arcs 080.100 and 100.110

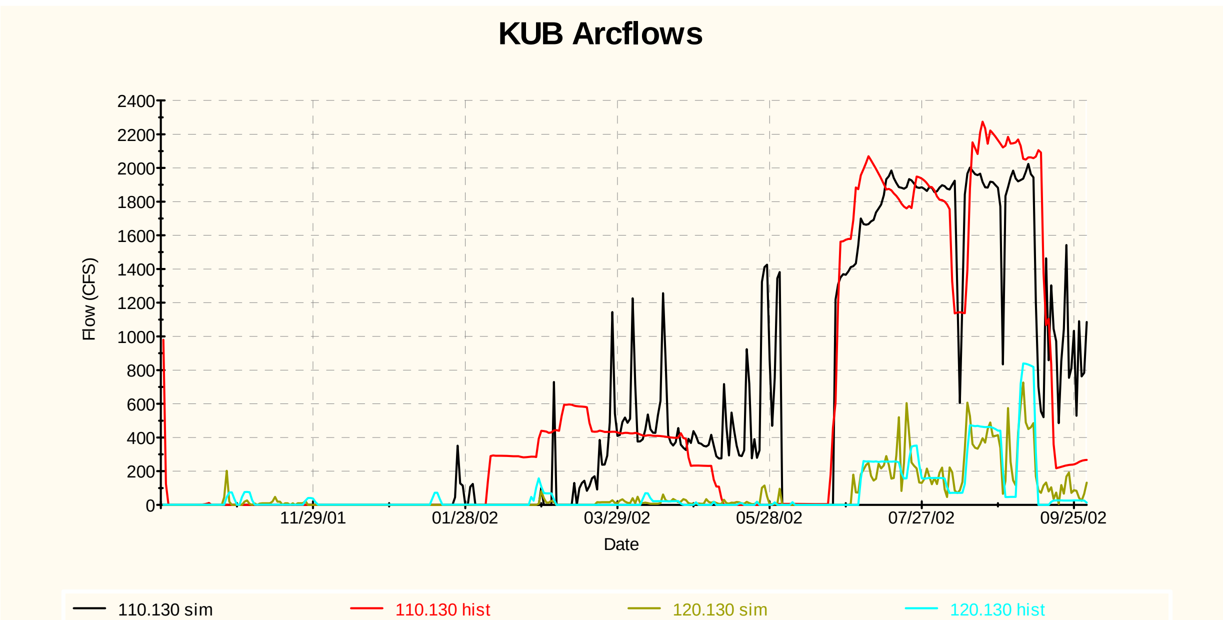

Figure 6-6: Simulated and historical flows in Arcs 110.130 and 120.130

By adhering more closely to the regulation schedule in the spring, the simulation keeps more water in the lakes upstream of Lake Cypress (Node 120) than was done historically. As a result, the simulated stages in Lake Cypress and the downstream lakes become increasingly lower than the historical stages throughout the dry spring (Figure 6-7 and Figure 6-8). Once the lateral inflows increase in the summer and fall, the simulated stages in these lakes rise with the historical until Lake Kissimmee (Node 150) reaches its target stage. Historically, the stage at

Lake Kissimmee exceeded the regulation schedule from July to September. The canal equations between lakes Kissimmee, Hatchineha and Cypress keep the two upstream lakes near the stage of Lake Kissimmee.

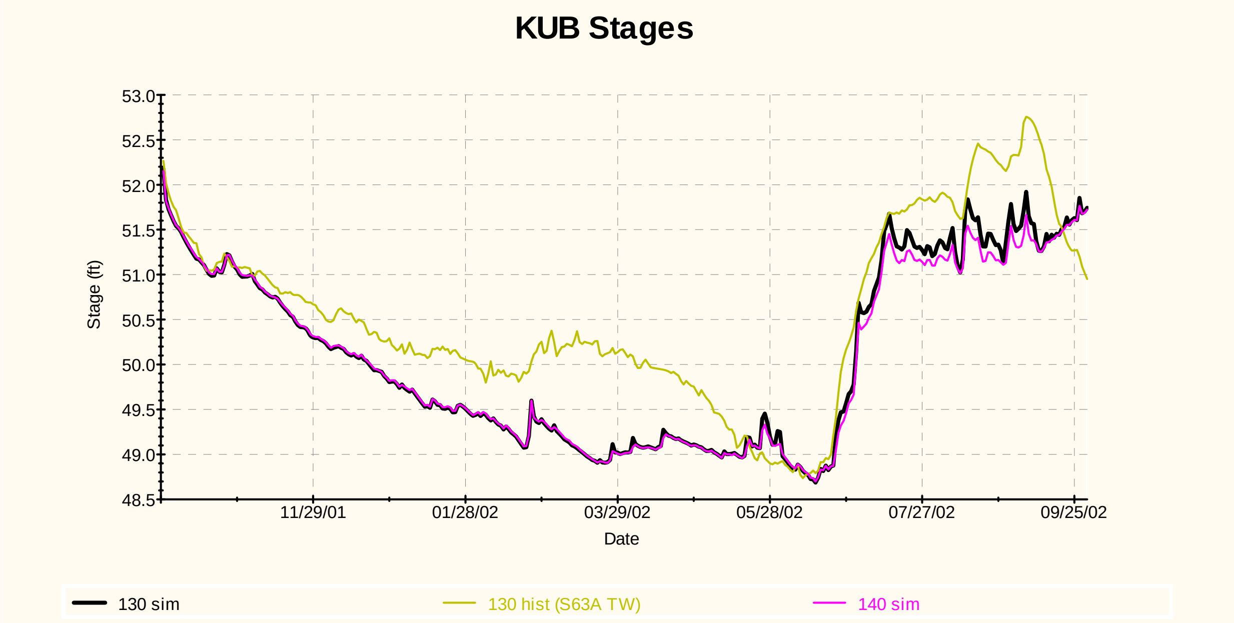

Figure 6-7: Simulated and historical stages at Node 130 and simulate stage at Node 140

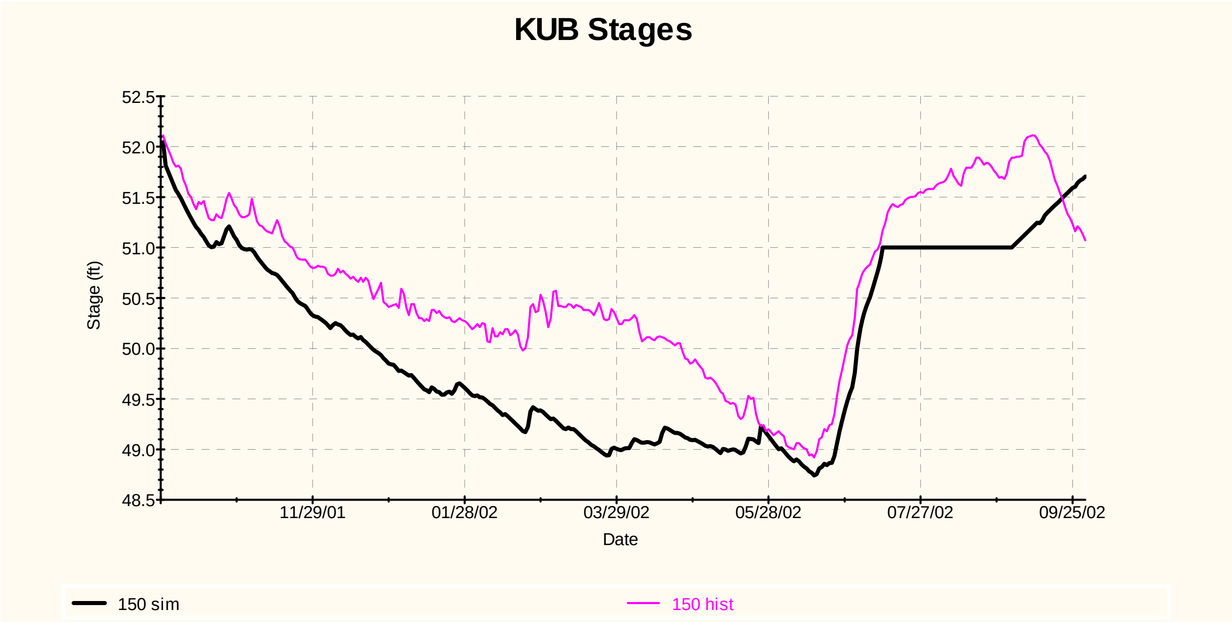

Figure 6-8: Simulated and historical stages at Node 150

6.1.2 Testing Operations in the Lower Kissimmee Basin

The LKB followed the same trend as the KUB. The target stages are maintained by the model and *arcflows* deviate from the historical values to do so. In this section, the historical and simulated stages are compared first, followed by an evaluation of the *arcflows*.

LKB Stages

Figure 6-9 to Figure 6-13 show both the HW and TW at all of the S-65 Structures. The HW at Node 150 is shown (Figure 6-8). The simulated TW agrees closely with the historical (Figure 6-9).

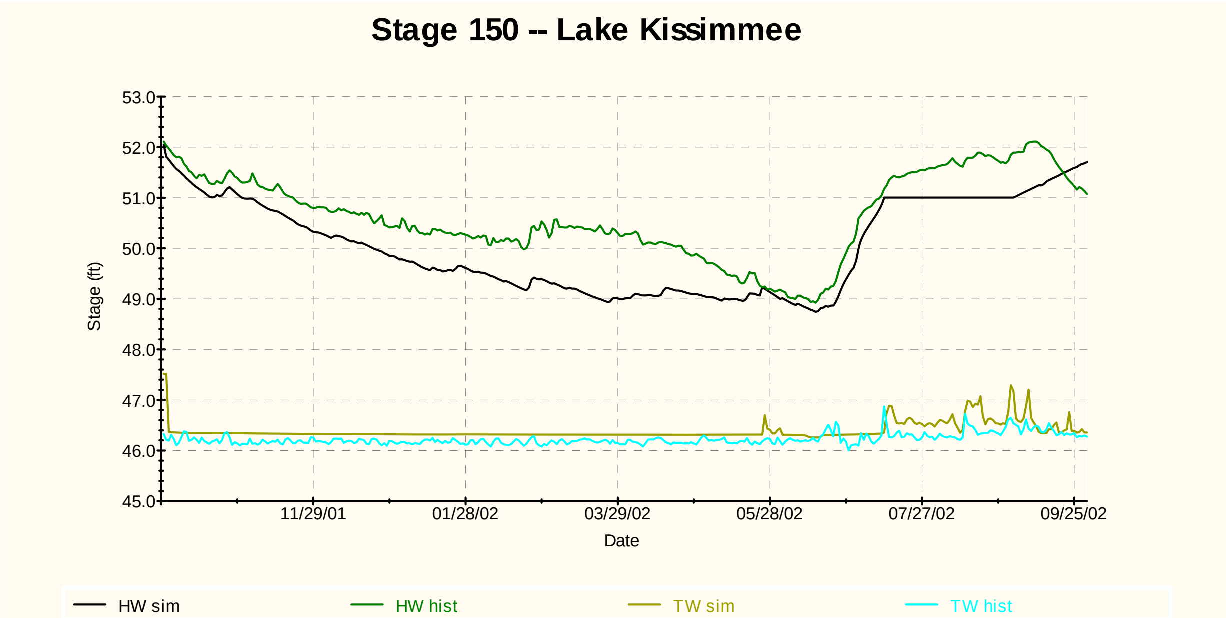

Figure 6-9: Simulated and historical stages (HW and TW) at Node 150

For Node 160 (Figure 6-10), both the simulated and historical HW remain close to the target stage throughout the year. The TW at this structure is a function of flow only, so deviations between the simulated and historical values are partially a reflection of deviations in the *arcflow* (Figure 6-14).

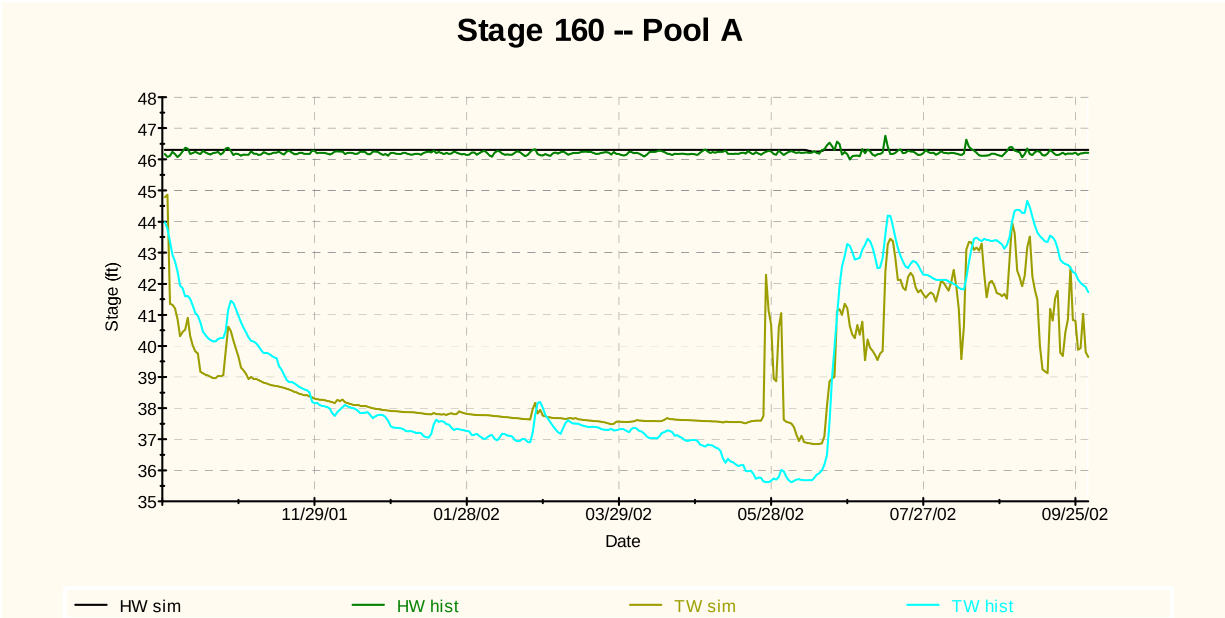

Figure 6-10: Simulated and historical stages (HW and TW) at Node 160

Pool C (Node 170) does not operate at a constant target stage like the other pools. Instead, it was observed that the stage is kept at 35.7 ft. during "high" flows and 33 ft. during "low" flows. Additionally, the target stage should not change by more than 0.1 ft./day. The threshold between high and low flows in Arc 160.169/170 was determined to be about 750 cfs by examining the data. This parameter is included in the OCL constants table so that the user can change it easily.

Once the *arcflow* falls below this threshold at the end of November, the historic stage decreases much more gradually than mandated by the 0.1 ft./day, as seen by the green line in Figure 6-11. Therefore, a ramp-down rate was also included in the OCL constants table for user-specification. Based on the history-matching time-period, 0.02 ft./day was used. A 0.1 ft./day ramp-up rate was used. Both the ramp-up rate and an initial target stage are also included in the OCL constants table.

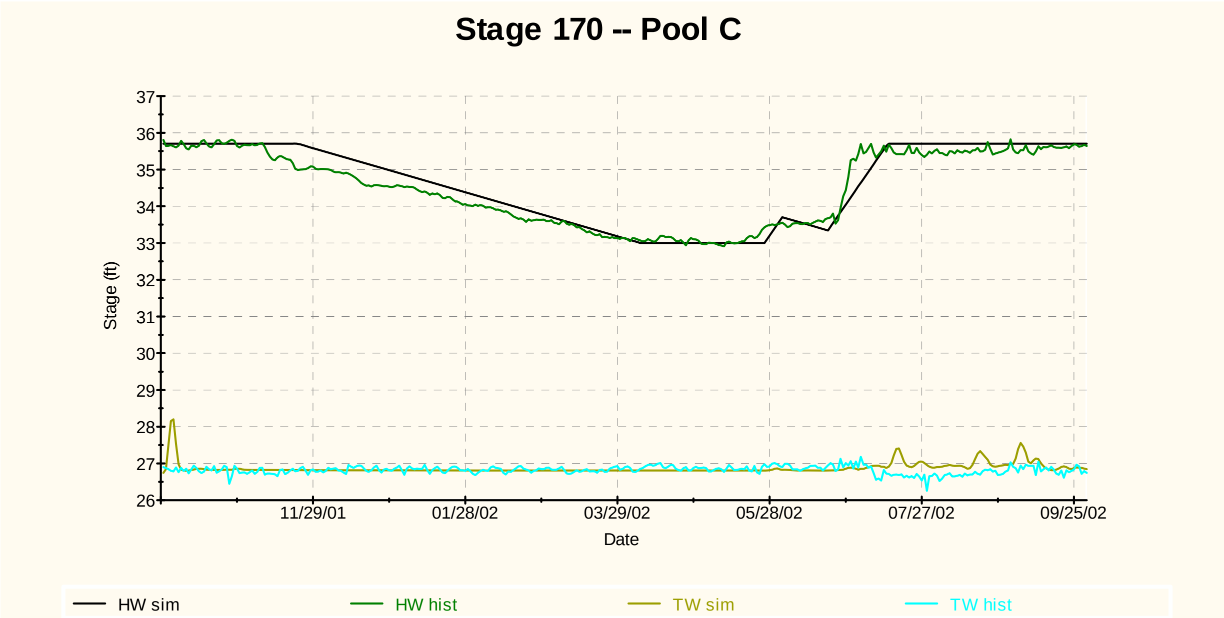

Figure 6-11: Simulated and historical stages (HW and TW) at Node 170

Both the simulated HW and TW at the S-65C Structure (Node 170) follow the historical values closely (Figure 6-11). The simulated TW is initially higher because of large flows during the first few days of the simulation. These flows occur because the actual initial storage in Pool C is unknown. Therefore, the model releases excess water from Pool C at the start of the simulation.

The simulated HW and TW at the S-65D Structure (Node 180) also follow the historical values closely (Figure 6-12). The simulated TW is consistently higher than historical by about 0.5 ft. This is due to a datum error found in the historical data. It is important to emphasize that the calculated TW is not used in the storage volume calculations. TW values are calculated as surrogates to potentially be used in the evaluation of Performance Measures. Stages at any point within the pool could also be evaluated using the same procedure utilized to calculate TW.

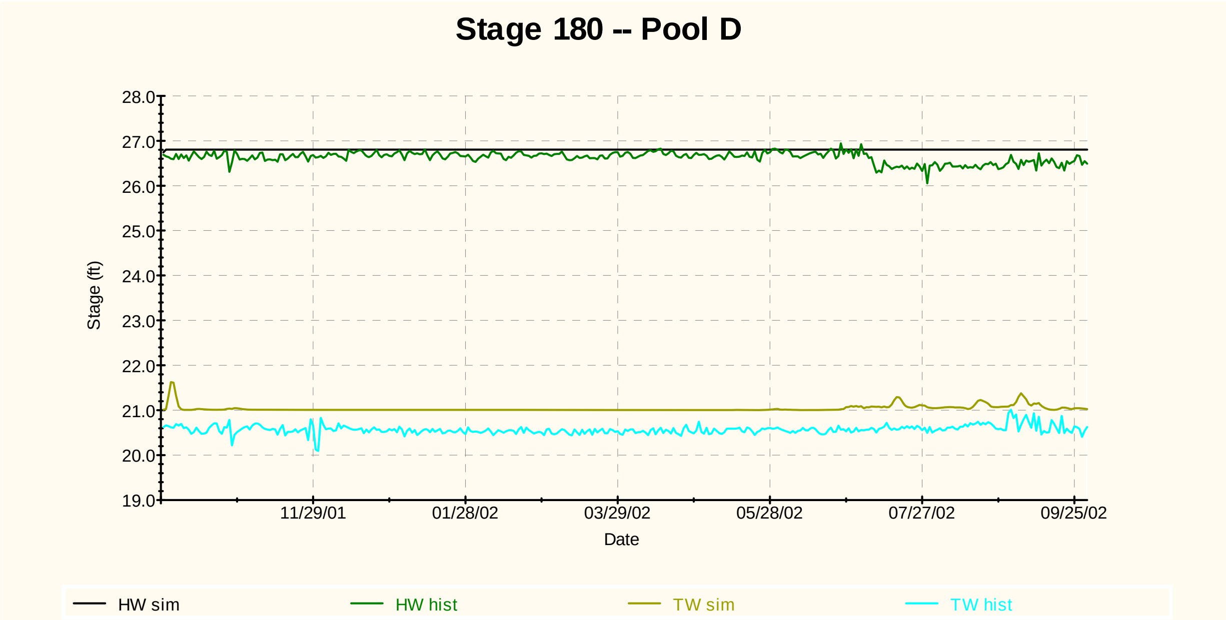

Figure 6-12: Simulated and historical stages (HW and TW) at Node 180

The simulated and historical HW at Node 190 closely agree, as shown in Figure 6-13. Note the y-axis scale in this figure where the entire axis is less than one foot. The TW at this node is controlled by Lake Okeechobee and is therefore not modeled in OKISS.

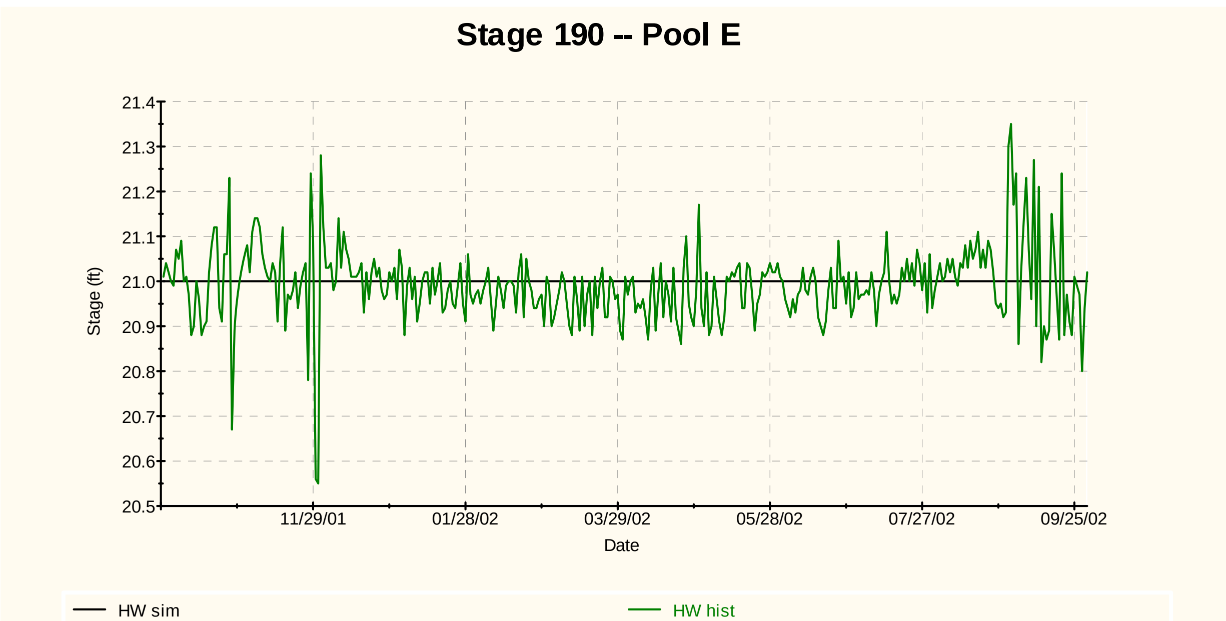

Figure 6-13: Simulated and historical stages (HW and TW) at Node 190

LKB arcflows

Because the stages in the LKB pools were maintained close to their target stages for most of the history-matching period, deviations between the simulated and historical *arcflows* are significantly lower than in the KUB. Figure 6-14 shows the *arcflow* through the first two reaches of the Kissimmee River. The pulse of water at the end of May is passed from the KUB, as seen in Figure 6-5 and Figure 6-6, to meet the regulation schedule in Node 100.

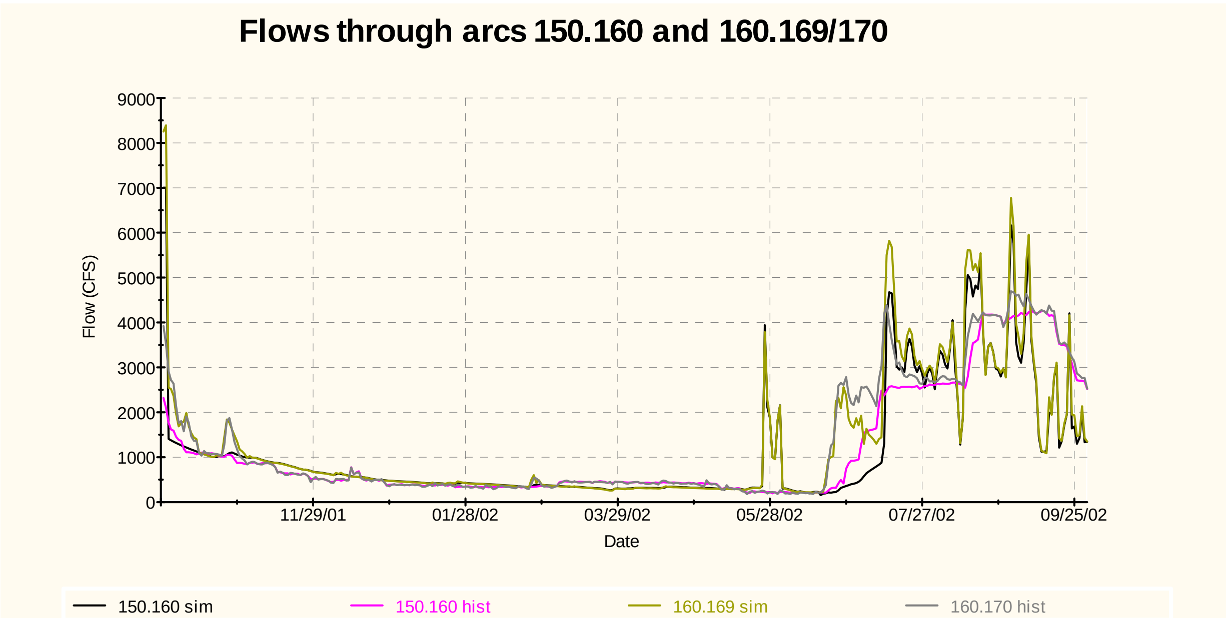

Figure 6-14: Simulated and historical flows in Arcs 150.160 and 160.169/170

The initial spike in simulated flow seen in Arc 160.169/170 and downstream (Figure 6-14 to Figure 6-16) results from an adjustment in Pool C reach storage. The flows are not affected beyond the first few days of the simulation.

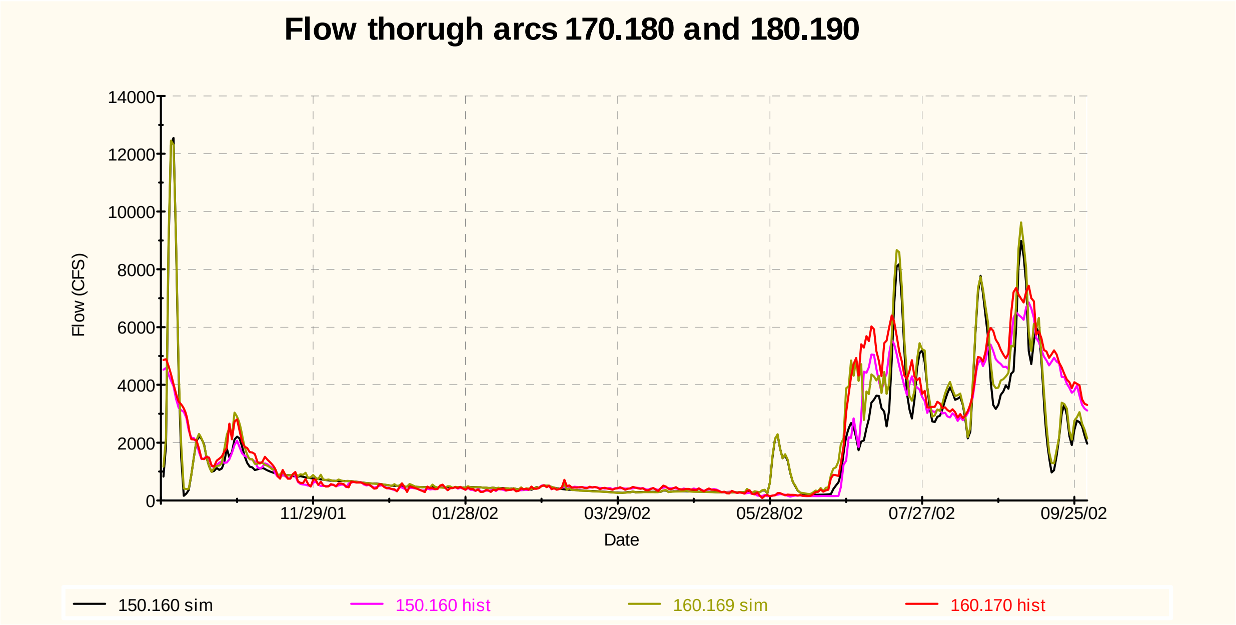

Figure 6-15: Simulated and historical flows in Arcs 170.180 and 180.190

The close agreement in *arcflows* downstream of the S-65C Structure (Figure 6-15 and Figure 6-16) demonstrates that the surrogate algorithm added to OKISS successfully approximates floodplain dynamics in Pool C.

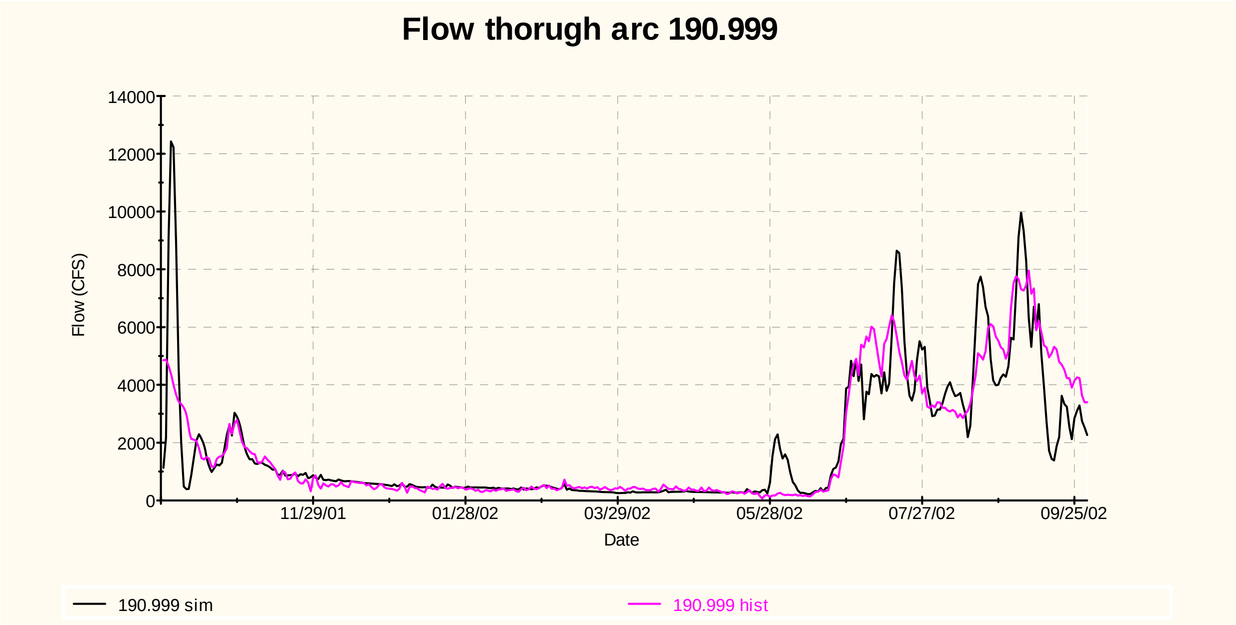

Figure 6-16: Simulated and historical flows in Arc 190.999

AECOM

6.1.3 Sensitivity to Changes in Lateral Inflows

Since the exercise was performed using a set of lateral inflows derived from historical records, a sensitivity of the simulation results to the lateral inflows was assessed by running OKISS with the lateral inflows increased and decreased by ten percent. The result of this analysis is presented in Appendix F.

6.2 OKISS Ability to Model Hydraulics of the Kissimmee Basin

A second verification exercise, or history matching, was performed with the final version of OKISS. The extended history matching process encompassed runs completed using the Screening Tool to simulate Post-Phase I KRR conditions. Results were compared to those generated by the fully-coupled AFET sometimes referred to in this section as the “Hydraulic Model”, during its calibration (Run 99). During the KBMOS alternative plan selection process, AFET-W replaced AFET. AFET-W was calibrated under Pre-Phase I conditions and was used to represent the fully restored conditions of the KRR Project. However it was not adapted to represent the Post-Phase I conditions as AFET was. The AFET hydraulic calibration of the Post-Phase I conditions was not altered during the calibration of AFET-W therefore the history matching exercise documented in this report refers to AFET and not AFET-W results.

OKISS model results were compared to the Hydraulic Model results rather than historical data because the set of lateral inflows used in OKISS were generated with the Hydraulic Model, avoiding the repetition of work that was already completed in the calibration of the Hydraulic Model, namely, the evaluation and analysis of goodness-of-fit metrics for the simulated variables. This eliminated from the OKISS comparison differences that could be explained by the tolerances used in the Hydraulic Model calibration criteria.

The purpose of the verification process documented in the following sections was to:

- Assess the ability of the Screening Tool to simulate stages at locations of interest within Pool B/C, for which implementation in the model required the use of look-up tables and surrogates, as described in Section 3.1.2.
- Assess the ability of the Screening Tool to simulate the hydraulics of the entire KB (KUB and LKB) for a wider range of flows, by extending the simulation period to that used in the AFET calibration (2001-2004)
- Assess the performance of the updated set of lateral inflows and HW-TW-Storage-Flow relationships in the LKB, both generated with the calibrated version of the Hydraulic Model

To meet these goals, stages were set at all structures throughout the basin to the end-of-day stages simulated by the Hydraulic Model at each time-step using target commands. As a result, the simulated stages were equal to the Hydraulic Model stages whenever possible, given water balances. The resulting flows at each structure were then compared to the flows simulated during the Hydraulic Model calibration, with an explanation of significant differences.

The Screening Tool results are compared with output from the Hydraulic Model calibration run (Run 99) (Earth Tech, 2007c). The Screening Tool has a daily time-step. Therefore, the end-of-day stages at each structure in the Hydraulic Model were used. The stages have been set to those in the Hydraulic Model at the HW of all structures present in the Screening Tool (S-58, S-57, S-62, S-59, S-61, S-60, S-63, S-65, S-65A, S-65C, S-65D, and S-65E).

The daily averages of 30-minute instantaneous flows through the structures were used for comparison. Lateral inflows were also determined from 30-minute output (see Section 3.3 and Appendix C).

There were occasionally negative flows through structures in the Hydraulic Model results, specifically at the S-60 and S-58 Structures. The Screening Tool does not permit reverse flows, except in the C-36 and C-37 Canals. For this exercise, those flows are simply not reproduced. The validation process to be performed at the end of the With Project base condition evaluation will determine if prohibiting negative flows at these structures affects the ability of the Screening Tool to produce comparable performance measure scores.

6.2.1 Results

The results of the history matching exercise are presented below. Each of the figures in this section shows the results from the Screening Tool simulation (black) and the Hydraulic Model calibration (green). On stage plots, the regulation schedule is shown (yellow) and on daily flow charts, the maximum allowable flow is shown (yellow).

6.2.2 Alligator Lake

The stages in Alligator Lake are shown in Figure 6-17. The Screening Tool stages track the Hydraulic Model closely throughout the calibration period.

Since the stages in the Screening Tool are set to a particular set of values (in this case, the Hydraulic Model results; a regulation schedule in general), the flows through the structures are "spiky", to match these stages exactly while respecting mass balance. This condition was also observed during the calibration of the Hydraulic Model and was explained by the methodology used in the calibration process. The evaluation of Base Conditions and the use of the models in the alternative selection process used a different approach, which generated a smoother time-series. Meanwhile, 7-day moving averages of flow are shown for the full calibration period. Daily flows are also shown in a separate figure to check the maximum allowable flow values.

There is more flow though the S-58 Structure (arc 010.060) in the Screening Tool run than the Hydraulic Model run (Figure 6-18). These excess releases are made by the Screening Tool to maintain desired stages in Lake Myrtle and its downstream lakes. Note that the Screening Tool does not permit flow above 110 cfs through the S-58 Structure, while the Hydraulic Model shows flows up to 135 cfs. The Screening Tool-simulated flows through the S-60 Structure track those simulated by the Hydraulic Model well after 2001 (Figure 6-19).

Figure 6-20 shows the daily average flows, rather than the 7-day moving average in Figure 6-18, through the S-58 Structure. The maximum allowable flows calculated in the Screening Tool are also shown (yellow line). At most structures, these are calculated by determining the maximum allowable gate opening for the HW and TW elevations and then using the dimensionless flow equations (Section 4.3) to find the flow for that gate opening. The S-58 Structure, however, is a culvert. The culvert hydraulic calculations of Section 4.3 are used here. The results appear consistent with the Hydraulic Model flows. When the maximum allowable flow falls suddenly in fall 2001, the Hydraulic Model flows decrease accordingly. When the maximum allowable flow falls to 0 in fall 2004, the Hydraulic Model flows go from slightly positive (as they are most of the time) to slightly negative.

For this exercise, meeting the stages of the Hydraulic Model was given priority over respecting the maximum allowable flows, which is why the flow through the S-58 Structure is higher than the maximum allowable flow in October 2004.

Figure 6-21 shows the daily average flows through the S-60 Structure for the period between August to December 2004, along with the maximum allowable flow calculated in the Screening Tool. The maximum flow was calculated by determining the maximum allowable gate opening for the HW and TW elevations and then using the dimensionless flow equations (Section 4.3) to find the flow for that gate opening. When the maximum allowable flow is greater than the largest value on the y-axis (prior to summer 2002, in this case), there is no gate opening limit for the HW-TW combination at that time. There is no cap on the flows at these times.

For the S-60 Structure, both the Hydraulic Model and Screening Tool respect the maximum allowable flow at all times.

The net outflow from a lake is defined as the release from the lake minus riverine inflow to the lake through the upstream structure(s). Ideally, the net outflow for each lake accumulated over the calibration period should match between the two models. The cumulative net outflow from Alligator Lake for the calibration period (11/1/2001 to 12/31/2004[4]) was 262 k-af for the Hydraulic Model and 261 k-af for the Screening Tool, a difference of 0.587 k-af or 0.2 percent[5].

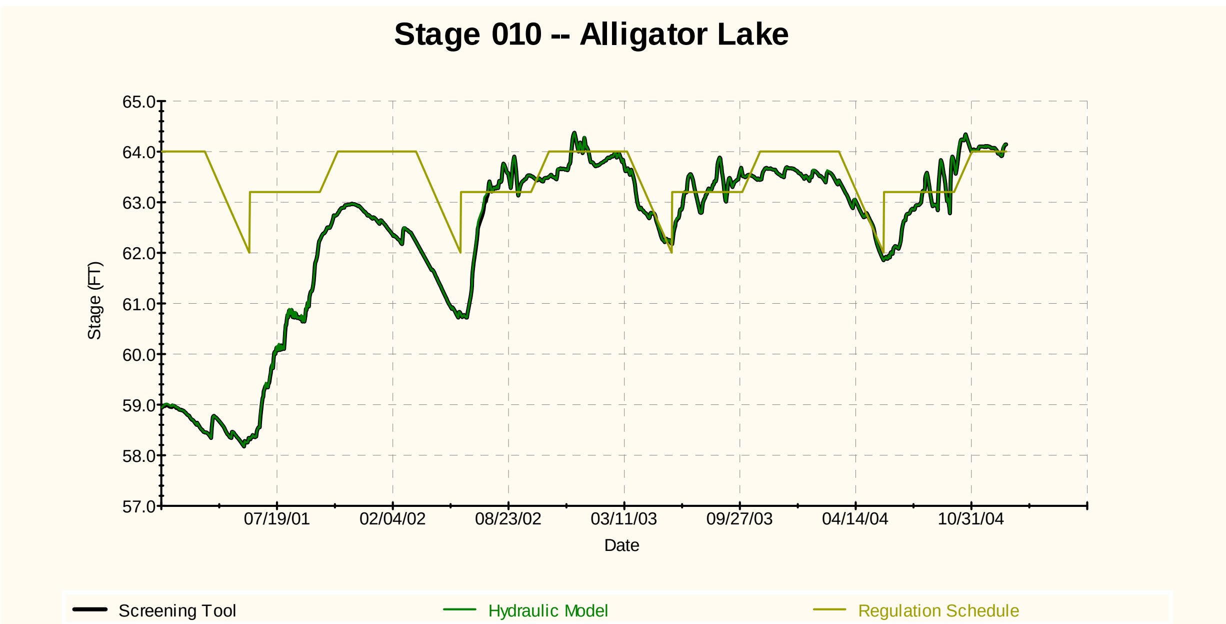

Figure 6-17: Stages in Alligator Lake

[4] The net cumulative outflow is calculated for this period at the other lakes and pools as well.
[5] Errors were calculated as (cumulative net outflow in Hydraulic Model – cumulative net outflow in the Screening Tool)/cumulative net outflow in Hydraulic Model.

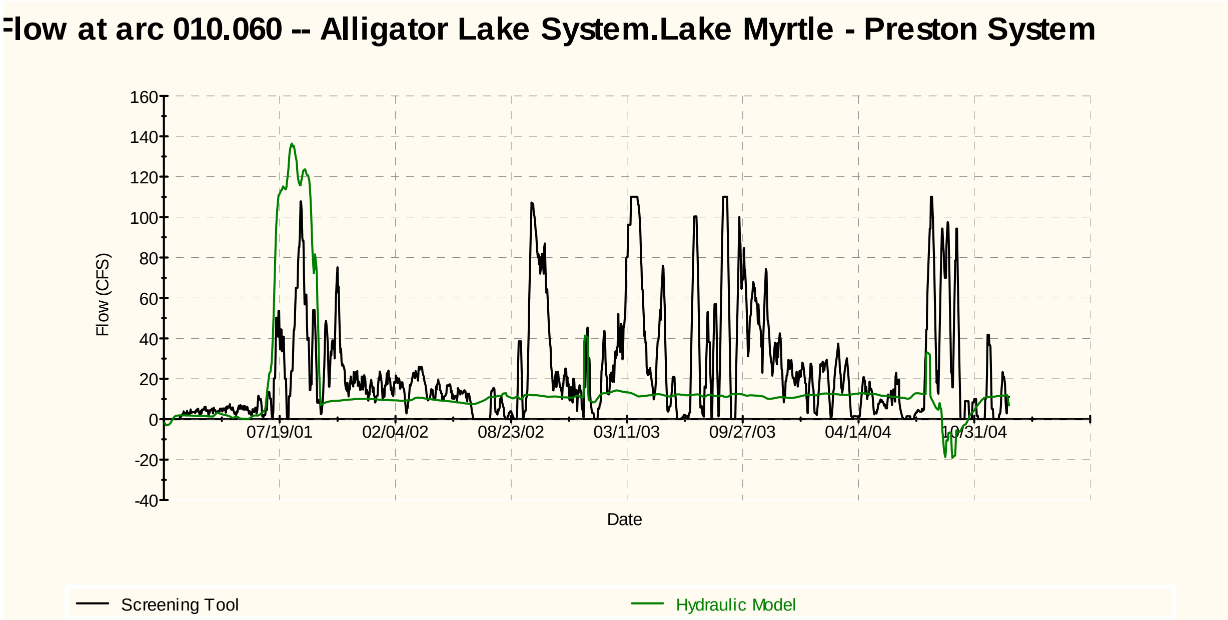

Figure 6-18: Flow between Alligator Lake and Lake Myrtle through the S-58 Structure, 7-day moving average

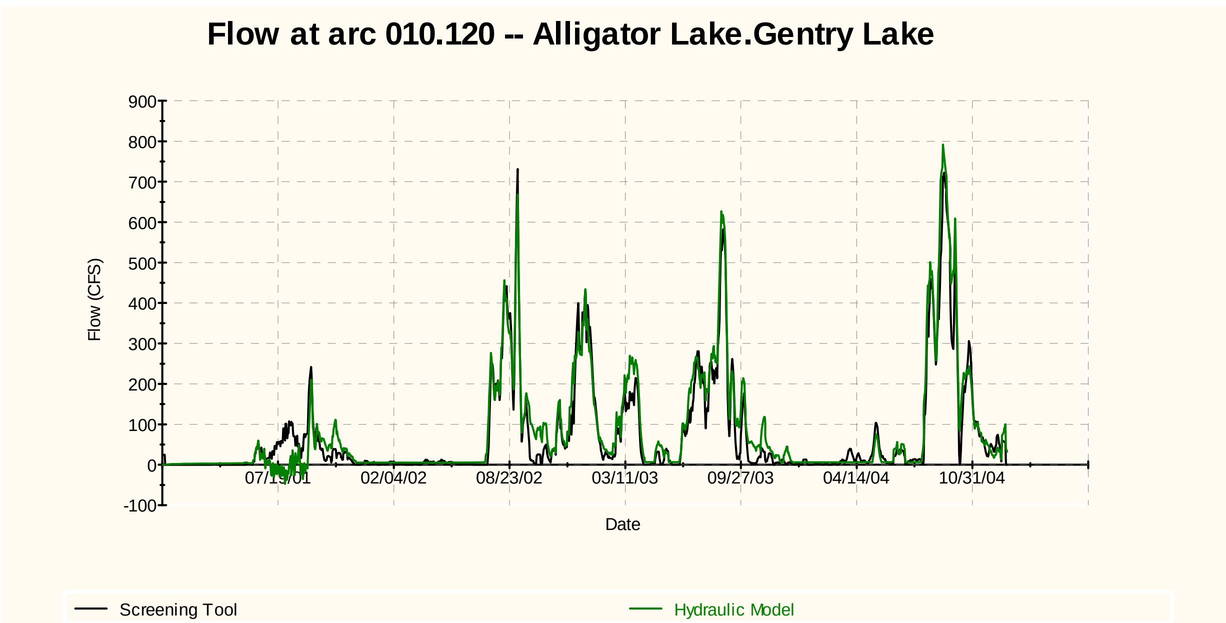

Figure 6-19: Flow between Alligator Lake and Lake Gentry through the S-60 Structure, 7-day moving average

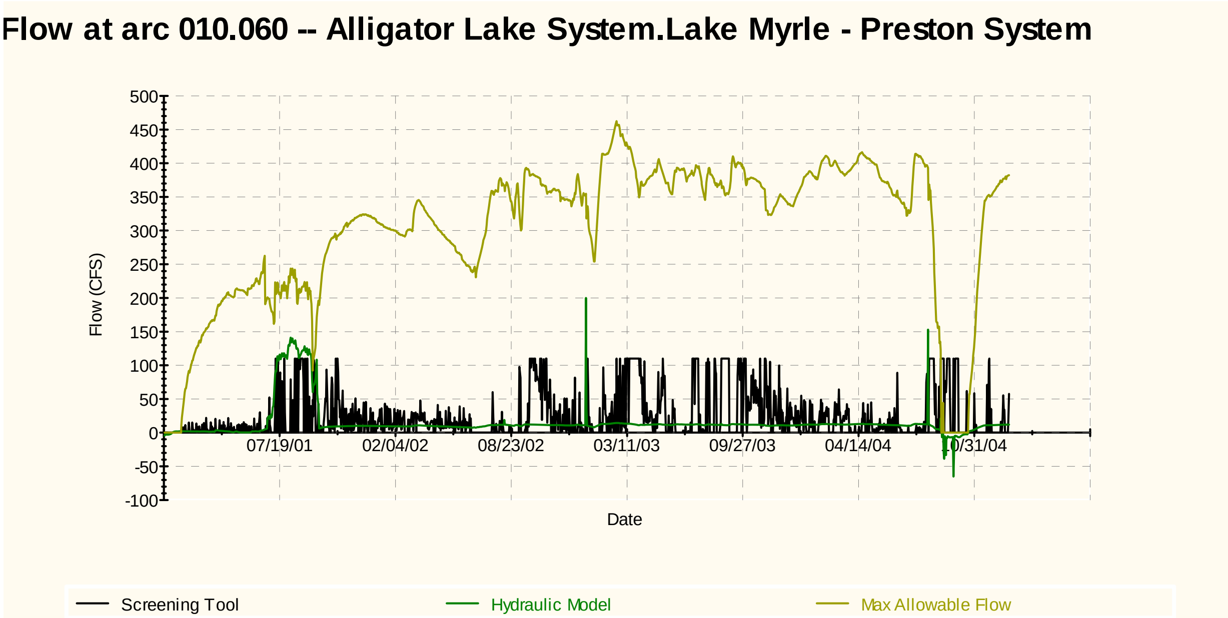

Figure 6-20: Flow between Alligator Lake and Lake Myrtle through the S-58 Structure

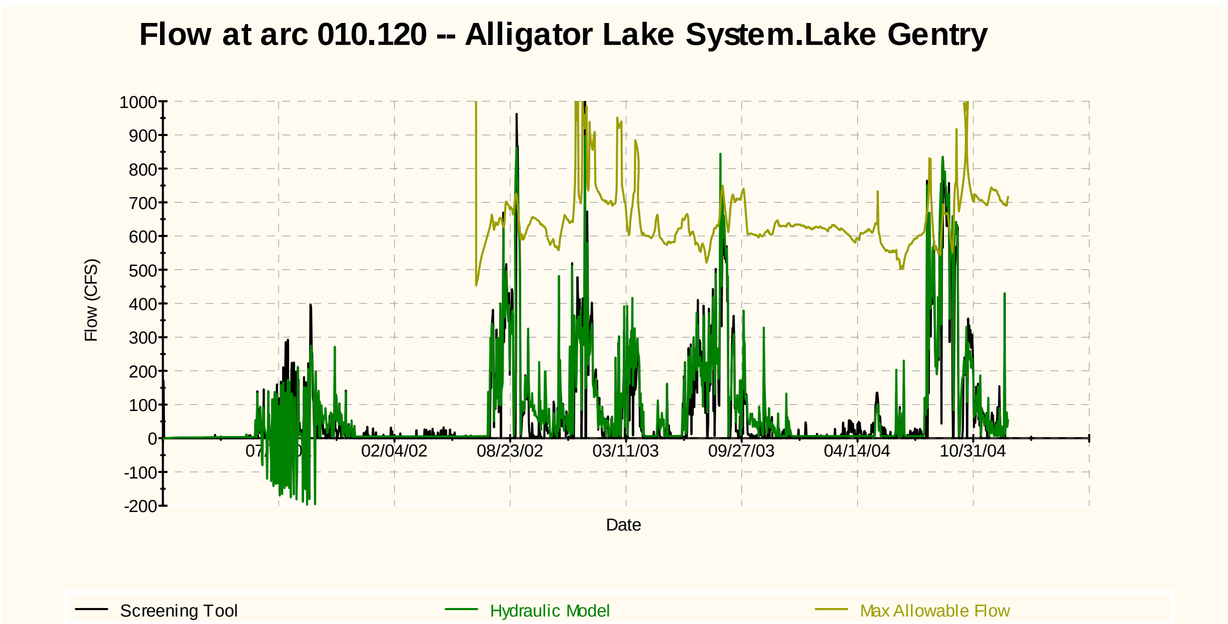

Figure 6-21: Flow between Alligator Lake and Lake Gentry through the S-60 Structure

6.2.3 Lake Myrtle

The Screening Tool-simulated stages follow Hydraulic Model-simulated stages closely throughout the calibration period (Figure 6-22). The Screening Tool does not reproduce the distribution of flow at the S-57 Structure for much of the time (Figure 6-23). However, the total volume of flow through Lake Myrtle is close. The cumulative net outflow is 27.5 k-af for the Screening Tool and 27.6 k-af for the Hydraulic model, a difference of 0.104 k-af or 0.4 percent.

This small error results from using Hydraulic Model stages with the SAE table in the internal mass balance of the Screening Tool (as opposed to actual volumes in the Hydraulic Model).

The maximum allowable flow shown in Figure 6-24 is respected by both models at all times.

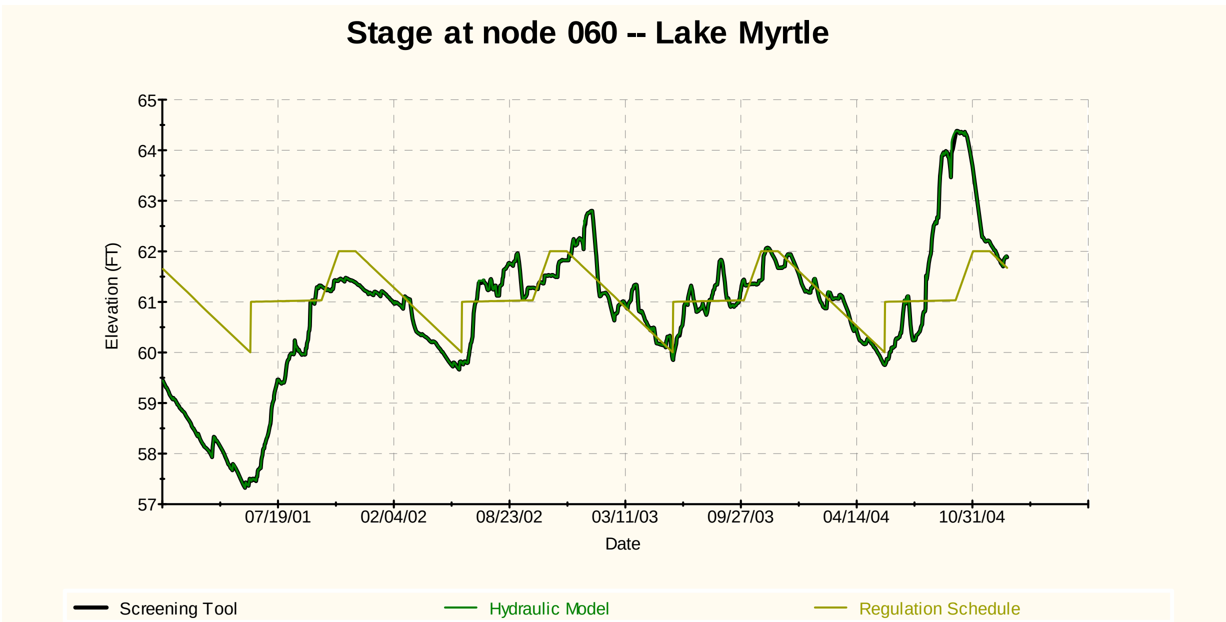

Figure 6-22: Stages in the Lake Myrtle – Preston System

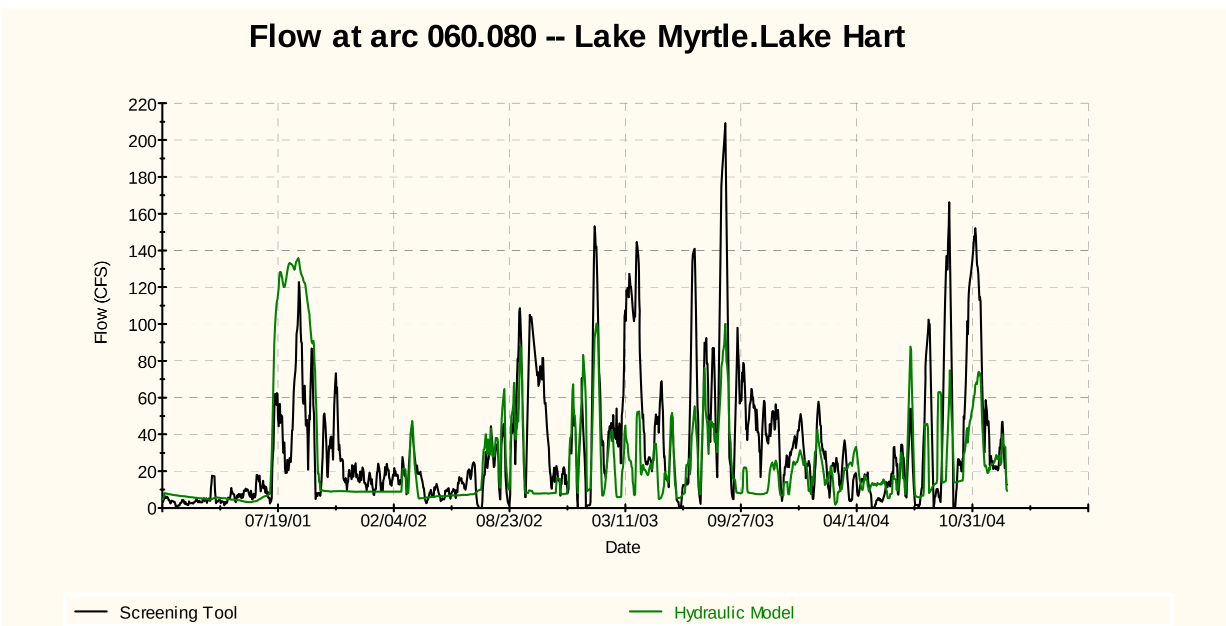

Figure 6-23: Flow between the Lake Myrtle – Preston System and the Lake Hart – Mary Jane System through the S-57 Structure, 7-day moving average

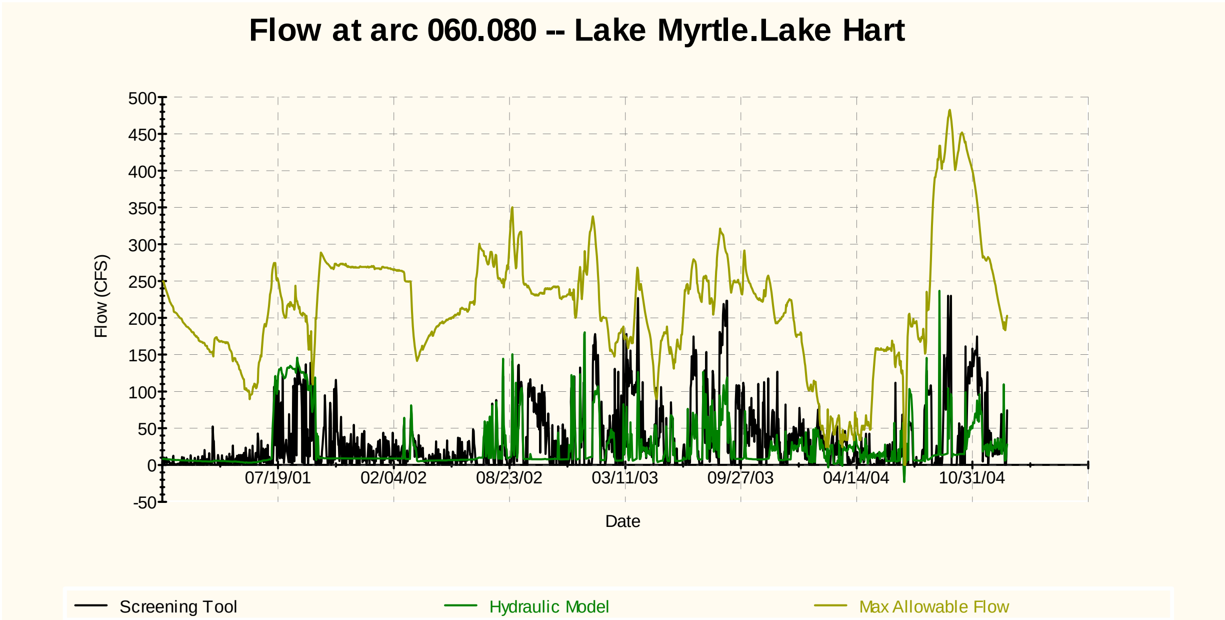

Figure 6-24: Flow between the Lake Myrtle – Preston System and the Lake Hart – Mary Jane System through the S-57 Structure

6.2.4 Lake Hart

The stages at Lake Hart follow closely throughout the calibration period (Figure 6-25). The flows through the S-62 Structure, simulated by the Screening Tool, follow those of the Hydraulic Model much of the time (Figure 6-26). The cumulative net outflow through Lake Hart is 138.0 k-af for the Screening Tool and 137.7 k-af for the hydraulic model, a 0.2 percent difference.

Both models, as shown in Figure 6-27, violate the maximum allowable flows occasionally.

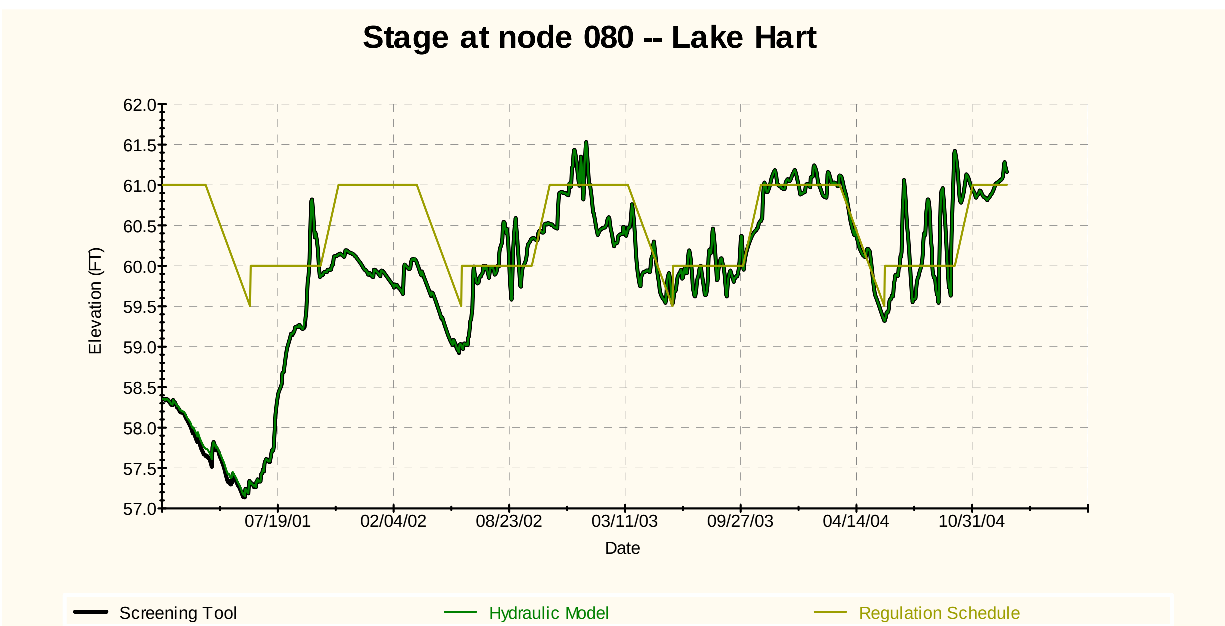

Figure 6-25: Stages in the Lake Hart – Mary Jane System

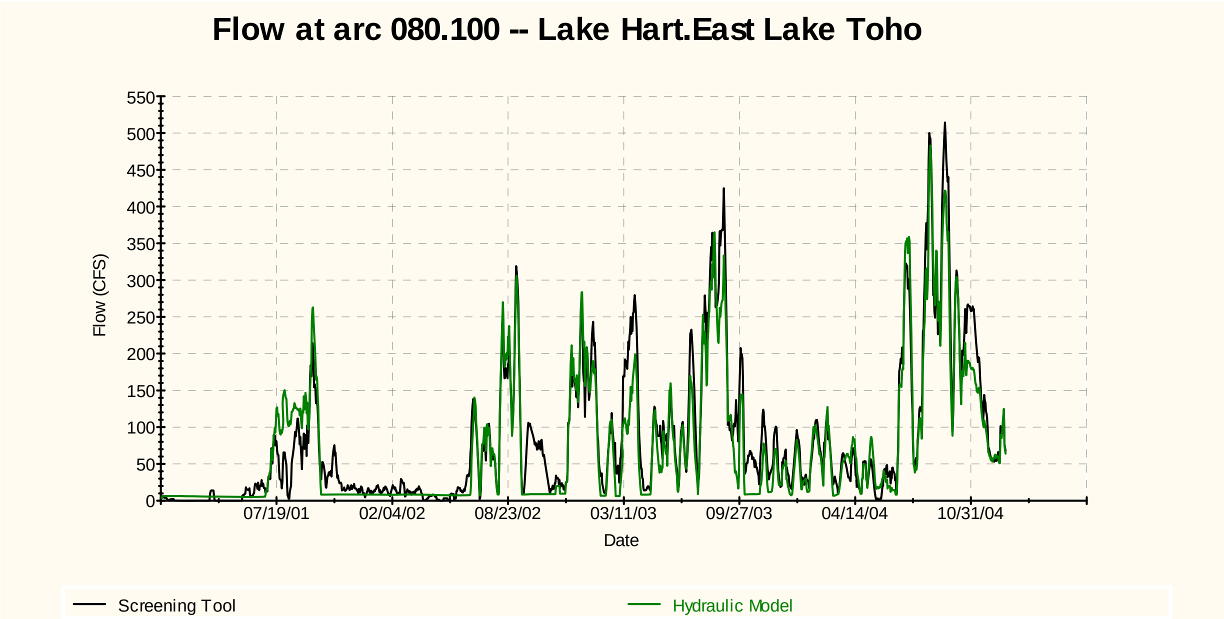

Figure 6-26: Flow between the Lake Hart – Mary Jane System and East Lake Tohopekaliga through the S-62 Structure, 7-day moving average

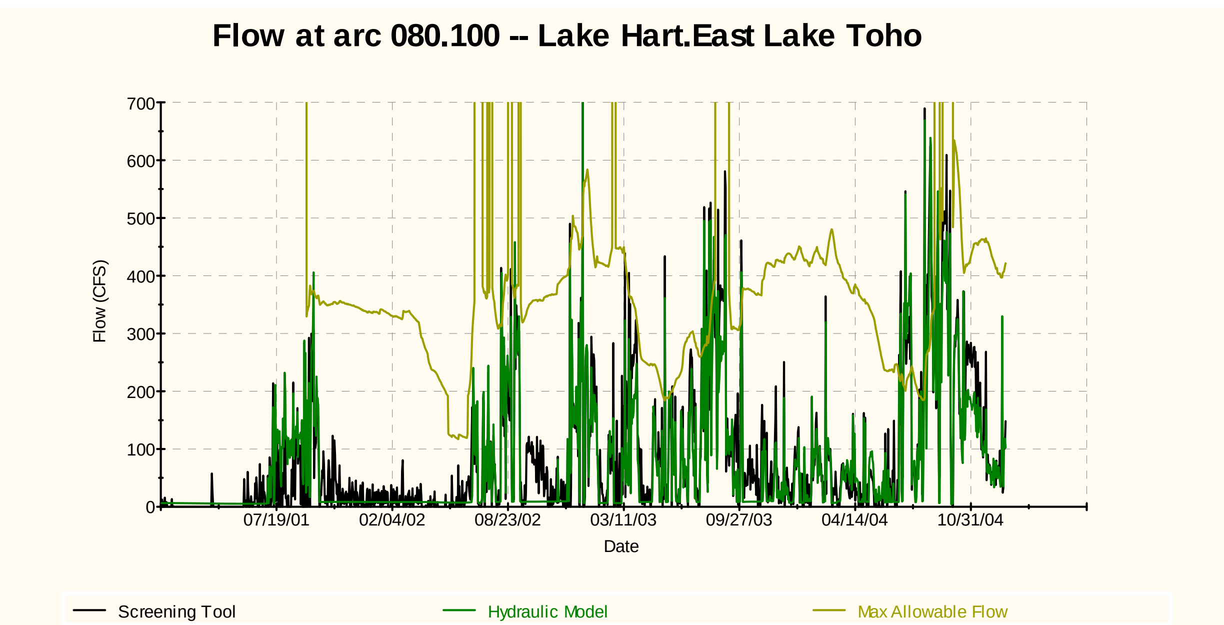

Figure 6-27: Flow between the Lake Hart – Mary Jane System and East Lake Tohopekaliga through the S-62 Structure

6.2.5 East Lake Tohopekaliga

The stages for East Lake Tohopekaliga (Toho) track well throughout the calibration period (Figure 6-28). The flows through the S-59 Structure also show close agreement throughout the calibration period (Figure 6-29). These flows frequently violate the maximum allowable releases (Figure 6-30). The maximum allowable flows should be checked against those determined in the Hydraulic Model.

The cumulative net outflow from East Lake Toho was 417 k-af for the Screening Tool and 424 k-af for the Hydraulic Model, a difference of 1.7 percent.

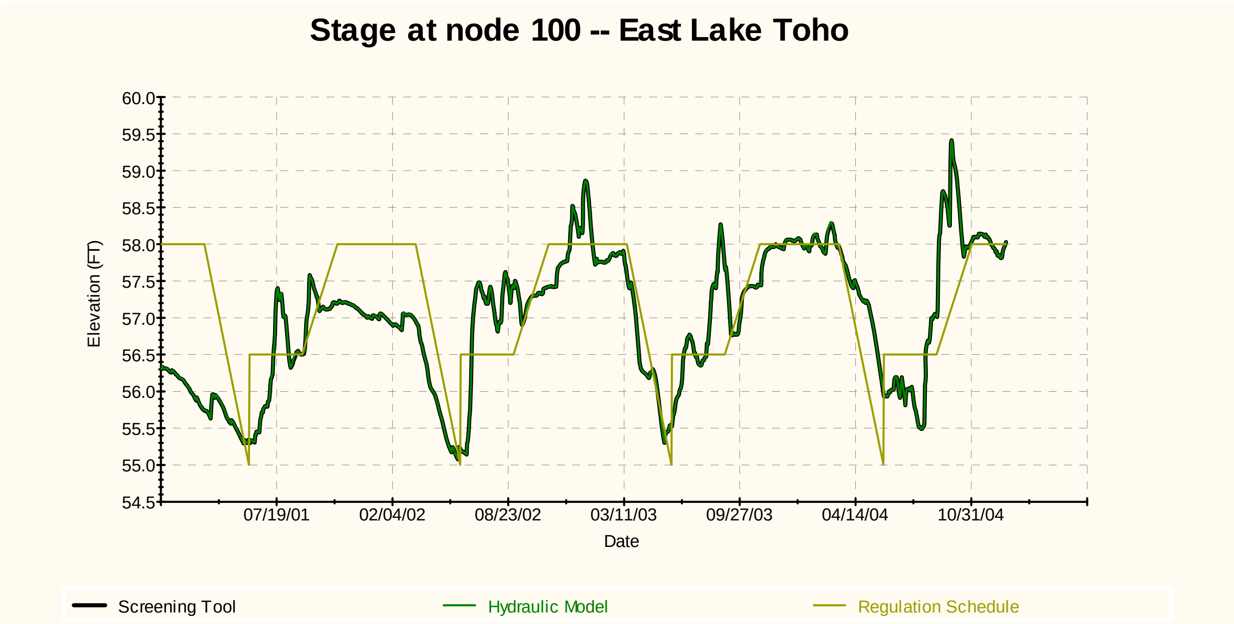

Figure 6-28: Stages in East Lake Tohopekaliga

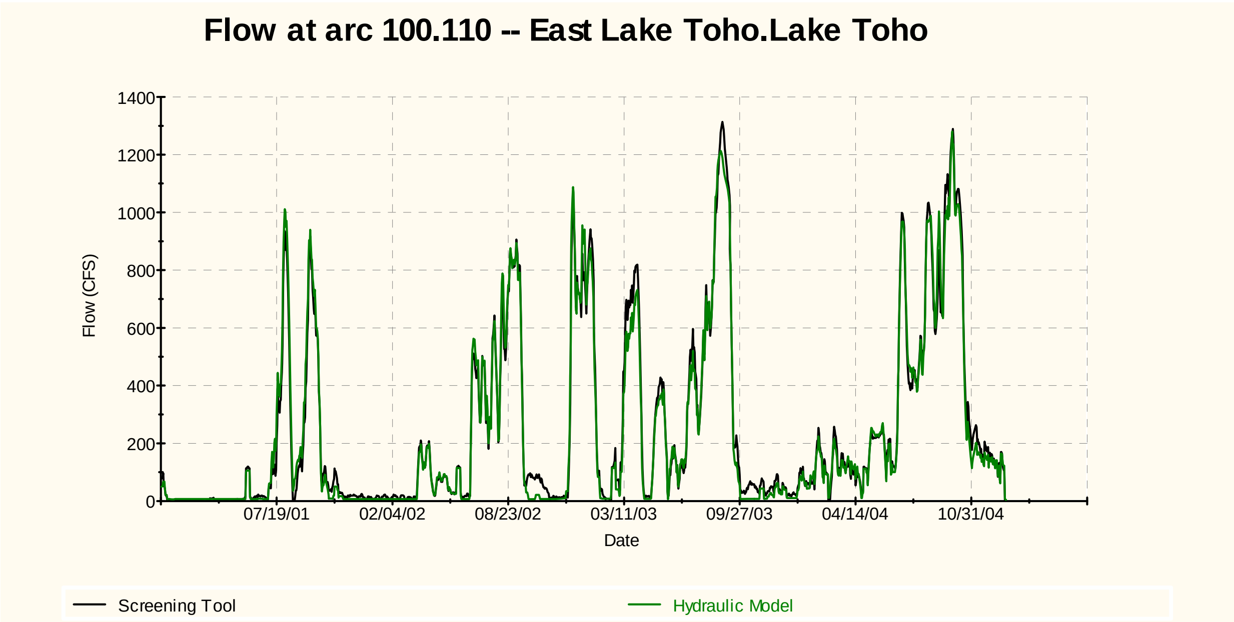

Figure 6-29: Flow between East Lake Tohopekaliga and Lake Tohopekaliga through the S-59 Structure, 7-day moving average

AECOM

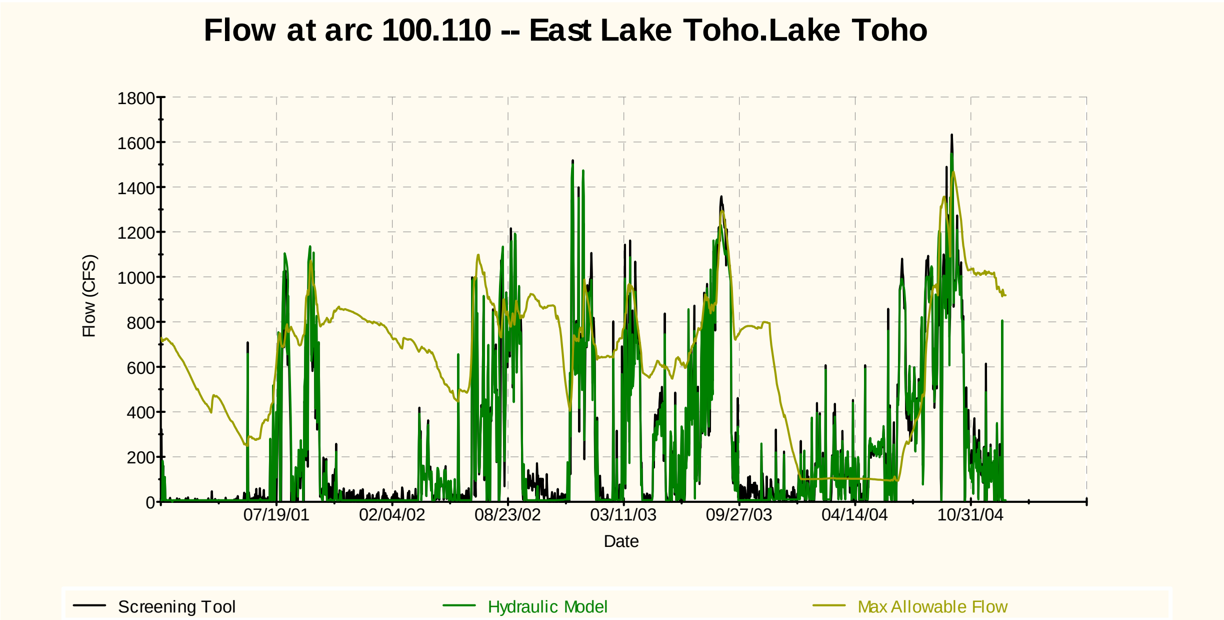

Figure 6-30: Flow between East Lake Tohopekaliga and Lake Tohopekaliga through the S-59 Structure

6.2.6 Lake Tohopekaliga

The Screening Tool-simulated stages in Lake Toho trace the Hydraulic Model-simulated stages well after 2001 **(**Figure 6-31). During 2001, the Screening Tool does not have sufficient water available to match the Hydraulic Model stages for two reasons. First, while the "mass balance errors" in the Hydraulic Model output are small (1.6 percent of total inflow), they are concentrated in 2001 (the accumulated "mass imbalance" from 1/1/2001 to 7/1/2001 is 38 percent of total inflow during this time-period). Additionally, the Screening Tool makes small releases from the S-65 Structure to meet the Hydraulic Model's stages in the LKB. These small releases (less than 50 cfs), accumulate to about 12,000 af between 1/1/2001 and 7/1/2001.

The smaller volume of water available in the Screening Tool during this period, due to these two factors, results in an inability to maintain the Hydraulic Model stages throughout the basin. The void could have been distributed throughout the KUB, but for simplicity in explanation, the void is concentrated at Lake Toho. It is important to note that, due to watershed stability issues (changes in infrastructure, operations and construction activities of the KRR features going on in the LKB), this period was not part of the official Hydraulic Model calibration period and was added to the calibration run as a "warming-up" period. The official calibration period of the Hydraulic Model does not start until November 2001. Therefore, the match for this lake is considered to be satisfactory.

The flows through the S-61 Structure track nicely throughout the calibration period (Figure 6-32). The additional releases made by the Screening Tool for the LKB can be seen before July 2001. These accumulate to about 10 k-af. This period does not fall within the Hydraulic Model calibration period. The flows at the S-61 Structure also violate the maximum allowable flow occasionally (Figure 6-33).

The cumulative net outflow from Lake Toho was 659 k-af for the Screening Tool and 665 k-af for the Hydraulic Model, a difference of 0.9 percent.

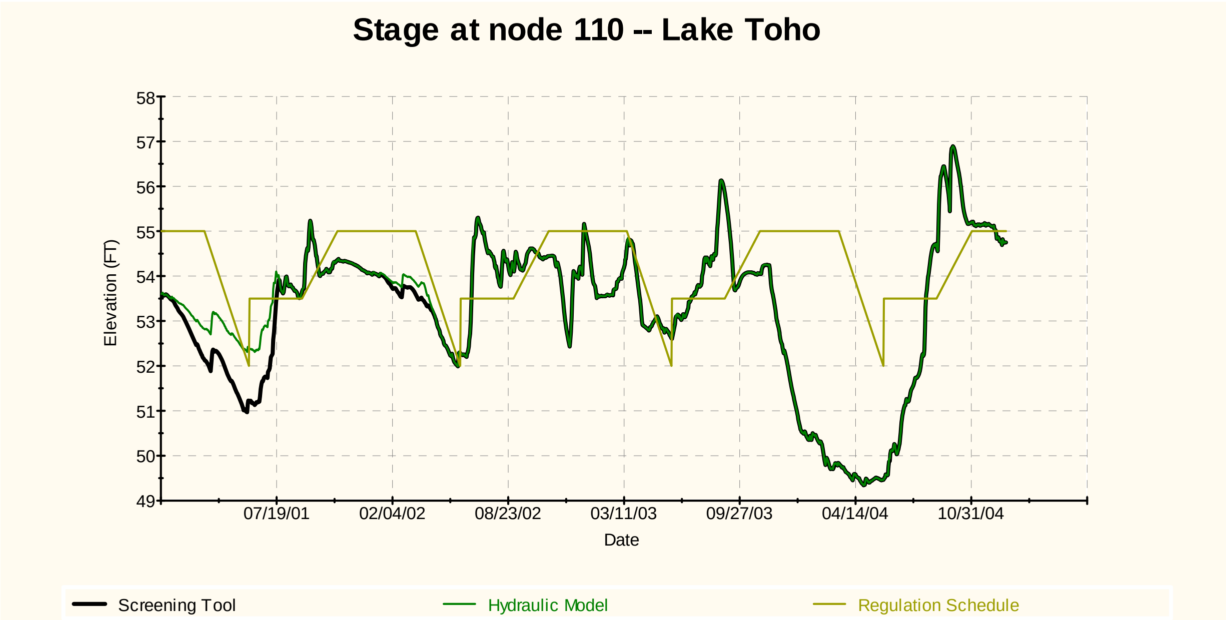

Figure 6-31: Stages in Lake Tohopekaliga

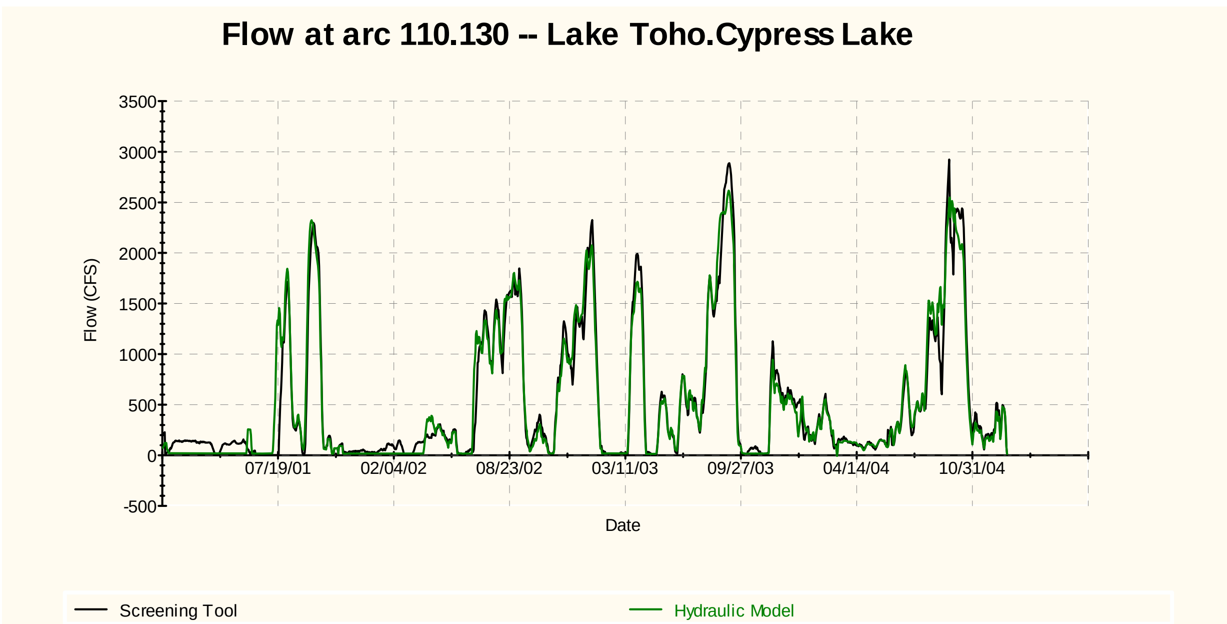

Figure 6-32: Flow between Lake Tohopekaliga and Cypress Lake through the S-61 Structure, 7-day moving averages

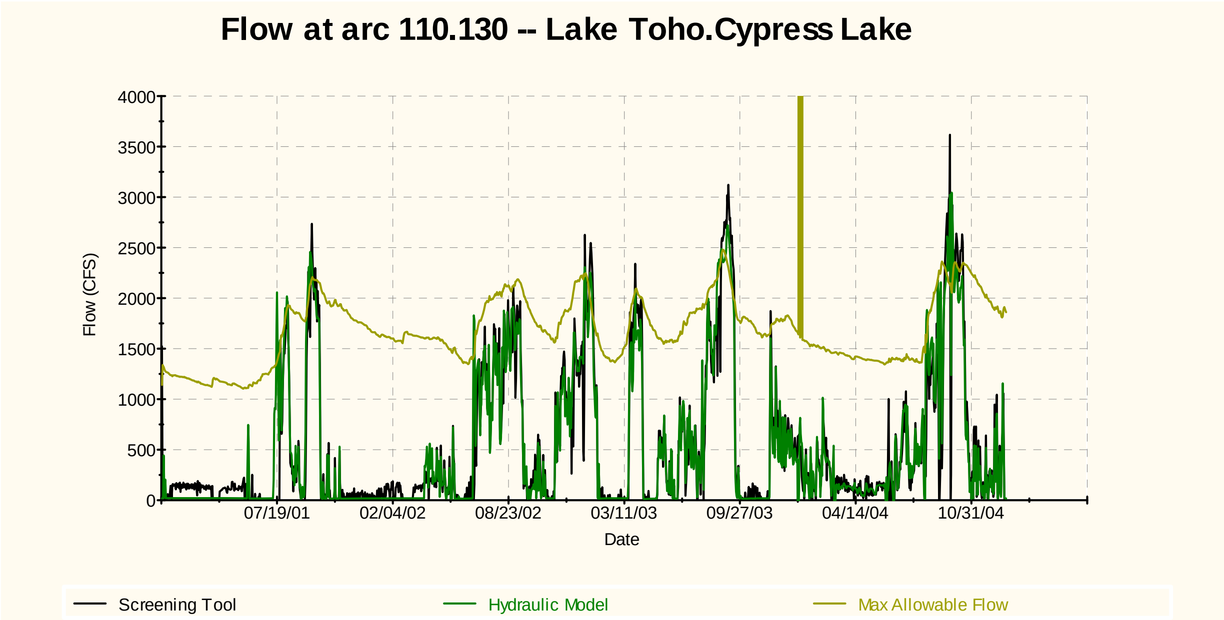

Figure 6-33: Flow between Lake Tohopekaliga and Cypress Lake through the S-61 Structure

6.2.7 Lake Gentry

The Screening Tool stages track the stages of the Hydraulic Model well throughout the calibration period (Figure 6-34). Flows through the S-63 Structure also match well, most of the time (Figure 6-35 and Figure 6-36). The Hydraulic Model with two exceptions, one day in August 2003 and a few days in summer 2004, respects the maximum allowable flows. The cumulative net outflow from Lake Gentry was 58.4 k-af for the Screening Tool and 58.1 k-af for the Hydraulic Model, a difference of 0.5 percent.

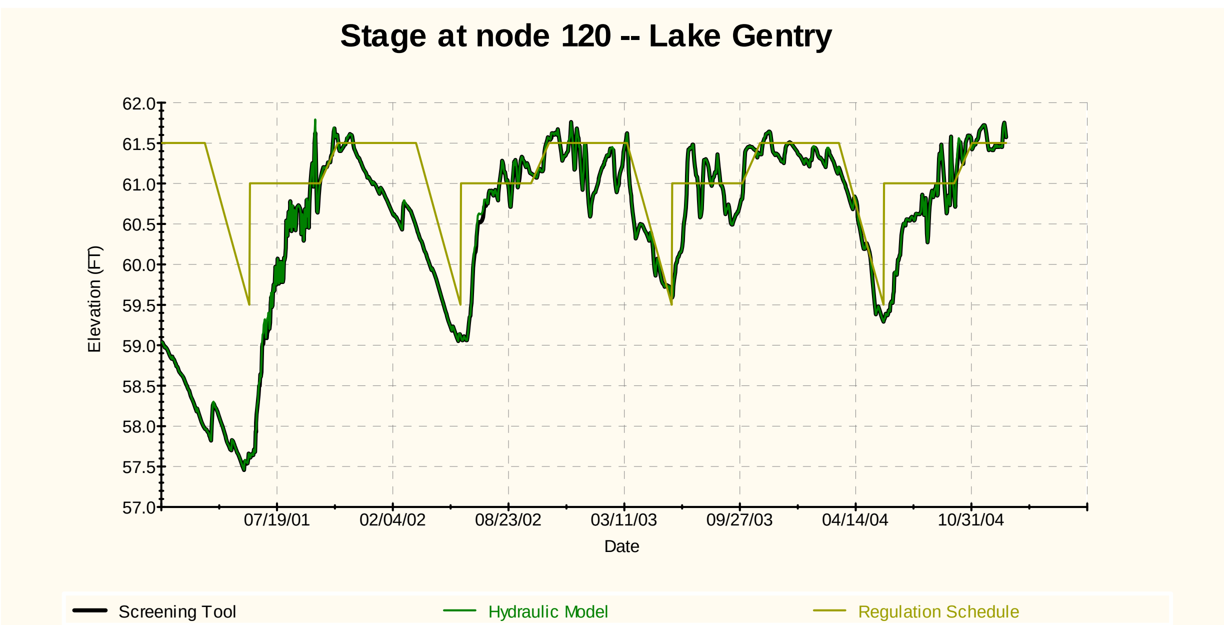

Figure 6-34: Stages at Lake Gentry

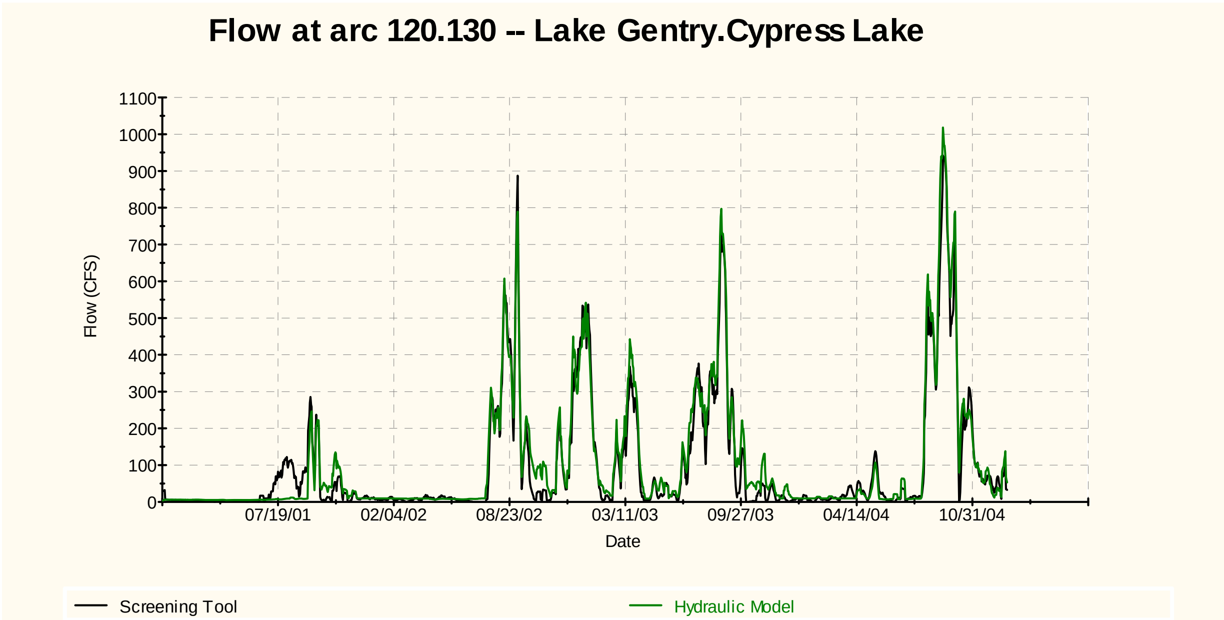

Figure 6-35: Flow between Lake Gentry and Cypress Lake through the S-63 Structure, 7-day moving average

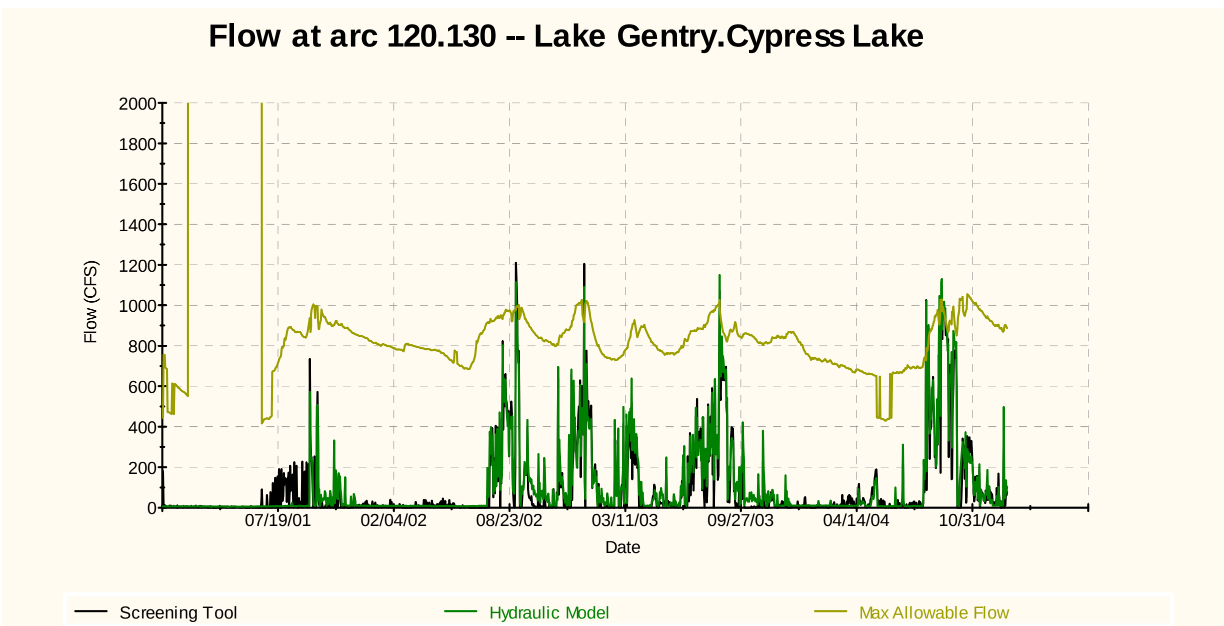

Figure 6-36: Flow between Lake Gentry and Cypress Lake through the S-63 Structure

6.2.8 Cypress Lake, Lake Hatchineha and Lake Kissimmee

The canal equations for the C-36 and C-37 Canals were already assessed in the history matching exercise documented in Section 6.1. The cumulative net outflow from these three lakes was 2943 k-af for the Screening Tool and 3027 kaf for the Hydraulic Model, a difference of 2.8 percent.

The Screening Tool-simulated stages follow the Hydraulic Model-simulated closely in Lake Kissimmee throughout the calibration period (Figure 6-37). The flows also track closely (Figure 6-38). The maximum allowable flows are respected by the Hydraulic Model with the exception of a few days in fall 2001 and fall 2002, as shown in Figure 6-39.

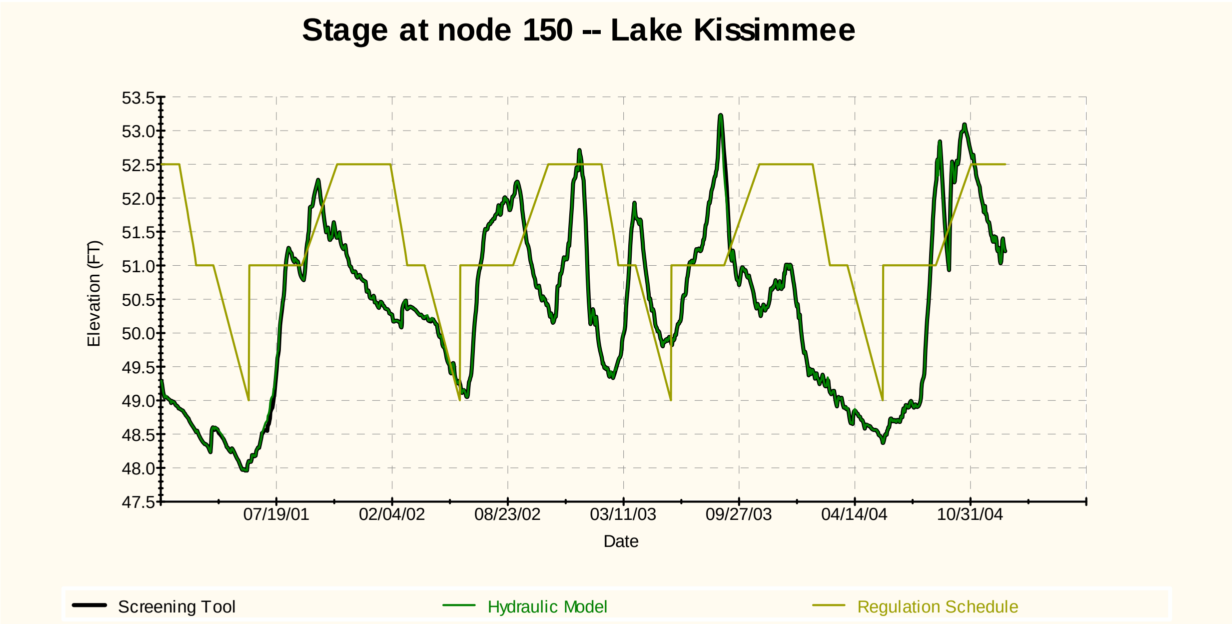

Figure 6-37: Stage at Lake Kissimmee

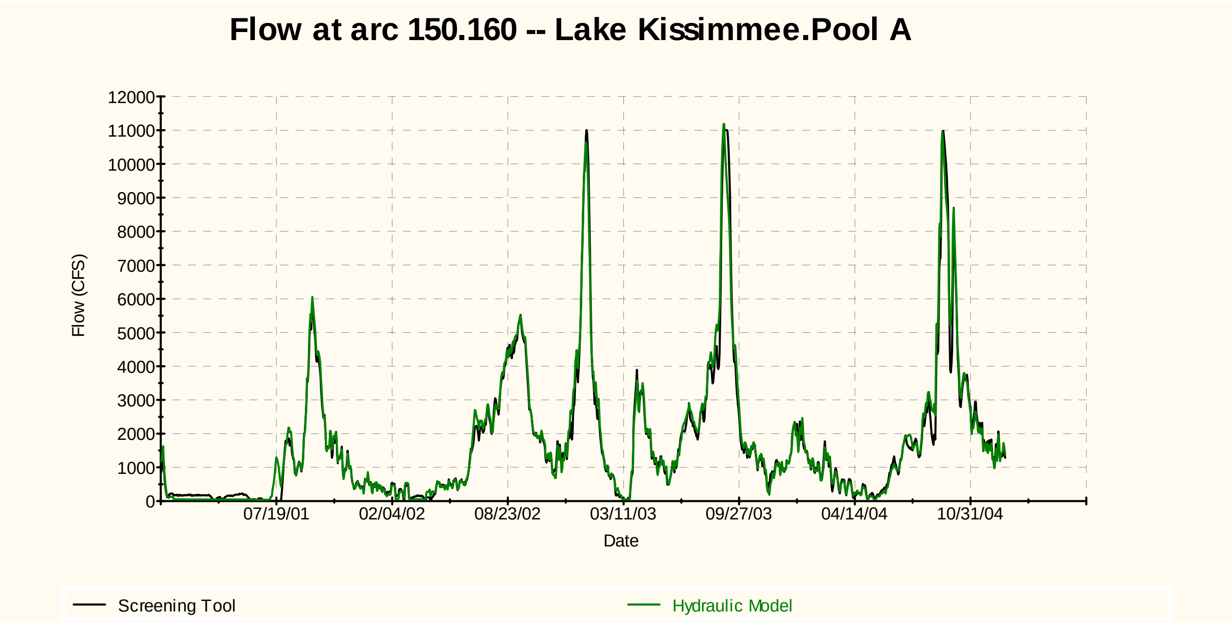

Figure 6-38: Flows between Lake Kissimmee and Pool A through the S-65 Structure, 7-day moving average

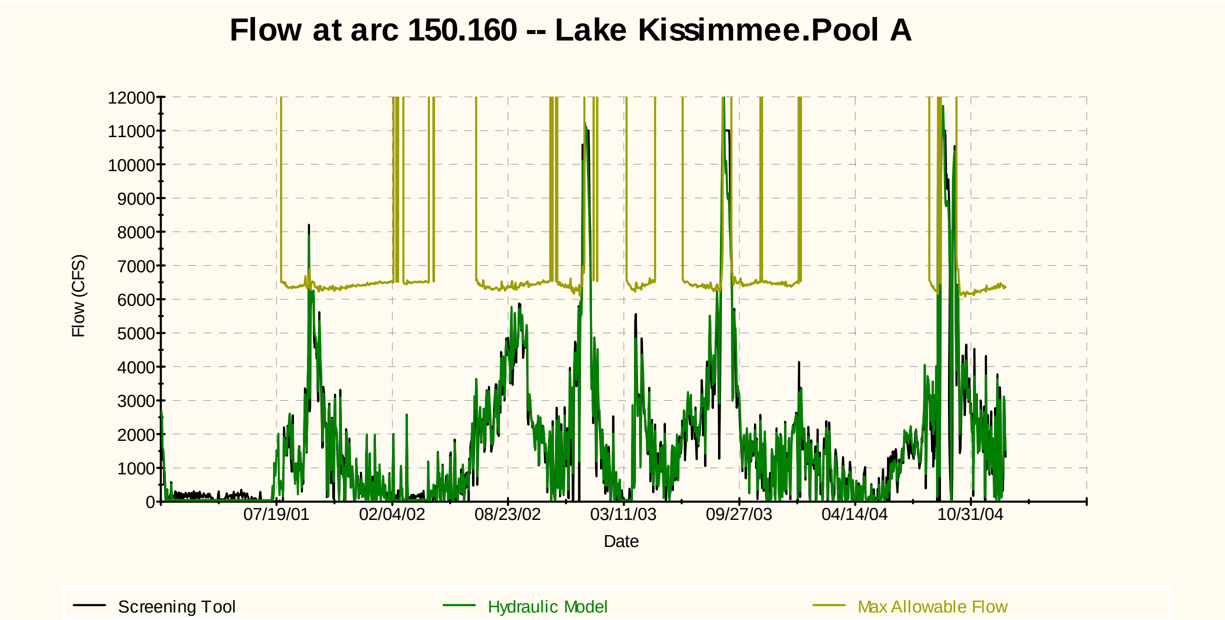

Figure 6-39: Flows between Lake Kissimmee and Pool A through the S-65 Structure

6.2.9 Pool A

The HW at the S-65A Structure tracks well with the exception of a few days in spring 2001 (Figure 6-40). Again, this period was not part of the Hydraulic Model calibration. To provide a qualitative assessment of the Screening Tool-simulated TW, the historical TW values are shown (blue line). The simulated TW is a function of flow. Since the Screening Tool flows are “spiky”, as previously discussed, the TW values are also “spiky”. However, the moving averages follow the historical values.

The flows out of Pool A through the S-65A Structure show close agreement as well (Figure 6-41). The maximum allowable flows are respected with the exception of a few days in fall 2001 and fall 2002 (Figure 6-42). The net cumulative flow through Pool A is 501 k-af in the Screening Tool and 479 k-af in the Hydraulic Model, which is 4.5 percent of the total net outflow.

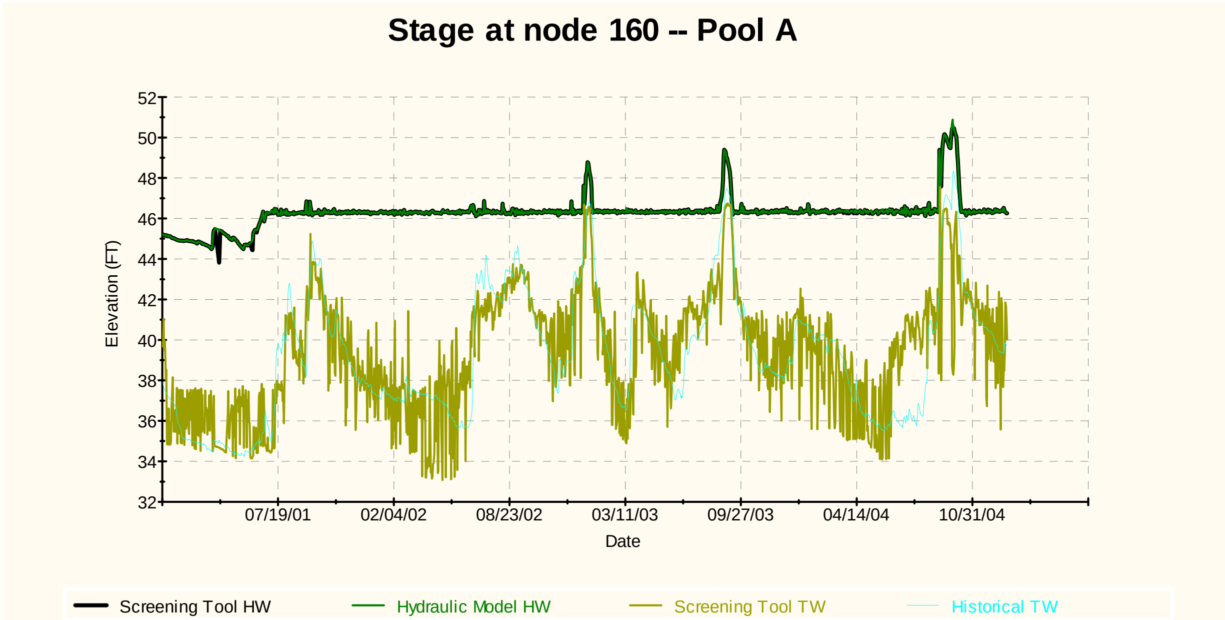

Figure 6-40: Headwater and tailwater elevations at the S-65A Structure

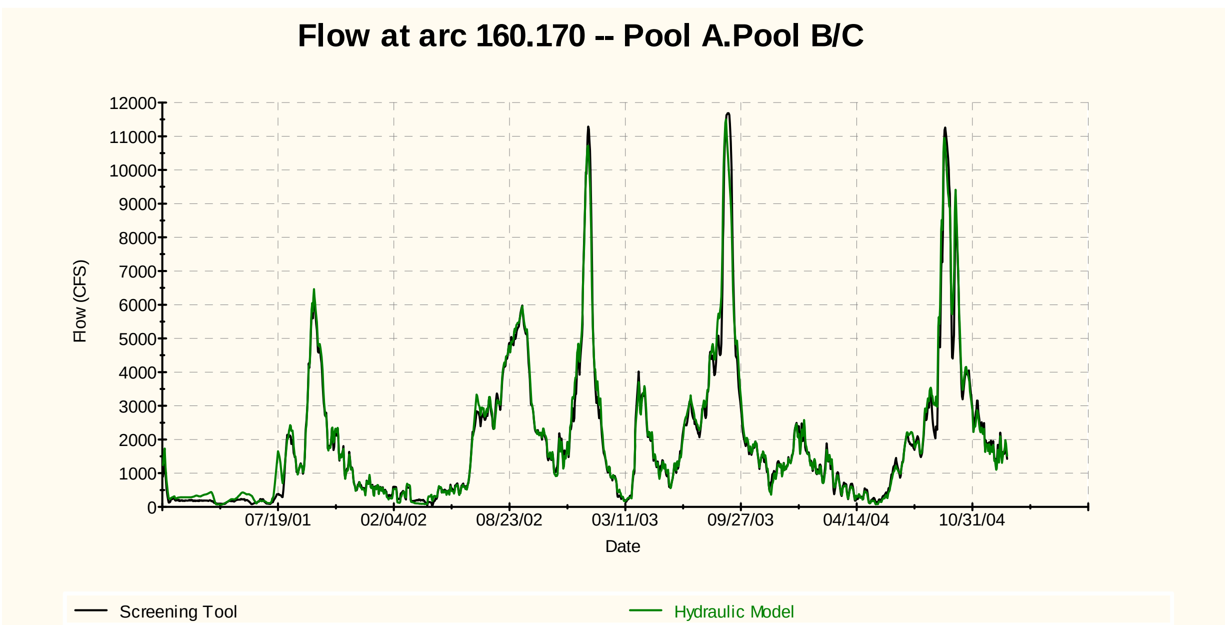

Figure 6-41: Flows between Pool A and Pool B/C through the S-65A Structure, 7-day moving average

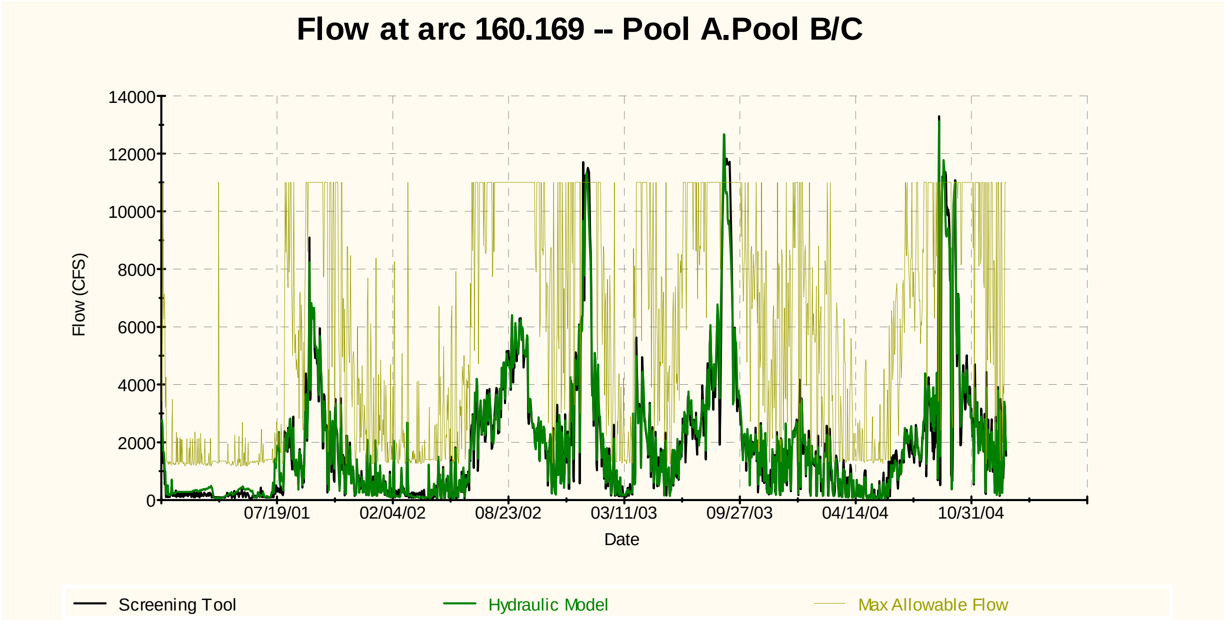

Figure 6-42: Flows between Pool A and Pool B/C through the S-65A Structure

6.2.10 Pool B/C

Six different locations in Pool B/C are simulated in the Screening Tool. The flow and stage at the S-65C Structure is calculated as part of the system-wide solution at each time-step. Stages at four interim locations are then calculated post-solve as described in Section 3.1.2. The additional interim point, represented by Node 169, is included to simulate reach hydraulics and does not correspond to a geographic location. There are therefore no corresponding Hydraulic Model records and results for this node are not included in the history matching exercise.

S-65C

Both the simulated HW and TW at the S-65C Structure match the Hydraulic Model and historical values closely (Figure 6-43). The Screening Tool-simulated outflows follow the Hydraulic Model-simulated values closely as well (Figure 6-44). The peak flows in the Screening Tool are higher than the peak flows in the Hydraulic Model. Table 6-1 shows the difference in flood releases for the two models based on daily average flows (Figure 6-45), where a flood is defined as days in which the flow at the S-65C Structure, from either model, is over 10,000 cfs. Note that the fall 2004 flood has been separated into two peaks.

Table 6-1: Summary of differences in flood flows through the S-65C Structure, Screening Tool (ST) and Hydraulic Model (HM).

Dates	Peak flow (cfs)		Net outflow during flood (af)		Difference in net outflow (AF)	
	ST	HM	ST	HM	total	per day
1/2-13/2003	12033	11272	26939	16217	10722	894
8/29 – 9/14/2003	14340	12466	52552	44137	8415	495
9/12-21/2004	14164	11940	19684	19075	609	61
10/3-7/2004	13942	10849	43360	34783	8577	1715

Most of the difference occurs because the Screening Tool requires higher flows than the Hydraulic Model to maintain the same stages. It is because the Hydraulic Model calculates the flow through the structure using instantaneous stages and gate openings every MIKE 11 time-step (which can be below 10 minutes), while OKISS calculates structure flows using daily averages. The influence of the daily flow versus instantaneous flows issue in the performance measures scores were to be evaluated during the validation of the Base Conditions Evaluation.

The maximum allowable flow is respected most of the time (Figure 6-45). The flow in both models does occasionally exceed the maximum flow for structural stability. These flows were also present in the historical record due to decisions taken by the structure operators. Conditions of flows higher than allow do not extend over a significant period of time and are presented at extreme stages or flooding conditions. This value were to be relaxed to allow flows as large as those simulated by the Hydraulic Model and observed in the historical record.

The net cumulative flow through Pool B/C is 570 k-af in the Screening Tool and 654 k-af in the Hydraulic Model, a difference of 13 percent of the total net outflow. The complex algorithm, used to simulate the floodplain storage within the pool, explains this difference. In any case, the difference is still below the calibration criteria set for AFET.

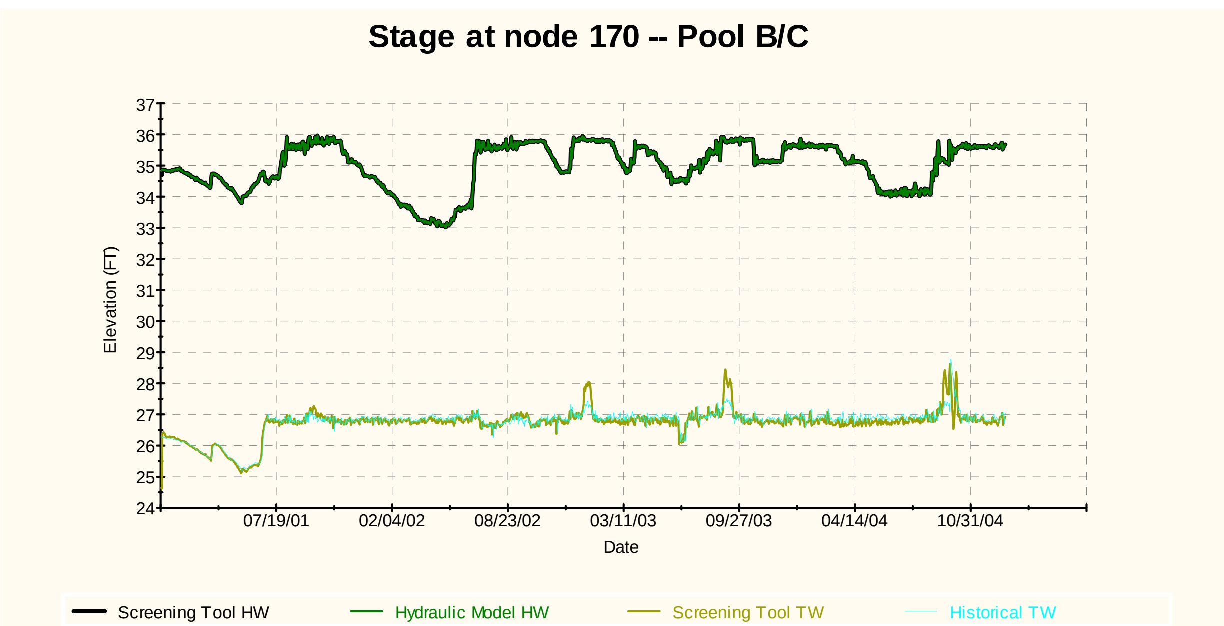

Figure 6-43: Headwater and tailwater elevations at the S-65C Structure

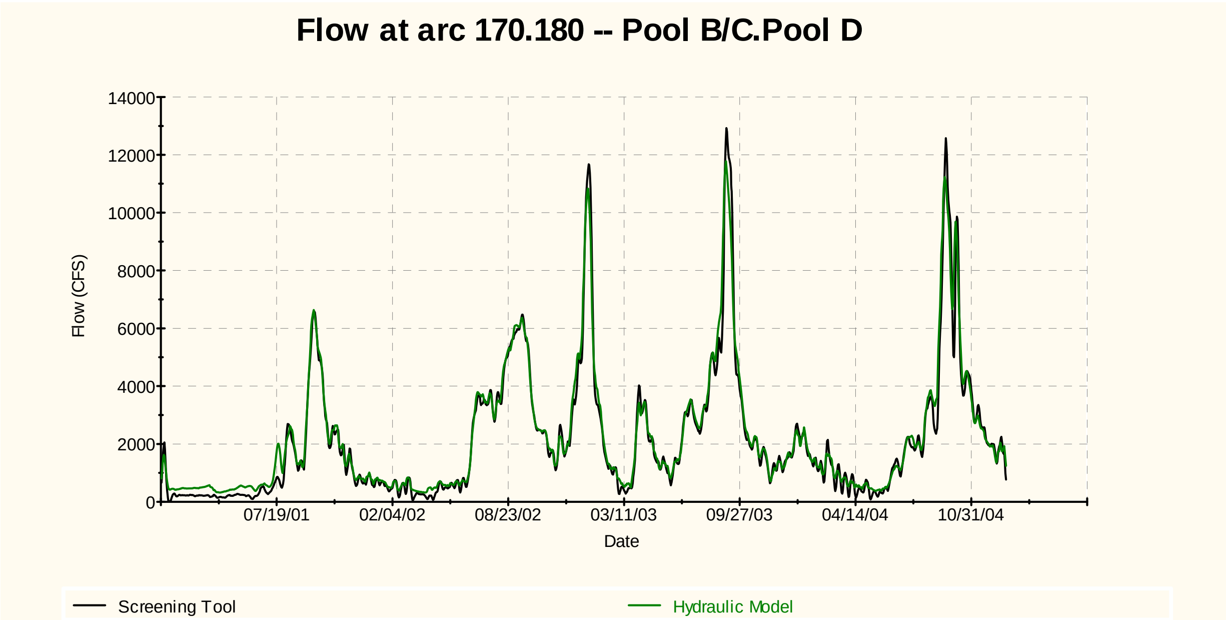

Figure 6-44: Flow between Pool B/C and Pool D through the S-65C Structure, 7-day moving average

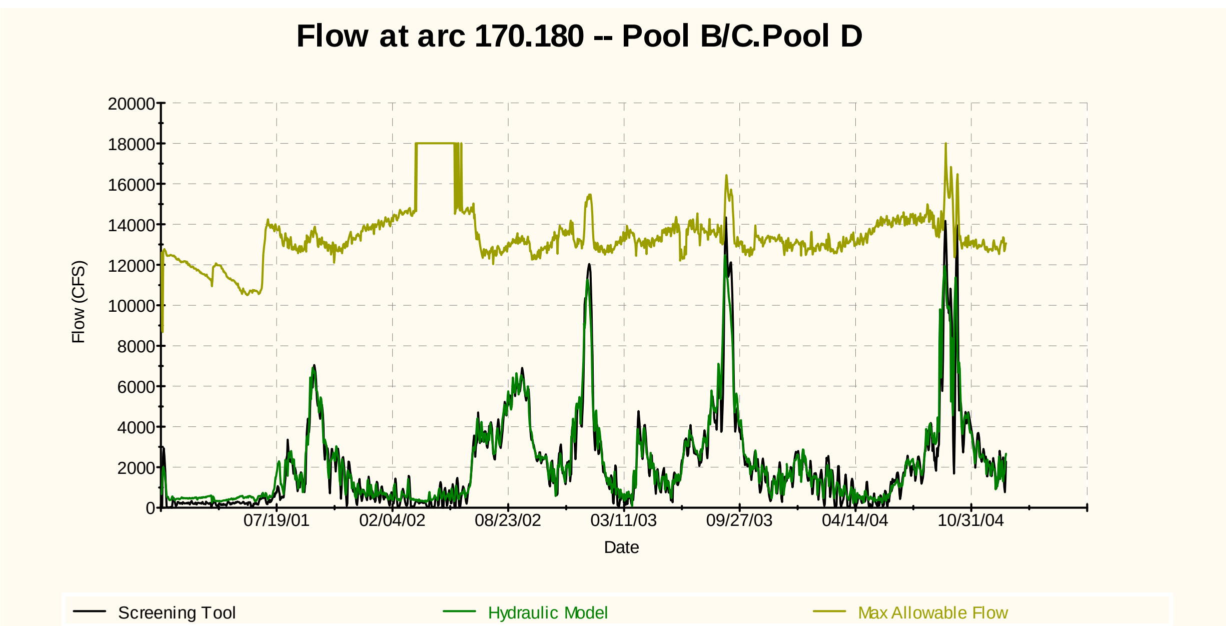

Figure 6-45: Flow between Pool B/C and Pool D through the S-65C Structure

Weir 2, Weir 1, PC62 and PC33

The stages at Weirs 1 and 2 are shown in Figure 6-46. Stages at the two weirs essentially overlap in both model runs, so that only the lines for Weir 2 are visible. The stages generated in both models tend to "jump around," often two feet from day-to-day. This happens in the Screening Tool because the look-up tables used to determine the stages are a function of flow through Pool

B/C and the flows vary widely from day-to-day as necessary to maintain given stages at the structures while preserving mass balance.

A 7-day centered running average is shown in Figure 6-47. The stages are reproduced closely throughout the calibration period with the exception of stages under 37 feet, which occur mostly outside of the Hydraulic Model Calibration period.

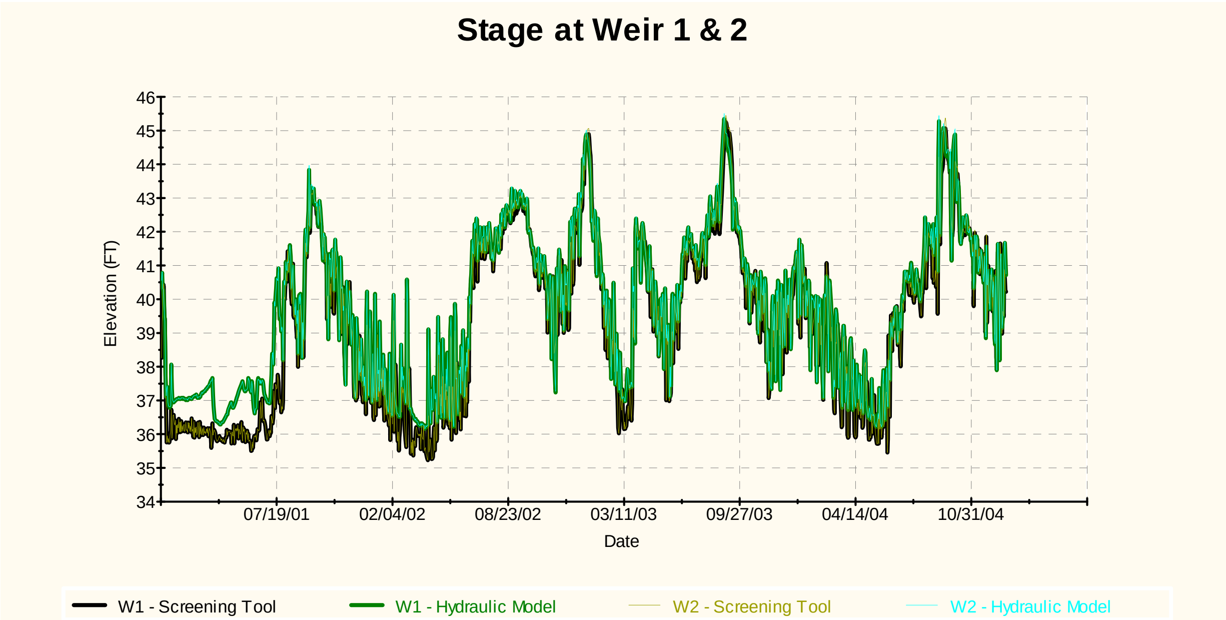

Figure 6-46: Stages at Weirs 1 and 2 in Pool B/C

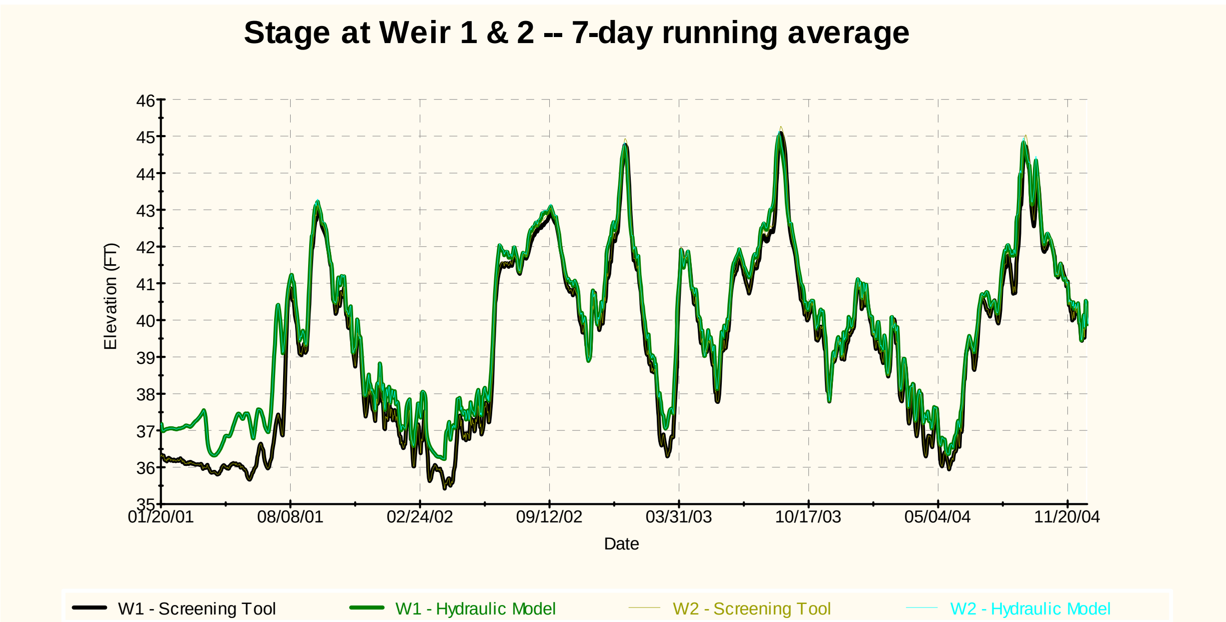

Figure 6-47: 7-day centered running averages of stages at Weirs 1 and 2

AECOM

The stages at PC62 and PC33 are shown in Figure 6-48 and Figure 6-49. The stages at both locations, PC33 and PC62, follow the stages of the Hydraulic Model closely.

Using running averages at PC62, in addition to Weirs 1 and 2, in performance measure evaluation is recommended if the spikiness is not reduced during the Base Conditions Evaluation. This is not necessary at PC33 because this stage is a stronger function of stage at the S-65C Structure and a weaker function of flow than stage at the other locations. Additionally, this stage is a function of flow at the S-65C Structure, which is less "spiky" than flow at the S-65A Structure. Any averaging however, should be done consistently with the Hydraulic Model, as the stages produced in this model are also "spiky."

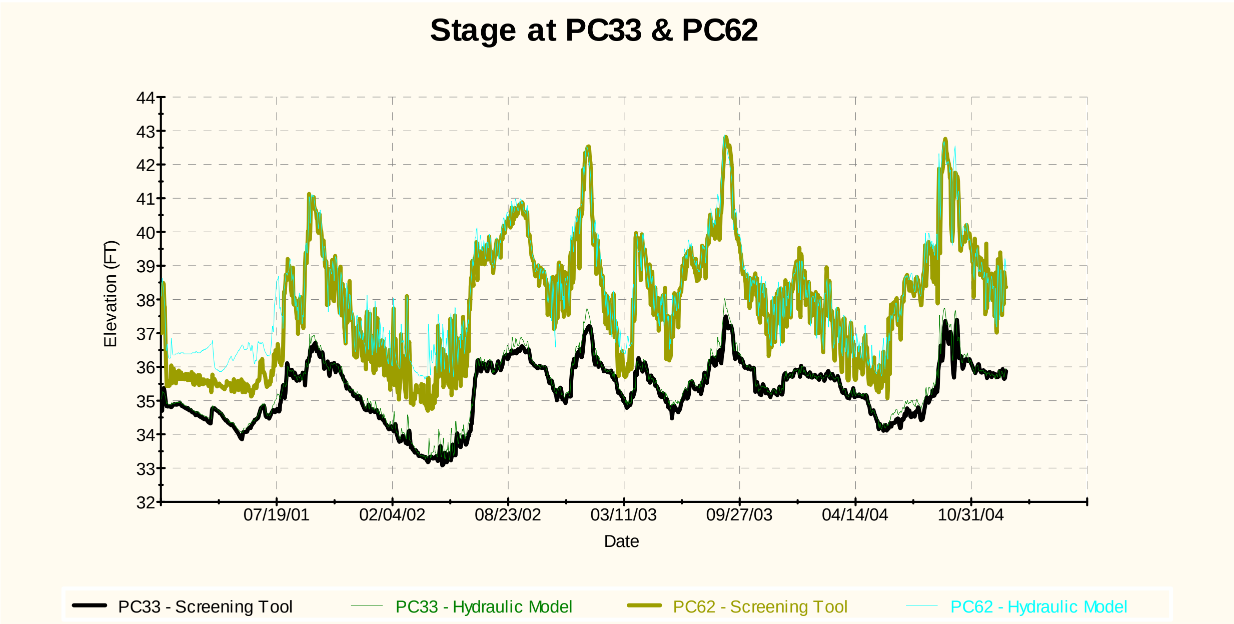

Figure 6-48: Stages at PC33 and PC62 in Pool B/C

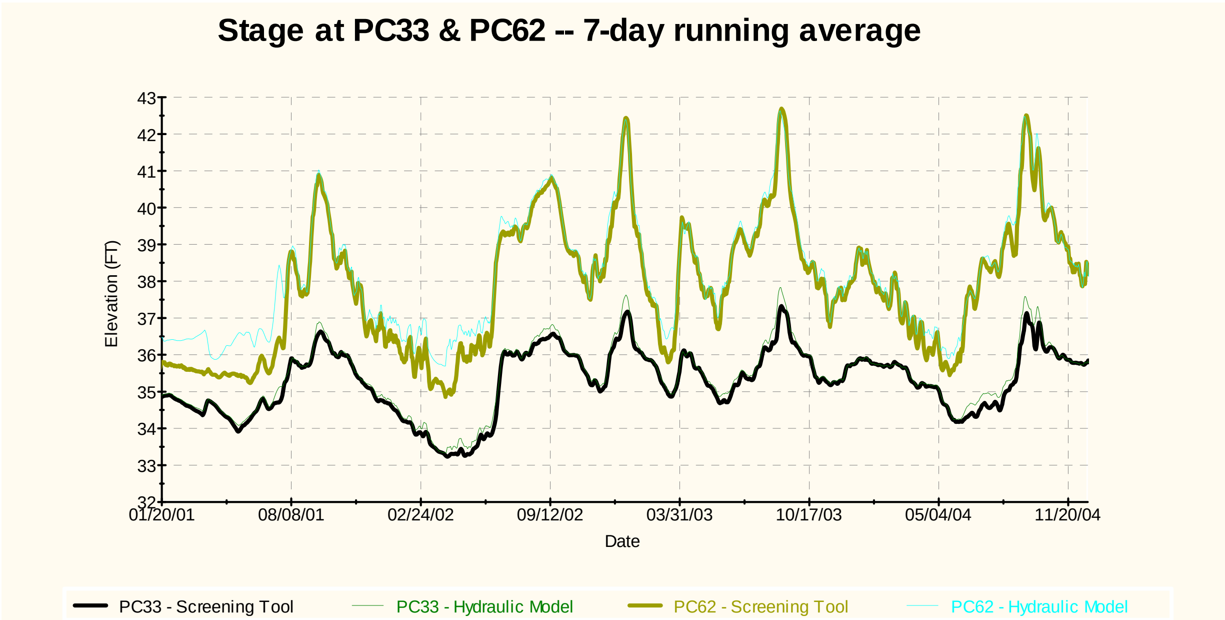

Figure 6-49: 7-day centered running averages of stages at Weirs PC33 and PC62

6.2.11 Pool D

The Screening Tool-simulated HW at the S-65D Structure matches the Hydraulic Model closely (Figure 6-50). The simulated TW values are slightly higher than the historical.

The outflows from Pool D through the S-65D Structure are shown in Figure 6-51. The Screening Tool-simulation follows the Hydraulic Model flows closely. The maximum allowable flow is respected at all times (Figure 6-52). The net cumulative flow through Pool D is 430 k-af in the Screening Tool and 430 k-af in the Hydraulic Model, a difference of 0.1 percent of the total net outflow.

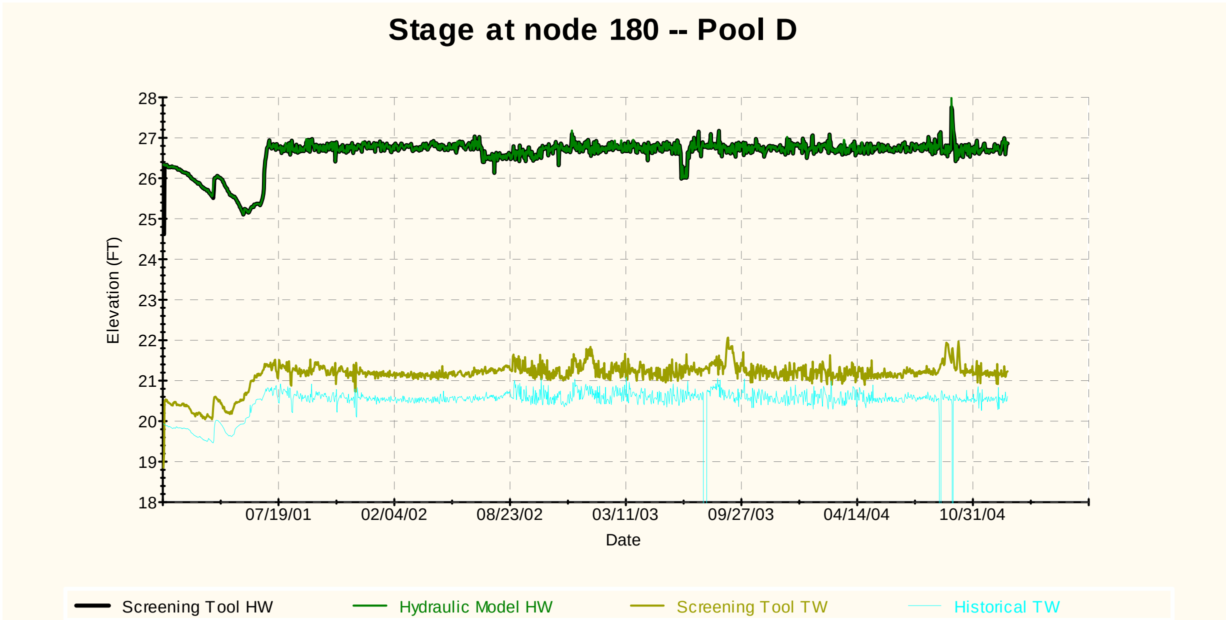

Figure 6-50: Headwater and tailwater elevations at the S-65D Structure

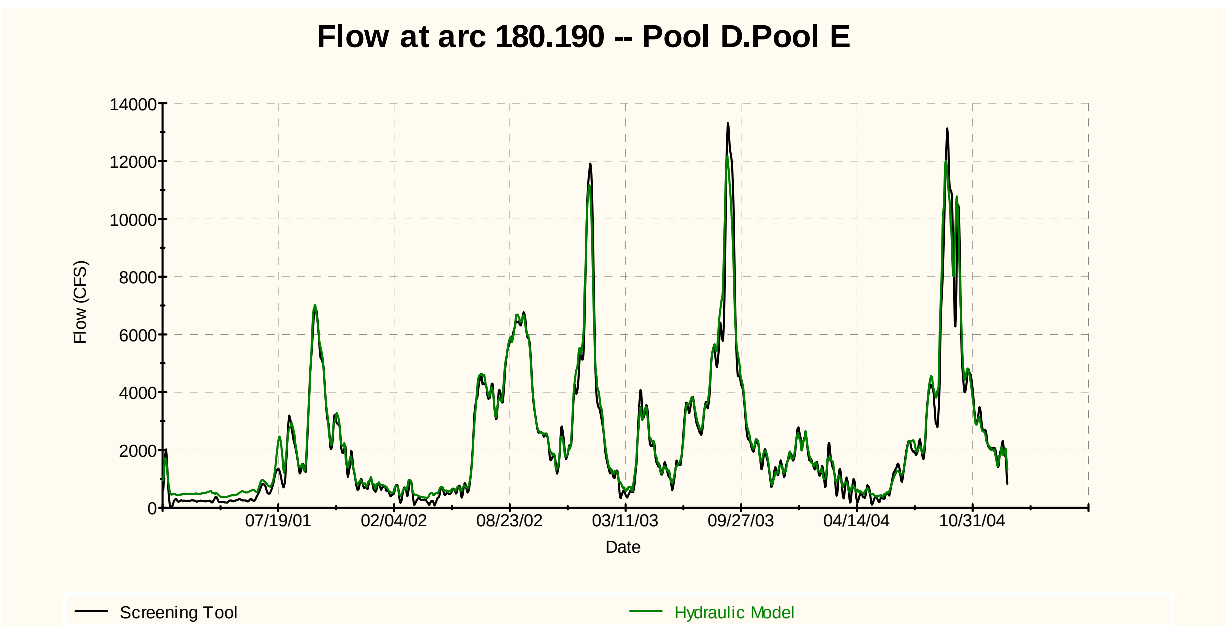

Figure 6-51: Flow between Pool D and Pool E through the S-65D Structure, 7-day moving average

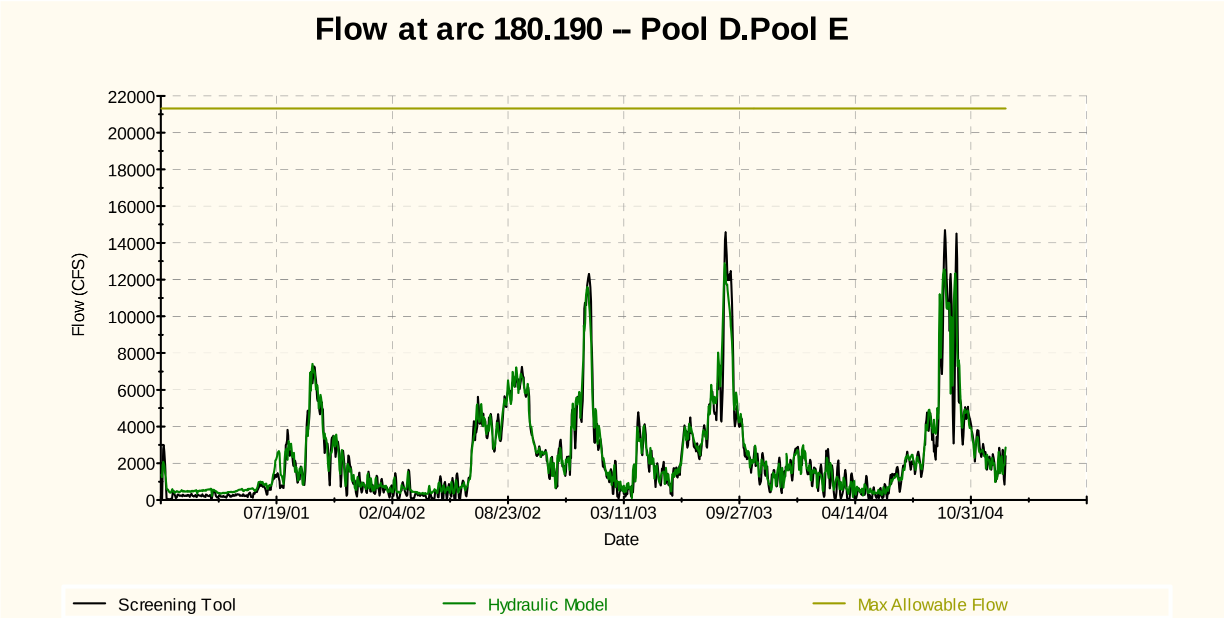

Figure 6-52: Flow between Pool D and Pool E through the S-65D Structure

6.2.12 Pool E

The Screening Tool-simulated HW tracks the Hydraulic Model stages closely (Figure 6-53). Since the Screening Tool does not model stages in Lake Okeechobee, the TW at the S-65E Structure is simply set to a constant value (about 10 feet) less than the HW. A technical memorandum (Earth Tech, 2007f) prepared to document the selection of the downstream boundary condition to be used by the Hydraulic Model during the evaluation of Base Conditions, showed that the TW stage of the S-65E Structure has limited influence on the flow calculations through the S-65E Structure.

The Screening Tool-simulated flows through the S-65E Structure track those of the Hydraulic Model-simulated flows (Figure 6-54). The maximum allowable flow is respected at all times (Figure 6-55). The net cumulative flow through Pool E is 107 k-af in the Screening Tool and 92 k-af in the Hydraulic Model, a difference of 16 percent of the total net outflow. It is important to emphasize that these percentages are calculated based on "net" outflows (flow through the S-65E Structure minus flow through the S-65D Structure). This difference is relatively low for all pools as compared to the total structure flow and it is even lower for Pool E. Therefore, calculating the percentage difference, based on net outflows, produces a value that is not representative of the fit seen in Figure 6-54.

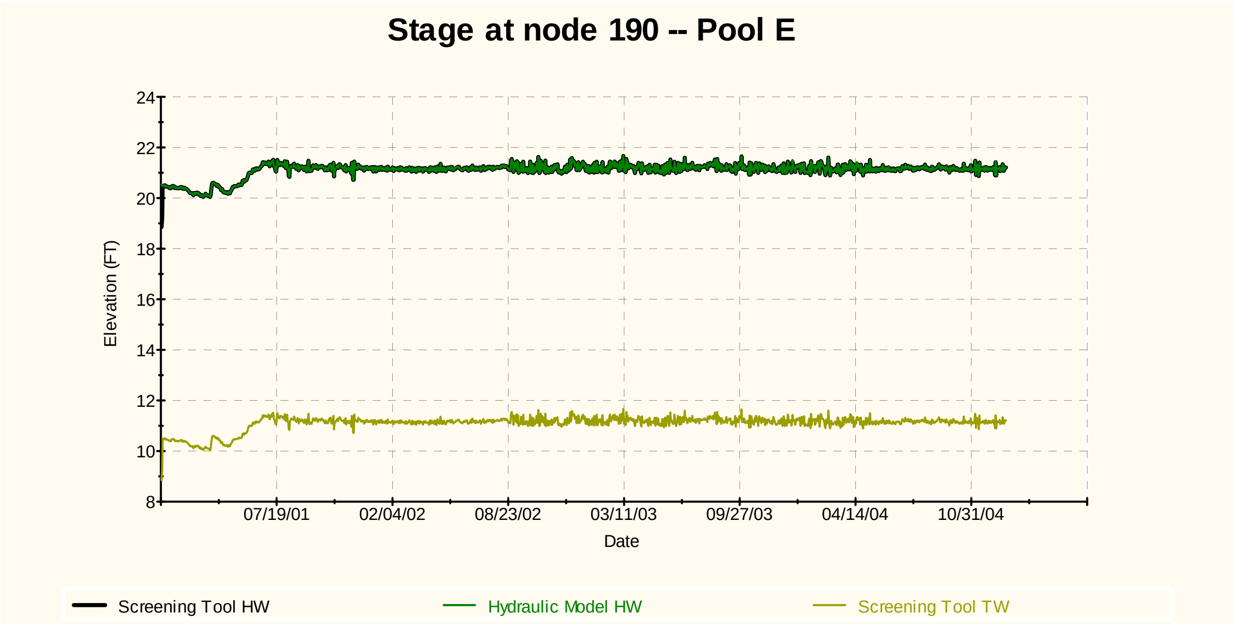

Figure 6-53: Headwater and tailwater elevations at the S-65E Structure

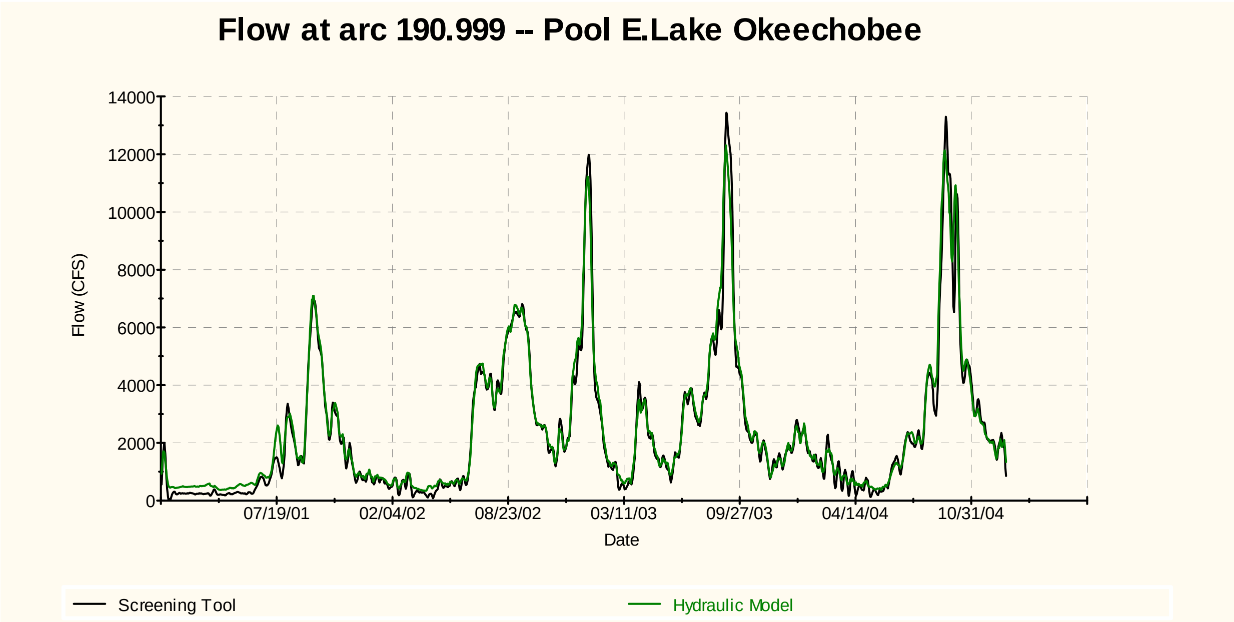

Figure 6-54: Flow between Pool E and Lake Okeechobee through the S-65E Structure, 7-day moving average

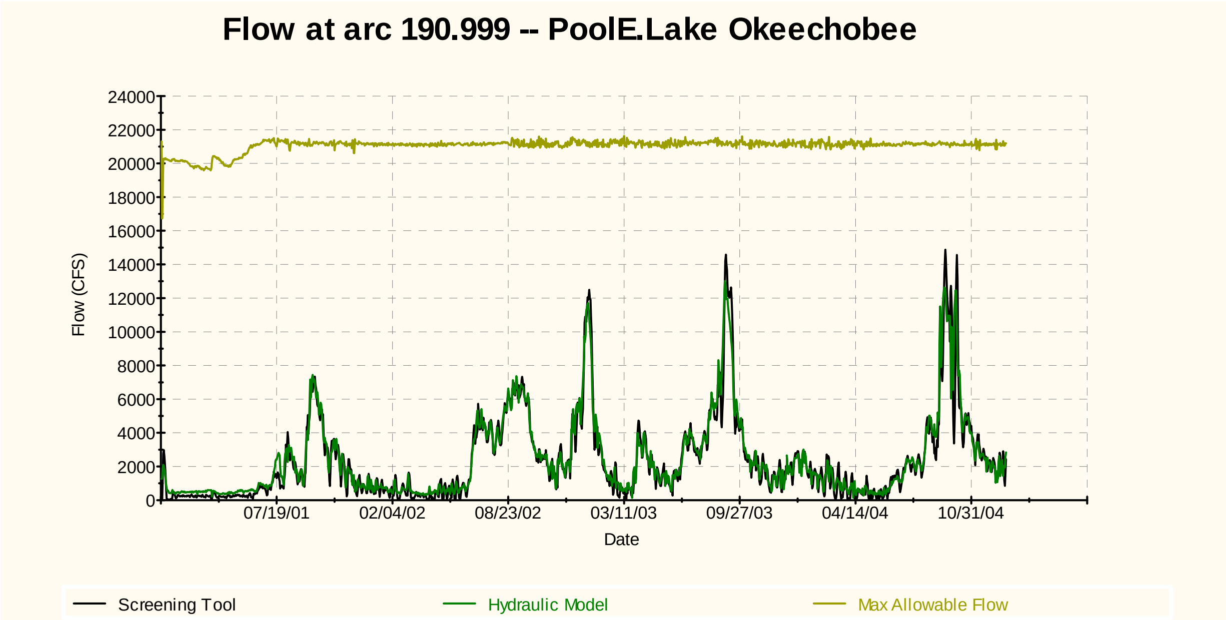

Figure 6-55: Flow between Pool E and Lake Okeechobee through the S-65E Structure

7 CONCLUSIONS

The approach taken to assess the Screening Tool, in the verification exercises presented in the report, was to set stages to the Hydraulic Model calibration values and compare flows through the structures. In general, the Screening Tool was able to follow the Hydraulic Model stages closely within its calibration period. Also it was demonstrated in previous documentation, (Earth Tech 2006a) that OKISS is able to simulate and duplicate the application of regulation schedules in the Kissimmee Upper Basin Lake. Errors associated with deviations from operating rules were not significant in differentiating between Alternative Plans. Most of the differences with observed stages were due to deviations from the effective operation criteria that were decided by operations. These operational deviations were not modeled in OKISS.

Given that the stages in the Screening Tool simulation were equal to the Hydraulic Model values throughout most of the calibration period, the resulting flows and interim stages could be used to address the three central goals of the history matching exercise:

1. Assess the ability of the Screening Tool to simulate stages at locations of interest within Pool B/C, which have been recently added to the model.

The Screening Tool successfully modeled stages at PC33 and PC62. The stages at Weirs 1 and 2 match closely, with the exception of slightly lower values in the Screening Tool at stages below 37 ft. Because the stages are a function of flow and flows in the Screening Tool tend to be "spiky" to maintain desired stages, the stages at Weir 2, Weir 1 and PC33 are also "spiky," vacillating more than two feet, at times, day-to-day. It was expected that the spikiness issues were to be resolved during the Evaluation of Base Conditions. Using running averages in evaluating performance measures may be an alternative to reduce the issues associated with these vacillations.

2. Assess the ability of the Screening Tool to simulate the hydraulics of the KB for a wider range of flows by extending the simulation period to that used in the Hydraulic Model calibration (2001-2004).

In the KUB, flows in the Hydraulic Model simulation were generally well-represented by the Screening Tool. The LKB flows also closely tracked the flows of the Hydraulic Model, with the exception of higher releases during flooding events in the Screening Tool. This suggests that to maintain the same stages, the Screening Tool requires higher flows than the Hydraulic Model. The effect of these differences was evaluated in the validation activities.

The flows in the two models would not match if different volumes of water are available to the basin. This can occur if the inflows do not mass balance with the Hydraulic Model output being used for comparison and SAE tables of the Screening Tool and LKB HW-Storage-Flow equations produce significantly different changes in storage than the internal end-of-day storages in the Hydraulic Model.

The magnitude of these two issues accumulated over the calibration period is summarized in Table 7-1. The mass balance was applied to the daily lateral inflow records, daily averages of 30-minute instantaneous flows and end-of-day storages, all produced by the Hydraulic Model. These results are shown in Columns 2 and 3.

The accumulated net outflow through each structure is a measure of the net effect of both issues. The net outflow is defined as the riverine outflow (flow through the outflow arc) minus the riverine inflow (flow through the inflow arc). These are shown in Column 4. By subtracting the two, the effect of the difference between changes in the Hydraulic Model's end-of-day storage and the Screening Tool's storage calculated from the Hydraulic Model's stages can be quantified (Column 5).

Table 7-1: Assessment of inflows, SAE tables and HW-Storage-Flow equations

Location	Accumulated imbalance in data extracted from Hydraulic Model Output		Difference in Net Outflow through Structure (af)[6]	Volume introduced by KUB SAE/LKB equations (col 2 - col 4) (af)
	Total (af)	% of net inflow		
Alligator	11645	3.70%	713	-10932
Myrtle	0	0%	541	541
Hart	0	0%	1661	1661
East Toho	7675	1.10%	9148	1473
Toho	3664	0.20%	10246	6582
Gentry	200	0.10%	262	62
Cypress, Hatch, Kiss	6622	0.20%	97032	90410
Pool A	31853	0.70%	37399	5546
Pool B/C	142699	2.20%	136962	-5737
Pool D	1785	0.03%	1690	-95
Pool E	16058	0.20%	15409	-649

Accumulated imbalance in the Hydraulic Model Output is small, as a percentage of the total inflow into the lake.

The error introduced by the SAE tables and LKB HW-Storage-flow equations is small, with the exception of lakes Cypress, Hatchineha and Kissimmee. The volumes at these locations in the two models could be compared, with changes to the SAE table made if appropriate.

The maximum allowable flows calculated by the Screening Tool appear to be appropriate with the exception of the S-59 Structure, where flows simulated by both models frequently exceed the maximum allowable. The maximum flows are also exceeded occasionally at the S-62 and S-61 Structures.

3. Assess the performance of recent updates to the Screening Tool, namely, an updated set of lateral inflows and HW-TW-Storage-Flow relationships in the LKB, both generated with the Hydraulic Model.

Lateral inflows used to drive the Screening Tool were obtained from the exchange between MIKE SHE and MIKE 11 in the AFET runs. There are two ways to obtain this set of lateral inflows: 1) Adding the terms that MIKE SHE uses to interact with MIKE 11 (Baseflow, drainage and overland flow) and 2) Performing a mass balance calculation where the lateral inflows are

[6] All numbers in this table were calculated for 1/1/2001-12/31/2004; the numbers in this column therefore differ from those in the text, which were calculated for the actual calibration period 11/1/2001-12/31/2004.

obtained based on inflows, outflows and delta storage. The second term produces more reliable results since they automatically balance the water budget. The first option is also influenced by the time step used to record the information, since MIKE SHE does not output cumulative values, then daily volumes have to be computed based on the average of instant values output by MIKE SHE at a pre-determined time step. As a check, the set of lateral inflows was calculated using both methods. Table 7-1 shows the difference between the two calculations of lateral inflows. Even though these differences were very low, it was decided to used the second method for all future runs since it proved to be more reliable and required the use of less resources. The HW-TW-Storage-Flow equations appear to produce comparable flows in the LKB, with the exception of peak flows in Pool B/C. The Screening Tool releases between 600 and 10,700 af more water during a flood event while maintaining the same stages for the S-65C Structure as the Hydraulic Model.

Based on these results, the following updates to the Screening Tool are recommended for consideration:

- Depending on the smoothness of the Base Conditions results, running average values can be used for stages at interim locations in Pool B/C in performance measure evaluations for both models. This is also recommended for TW values in the LKB if they are used in performance measures.
- Compare the maximum gate openings and flows determined in the Hydraulic Model with those in the Screening Tool at the S-59, S-62 and S-61 Structures to explain discrepancies.

7.1 Model Limitations

The following is a summary of potential limitations of the OKISS model as currently developed. The Study Team does not feel that these limitations adversely affect the ability of the OKISS model to be applied in the KBMOS. However, they may need to be addressed if the model is considered for another application:

- OKISS does not currently include the use of forecasts to reduce Zone A discharges to provide a “soft landing”. A transition rule exercise was performed where flood releases were transitioned to environmental releases within 14 days. The model and the results of this exercise are not documented in this report.
- The OKISS operating rules do not restrict gate openings to keep hydraulic jumps on the apron of the structures. This functionality is beyond the scope of the model and currently, there is no information available to build the required surrogates or functional tables.
- Groundwater storage in the basin. Inflows to the surface water network are specified from an outside source, which already takes into account the groundwater storage (AFET). AFET is an integrated model that simulates the saturated zone using state-of-the-art procedures. Including groundwater storage in OKISS may be possible, if needed in projects outside of the KBMOS. This effort would not only be cumbersome, but would also add uncertainties to a tool like OKISS that is intended to be a simple and quick decision tool.

8 REFERENCES

AECOM, 2009, KCOL Surface Water Supply Availability Study, Evaluation of "With Project" Base Conditions Report, prepared for SFWMD

Ansar, Matahel, Chen, Zhiming, Gonzalez, Juan A. and M.J. Chen, Technical Publication, SHDM Report, Dimensionless Flow Ratings at Kissimmee River Gated Spillways, December 2005, SFWMD

Earth Tech, 2005, Kissimmee Basin Hydrologic Assessment, Modeling, and Operations Planning Study, Proof of Concept Test Plan, prepared for SFWMD

Earth Tech, 2006a, Kissimmee Basin Hydrologic Assessment, Modeling, and Operations Planning Study, OASIS KCOL Model Report, prepared for SFWMD

Earth Tech, 2006b, Kissimmee Basin Hydrologic Assessment, Modeling, and Operations Planning Study, Screening Tool Technical Design Document, prepared for SFWMD

Earth Tech, 2006c, Kissimmee Basin Hydrologic Assessment, Modeling, and Operations Planning Study, OKISS Documentation, prepared for SFWMD

Earth Tech, 2006d, Kissimmee Basin Hydrologic Assessment, Modeling, and Operations Planning Study, Topographic Data Development and Implementation Technical Memorandum, prepared for SFWMD

Earth Tech, 2007a, Kissimmee Basin Hydrologic Assessment, Modeling, and Operations Planning Study, Phase II Model Development Work Plan Update, prepared for SFWMD.

Earth Tech, 2007b, Kissimmee Basin Hydrologic Assessment, Modeling, and Operations Planning Study, OKISS History Matching Summary Interim Technical Memorandum, prepared for SFWMD

Earth Tech, 2007c, Kissimmee Basin Hydrologic Assessment, Modeling, and Operations Planning Study, AFET Model Documentation / Calibration Report, prepared for SFWMD

Earth Tech, 2007d, Kissimmee Basin Hydrologic Assessment, Modeling, and Operations Planning Study, Summary of Base Conditions Report, prepared for SFWMD

Earth Tech, 2007e, Kissimmee Basin Hydrologic Assessment, Modeling, and Operations Planning Study, Documentation of the Performance Measure Evaluation Tool, prepared for SFWMD

Earth Tech, 2007f, Kissimmee Basin Hydrologic Assessment, Modeling, and Operations Planning Study, Evaluation of Downstream Boundary Conditions Technical Memorandum, prepared for SFWMD

Earth Tech | AECOM, 2008, KCOL Surface Water Supply Availability Study, AFET-W Calibration Report, prepared for SFWMD

Earth Tech | AECOM, 2008a, KCOL Surface Water Supply Availability Study, Summary of "With Project" Base Conditions, prepared for SFWMD

Hydrologics, Inc. 2006, User Manual OASIS with OCL

AECOM

Alligator Chain of Lakes looking south from Structure S-58
Photographs provided by South Florida Water Management District

APPENDIX A

Calculation of the KUB Storage – Area Tables Technical Memorandum

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August 2, 2006

To: DISTRIBUTION

Copy: Chris Carlson, SFWMD

From: Joe Helkowski, Guillermo Regalado

Subject: **Storage Area Evaluation of the Water Control Catchments in the KUB**

The initial objective of this task was to perform a comprehensive evaluation of lake storage area (SAE) for each of the major water bodies in the Kissimmee Upper Basin (KUB). The evaluation was them expanded to also include the lake's respective water control catchment (WCC). The SAE was carried out following a multi-step process. The following text is the methodology that was developed and applied to perform the storage area analysis.

In order to account for the variability in the contour of the land surface, the total sum of area was first calculated at increments of one-foot elevations from a 32-foot x 32-foot Digital Elevation Model DEM). The DEM consisted of elevation data from the USGS Nation Elevation Dataset (NED) for the land surface and USACE 1950 bathymetry data burned into the NED that represented the elevations for the following lake bottoms:

- Alligator Lake
- Brick Lake
- Lake Center
- Lake Cypress
- East Lake Tohopekaliga
- Fells Cove
- Lake Gentry
- Lake Hart
- Lake Hatchineha
- Lake Jackson
- Lake Joel
- Lake Kissimmee
- Lake Lizzie
- Lost Lake (Coon Lake)
- Lake Marian
- Lake Mary Jane
- Lake Myrtle

- Lake Preston
- Lake Rosalie
- Tiger Lake
- Lake Tohopekaliga
- Trout Lake
- Lake Weohyakapka

Using ArcGIS 9.1, zonal averages were calculated for each of the WCC as defined by the WCC boundary shapefile for the UKISS 2005 version provided by the Kissimmee Division, South Florida Water Management District (SFWMD). The total sum of areas for each WCU at each of the one-foot intervals were next imported into Microsoft Excel and sorted from the lowest elevation interval to the highest. In the last step, the final storage area for the entire elevation range of each WCC was then ascertained by accumulating the total sum of area at each one-foot interval in an ascending order. For example, the total storage area for an elevation at 30 feet within a WCC was the sum all one-foot interval areas at the lower elevations plus its own. The final storage areas at the one-foot interval for each of the WCCs are located in the following tables.

The method used to calculate Storage Area Elevation tables agrees with the methodology used to extract lateral inflows from the AFET (Hydraulic Model). Lateral Inflows are extracted at the interface between MIKE SHE and MIKE 11, therefore every drop of water that is made available to the MIKE 11 is considered part of the lateral inflows. MIKE 11 is based exclusively on above ground geometry, where groundwater storage is not used.

.

Alligator Lake

Storage area accumulated by ascending elevation

Elevation (ft)	Storage Area (acres)
32	5.8
33	21.2
34	30.5
35	40.0
36	48.2
37	55.7
38	65.4
39	77.0
40	173.1
41	219.0
42	259.2
43	300.0
44	345.6
45	390.2
46	432.6
47	478.2
48	525.0
49	576.3
50	642.8
51	727.2
52	925.8
53	1,125.6
54	1,371.1
55	1,692.9
56	2,032.9
57	2,317.7
58	2,539.1
59	2,758.6
60	2,981.8
61	3,116.8
62	3,220.4
63	3,326.7
64	3,775.4
65	4,966.9
66	5,647.1
67	6,353.7
68	7,057.8
69	7,781.4
70	8,937.9
71	10,359.6
72	10,978.3
73	11,560.6
74	12,298.4
75	13,604.8
76	15,434.6
77	16,473.8
78	16,969.4
79	17,145.7
80	17,165.0

Brick Lake

Storage area accumulated by ascending elevation

Elevation (ft)	Storage Area (acres)
32	0.0
33	0.0
34	0.0
35	0.0
36	0.0
37	0.0
38	0.0
39	0.0
40	0.0
41	0.0
42	0.0
43	39.7
44	71.5
45	91.6
46	109.5
47	130.1
48	155.3
49	185.8
50	221.4
51	260.3
52	316.1
53	352.1
54	389.6
55	426.9
56	457.3
57	488.4
58	523.5
59	569.7
60	606.8
61	651.8
62	878.7
63	1,119.0
64	1,291.7
65	1,432.6
66	1,551.4
67	1,675.3
68	2,040.6
69	2,304.0
70	2,494.4
71	2,660.6
72	2,773.4
73	2,875.6
74	2,982.0
75	3,033.2
76	3,063.0
77	3,090.4
78	3,127.5
79	3,133.5
80	3,133.5

Lake Center

Storage area accumulated by ascending elevation

Elevation (ft)	Storage Area (acres)
32	0.0
33	0.0
34	0.0
35	0.0
36	0.0
37	0.0
38	0.0
39	0.0
40	0.0
41	0.0
42	0.0
43	0.0
44	0.0
45	0.0
46	0.0
47	0.0
48	0.0
49	0.0
50	0.0
51	0.0
52	0.0
53	0.0
54	120.9
55	160.9
56	201.8
57	230.2
58	261.0
59	300.0
60	334.3
61	361.2
62	383.8
63	410.0
64	556.2
65	676.9
66	804.6
67	1,061.4
68	1,496.3
69	2,562.9
70	3,693.6
71	4,908.2
72	5,437.1
73	5,829.6
74	6,084.7
75	6,260.5
76	6,437.6
77	6,567.0
78	6,662.2
79	6,754.0
80	6,754.0

Lake Cypress

Storage area accumulated by ascending elevation

Elevation (ft)	Storage Area (acres)
32	0.0
33	0.0
34	0.0
35	0.0
36	0.0
37	0.0
38	0.0
39	0.0
40	0.0
41	0.0
42	0.0
43	281.6
44	1,443.9
45	1,986.0
46	2,495.0
47	2,831.5
48	3,079.6
49	3,410.2
50	3,665.9
51	3,876.0
52	4,513.3
53	6,427.0
54	9,956.8
55	13,281.4
56	16,060.1
57	19,505.5
58	21,209.5
59	22,708.2
60	24,126.4
61	25,397.1
62	26,454.3
63	27,507.1
64	28,842.2
65	30,076.8
66	31,671.3
67	32,242.3
68	32,519.8
69	32,690.7
70	32,815.9
71	32,890.1
72	32,920.8
73	32,933.8
74	32,933.8
75	32,933.8
76	32,933.8
77	32,933.8
78	32,933.8
79	32,933.8
80	32,933.8

East Lake Tohopekaliga
Storage area accumulated by ascending elevation

Elevation (ft)	Storage Area (acres)
32	0.0
33	0.0
34	0.0
35	0.0
36	0.0
37	0.0
38	0.0
39	0.0
40	0.0
41	297.1
42	1,708.7
43	2,214.5
44	2,752.8
45	4,134.2
46	5,122.4
47	6,019.2
48	6,741.2
49	7,417.4
50	7,973.3
51	8,472.2
52	8,929.2
53	9,569.3
54	10,105.4
55	10,514.5
56	10,984.7
57	11,324.5
58	11,666.7
59	12,002.0
60	12,339.2
61	12,689.6
62	13,083.1
63	13,564.7
64	14,182.2
65	14,842.4
66	15,475.3
67	16,083.6
68	16,588.9
69	17,106.6
70	17,845.3
71	18,621.3
72	19,619.6
73	20,842.8
74	22,172.2
75	23,248.8
76	24,515.7
77	25,782.2
78	26,734.3
79	27,829.8
80	28,690.6

Fells Cove

Storage area accumulated by ascending elevation

Elevation (ft)	Storage Area (acres)
32	0.0
33	0.0
34	0.0
35	0.0
36	0.0
37	0.0
38	0.0
39	0.0
40	0.0
41	0.0
42	0.0
43	0.0
44	0.0
45	0.0
46	0.0
47	0.0
48	0.0
49	219.0
50	305.8
51	354.2
52	401.2
53	457.5
54	569.3
55	690.6
56	967.4
57	1,099.2
58	1,231.6
59	1,375.6
60	1,548.4
61	1,733.6
62	2,049.9
63	2,518.4
64	2,991.2
65	3,387.7
66	3,677.2
67	3,927.4
68	4,217.6
69	4,496.0
70	4,816.0
71	4,995.5
72	5,201.3
73	5,407.0
74	5,626.8
75	5,829.0
76	6,053.3
77	6,493.8
78	6,919.3
79	7,579.2
80	8,459.3

Lake Gentry
Storage area accumulated by ascending elevation

Elevation (ft)	Storage Area (acres)
32	0.0
33	0.0
34	0.0
35	0.0
36	0.0
37	0.0
38	0.0
39	0.0
40	0.0
41	0.0
42	0.0
43	0.0
44	36.7
45	189.5
46	274.8
47	343.3
48	422.6
49	508.9
50	673.9
51	788.3
52	884.2
53	974.0
54	1,071.7
55	1,182.9
56	1,301.6
57	1,406.5
58	1,514.4
59	1,596.0
60	1,680.1
61	1,758.9
62	2,134.8
63	2,490.1
64	2,934.5
65	4,554.5
66	6,082.2
67	8,008.8
68	9,454.5
69	10,650.9
70	12,684.1
71	19,014.4
72	20,057.4
73	21,301.0
74	22,873.0
75	23,661.1
76	24,463.5
77	25,118.8
78	25,761.2
79	26,725.2
80	28,208.0

Lake Hart

Storage area accumulated by ascending elevation

Elevation (ft)	Storage Area (acres)
32	0.0
33	0.0
34	0.0
35	0.0
36	0.0
37	0.0
38	0.0
39	0.0
40	27.4
41	42.1
42	51.7
43	63.3
44	77.4
45	105.0
46	154.2
47	238.1
48	446.3
49	540.2
50	687.4
51	857.0
52	992.1
53	1,099.7
54	1,209.1
55	1,311.8
56	1,402.4
57	1,511.1
58	1,646.0
59	1,880.2
60	2,221.1
61	2,434.4
62	2,573.7
63	2,803.5
64	3,155.8
65	3,495.9
66	3,888.9
67	4,399.7
68	4,776.2
69	5,222.8
70	5,760.8
71	6,151.2
72	6,533.6
73	7,030.8
74	7,673.3
75	8,334.4
76	8,875.8
77	9,475.7
78	10,472.4
79	11,754.1
80	13,199.9

Lake Hatchineha

Storage area accumulated by ascending elevation

Elevation (ft)	Storage Area (acres)
32	0.0
33	0.0
34	0.0
35	0.0
36	0.0
37	0.0
38	0.0
39	0.0
40	0.0
41	76.4
42	90.0
43	1,841.2
44	2,536.3
45	3,403.6
46	3,984.2
47	4,547.9
48	5,437.4
49	6,017.6
50	6,491.3
51	6,949.4
52	9,555.0
53	12,991.0
54	15,555.0
55	16,981.3
56	18,441.5
57	19,714.8
58	20,743.3
59	21,632.6
60	22,807.1
61	23,878.3
62	24,501.5
63	25,089.9
64	25,359.0
65	25,508.3
66	25,703.0
67	25,801.1
68	25,807.9
69	25,813.9
70	25,819.9
71	25,826.2
72	25,832.6
73	25,839.0
74	25,845.9
75	25,852.5
76	25,859.5
77	25,866.6
78	25,874.0
79	25,883.0
80	25,896.3

Lake Jackson

Storage area accumulated by ascending elevation

Elevation (ft)	Storage Area (acres)
32	0.0
33	0.0
34	0.0
35	0.0
36	0.0
37	0.0
38	0.0
39	0.0
40	0.0
41	0.0
42	0.0
43	0.0
44	0.0
45	0.0
46	0.0
47	57.0
48	198.0
49	731.1
50	999.0
51	1,123.6
52	1,251.5
53	1,383.6
54	1,523.3
55	1,782.4
56	2,106.9
57	2,517.9
58	2,892.6
59	3,280.5
60	4,433.1
61	5,350.0
62	6,283.9
63	6,854.8
64	7,144.0
65	7,474.7
66	7,893.0
67	8,547.9
68	9,176.4
69	9,881.7
70	10,856.4
71	12,975.2
72	13,873.1
73	14,951.0
74	17,127.3
75	18,035.8
76	19,051.5
77	20,684.1
78	21,438.3
79	22,320.8
80	23,836.9

Lake Joel
Storage area accumulated by ascending elevation

Elevation (ft)	Storage Area (acres)
32	0.0
33	0.0
34	0.0
35	0.0
36	0.0
37	0.0
38	0.0
39	0.0
40	0.0
41	0.0
42	0.0
43	0.0
44	0.0
45	0.0
46	0.0
47	0.0
48	0.0
49	0.0
50	0.0
51	0.0
52	0.0
53	140.7
54	170.3
55	207.8
56	254.4
57	304.6
58	359.6
59	427.4
60	484.5
61	530.5
62	797.2
63	956.3
64	1,112.4
65	1,233.3
66	1,414.0
67	1,666.1
68	1,918.8
69	2,216.0
70	2,861.3
71	3,037.4
72	3,160.9
73	3,345.4
74	3,756.7
75	4,123.4
76	4,182.4
77	4,182.4
78	4,182.4
79	4,182.4
80	4,182.4

Lake Kissimmee

Storage area accumulated by ascending elevation

Elevation (ft)	Storage Area (acres)
32	0.0
33	0.0
34	0.0
35	0.0
36	1,634.8
37	2,285.4
38	3,046.3
39	3,923.3
40	6,135.6
41	11,454.2
42	13,492.5
43	15,803.6
44	18,406.2
45	24,293.7
46	27,065.3
47	28,433.8
48	29,829.3
49	31,319.8
50	33,058.0
51	40,227.0
52	43,143.2
53	45,665.9
54	48,659.9
55	52,224.0
56	55,867.5
57	61,355.5
58	65,308.0
59	68,829.8
60	72,903.5
61	78,350.7
62	81,483.4
63	84,741.7
64	89,210.9
65	90,725.7
66	91,982.6
67	93,407.1
68	94,441.6
69	95,456.5
70	96,471.8
71	97,539.7
72	98,241.7
73	98,865.4
74	99,539.5
75	100,192.1
76	100,916.6
77	101,605.6
78	102,036.7
79	102,451.9
80	103,191.4

Lake Lizzie

Storage area accumulated by ascending elevation

Elevation (ft)	Storage Area (acres)
32	0.0
33	0.0
34	0.0
35	0.0
36	0.0
37	0.0
38	0.0
39	0.0
40	0.0
41	0.0
42	0.0
43	38.3
44	56.4
45	70.4
46	80.6
47	90.9
48	102.5
49	113.8
50	126.8
51	166.0
52	201.7
53	238.8
54	276.9
55	318.4
56	366.0
57	420.8
58	520.7
59	623.2
60	699.6
61	731.4
62	757.1
63	784.3
64	897.4
65	1,292.8
66	1,572.5
67	1,869.4
68	2,076.2
69	2,239.7
70	2,690.5
71	2,888.2
72	3,076.4
73	3,312.7
74	3,696.6
75	3,789.5
76	3,929.5
77	4,102.9
78	4,206.0
79	4,227.3
80	4,245.4

Lost Lake (Coon)
Storage area accumulated by ascending elevation

Elevation (ft)	Storage Area (acres)
32	0.0
33	0.0
34	0.0
35	0.0
36	0.0
37	0.0
38	0.0
39	0.0
40	0.0
41	0.0
42	0.0
43	0.0
44	0.0
45	0.0
46	0.0
47	0.0
48	0.0
49	0.0
50	9.1
51	14.7
52	20.9
53	28.9
54	37.3
55	49.7
56	64.8
57	80.6
58	93.7
59	105.7
60	115.5
61	123.4
62	131.4
63	140.0
64	271.2
65	372.1
66	442.7
67	539.4
68	582.8
69	600.5
70	600.5
71	600.5
72	600.5
73	600.5
74	600.5
75	600.5
76	600.5
77	600.5
78	600.5
79	600.5
80	600.5

Lake Marian

Storage area accumulated by ascending elevation

Elevation (ft)	Storage Area (acres)
32	0.0
33	0.0
34	0.0
35	0.0
36	0.0
37	0.0
38	0.0
39	0.0
40	0.0
41	0.0
42	138.1
43	613.2
44	838.3
45	1,186.4
46	1,901.4
47	2,460.5
48	2,801.1
49	3,134.9
50	3,459.9
51	3,696.6
52	3,885.2
53	4,043.1
54	4,195.0
55	4,351.9
56	4,519.3
57	4,671.8
58	4,785.9
59	4,893.4
60	6,908.2
61	8,258.7
62	9,172.2
63	10,263.8
64	12,617.3
65	14,583.0
66	16,471.9
67	19,226.2
68	22,635.1
69	24,937.4
70	29,349.3
71	33,798.8
72	35,393.6
73	36,791.7
74	36,909.6
75	36,974.2
76	37,036.2
77	37,036.2
78	37,036.2
79	37,036.2
80	37,036.2

Lake Mary Jane

Storage area accumulated by ascending elevation

Elevation (ft)	Storage Area (acres)
32	0.0
33	0.0
34	0.0
35	0.0
36	0.0
37	0.0
38	0.0
39	0.0
40	0.0
41	0.0
42	0.0
43	0.0
44	0.0
45	0.0
46	0.0
47	0.0
48	0.0
49	0.0
50	104.9
51	276.2
52	390.1
53	485.5
54	575.9
55	662.2
56	759.9
57	900.5
58	1,024.2
59	1,112.8
60	1,175.3
61	1,376.2
62	1,549.4
63	1,882.1
64	2,388.2
65	2,986.3
66	3,632.6
67	4,434.4
68	5,040.7
69	5,821.7
70	7,296.3
71	7,633.1
72	7,802.1
73	7,917.9
74	7,940.4
75	7,957.0
76	7,971.3
77	7,980.6
78	7,980.6
79	7,980.6
80	7,980.6

Lake Myrtle

Storage area accumulated by ascending elevation

Elevation (ft)	Storage Area (acres)
32	0.0
33	0.0
34	0.0
35	0.0
36	0.0
37	0.0
38	0.0
39	0.0
40	0.0
41	0.0
42	0.0
43	0.0
44	0.0
45	0.0
46	0.0
47	0.0
48	0.0
49	0.0
50	0.0
51	0.0
52	71.0
53	82.7
54	95.3
55	109.3
56	123.4
57	138.0
58	152.2
59	169.6
60	188.6
61	235.6
62	714.5
63	1,117.3
64	1,696.4
65	2,472.7
66	3,060.6
67	3,673.0
68	4,037.7
69	4,386.2
70	4,710.8
71	4,802.3
72	4,805.8
73	4,810.4
74	4,821.2
75	4,841.2
76	4,862.5
77	4,862.5
78	4,862.5
79	4,862.5
80	4,862.5

Lake Preston

Storage area accumulated by ascending elevation

Elevation (ft)	Storage Area (acres)
32	0.0
33	0.0
34	0.0
35	0.0
36	0.0
37	0.0
38	0.0
39	0.0
40	0.0
41	0.0
42	0.0
43	0.0
44	0.0
45	0.0
46	0.0
47	0.0
48	0.0
49	0.0
50	0.0
51	0.0
52	132.3
53	220.2
54	299.7
55	364.0
56	418.7
57	465.1
58	512.2
59	567.0
60	632.4
61	782.7
62	1,238.2
63	1,424.1
64	1,594.0
65	1,800.9
66	2,014.4
67	2,333.9
68	2,952.2
69	3,441.9
70	4,311.9
71	4,564.8
72	4,763.2
73	4,866.8
74	4,884.3
75	4,889.3
76	4,893.6
77	4,893.6
78	4,893.6
79	4,893.6
80	4,893.6

Lake Rosalie

Storage area accumulated by ascending elevation

Elevation (ft)	Storage Area (acres)
32	0.0
33	0.0
34	0.0
35	0.0
36	0.0
37	0.0
38	812.4
39	1,217.9
40	1,677.8
41	2,140.0
42	2,329.3
43	2,519.1
44	2,713.9
45	2,921.9
46	3,134.0
47	3,355.6
48	3,611.7
49	3,866.4
50	4,128.0
51	4,294.9
52	4,441.1
53	4,646.4
54	5,216.1
55	5,750.3
56	6,224.7
57	6,931.8
58	7,919.4
59	8,733.0
60	10,074.9
61	11,048.9
62	12,778.2
63	13,518.6
64	14,186.9
65	15,151.9
66	15,850.8
67	16,479.7
68	16,845.7
69	17,204.6
70	17,720.4
71	17,976.3
72	18,195.3
73	18,332.6
74	18,426.9
75	18,512.3
76	18,591.7
77	18,664.8
78	18,734.1
79	18,799.0
80	18,861.4

Tiger Lake

Storage area accumulated by ascending elevation

Elevation (ft)	Storage Area (acres)
32	0.0
33	0.0
34	0.0
35	0.0
36	0.0
37	0.0
38	0.0
39	0.0
40	0.0
41	0.0
42	682.6
43	1,183.1
44	1,386.4
45	1,553.2
46	1,690.4
47	1,837.6
48	1,981.0
49	2,153.3
50	2,448.6
51	2,694.8
52	2,905.0
53	3,130.6
54	3,410.4
55	3,800.9
56	4,110.4
57	4,449.5
58	4,858.3
59	5,267.3
60	5,899.7
61	6,351.8
62	6,915.5
63	7,608.7
64	7,883.1
65	8,231.4
66	8,736.5
67	9,830.0
68	10,309.1
69	10,532.9
70	10,797.7
71	10,935.7
72	11,084.9
73	11,287.5
74	11,394.0
75	11,504.8
76	11,624.6
77	11,733.9
78	11,769.5
79	11,790.6
80	11,808.8

Tiger Tohopekaliga
Storage area accumulated by ascending elevation

Elevation (ft)	Storage Area (acres)
32	0.0
33	0.0
34	0.0
35	0.0
36	0.0
37	0.0
38	0.0
39	0.0
40	0.0
41	0.0
42	0.0
43	285.3
44	1,445.7
45	4,033.8
46	6,607.1
47	8,568.2
48	10,750.0
49	13,208.5
50	15,228.3
51	16,398.4
52	17,539.6
53	19,451.7
54	20,801.5
55	22,018.5
56	23,254.8
57	24,681.7
58	26,127.0
59	27,945.6
60	29,832.5
61	31,657.8
62	33,787.6
63	36,376.0
64	39,704.5
65	44,350.7
66	48,819.5
67	52,438.2
68	55,507.0
69	58,568.8
70	61,141.1
71	63,392.9
72	65,264.4
73	67,622.1
74	70,804.1
75	72,644.9
76	74,284.0
77	75,304.0
78	76,779.3
79	78,064.0
80	78,564.7

Trout Lake

Storage area accumulated by ascending elevation

Elevation (ft)	Storage Area (acres)
32	0.0
33	0.0
34	0.0
35	0.0
36	0.0
37	0.0
38	0.0
39	0.0
40	0.0
41	0.0
42	0.0
43	0.0
44	0.0
45	0.0
46	0.0
47	0.0
48	0.0
49	0.0
50	0.0
51	10.8
52	21.0
53	34.3
54	76.3
55	126.9
56	153.1
57	175.6
58	196.3
59	216.9
60	240.3
61	260.6
62	307.3
63	432.1
64	609.2
65	774.5
66	962.7
67	1,160.6
68	1,312.3
69	1,467.1
70	1,656.3
71	1,656.3
72	1,656.3
73	1,656.3
74	1,656.3
75	1,656.3
76	1,656.3
77	1,656.3
78	1,656.3
79	1,656.3
80	1,656.3

Lake Weohyakapka
Storage area accumulated by ascending elevation

Elevation (ft)	Storage Area (acres)
32	0.0
33	0.0
34	0.0
35	0.0
36	0.0
37	0.0
38	0.0
39	0.0
40	0.0
41	0.0
42	0.0
43	0.0
44	0.0
45	0.0
46	0.0
47	0.0
48	0.0
49	0.0
50	0.0
51	848.2
52	2,276.7
53	3,506.8
54	4,526.0
55	5,629.2
56	6,167.3
57	6,733.1
58	6,897.5
59	7,041.6
60	7,259.0
61	7,443.8
62	7,666.0
63	8,475.8
64	9,291.7
65	10,414.9
66	11,645.2
67	12,645.8
68	13,338.8
69	13,953.5
70	14,926.0
71	15,369.6
72	15,812.3
73	16,250.0
74	16,727.5
75	17,271.6
76	17,870.8
77	18,745.9
78	19,637.4
79	21,262.7
80	22,663.8

APPENDIX B

MIKE 11 Evaluations of the LKB to Extract HW-TW-Q and TW-V-Q Lookup Tables

August 2, 2007

TO: Guillermo Regalado / Earth Tech

BY: Hong Xu / A.D.A. Engineering, Inc.
Brent Whitfield / A.D.A. Engineering, Inc.
Alex Vazquez / A.D.A. Engineering, Inc.

SUBJECT: Work Order No. CN040920-WO02

Kissimmee Basin Hydrologic Assessment, Modeling, and Operations Planning, Phase II- Development and Implementation of Modeling Tools and Recommendation of Alternative Operating Criteria

TASK: Task 2.4.2.5 Update to Post-Phase 1 OKISS Model

B-1) Introduction

To calculate and simulate the storage capacity and headwater for the pools of the Lower Kissimmee Basin, 288 computer model runs were made using MIKE 11 modeling software. The Final AFET Calibration Model (Run 99) which represents the Post-Phase I KRRP conditions was used in this analysis. The MIKE 11 portion of the AFET Run 99 was extracted from AFET. Only the MIKE 11 portion was used, since the flows and boundary conditions used in the analysis were assigned according to the case being simulates as explained further in this document. The MIKE 11 model was subdivided into four sub-models. Each sub-model represents one pool. Consequently, each pool was analyzed individually. Pool A is from Structure S-65 to Structure S-65A, Pool BC is from Structure S-65A to Structure S-65C, Pool D is from Structure S-65C to Structure S-65D and Pool E is from Structure S-65D to Structure S-65E. These were set up in MIKE 11 network input files for each pool. The analyses and results provided in this document correspond to the existing conditions (post phase I restoration).

The boundary conditions used to run the MIKE 11 model (upstream flow and downstream elevation) were obtained from the SFWMD daily recording database by river station. Different upstream flow values and downstream elevation values were chosen for every pool. Table B-1 lists upstream flow and downstream elevation values used by pool. These values were used as input for MIKE 11 boundary input files.

In this Technical Memorandum, TW refers to the tailwater of the reach of Pool and HW refers to the headwater of the reach of pool. This nomenclature is opposite to the nomenclature use to define flow through structures, since the element being analyzed is the pool and not the structure.

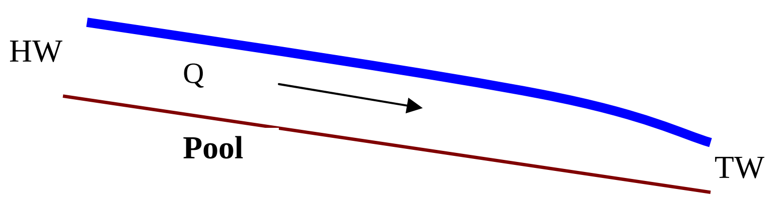

Table B-1: Upstream flow and downstream elevation values used by pools (Input Table)

Pool A		Pool BC		Pool D		Pool E	
Tw (ft)	Q (cfs)	Tw (ft)	Q (cfs)	Tw (ft)	Q (cfs)	Tw (ft)	Q (cfs)
40.50	600	31.50	0	22.00	100	15.75	100
43.50	650	32.00	1000	25.00	950	18.75	900
46.25	1250	33.00	2000	26.75	1750	21.00	1700
48.50	2650	34.00	3000	27.25	4700	22.00	5000
50.75	4050	35.00	4000	27.75	7650	23.00	8250
53.75	5450	36.00	6000	29.25	10600	24.50	11500
	6850	37.00	8000	30.75	13550	26.00	14750
	8250	38.00	10000		16500		18000
	15100		12000		20100		21000
	22000		15000		24000		24000
			20000				

B-2) Results

The results obtained for each individual pool are summarized in following tables and figures. For pool A: Figures B-1 and B-2 and Tables B-2 and B-3; for pool D: Figures B-3 and B-4 and Tables B-4 and B-5; and for pool E: Figures B-5 and B-6 and Tables B-6 and B-7; and for pool BC: Figures B-7 and B-8 and Tables B-8 and B-9. For each pool, there are two tables and figures associated with it: one is S-TW-Q (storage-tailwater-flow) and the other is HW-TW-Q (headwater-tailwater-flow).

For pool B-C, the four locations of the performance evaluation sites were selected to develop HW-TW-Q (headwater-tailwater-flow) look up tables. The MIKE 11 chainage corresponding to the locations for these sites are as follows:

Site 1: Weir 2 - Located at chainage 29088 meter on C-38;

Site 2: Weir 1 - Located at chainage 33115.50 meter on C-38;

Site 3: PC 62 - Located at chainage 6096 meter on Kissimmee River;

Site 4: PC 33 - Located at chainage 19581.4 meter on Kissimmee River.

The results are summarized in the following tables and figures. For performance evaluation site 1: Figure B-9 and Table B-10; for performance evaluation site 2: Figure B-10 and Table B-11; for performance evaluation site 3: Figure B-11 and Table B-12; and for performance evaluation site 4: Figure B-12 and Table B-13.

Table B-2: Pool A Storage Volume

	Storage Volume (acre-ft)					
Q(cfs\H ft)	**40.50**	**43.50**	**46.25**	**48.50**	**50.75**	**53.75**
100	4870	5977	7235	10949	16126	23316
650	4878	5981	7237	10951	16127	23317
1250	4888	5987	7240	10957	16132	23319
2650	4919	6008	7251	10985	16152	23332
4050	4961	6037	7271	11032	16187	23354
5450	5012	6077	7307	11100	16236	23384
6850	5072	6125	7349	11188	16300	23424
8250	5144	6183	7407	11297	16377	23472
15100	5626	6594	7981	12121	16953	23834
22000	6288	7179	9628	13378	17833	24398

Figure B-1: Pool A Storage Volume

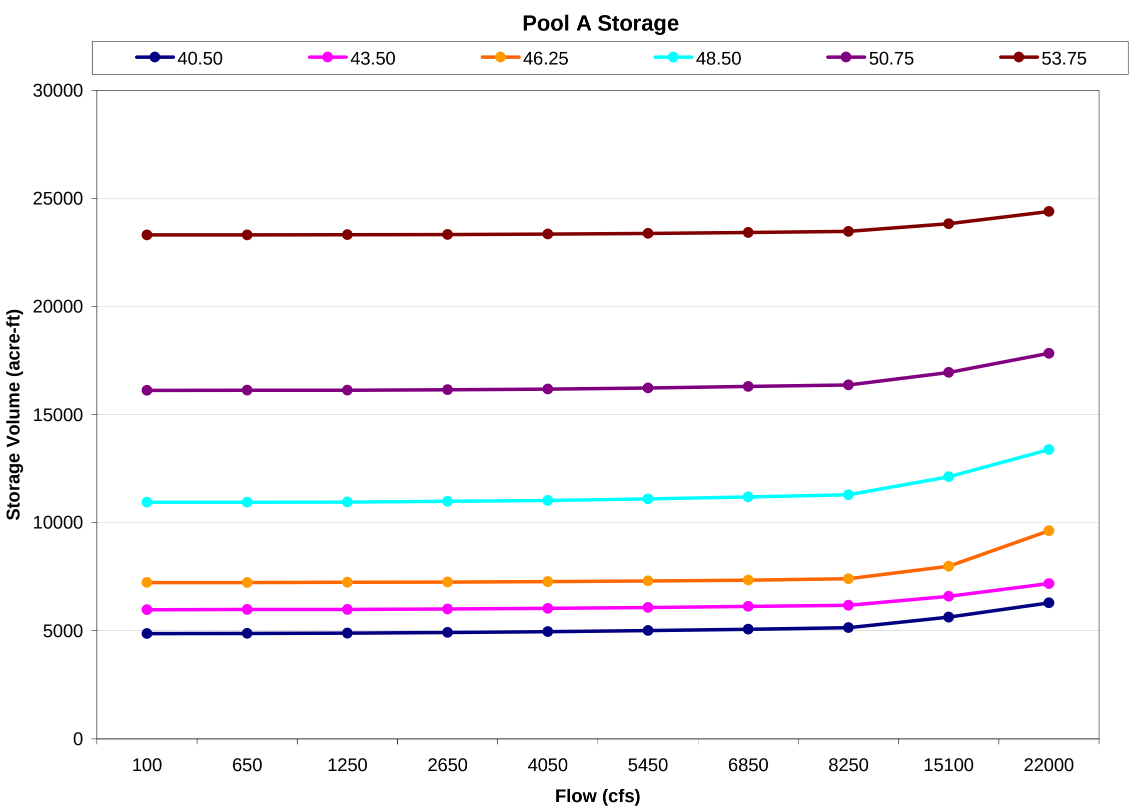

Table B-3: Pool A Headwater

	Headwater (ft)					
Q(cfs\H ft)	**40.50**	**43.50**	**46.25**	**48.50**	**50.75**	**53.75**
100	40.52	43.51	46.26	48.49	50.75	53.74
650	40.55	43.52	46.27	48.49	50.76	53.74
1250	40.61	43.55	46.28	48.50	50.76	53.74
2650	40.78	43.63	46.34	48.53	50.78	53.76
4050	41.01	43.76	46.43	48.59	50.82	53.78
5450	41.29	43.93	46.55	48.67	50.88	53.82
6850	41.63	44.14	46.70	48.78	50.94	53.86
8250	42.00	44.39	46.87	48.90	51.03	53.91
15100	44.48	46.02	48.05	49.77	51.63	54.30
22000	46.81	48.16	49.64	50.95	52.51	54.88

Figure B-2: Pool A Headwater

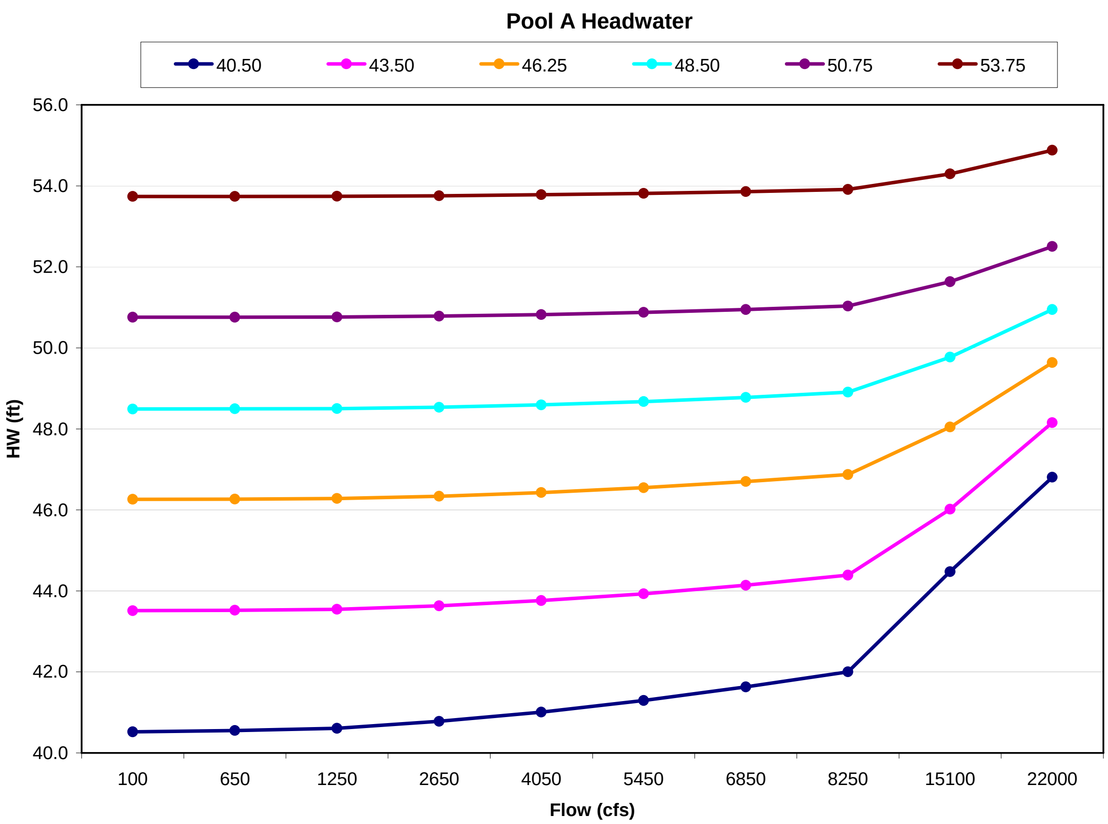

Table B-4: Pool D Storage Volume

	Storage Volume (acre-ft)						
Q(cfs\H ft)	**22.00**	**25.00**	**26.75**	**27.25**	**27.75**	**29.25**	**30.75**
100	7483	9115	10570	11144	12040	16276	22517
950	7491	9123	10579	11151	12052	16302	22556
1750	7501	9126	10587	11166	12062	16322	22583
4700	7566	9171	10638	11219	12119	16417	22706
7650	7678	9247	10703	11309	12211	16564	22887
10600	7835	9358	10798	11443	12349	16770	23135
13550	8027	9500	10935	11612	12556	17049	23463
16500	8250	9676	11116	11824	12823	17398	23882
20100	8558	9923	11374	12184	13248	17942	24491
24000	8969	10235	11783	12678	13839	18678	25270

Figure B-3: Pool D Storage Volume

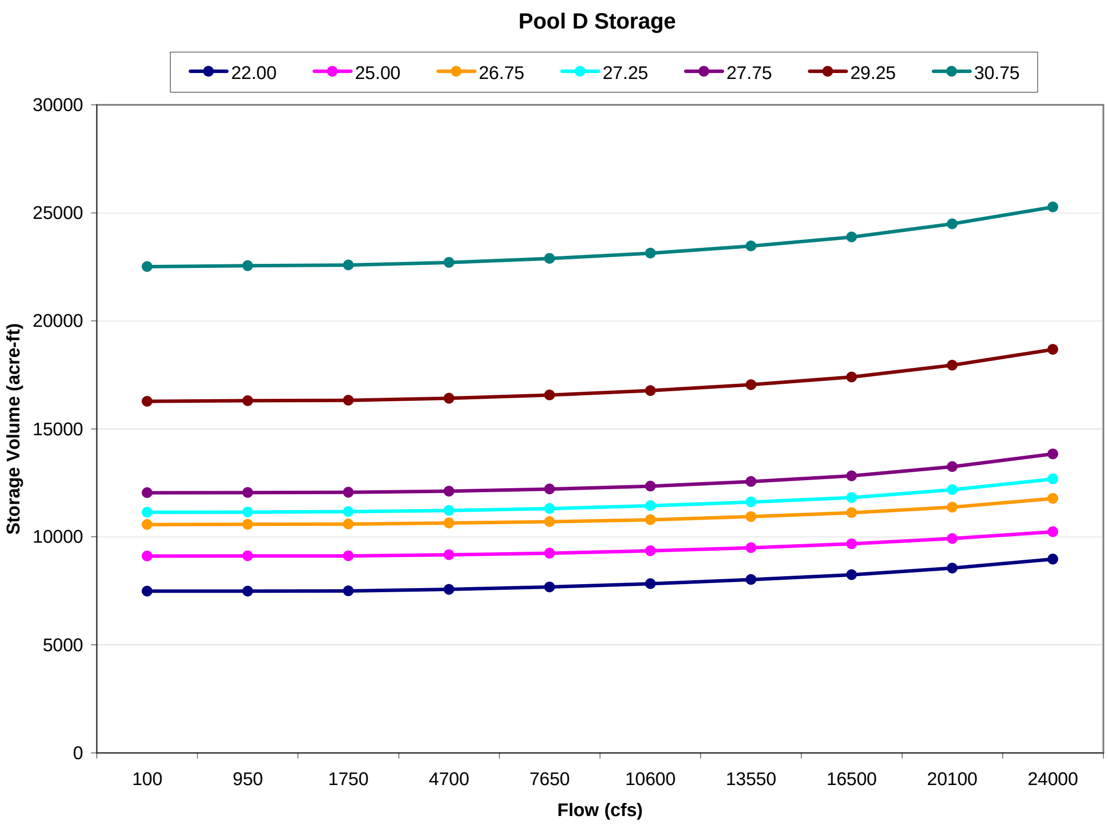

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Table B-5: Pool D Headwater

	Headwater (ft)						
Q(cfs\H ft)	**22.00**	**25.00**	**26.75**	**27.25**	**27.75**	**29.25**	**30.75**
100	22.01	25.01	26.76	27.26	27.76	29.26	30.76
950	22.04	25.03	26.78	27.28	27.78	29.27	30.77
1750	22.08	25.06	26.80	27.30	27.79	29.29	30.78
4700	22.40	25.24	26.94	27.42	27.91	29.38	30.86
7650	22.95	25.56	27.17	27.64	28.12	29.55	30.99
10600	23.65	25.99	27.50	27.95	28.40	29.77	31.17
13550	24.46	26.52	27.92	28.34	28.76	30.06	31.40
16500	25.31	27.12	28.40	28.78	29.18	30.40	31.68
20100	26.38	27.92	29.05	28.78	29.75	30.87	32.07
24000	27.54	28.83	29.81	30.11	30.43	31.44	32.54

Figure B-4: Pool D Headwater

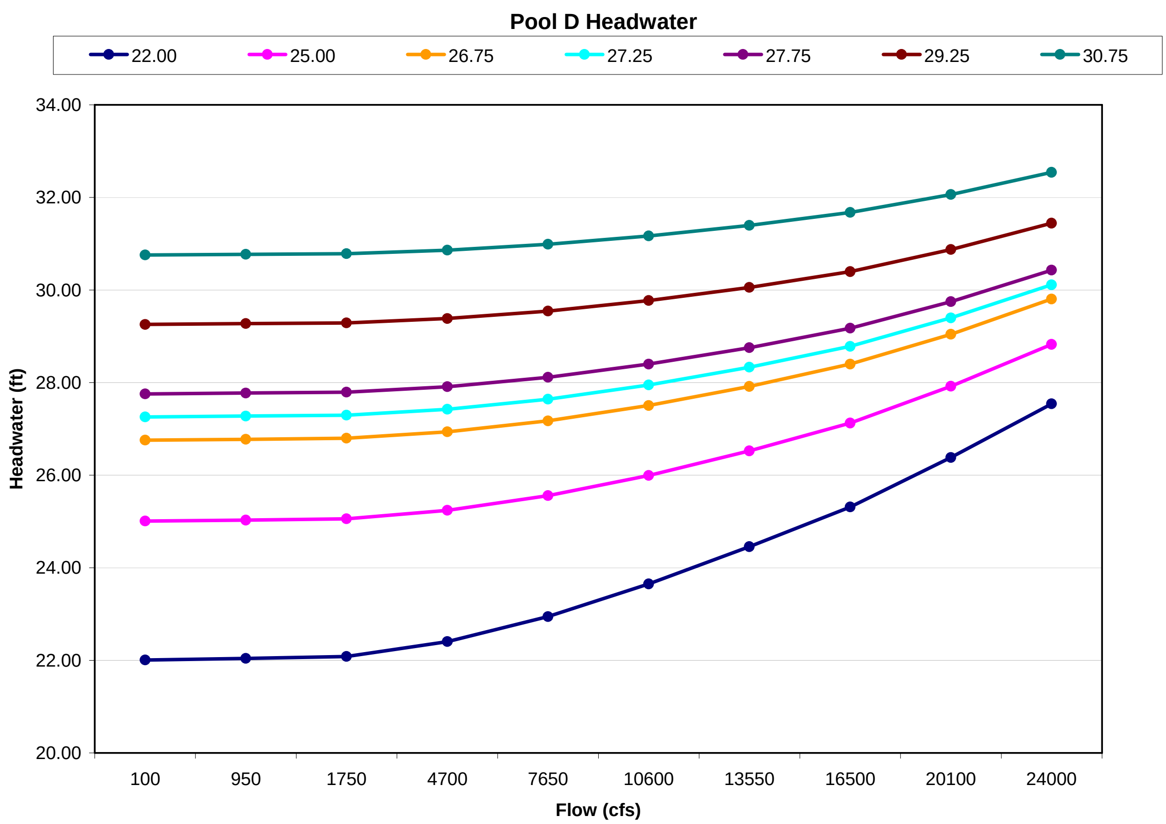

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Table B-6: Pool E Storage

	Storage Volume (acre-ft)						
Q(cfs\H ft)	**15.75**	**18.75**	**21.00**	**22.00**	**23.00**	**24.50**	**26.00**
100	9204	10716	12031	12779	13698	15483	18370
900	9204	10716	12031	12780	13698	15483	18371
1700	9205	10717	12032	12780	13699	15484	18373
5000	9216	10724	12039	12788	13709	15496	18391
8250	9238	10738	12053	12803	13728	15520	18427
11500	9270	10759	12074	12827	13757	15556	18480
14750	9312	10787	12104	12858	13796	15604	18550
18000	9363	10821	12139	12899	13845	15664	18638
21000	9417	10858	12179	12945	13901	15732	18734
24000	9478	10900	12226	13000	13967	15811	18845

Figure B-5: Pool E Storage

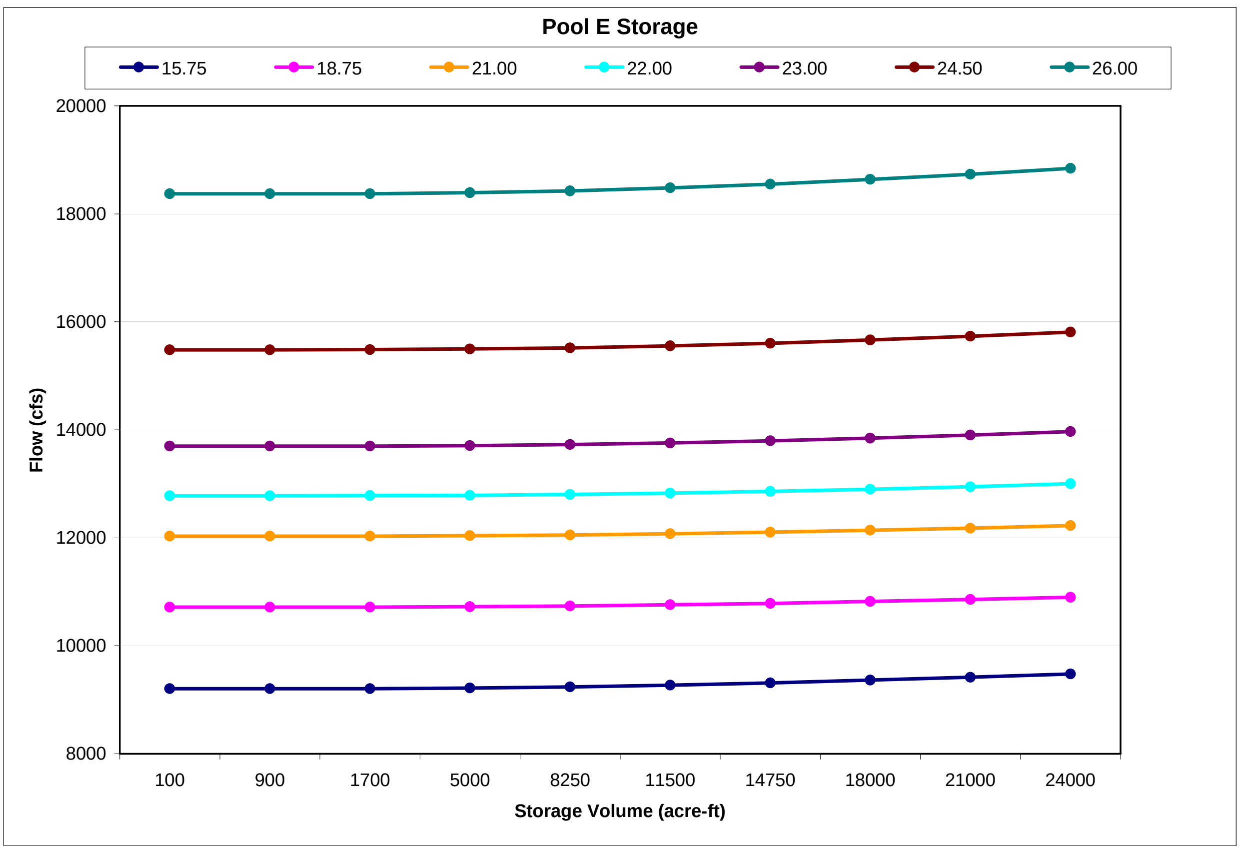

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Table B-7: Pool E Headwater

	Headwater (ft)						
Q(cfs\H ft)	**15.75**	**18.75**	**21.00**	**22.00**	**23.00**	**24.50**	**26.00**
100	15.75	18.75	21.00	22.00	23.00	24.50	26.00
900	15.76	18.75	21.00	22.00	23.00	24.50	26.00
1700	15.85	18.76	21.01	22.00	23.00	24.50	26.00
5000	16.01	18.81	21.04	22.04	23.03	24.53	26.02
8250	16.26	18.91	21.12	22.10	23.09	24.57	26.06
11500	16.55	19.06	21.23	22.20	23.18	24.64	26.11
14750	16.91	19.26	21.38	22.33	23.29	24.74	26.19
18000	17.29	19.52	21.55	22.48	23.44	24.86	26.28
21000	17.33	19.75	21.76	22.65	23.57	24.98	26.38
24000	17.75	20.04	21.96	22.87	23.74	25.11	26.48

Figure B-6: Pool E Headwater

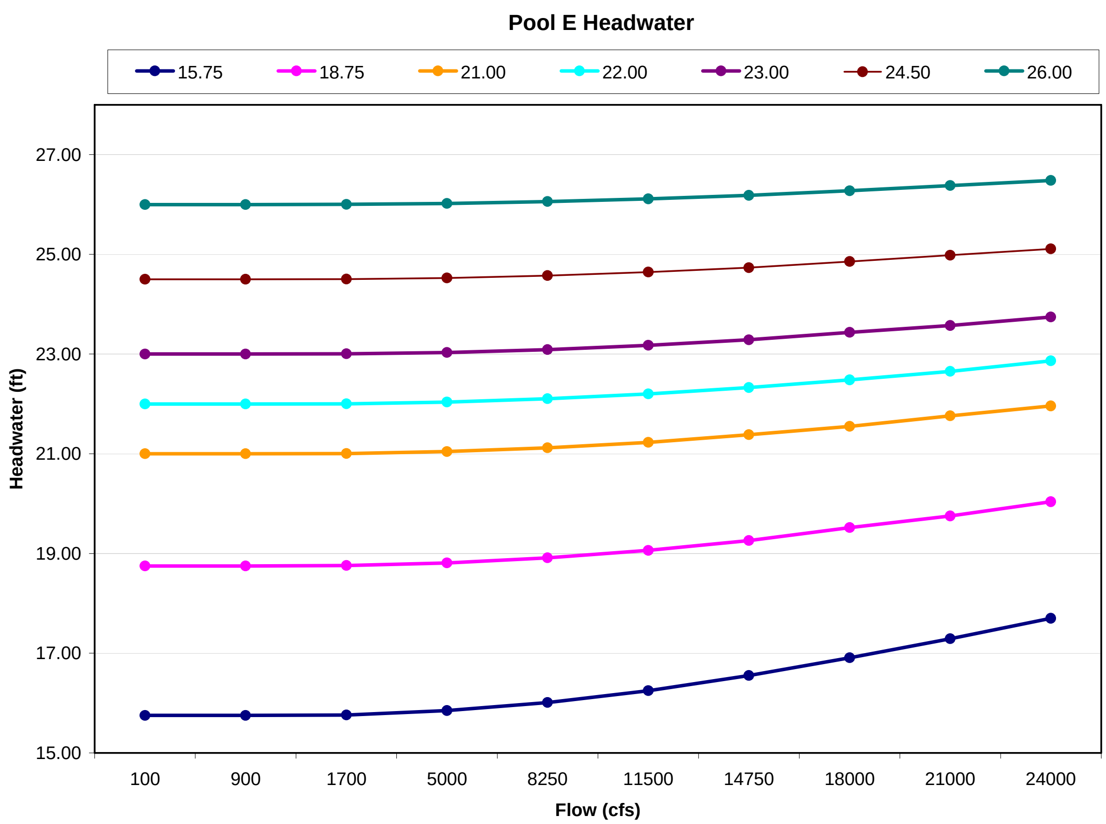

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Table B-8: Pool BC Storage Volume

	Storage Volume (acre-ft)							
Q(cfs\H ft)	**31.50**	**32.00**	**33.00**	**34.00**	**35.00**	**36.00**	**37.00**	**38.00**
0	8652	8786	9213	10758	13922	18929	25773	34330
1000	12459	12589	12990	14329	17078	21674	27874	35985
2000	17255	17347	17929	19573	22315	26091	31789	39130
3000	23502	23618	24241	24241	29116	32302	37333	43930
4000	29511	29585	30611	32856	34888	37561	41780	47768
6000	42517	42552	42798	43246	44456	46772	50127	55173
8000	51989	52011	52151	52577	53333	55343	58351	62605
10000	61031	61077	61211	61496	62063	63279	66325	70023
12000	69559	69556	69539	69776	70278	71183	73727	77134
15000	81228	81171	81041	81198	81557	82138	83582	87218
20000	99048	98922	98597	98441	98489	98999	100176	102470

Figure B-7: Pool BC Storage Volume

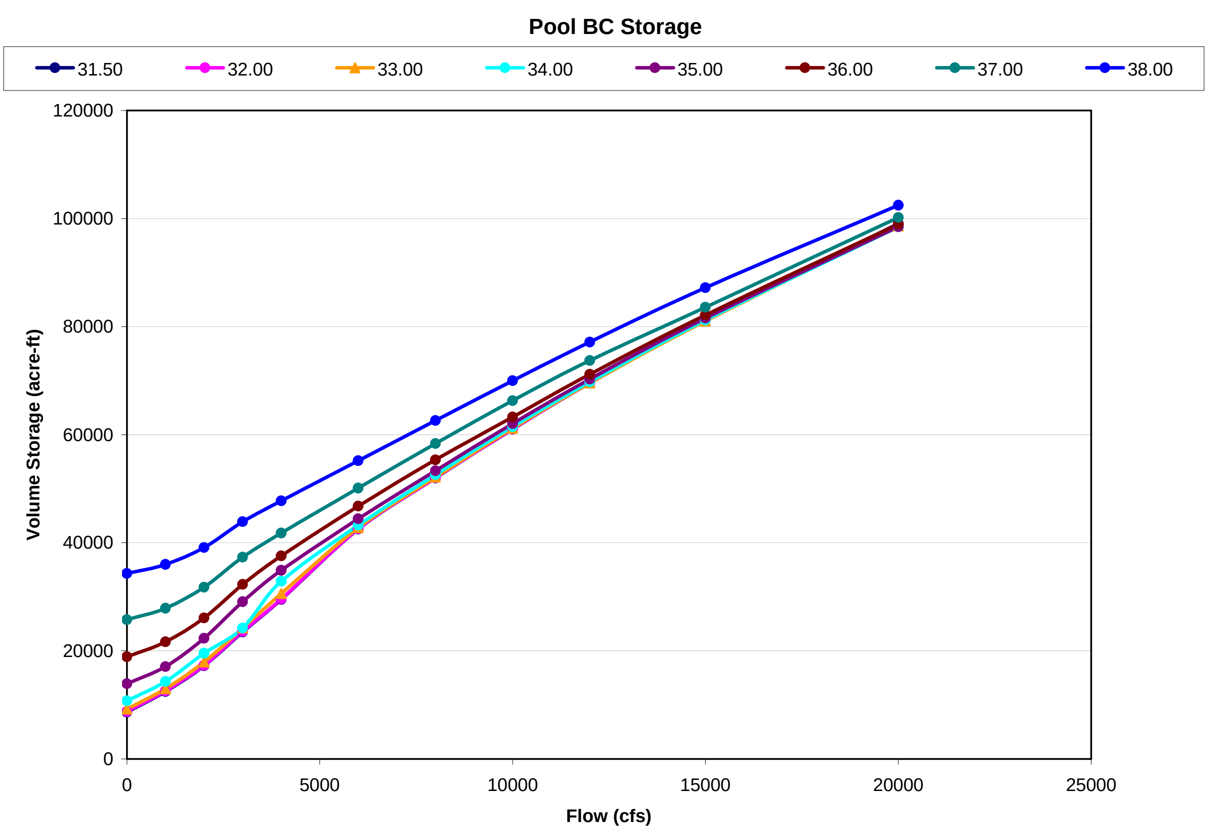

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Table B-9: Pool BC Headwater

	Headwater (ft)							
Q(cfs\H ft)	**31.50**	**32.00**	**33.00**	**34.00**	**35.00**	**36.00**	**37.00**	**38.00**
0	34.94	34.96	35.06	35.26	35.60	36.20	37.05	38.01
1000	38.94	38.94	38.94	38.94	38.94	38.99	39.15	39.48
2000	40.58	40.58	40.58	40.58	40.58	40.58	40.58	40.60
3000	41.76	41.76	41.76	41.76	41.76	41.76	41.77	41.79
4000	42.39	42.39	42.39	42.39	42.39	42.40	42.40	42.42
6000	43.52	43.52	43.52	43.52	43.52	43.52	43.52	43.53
8000	44.60	44.60	44.60	44.60	44.60	44.60	44.60	44.61
10000	45.69	45.70	45.70	45.69	45.70	45.70	45.70	45.71
12000	46.82	46.82	46.82	46.82	46.82	46.82	46.82	46.83
15000	48.51	48.51	48.51	48.51	48.51	48.51	48.51	48.52
20000	51.28	51.26	51.26	51.14	51.21	51.26	51.26	51.20

Figure B-8: Pool BC Headwater

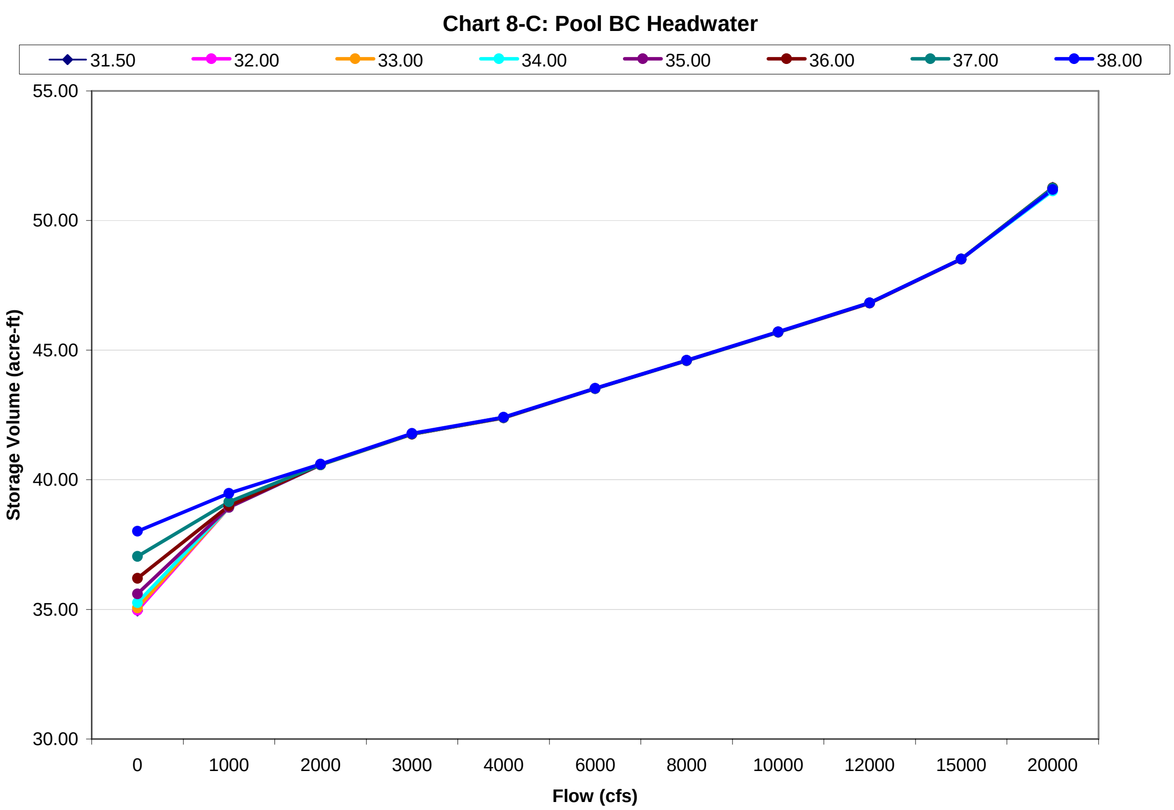

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Table B-10: Pool BC Stage at Performance Evaluation Site 1

	Headwater (ft)							
Q(cfs\H ft)	**31.50**	**32.00**	**33.00**	**34.00**	**35.00**	**36.00**	**37.00**	**38.00**
0	34.93	34.95	35.05	35.25	35.59	36.19	37.04	38.01
1000	38.91	38.91	38.91	38.91	38.90	38.96	39.11	39.44
2000	40.50	40.50	40.50	40.50	40.50	40.50	40.49	40.52
3000	41.61	41.61	41.61	41.61	41.61	41.61	41.62	41.64
4000	42.14	42.14	42.14	42.14	42.14	42.15	42.15	42.17
6000	43.01	43.01	43.01	43.01	43.01	43.01	43.01	43.02
8000	43.77	43.77	43.77	43.77	43.77	43.77	43.77	43.79
10000	44.49	44.49	44.49	44.49	44.50	44.50	44.50	44.52
12000	45.21	45.21	45.21	45.21	45.21	45.21	45.22	45.22
15000	46.21	46.21	46.21	46.21	46.21	46.21	46.22	46.22
20000	48.03	48.03	48.03	48.09	48.03	48.03	48.03	48.08

Figure B-9: Pool BC Stage at Performance Evaluation Site 1

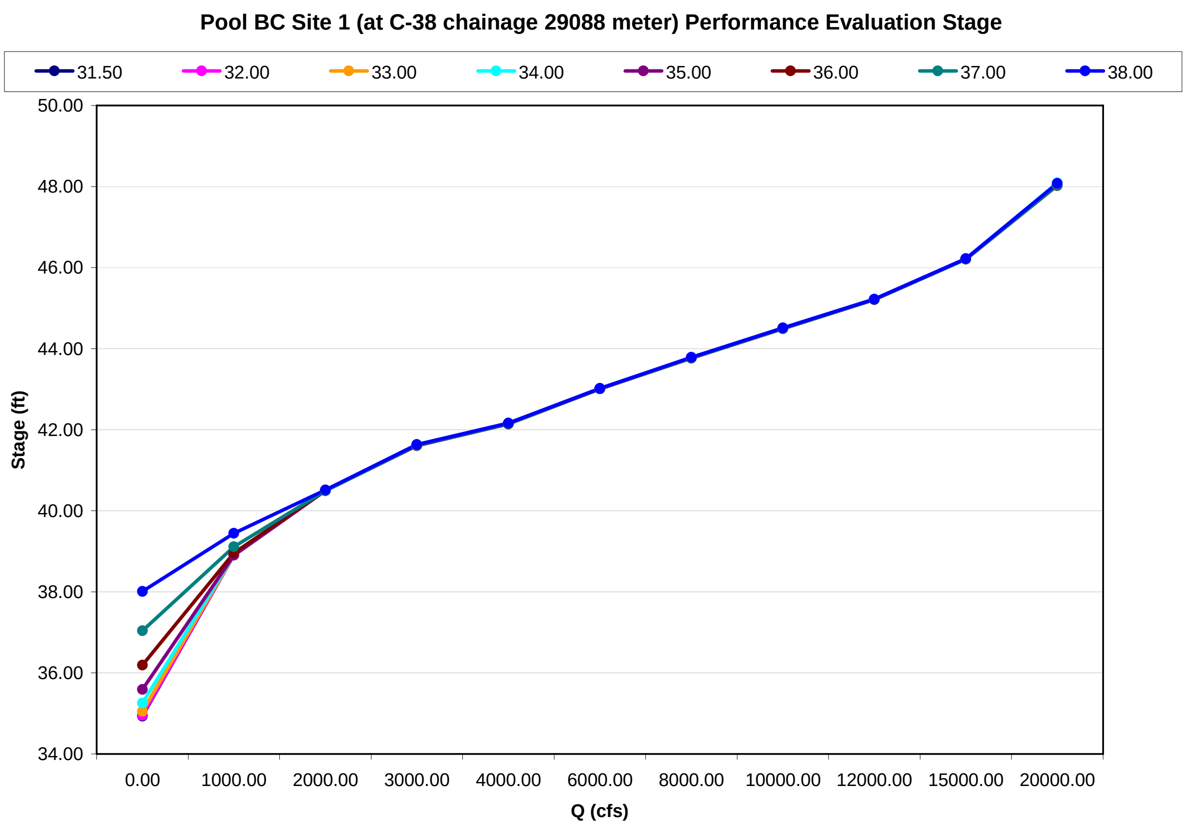

Table B-11: Pool BC Stage at Performance Evaluation Site 2

	Headwater (ft)							
Q(cfs\H ft)	**31.50**	**32.00**	**33.00**	**34.00**	**35.00**	**36.00**	**37.00**	**38.00**
0	34.93	34.95	35.05	35.25	35.59	36.19	37.04	38.01
1000	38.90	38.90	38.90	38.90	38.90	38.95	39.11	39.44
2000	40.48	40.48	40.48	40.48	40.48	40.48	40.48	40.50
3000	41.58	41.58	41.58	41.58	41.59	41.59	41.59	41.61
4000	42.11	42.11	42.11	42.11	42.11	42.11	42.12	42.13
6000	42.95	42.95	42.95	42.95	42.95	42.95	42.95	42.96
8000	43.68	43.68	43.68	43.68	43.68	43.68	43.69	43.70
10000	44.38	44.38	44.38	44.38	44.38	44.38	44.39	44.40
12000	45.06	45.06	45.06	45.07	45.07	45.07	45.07	45.08
15000	46.02	46.02	46.02	46.02	46.02	46.02	46.02	46.03
20000	47.78	47.77	47.77	47.84	47.78	47.77	47.78	47.83

Figure B-10: Pool BC Stage at Performance Evaluation Site 2

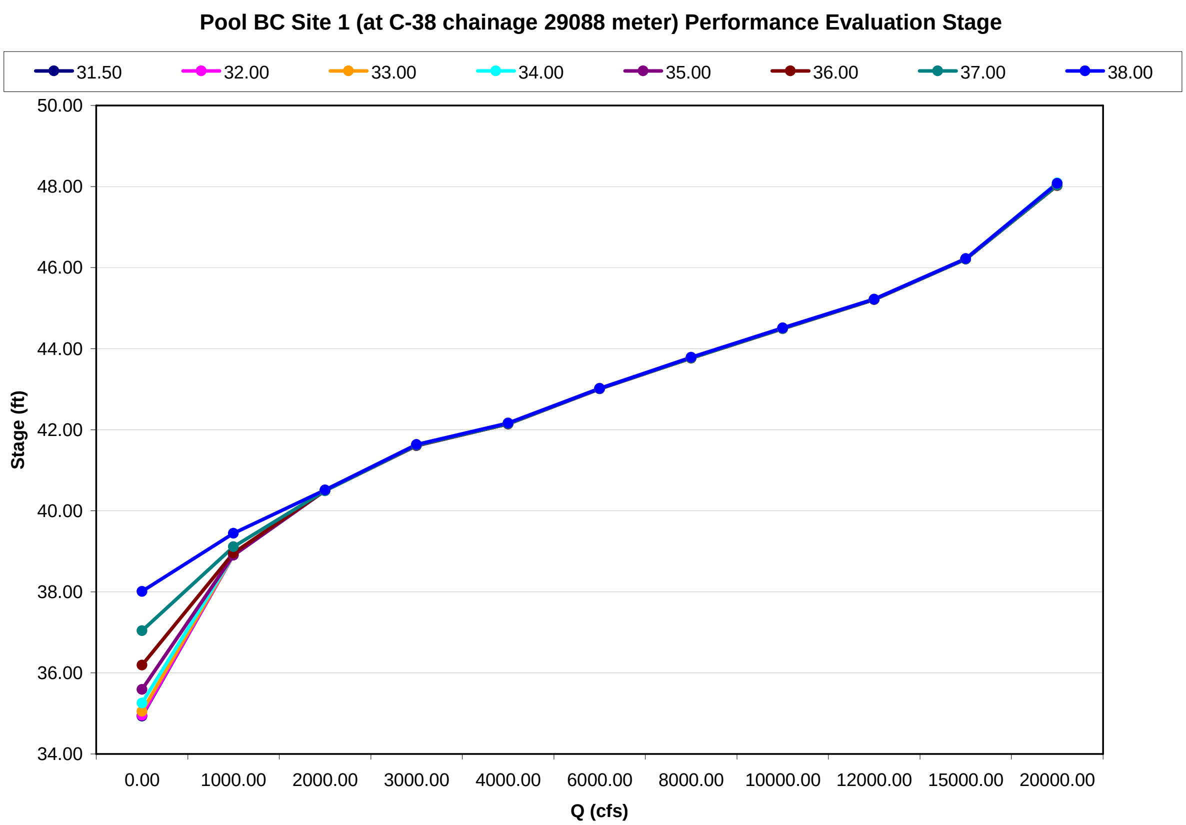

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Table B-12: Pool BC Stage at Performance Evaluation Site 3

	Headwater (ft)							
Q(cfs\H ft)	**31.50**	**32.00**	**33.00**	**34.00**	**35.00**	**36.00**	**37.00**	**38.00**
0	34.28	34.33	34.54	34.89	35.38	36.10	37.01	38.00
1000	37.42	37.42	37.42	37.42	37.41	37.54	37.78	38.37
2000	38.49	38.49	38.49	38.50	38.52	38.55	38.68	39.00
3000	39.26	39.26	39.26	39.28	39.30	39.33	39.42	39.58
4000	39.87	39.87	39.87	39.89	39.90	39.92	39.96	40.08
6000	40.78	40.78	40.78	40.78	40.78	40.79	40.82	40.91
8000	41.49	41.49	41.49	41.49	41.49	41.50	41.53	41.60
10000	42.10	42.10	42.10	42.10	42.10	42.11	42.14	42.19
12000	42.64	42.64	42.64	42.64	42.64	42.65	42.68	42.71
15000	43.36	43.36	43.36	43.36	43.36	43.36	43.37	43.40
20000	44.34	44.34	44.33	44.34	44.35	44.34	44.35	44.39

Figure B-11: Pool BC Stage at Performance Evaluation Site 3

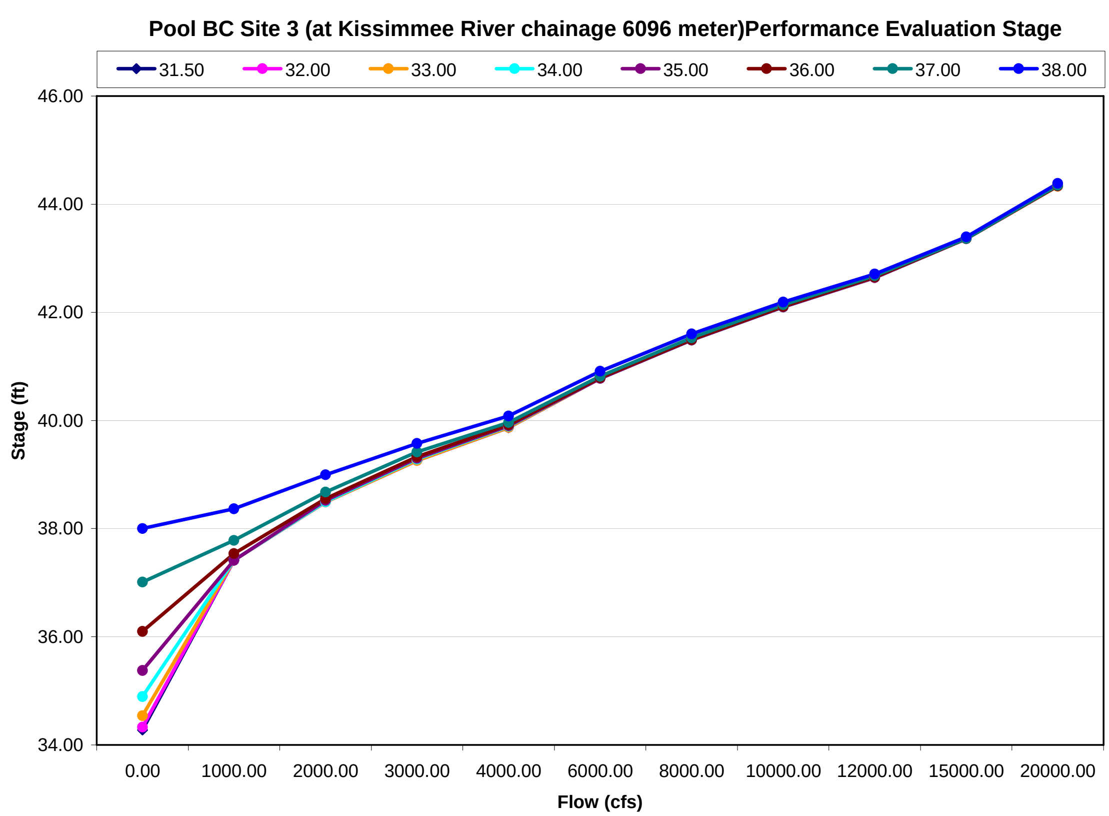
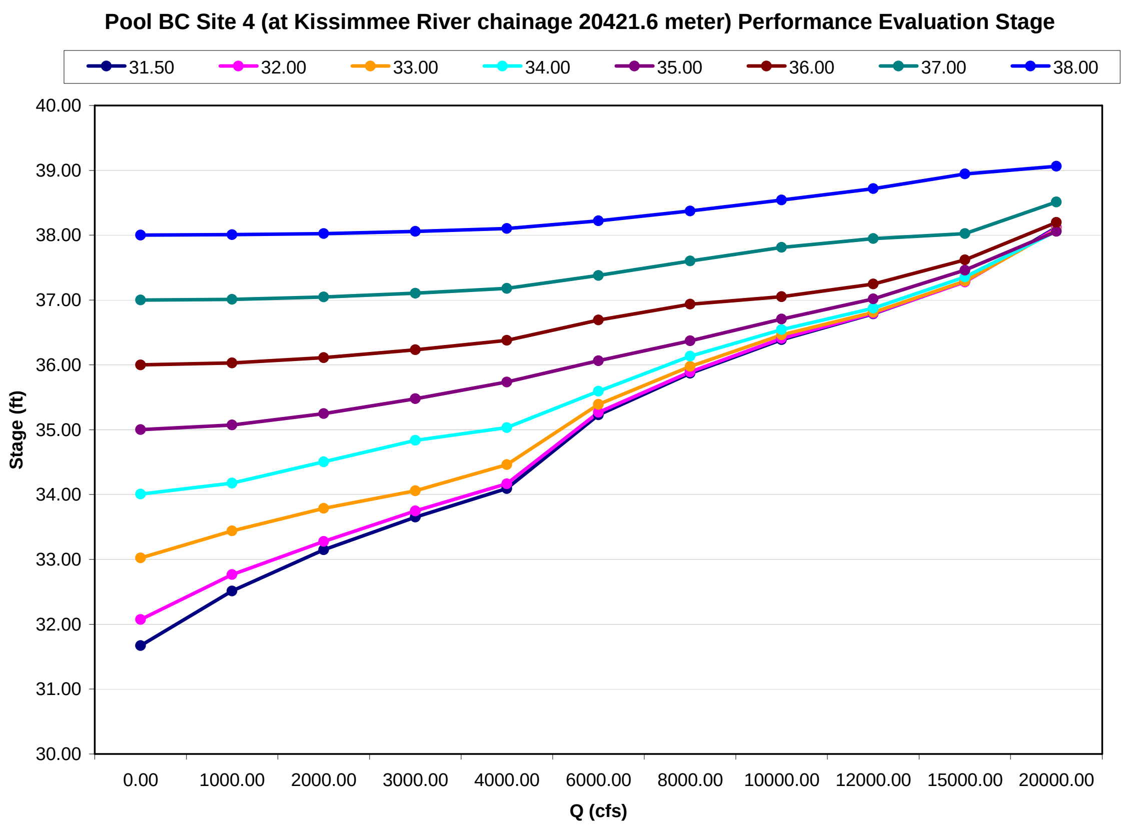


Table B-13: Pool BC Stage at Performance Evaluation Site 4

	Headwater (ft)							
Q(cfs\H ft)	**31.50**	**32.00**	**33.00**	**34.00**	**35.00**	**36.00**	**37.00**	**38.00**
0	31.74	32.12	33.05	34.02	35.00	36.00	37.00	38.00
1000	33.18	33.35	33.81	34.32	35.11	36.04	37.02	38.01
2000	33.99	34.04	34.3	34.72	35.36	36.15	37.06	38.03
3000	34.46	34.49	34.6	35.15	35.65	36.30	37.14	38.07
4000	34.76	34.8	35.02	35.49	35.96	36.48	37.23	38.12
6000	36.01	36.03	36.07	36.13	36.39	36.87	37.47	38.27
8000	36.52	36.53	36.57	36.64	36.78	37.18	37.73	38.45
10000	36.97	36.98	37.02	37.06	37.15	37.37	37.98	38.65
12000	37.33	37.34	37.25	37.38	37.46	37.61	38.16	38.86
15000	37.81	37.81	37.81	37.85	37.92	38.03	38.35	39.14
20000	38.65	38.64	38.62	38.6	38.60	38.70	38.94	39.40

Figure B-12: Pool BC Stage at Performance Evaluation Site 4



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APPENDIX C

Extraction of Lateral Inflows from AFET and Lake's Water Budgets

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September 9, 2007

To: Chris Carlson, Ken Konyha, Rama Rani (SFWMD)

Copy: Mark Abbott, Melba Fernandez (Earth Tech, Inc)

From: Guillermo Regalado (Earth Tech , Inc), Joseph Hughes (DHI)

Subject: Calculation of AFET Lateral Inflows

This document summarizes the process used to compute time series of lateral inflows from the AFET output and it was prepared to document the calculation spreadsheet posted in the Study FTP site, along with this text.

Lateral inflows are calculated for each Water Control Unit (WCU)[1] as follows:

1. Lateral Inflows are divided into two basic components:
    a. MIKE SHE/MIKE 11 interactions within the WCU
    b. MIKE 11 Hydrographs coming to the WCU from their tributaries. These hydrographs implicitly include the runoff and MIKE SHE/MIKE 11 interactions occurring at the watersheds draining towards the WCU.

The set of lateral inflows is going to be used by OKISS. Since OKISS is a water budget model, it only deals with water bodies. It does not represent catchment areas. Therefore, lateral inflows were calculated by WCU. The lateral inflow calculations will focus on the inflow discharged to each lake by each one of its tributaries as a point discharge, plus the actual lateral inflow or non-point discharges coming from the interaction between the drained areas (including the unsaturated and saturated zones). Figure C-1 shows an example of the two components described above. Each one of these components is described in the following paragraphs.

[1] A WCU is a water body or a set of interconnected water bodies (for example, a lake and its adjoining canals).

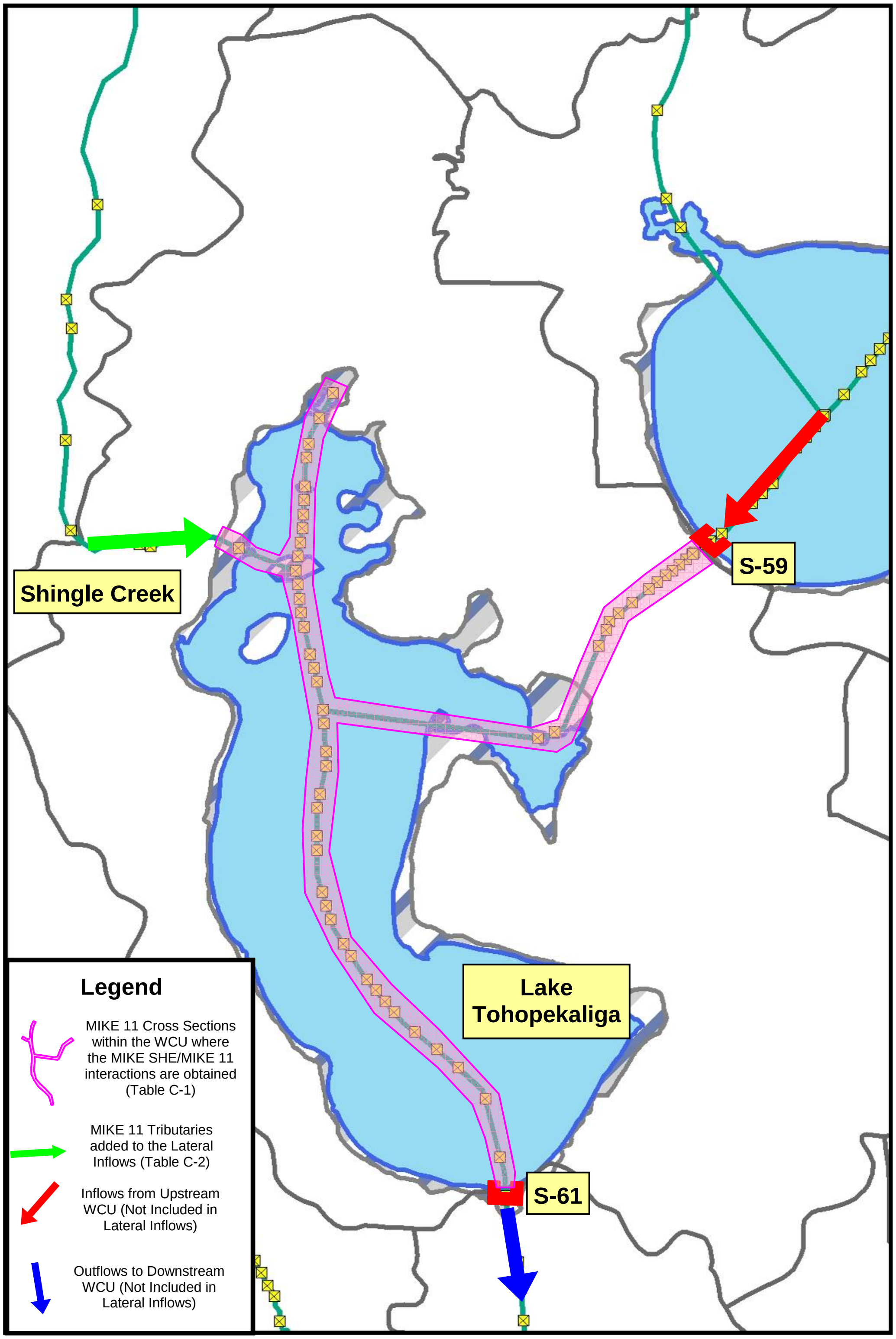


Figure C- 1 : Sample description of Lateral Inflow Components (Lake Tohopekaliga)

A) MIKE SHE/MIKE 11 interactions within the WCU

First, MIKE11 branches and chainages that comprise each WCU were defined. These chainages correspond to cross-sections in the MIKE 11 model and correspond only to the lakes and adjoining canals within each WCU that are part of each one of the OKISS nodes. In essence, the MIKE11 cross-sections located within the space, each represented by one OKISS node, were used in this analysis.

Table **C-1** lists the chainages within each WCU or OKISS node. MIKE SHE/MIKE 11 interactions occurring within the chainages listed in the aforementioned table were extracted using the AFET Data Extraction Tool (AFET-DET) developed as part of the Performance Measures Evaluation (PME) Tool. The documentation of the AFET-DET is included in the PME Tool documentation. The AFET-DET was built in such a way that it can be used for several purposes and is not limited to the requirements of the PME Tool. The AFET-DET reads a text file that contains the specifications of the type of data (variables) needed to be extracted from the MIKE SHE output files, along with the locations of interest. Attachment 2 contains the text files used to extract the MIKE SHE/MIKE 11 interactions within each WCU.

There are ONLY three types of MIKE SHE/MIKE 11 interactions, which are described below:

- **Baseflow** – This term includes the interaction between MIKE SHE and MIKE 11 through the Saturated Zone for all coupled branches with non-zero leakage coefficients. This term can include positive and negative values. A leakage coefficient of zero was defined for all KUB lakes because the flooding option was used and the overland term includes all groundwater MIKE 11 exchanges, as discussed below.
- **Drainage** – This term includes the interaction between MIKE SHE and MIKE 11 through the drainage module. This term is always positive.
- **Overland** – This term includes the interaction between MIKE SHE and MIKE 11 through the overland component. For flooded cells, where the volume of water is shared between MIKE 11 and MIKE SHE, this term also includes rainfall to flooded cells, evapotranspiration from flooded cells and direct MIKE SHE overland to MIKE SHE groundwater exchanges. This term can include positive and negative values. In AFET, the flooding option was used for all of the lakes in the KUB. *Therefore, the overland component in the KUB contains not only the overland runoff, but also rainfall and evapotranspiration to and out of the lakes and groundwater interaction.* This explains the large negative terms observed in the extracted information.

Each component of the MIKE SHE/MIKE 11 interaction is then totalized in the calculation spreadsheet to come up with a single term for this exchange for each output time-step (which for the calibration runs was 6 hours).

Table C-1 : MIKE 11 Branches and Chainages within each WCU

WCU	MIKE 11Branch	Chainage
Lake Hart	LK-HART SUM	from 0 to 3750 m
	C-29	from 0 to 500 m
	UPPER-ALLIGATOR	from 9509 to 15000 m
East Lake Tohopekaliga	LOWER-E-TOHO	from 0 to 11100 m
	LK-HART	from 3750 to 7400 m
Lake Myrtle	LK-PRESTON	from 0 to 1950 m
	UPPER-ALLIGATOR	from 1748 to 9509 m
Lake Tohopekaliga	C-31	from 0 to 5800 m
	LOWER-E-TOHO	from 11100 to 11120 m
	TOHO-MAIN	from 0 to 18975 m
Lake Gentry	ALLIGATOR-CHAIN	from 11772 to 18854 m
Lake Cypress	ALLIGATOR-CHAIN	from 18874 to 32000 m
	SHORT_CANAL	from 0 to 9852 m
	TOHO-MAIN	from 18975 to 25008 m
Lake Hatchineha	C-36	from 0 to 3852 m
	EAST_LK_HATCHINEHA	from 0 to 4726 m
	WEST_LK_HATCHINEHA	from 0 to 7833 m
Lake Kissimmee	C-37	from 0 to 5496 m
	KISSIMMEE	from 0 to 23615 m
Alligator Lake	LK Lizzie	from 0 to 5200 m
	upper alligator	from 0 to 1748 m
	ALLIGATOR-CHAIN	from 0 to 11772 m
	LK Brick	from 0 to 3900 m
Pool A	C-38	from 0 to 17284 m
	ARMSTRONG_SLOUGH	from 5000 to 12305 m
	MEANDER1	from 0 to 3105 m
	MEANDER2	from 0 to 1967 m
	MEANDER3	from 0 to 1545 m
	MEANDER4	from 0 to 2266 m
	MEANDER5	from 0 to 4595 m
	MEANDER6	from 0 to 2560 m
Pool BC	C-38	from 17332 to 35913 m
	KISSIMMEE_RIVER	from 0 to 22049 m
	MEANDER7	from 0 to 1044 m
	MEANDER8	from 0 to 3260 m
	MEANDER9	from 0 to 3640 m
	MEANDER10	from 0 to 1300 m
	MEANDER11	from 0 to 880 m
	MEANDER12	from 0 to 2440 m
	SEVENMILE_SLOUGH	from 2252 to 13031 m
	ISTOKPOGA_CANAL	from 2400 to 4656 m
	PINE_ISLAND_SLOUGH	from 5126 to 13442 m
	MEANDER17	from 0 to 4320 m
	KR-M17-CANAL	from 0 to 3819 m
	OAK_CREEK	from 0 to 2945 m
	LOWER_C-38	from 47705 to 50968 m
Pool D	CHANDLER_SLOUGH1	from 0 to 3991 m
	CYPRESS_SLOUGH	at 9269.8 m
	MEANDER18	from 2338 to 7906 m
	MEANDER19	from 0 to 2889 m
	MEANDER20	from 0 to 2247 m
	MEANDER21	from 0 to 4658 m
	MEANDER22	from 0 to 2150 m
	LOWER_C-38	from 51032 to 65211 m
Pool E	MEANDER23	from 0 to 6484 m
	S65E_HCONNECTION	from 0 to 588 m
	LOWER_C38TOC41A	from 0 to 3160 m
	LOWER_C-38	from 65323 to 76009 m

B) MIKE 11 HYDROGRAPHS FROM TR-SHE/MIKE 11 INTERACTIONS

MIKE 11 flow hydrographs were extracted from the AFET output file (res11 file) from all tributaries of each WCU. Table C-2 includes the MIKE 11 branch name of each tributary, along with the chainage from which the hydrographs were extracted.

Table C-2 : MIKE 11 Tributaries to each WCU

	MIKE11 TRIBUTARY	
WCU	**MIKE 11Branch**	**Chainage (m)**
Lake Hart	--none--	
East Lake Tohopekaliga	BOGGY-CREEK	19119
Lake Myrtle	--none--	
Lake Tohopekaliga	SHINGLE-CREEK	35062.15
Lake Gentry	--none--	
Lake Cypress	LOWER_RC	1474
Lake Hatchineha *	LK_MARION_CREEK	21933.8
	DEAD_CREEK	3354.65
	CATFISH_CREEK	7612.5
Lake Kissimmee	ZIPPER_CANAL	3009.2
	TIGER_LAKE	1728.5
	JACKSON_CANAL	4245.45
Alligator Lake	--none--	
Pool A	ARMSTRONG_SLOUGH	9476
	ARMSTRONG_TRIB1	4750
Pool BC	PINE_ISLAND_SLOUGH_US	492.85
	ISTOKPOGA_CANAL	2650
	OAK_CREEK	1759.85
	OAK_CREEK	2415.25
	SEVENMILE_SLOUGH	7870.1
Pool D	CYPRESS_SLOUGH	8642.15
	CHANDLER_SLOUGH1	3725.65
Pool E	--none--	

AECOM

C) LATERAL INFLOWS

Components A and B were added together for each time-step to obtain a timeseries of lateral inflows for the simulation period. In the case of the Calibration Run, these time series have a 6-hour time-step. A conversion was needed to be applied to daily values to adapt the date to the needs of the KBMOS Screening Tool (OKISS).

Attachment 1 contains mass balance plots for each water control unit. These plots also show the cumulative error in the mass balance calculations.

The Water Budget equation that includes the components of the mass balances, included in Attachment 1, is described below:

Cumulative Inflows - Cumulative Outflows = Delta Storage + Mass Balance Error

then:

Mass Balance Error = Cumulative Inflows - Cumulative Outflows - Delta Storage

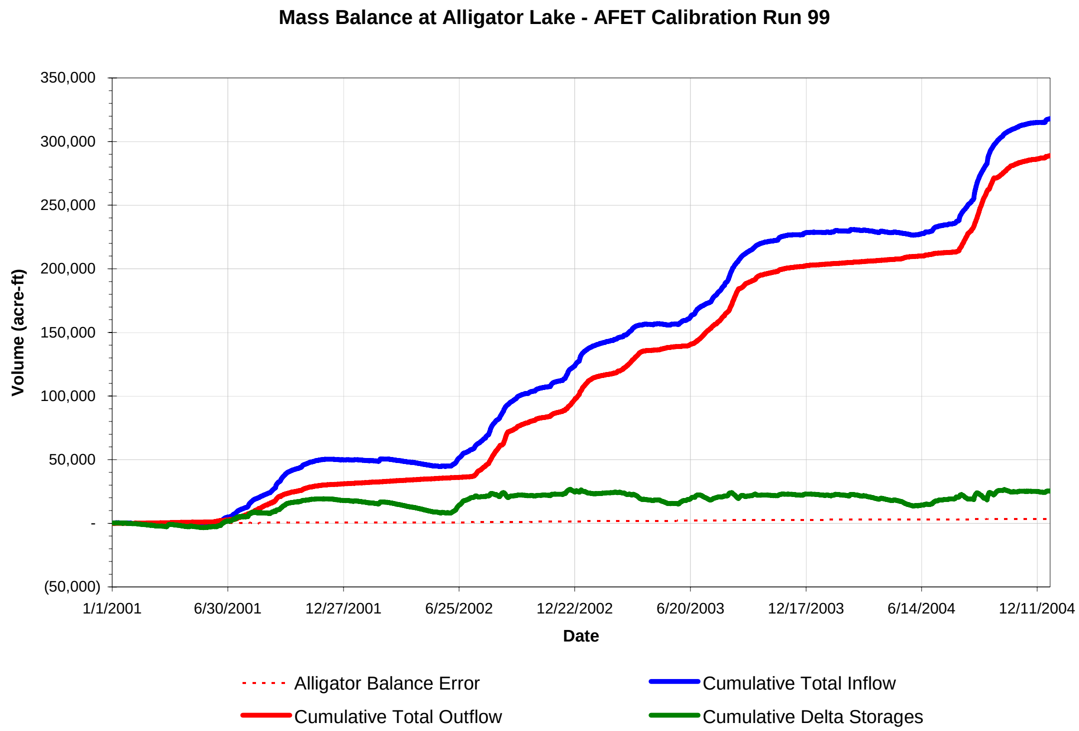
where:

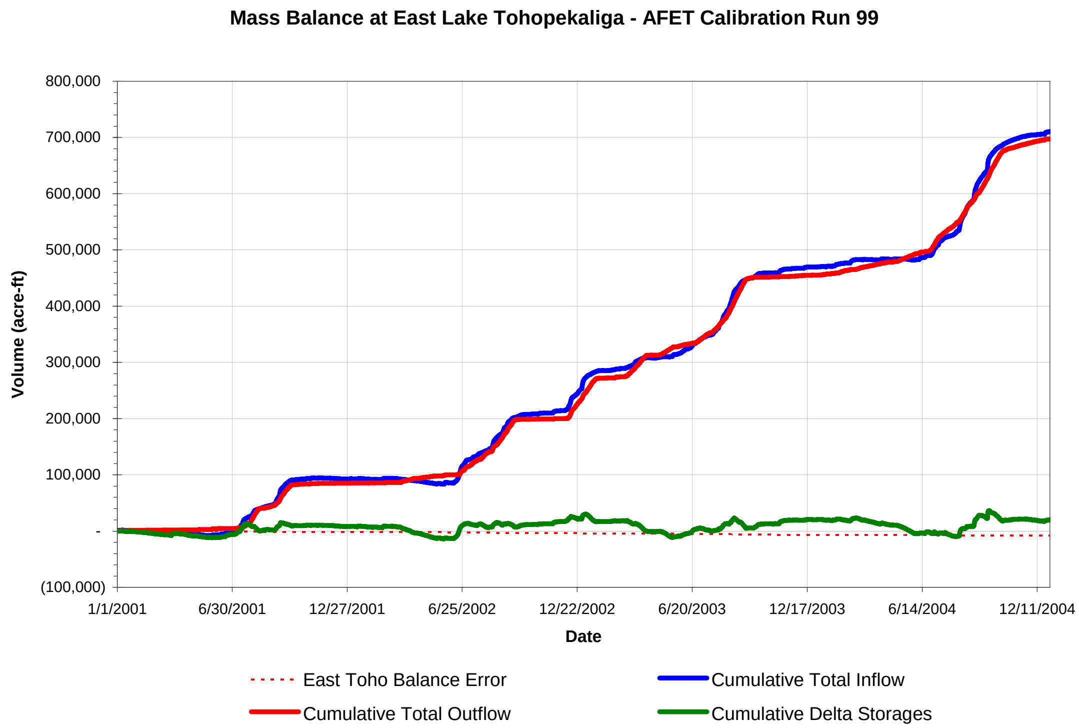
Cumulative Inflows =	Sum of the lateral inflows and the hydrographs coming from upstream WCU
Cumulative Outflows =	Sum of hydrographs being discharged through the Control Structure and routed to the downstream WCU
Delta Storage =	Cumulative change in storage at the end of each day at each WCU (lakes and canals).

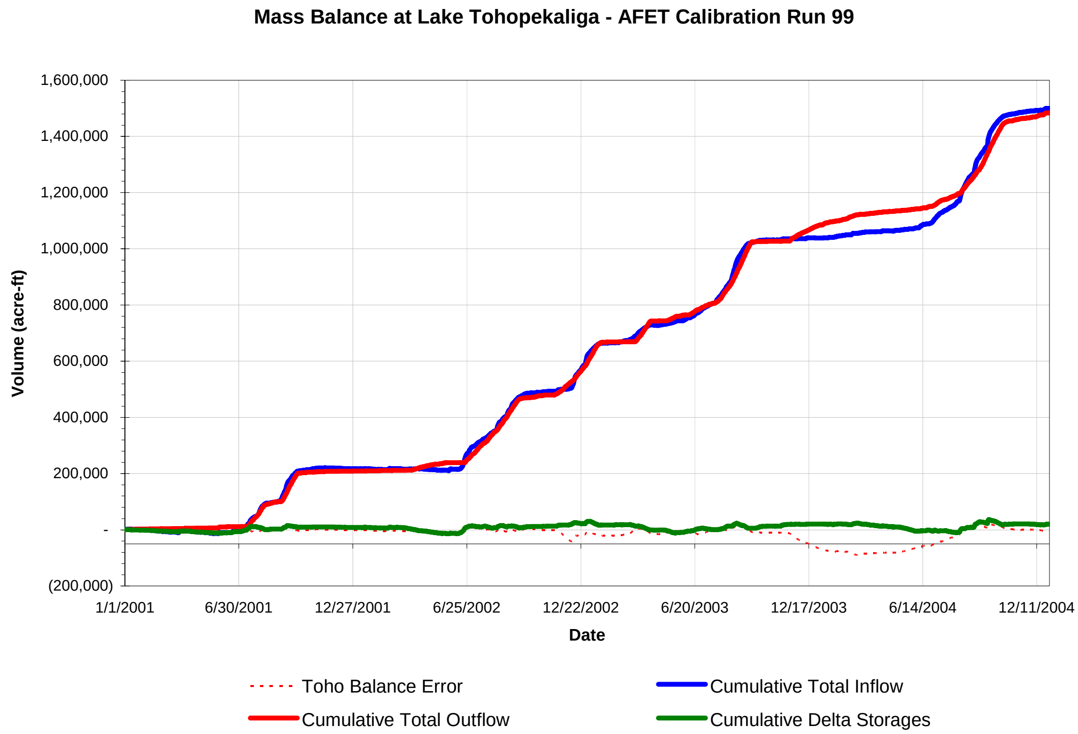
The error shown in the plots, although very small, is caused by the time-step used to extract data from AFET. Due to the strategy used for calibration, the calibration run shows oscillation of stages and flows, which resulted in the small errors seen in the plots. These oscillations will not be observed in the Base Conditions and Alternative Evaluation runs.

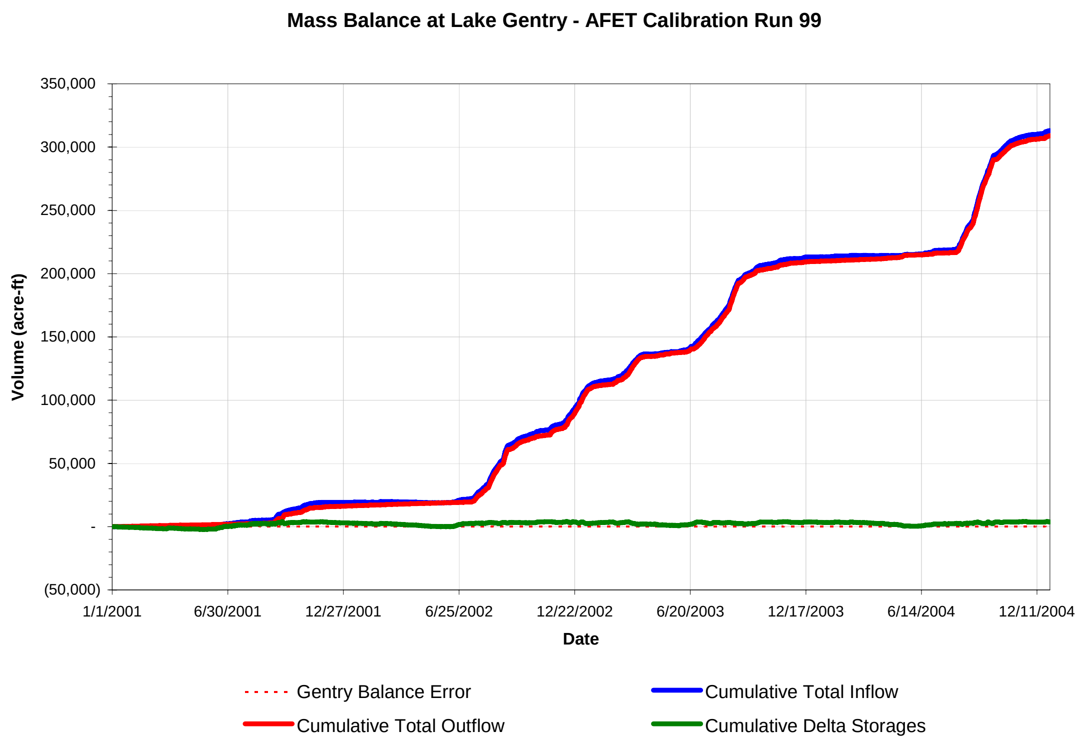
ATTACHMENT 1

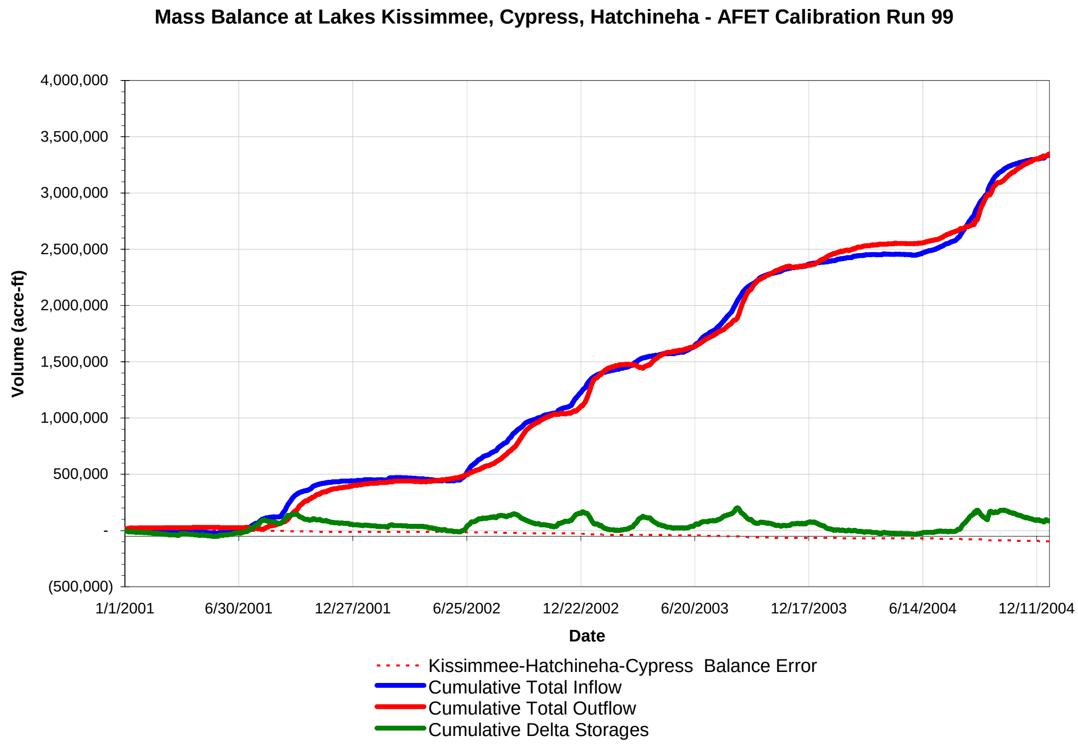
MIKE 11 MASS BALANCE PLOTS FOR THE KBMOS WCU

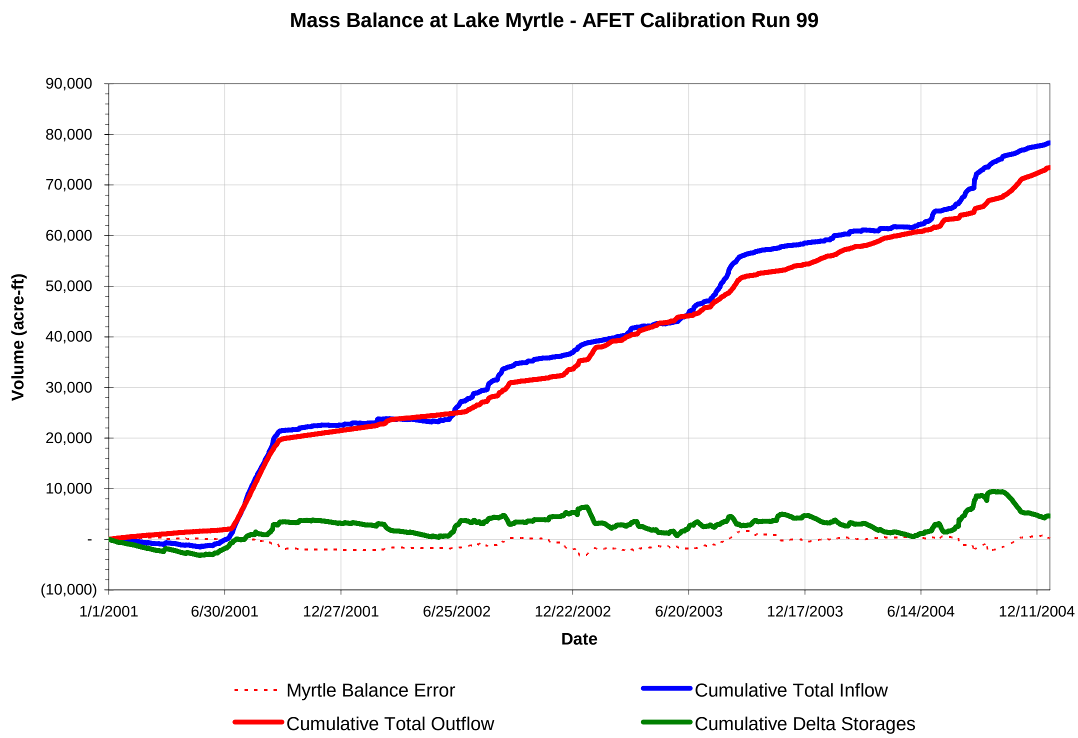




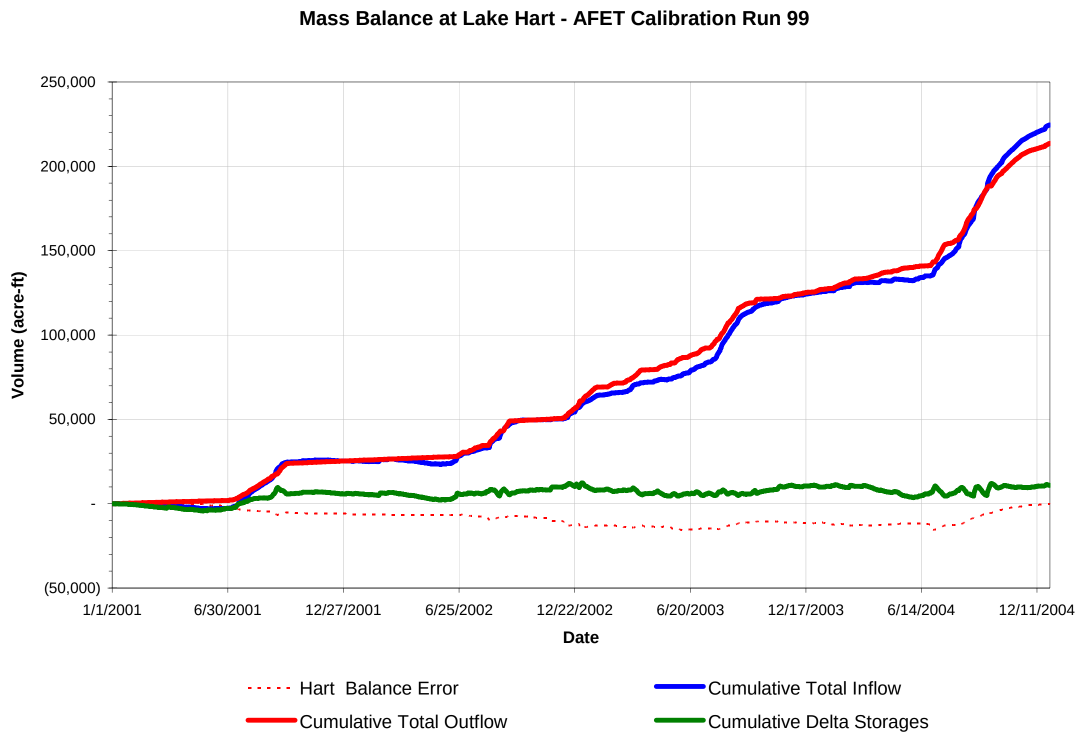

Mass Balance at Lake Tohopekaliga - AFET Calibration Run 99
1,600,000
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
-
(200,000)
Volume (acre-ft)
1/1/2001
6/30/2001
12/27/2001
6/25/2002
12/22/2002
6/20/2003
12/17/2003
6/14/2004
12/11/2004
Date
Toho Balance Error
Cumulative Total Inflow
Cumulative Total Outflow
Cumulative Delta Storages

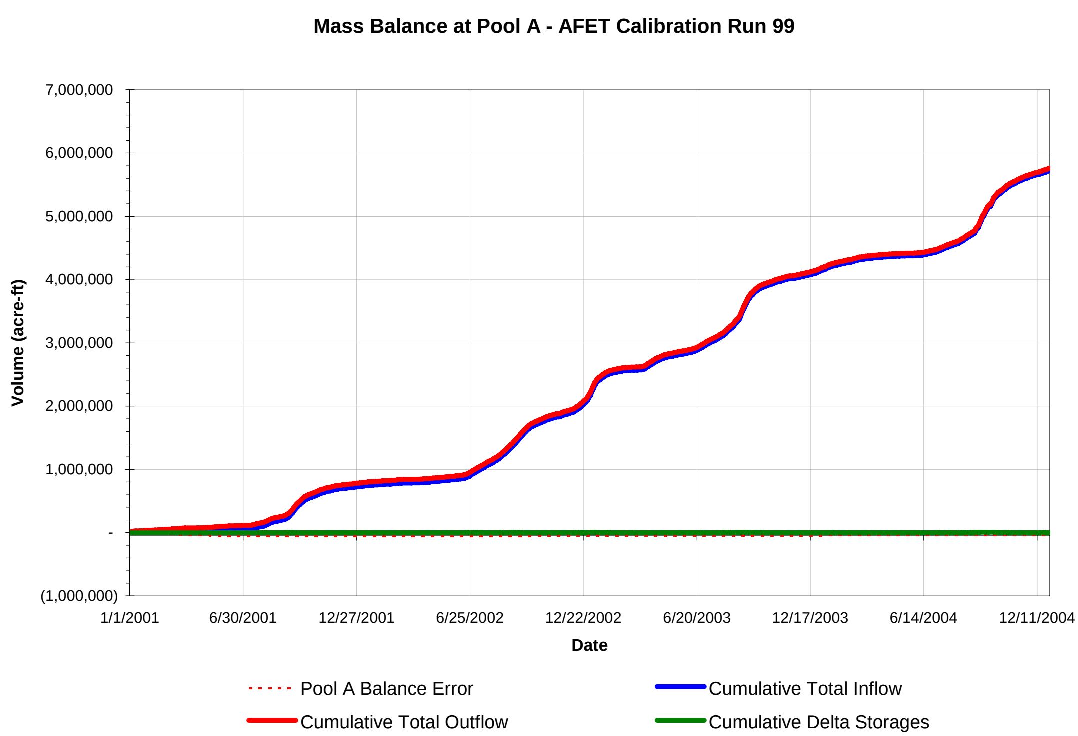

Mass Balance at Lake Gentry - AFET Calibration Run 99
350,000
300,000
250,000
200,000
150,000
100,000
50,000
-
(50,000)
Volume (acre-ft)
1/1/2001
6/30/2001
12/27/2001
6/25/2002
12/22/2002
6/20/2003
12/17/2003
6/14/2004
12/11/2004
Date
Gentry Balance Error
Cumulative Total Inflow
Cumulative Total Outflow
Cumulative Delta Storages

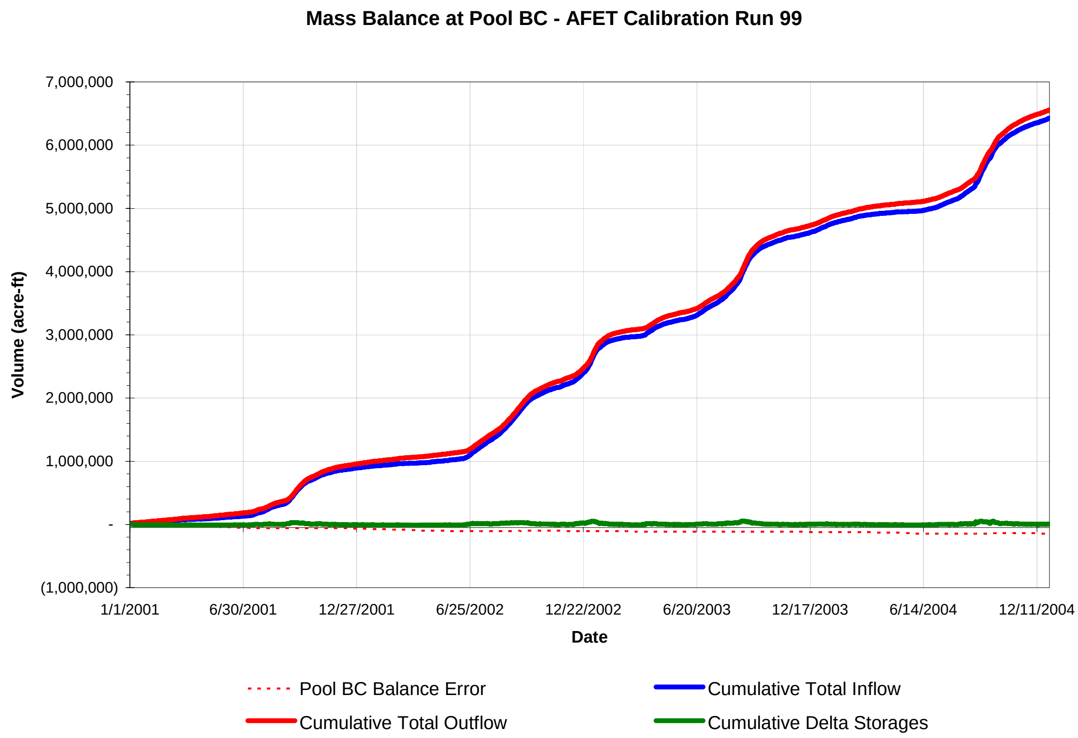

Mass Balance at Lakes Kissimmee, Cypress, Hatchineha - AFET Calibration Run 99
Volume (acre-ft)
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
-
(500,000)
1/1/2001
6/30/2001
12/27/2001
6/25/2002
12/22/2002
6/20/2003
12/17/2003
6/14/2004
12/11/2004
Date
Kissimmee-Hatchineha-Cypress Balance Error
Cumulative Total Inflow
Cumulative Total Outflow
Cumulative Delta Storages

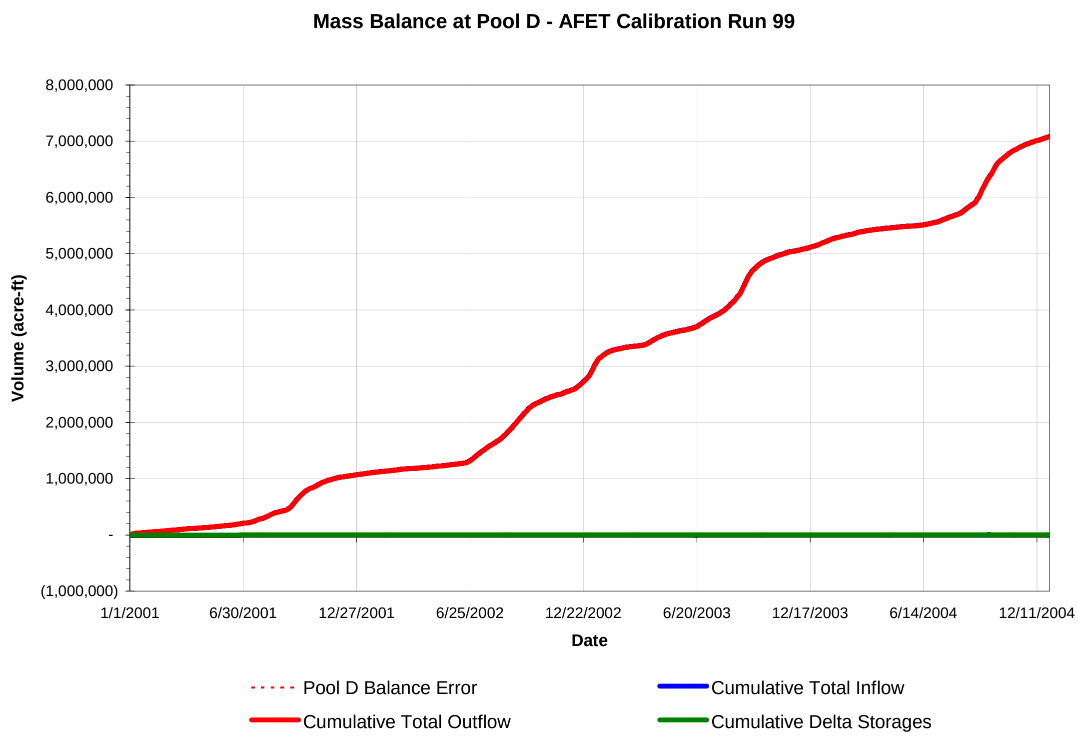

Mass Balance at Lake Myrtle - AFET Calibration Run 99
Volume (acre-ft)
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
-
(10,000)
1/1/2001
6/30/2001
12/27/2001
6/25/2002
12/22/2002
6/20/2003
12/17/2003
6/14/2004
12/11/2004
Date
Myrtle Balance Error
Cumulative Total Inflow
Cumulative Total Outflow
Cumulative Delta Storages

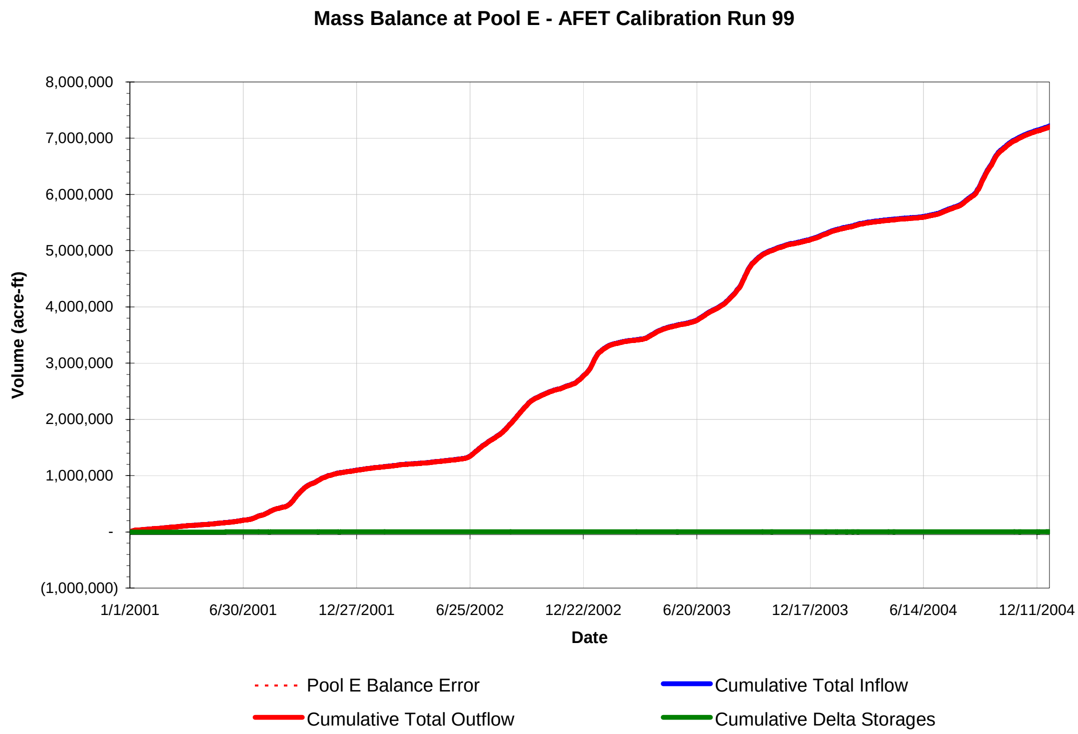
AECOM


Mass Balance at Lake Hart - AFET Calibration Run 99
250,000
200,000
150,000
100,000
50,000
-
(50,000)
Volume (acre-ft)
1/1/2001
6/30/2001
12/27/2001
6/25/2002
12/22/2002
6/20/2003
12/17/2003
6/14/2004
12/11/2004
Date
Hart Balance Error
Cumulative Total Inflow
Cumulative Total Outflow
Cumulative Delta Storages


Mass Balance at Pool A - AFET Calibration Run 99
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
-
(1,000,000)
Volume (acre-ft)
1/1/2001
6/30/2001
12/27/2001
6/25/2002
12/22/2002
6/20/2003
12/17/2003
6/14/2004
12/11/2004
Date
Pool A Balance Error
Cumulative Total Inflow
Cumulative Total Outflow
Cumulative Delta Storages


Mass Balance at Pool BC - AFET Calibration Run 99
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
-
(1,000,000)
Volume (acre-ft)
1/1/2001
6/30/2001
12/27/2001
6/25/2002
12/22/2002
6/20/2003
12/17/2003
6/14/2004
12/11/2004
Date
Pool BC Balance Error
Cumulative Total Inflow
Cumulative Total Outflow
Cumulative Delta Storages


Mass Balance at Pool D - AFET Calibration Run 99
8,000,000
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
-
(1,000,000)
Volume (acre-ft)
1/1/2001
6/30/2001
12/27/2001
6/25/2002
12/22/2002
6/20/2003
12/17/2003
6/14/2004
12/11/2004
Date
Pool D Balance Error
Cumulative Total Inflow
Cumulative Total Outflow
Cumulative Delta Storages


Mass Balance at Pool E - AFET Calibration Run 99
Volume (acre-ft)
8,000,000
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
-
(1,000,000)
1/1/2001
6/30/2001
12/27/2001
6/25/2002
12/22/2002
6/20/2003
12/17/2003
6/14/2004
12/11/2004
Date
Pool E Balance Error
Cumulative Total Inflow
Cumulative Total Outflow
Cumulative Delta Storages

ATTACHMENT 2

SAMPLE DATA EXTRACTION UTILITY TEXT FILE

```
[AFETDataExtractor]
   SIUnits = true
   [DataExtraction]
      InputFile = |.\KBMOS_PH1_1K_99_HFOHDAdd-inflows.res11|
      OutputFile = |.\KBMOS_PH1_1K_99_HFO_LateralInflows-overland_KUB.dat|

      [Item]
         Name = 'Lake Hart'
         Branch = 'LK-HART'
         SpecifiedRange = true
         Chainage = 0
         ChainageEnd = 3750
         DataType = 'LATERAL INFLOW SHE OVERLAND'
         SpecifiedOperator = true
         Operator = 'SUM'
         units = 'meter'
      EndSect  // Item

      [Item]
         Name = 'Lake Hart'
         Branch = 'C-29'
         SpecifiedRange = true
         Chainage = 0
         ChainageEnd = 500
         DataType = 'LATERAL INFLOW SHE OVERLAND'
         SpecifiedOperator = true
         Operator = 'SUM'
         units = 'meter'
      EndSect  // Item

      [Item]
         Name = 'Lake Hart'
         Branch = 'UPPER-ALLIGATOR'
         SpecifiedRange = true
         Chainage = 9509
         ChainageEnd = 15000
         DataType = 'LATERAL INFLOW SHE OVERLAND'
         SpecifiedOperator = true
         Operator = 'SUM'
         units = 'meter'
      EndSect  // Item

      [Item]
         Name = 'E. Lake Toho'
         Branch = 'Lower-E-Toho'
         SpecifiedRange = true
         Chainage = 0
         ChainageEnd = 11100
         DataType = 'LATERAL INFLOW SHE OVERLAND'
         SpecifiedOperator = true
         Operator = 'SUM'
         units = 'meter'
      EndSect  // Item

      [Item]
         Name = 'E. Lake Toho'
         Branch = 'LK-HART'
         SpecifiedRange = true
         Chainage = 3750
         ChainageEnd = 7400
         DataType = 'LATERAL INFLOW SHE OVERLAND'
         SpecifiedOperator = true
         Operator = 'SUM'
         units = 'meter'
      EndSect  // Item

      [Item]
         Name = 'Lake Myrtle'
         Branch = 'LK-PRESTON'
         SpecifiedRange = true
         Chainage = 0
         ChainageEnd = 1950
         DataType = 'LATERAL INFLOW SHE OVERLAND'
         SpecifiedOperator = true
```

```
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'Lake Myrtle'
      Branch = 'Upper-Alligator'
      SpecifiedRange = true
      Chainage = 1748
      ChainageEnd = 9509
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'Lake Toho'
      Branch = 'C-31'
      SpecifiedRange = true
      Chainage = 0
      ChainageEnd = 5800
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'Lake Toho'
      Branch = 'Lower-E-Toho'
      SpecifiedRange = true
      Chainage = 11100
      ChainageEnd = 11120
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'Lake Toho'
      Branch = 'TOHO-MAIN'
      SpecifiedRange = true
      Chainage = 0
      ChainageEnd = 18975
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'Alligator Lake'
      Branch = 'Alligator-chain'
      SpecifiedRange = true
      Chainage = 0
      ChainageEnd = 11772
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'Lake Gentry'
      Branch = 'Alligator-chain'
      SpecifiedRange = true
      Chainage = 11772
      ChainageEnd = 18854
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'Lake Cypress'
      Branch = 'Alligator-chain'
```

```
      SpecifiedRange = true
      Chainage = 18874
      ChainageEnd = 32000
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'Lake Cypress'
      Branch = 'Short_Canal'
      SpecifiedRange = true
      Chainage = 0
      ChainageEnd = 9852
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'Lake Cypress'
      Branch = 'TOHO-MAIN'
      SpecifiedRange = true
      Chainage = 18975
      ChainageEnd = 25008
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'Lake Hatchineha'
      Branch = 'C-36'
      SpecifiedRange = true
      Chainage = 0
      ChainageEnd = 3852
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'Lake Hatchineha'
      Branch = 'East_Lk_Hatchineha'
      SpecifiedRange = true
      Chainage = 0
      ChainageEnd = 4726
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'Lake Hatchineha'
      Branch = 'West_Lk_Hatchineha'
      SpecifiedRange = true
      Chainage = 0
      ChainageEnd = 7833
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'Lake Kissimmee'
      Branch = 'C-37'
      SpecifiedRange = true
      Chainage = 0
      ChainageEnd = 5496
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
```

```
EndSect  // Item

[Item]
   Name = 'Lake Kissimmee'
   Branch = 'KISSIMMEE'
   SpecifiedRange = true
   Chainage = 0
   ChainageEnd = 23615
   DataType = 'LATERAL INFLOW SHE OVERLAND'
   SpecifiedOperator = true
   Operator = 'SUM'
   units = 'meter'
EndSect  // Item

[Item]
   Name = 'Alligator Lake'
   Branch = 'LK-LIZZIE'
   SpecifiedRange = true
   Chainage = 0
   ChainageEnd = 5200
   DataType = 'LATERAL INFLOW SHE OVERLAND'
   SpecifiedOperator = true
   Operator = 'SUM'
   units = 'meter'
EndSect  // Item

[Item]
   Name = 'Alligator Lake'
   Branch = 'UPPER-ALLIGATOR'
   SpecifiedRange = true
   Chainage = 0
   ChainageEnd = 1748
   DataType = 'LATERAL INFLOW SHE OVERLAND'
   SpecifiedOperator = true
   Operator = 'SUM'
   units = 'meter'
EndSect  // Item

[Item]
   Name = 'Alligator Lake'
   Branch = 'LK-BRICK'
   SpecifiedRange = true
   Chainage = 0
   ChainageEnd = 3900
   DataType = 'LATERAL INFLOW SHE OVERLAND'
   SpecifiedOperator = true
   Operator = 'SUM'
   units = 'meter'
EndSect  // Item


[Item]
   Name = 'C-38 0-17284'
   Branch = 'C-38'
   SpecifiedRange = true
   Chainage = 0
   ChainageEnd = 17284
   DataType = 'LATERAL INFLOW SHE OVERLAND'
   SpecifiedOperator = true
   Operator = 'SUM'
   units = 'meter'
EndSect  // Item

[Item]
   Name = 'Armstrong_Slough 5000-12305'
   Branch = 'Armstrong_Slough'
   SpecifiedRange = true
   Chainage = 5000
   ChainageEnd = 12305
   DataType = 'LATERAL INFLOW SHE OVERLAND'
   SpecifiedOperator = true
   Operator = 'SUM'
   units = 'meter'
EndSect  // Item

[Item]
   Name = 'Meander1 0-3105'
   Branch = 'Meander1'
   SpecifiedRange = true
```

```
      Chainage = 0
      ChainageEnd = 3105
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'Meander2 0-1967'
      Branch = 'Meander2'
      SpecifiedRange = true
      Chainage = 0
      ChainageEnd = 1967
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'Meander3 0-1545'
      Branch = 'Meander3'
      SpecifiedRange = true
      Chainage = 0
      ChainageEnd = 1545
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'Meander4 0-2266'
      Branch = 'Meander4'
      SpecifiedRange = true
      Chainage = 0
      ChainageEnd = 2266
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'Meander5 0-4595'
      Branch = 'Meander5'
      SpecifiedRange = true
      Chainage = 0
      ChainageEnd = 4595
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'Meander6 0-2560'
      Branch = 'Meander6'
      SpecifiedRange = true
      Chainage = 0
      ChainageEnd = 2560
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'C-38 17332-35913'
      Branch = 'C-38'
      SpecifiedRange = true
      Chainage = 17332
      ChainageEnd = 35913
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item
```

```
[Item]
   Name = 'Kissimmee River 0-22049'
   Branch = 'Kissimmee_River'
   SpecifiedRange = true
   Chainage = 0
   ChainageEnd = 22049
   DataType = 'LATERAL INFLOW SHE OVERLAND'
   SpecifiedOperator = true
   Operator = 'SUM'
   units = 'meter'
EndSect  // Item

[Item]
   Name = 'Meander10 0-1300'
   Branch = 'Meander10'
   SpecifiedRange = true
   Chainage = 0
   ChainageEnd = 1300
   DataType = 'LATERAL INFLOW SHE OVERLAND'
   SpecifiedOperator = true
   Operator = 'SUM'
   units = 'meter'
EndSect  // Item

[Item]
   Name = 'Meander11 0-880'
   Branch = 'Meander11'
   SpecifiedRange = true
   Chainage = 0
   ChainageEnd = 880
   DataType = 'LATERAL INFLOW SHE OVERLAND'
   SpecifiedOperator = true
   Operator = 'SUM'
   units = 'meter'
EndSect  // Item

[Item]
   Name = 'Meander12 0-2440'
   Branch = 'Meander12'
   SpecifiedRange = true
   Chainage = 0
   ChainageEnd = 2440
   DataType = 'LATERAL INFLOW SHE OVERLAND'
   SpecifiedOperator = true
   Operator = 'SUM'
   units = 'meter'
EndSect  // Item

[Item]
   Name = 'Meander7 0-1044'
   Branch = 'Meander7'
   SpecifiedRange = true
   Chainage = 0
   ChainageEnd = 1044
   DataType = 'LATERAL INFLOW SHE OVERLAND'
   SpecifiedOperator = true
   Operator = 'SUM'
   units = 'meter'
EndSect  // Item

[Item]
   Name = 'Meander8 0-3260'
   Branch = 'Meander8'
   SpecifiedRange = true
   Chainage = 0
   ChainageEnd = 3260
   DataType = 'LATERAL INFLOW SHE OVERLAND'
   SpecifiedOperator = true
   Operator = 'SUM'
   units = 'meter'
EndSect  // Item

[Item]
   Name = 'Meander9 0-3640'
   Branch = 'Meander9'
   SpecifiedRange = true
   Chainage = 0
   ChainageEnd = 3640
```

```
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'Pine_Island_Slough 5126-13442'
      Branch = 'Pine_Island_Slough'
      SpecifiedRange = true
      Chainage = 5126
      ChainageEnd = 13442
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'Sevenmile_Slough 2252-13031'
      Branch = 'Sevenmile_Slough'
      SpecifiedRange = true
      Chainage = 2252
      ChainageEnd = 13031
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'Istokpoga_Canal 2400-4656'
      Branch = 'Istokpoga_Canal'
      SpecifiedRange = true
      Chainage = 2400
      ChainageEnd = 4656
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'Meander17 0-4320'
      Branch = 'Meander17'
      SpecifiedRange = true
      Chainage = 0
      ChainageEnd = 4320
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'Oak_Creek 0-2945'
      Branch = 'Oak_Creek'
      SpecifiedRange = true
      Chainage = 0
      ChainageEnd = 2945
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'Lower_C-38 47705-50968'
      Branch = 'Lower_C-38'
      SpecifiedRange = true
      Chainage = 47705
      ChainageEnd = 50968
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
```

```
    Name = 'KR-M17-Canal 0-3819'
    Branch = 'KR-M17-Canal'
    SpecifiedRange = true
    Chainage = 0
    ChainageEnd = 3819
    DataType = 'LATERAL INFLOW SHE OVERLAND'
    SpecifiedOperator = true
    Operator = 'SUM'
    units = 'meter'
 EndSect  // Item

 [Item]
    Name = 'Chandler_Slough1 0-3991'
    Branch = 'Chandler_Slough1'
    SpecifiedRange = true
    Chainage = 0
    ChainageEnd = 3991
    DataType = 'LATERAL INFLOW SHE OVERLAND'
    SpecifiedOperator = true
    Operator = 'SUM'
    units = 'meter'
 EndSect  // Item

 [Item]
    Name = 'Cypress_Slough 0-9270'
    Branch = 'Cypress_Slough'
    SpecifiedRange = false
    Chainage = 9269
    ChainageEnd = 9270
    DataType = 'LATERAL INFLOW SHE OVERLAND'
    SpecifiedOperator = false
    Operator = 'SUM'
    units = 'meter'
 EndSect  // Item

 [Item]
    Name = 'Meander18 2338-7906'
    Branch = 'Meander18'
    SpecifiedRange = true
    Chainage = 2338
    ChainageEnd = 7906
    DataType = 'LATERAL INFLOW SHE OVERLAND'
    SpecifiedOperator = true
    Operator = 'SUM'
    units = 'meter'
 EndSect  // Item

 [Item]
    Name = 'Meander19 0-2889'
    Branch = 'Meander19'
    SpecifiedRange = true
    Chainage = 0
    ChainageEnd = 2889
    DataType = 'LATERAL INFLOW SHE OVERLAND'
    SpecifiedOperator = true
    Operator = 'SUM'
    units = 'meter'
 EndSect  // Item

 [Item]
    Name = 'Meander20 0-2247'
    Branch = 'Meander20'
    SpecifiedRange = true
    Chainage = 0
    ChainageEnd = 2247
    DataType = 'LATERAL INFLOW SHE OVERLAND'
    SpecifiedOperator = true
    Operator = 'SUM'
    units = 'meter'
 EndSect  // Item

 [Item]
    Name = 'Meander21 0-4658'
    Branch = 'Meander21'
    SpecifiedRange = true
    Chainage = 0
    ChainageEnd = 4658
    DataType = 'LATERAL INFLOW SHE OVERLAND'
    SpecifiedOperator = true
```

```
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'Meander22 0-2150'
      Branch = 'Meander22'
      SpecifiedRange = true
      Chainage = 0
      ChainageEnd = 2150
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'Lower_C-38 51032-65211'
      Branch = 'Lower_C-38'
      SpecifiedRange = true
      Chainage = 51032
      ChainageEnd = 65211
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'Meander23 0-6484'
      Branch = 'Meander23'
      SpecifiedRange = true
      Chainage = 0
      ChainageEnd = 6484
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'S65E_HConnection 0-588'
      Branch = 'S65E_HConnection'
      SpecifiedRange = true
      Chainage = 0
      ChainageEnd = 588
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'S65E_HConnection 0-588'
      Branch = 'S65E_HConnection'
      SpecifiedRange = true
      Chainage = 0
      ChainageEnd = 588
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item

   [Item]
      Name = 'Lower_C38ToC41A 0-3160'
      Branch = 'Lower_C38ToC41A'
      SpecifiedRange = true
      Chainage = 0
      ChainageEnd = 3160
      DataType = 'LATERAL INFLOW SHE OVERLAND'
      SpecifiedOperator = true
      Operator = 'SUM'
      units = 'meter'
   EndSect  // Item


   [Item]
      Name = 'Lower_C-38 65323-76009'
```

```
        Branch = 'Lower_C-38'
        SpecifiedRange = true
        Chainage = 65323
        ChainageEnd = 76009
        DataType = 'LATERAL INFLOW SHE OVERLAND'
        SpecifiedOperator = true
        Operator = 'SUM'
        units = 'meter'
     EndSect  // Item

  EndSect  // DataExtraction


EndSect  // AFETDataExtractor
```

APPENDIX D

Development of C-36 & C-37 Flow Equations

Development of C-36 & C-37 Flow Equations

The Post-Phase I KRRP HEC-RAS model was used to perform model runs to relate stage and flow in canals C-36 and C-37. A two-dimensional regression equation was fit to these data and coded into *CanalCaps.ocl*. See Section 2 for more details.

Note, only data in the historic range (marked in the figures) were used in formulating and evaluating the regression equations.

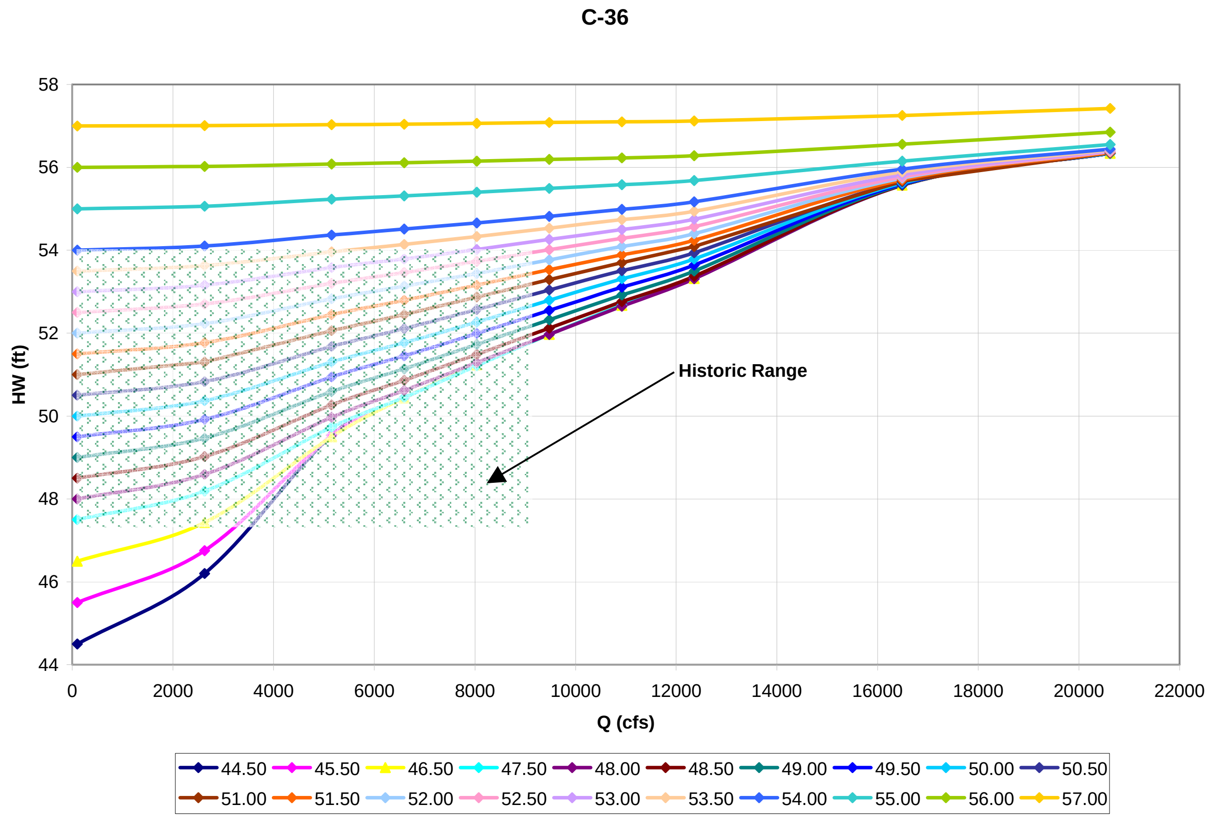


Figure D-1: HEC-RAS model results relating flow, HW, and TW in Canal C-36. Values are given in Table D-1.

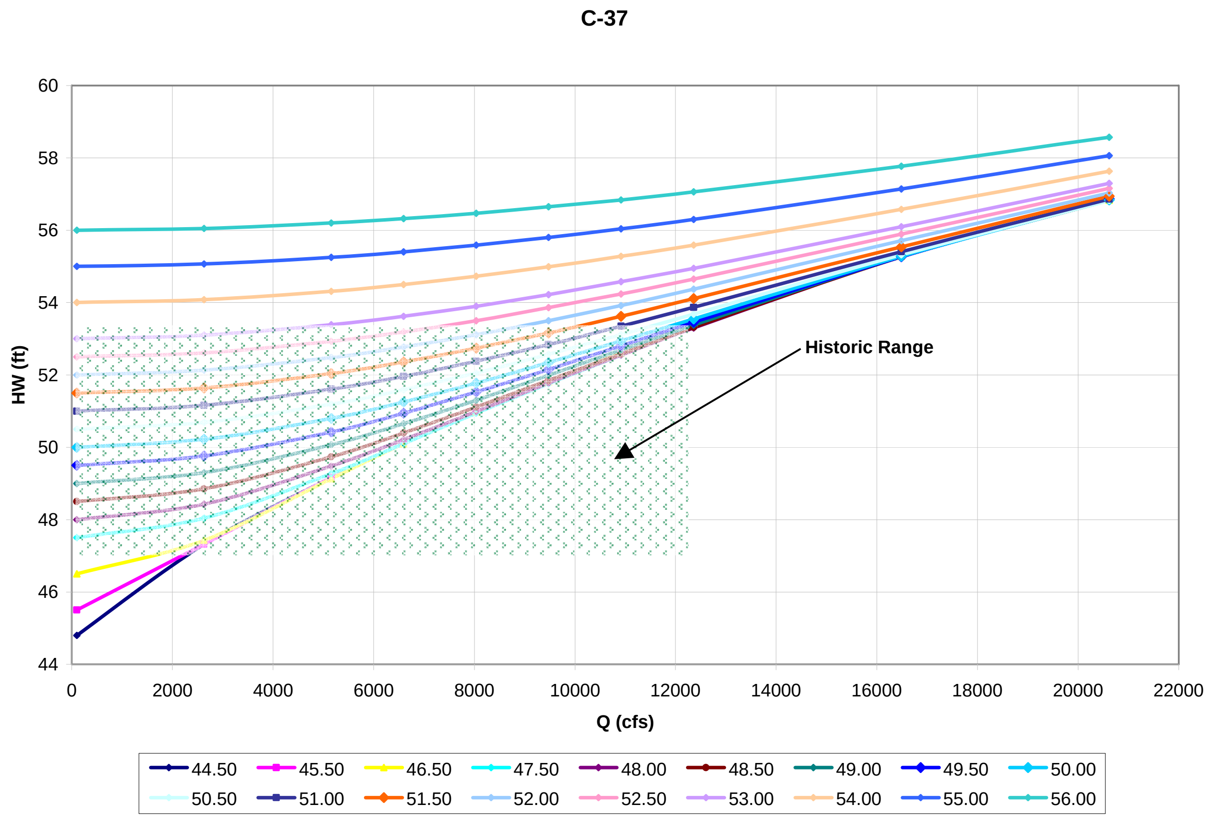


Figure D-2: HEC-RAS model results relating flow, HW, and TW in Canal C-37. Values are given in Table D-2.

Table D-1: Headwater as a function of tailwater (columns) and flow (rows) in Canal C-36 from HEC-RAS model runs

Q cfs \ H ft	**44.50**	**45.50**	**46.50**	**47.50**	**48.00**	**48.50**	**49.00**
100	44.50	45.50	46.50	47.50	48.00	48.50	49.00
2628	46.20	46.75	47.43	48.19	48.59	49.02	49.47
5155	49.54	49.53	49.50	49.73	49.97	50.27	50.59
6596	50.44	50.44	50.44	50.45	50.62	50.86	51.14
8036	51.23	51.23	51.23	51.21	51.29	51.49	51.73
9477	51.97	51.97	51.97	51.97	51.97	52.12	52.32
10917	52.67	52.67	52.67	52.67	52.65	52.76	52.92
12358	53.32	53.32	53.32	53.32	53.31	53.37	53.50
16489	55.57	55.57	55.57	55.57	55.57	55.57	55.58
20620	56.34	56.34	56.34	56.34	56.34	56.34	56.34
Q cfs \ H ft	**49.50**	**50.00**	**50.50**	**51.00**	**51.50**	**52.00**	**52.50**
100	49.50	50.00	50.50	51.00	51.50	52.00	52.50
2628	49.92	50.37	50.83	51.30	51.77	52.23	52.70
5155	50.94	51.30	51.68	52.06	52.45	52.83	53.20
6596	51.45	51.77	52.11	52.45	52.79	53.13	53.46
8036	51.99	52.27	52.57	52.87	53.16	53.44	53.73
9477	52.55	52.79	53.04	53.29	53.53	53.77	54.01
10917	53.11	53.31	53.51	53.70	53.89	54.09	54.29
12358	53.64	53.79	53.94	54.09	54.24	54.40	54.57
16489	55.60	55.62	55.65	55.67	55.70	55.74	55.77
20620	56.34	56.34	56.35	56.35	56.36	56.38	56.38
Q cfs \ H ft	**53.00**	**53.50**	**54.00**	**55.00**	**56.00**	**57.00**	
100	53.00	53.50	54.00	55.00	56.00	57.00	
2628	53.16	53.63	54.10	55.06	56.02	57.01	
5155	53.58	53.96	54.37	55.23	56.08	57.03	
6596	53.79	54.14	54.51	55.31	56.11	57.04	
8036	54.02	54.33	54.66	55.40	56.15	57.06	
9477	54.26	54.53	54.82	55.49	56.19	57.08	
10917	54.50	54.74	54.99	55.58	56.23	57.10	
12358	54.75	54.94	55.17	55.68	56.28	57.12	
16489	55.82	55.89	55.96	56.15	56.56	57.25	
20620	56.40	56.42	56.44	56.55	56.85	57.42	

Table D-2: Headwater as a function of tailwater (columns) and flow (rows) in Canal C-37 from HEC-RAS model runs.

Q cfs \ H ft	**44.50**	**45.50**	**46.50**	**47.50**	**48.00**	**48.50**	**49.00**
100	44.80	45.50	46.50	47.50	48.00	48.50	49.00
2628	47.32	47.32	47.43	48.04	48.43	48.85	49.30
5155	49.16	49.16	49.13	49.27	49.48	49.74	50.07
6596	50.10	50.10	50.10	50.10	50.21	50.40	50.65
8036	50.98	50.98	50.98	50.94	50.99	51.11	51.30
9477	51.81	51.81	51.81	51.76	51.78	51.85	51.99
10917	52.60	52.60	52.60	52.55	52.55	52.58	52.69
12358	53.39	53.39	53.39	53.35	53.30	53.32	53.38
16489	55.28	55.28	55.28	55.28	55.27	55.27	55.27
20620	56.83	56.83	56.83	56.83	56.84	56.86	56.87
Q cfs \ H ft	**49.50**	**50.00**	**50.50**	**51.00**	**51.50**	**52.00**	**52.50**
100	49.50	50.00	50.50	51.00	51.50	52.00	52.50
2628	49.76	50.22	50.69	51.16	51.64	52.13	52.61
5155	50.42	50.80	51.19	51.61	52.04	52.48	52.93
6596	50.94	51.25	51.59	51.96	52.36	52.77	53.19
8036	51.53	51.77	52.05	52.38	52.74	53.11	53.50
9477	52.15	52.34	52.57	52.84	53.16	53.50	53.86
10917	52.80	52.94	53.11	53.35	53.62	53.92	54.24
12358	53.46	53.55	53.68	53.87	54.11	54.37	54.65
16489	55.27	55.28	55.32	55.41	55.54	55.71	55.89
20620	56.87	56.84	56.82	56.86	56.94	57.03	57.16
Q cfs \ H ft	**53.00**	**54.00**	**55.00**	**56.00**			
100	53.00	54.00	55.00	56.00			
2628	53.10	54.08	55.07	56.05			
5155	53.39	54.31	55.25	56.20			
6596	53.62	54.50	55.40	56.32			
8036	53.90	54.73	55.59	56.47			
9477	54.22	54.99	55.80	56.65			
10917	54.58	55.28	56.04	56.84			
12358	54.95	55.59	56.30	57.06			
16489	56.10	56.58	57.14	57.77			
20620	57.30	57.63	58.06	58.57			

APPENDIX E

Maximum Allowable Gate Opening Regression Equations

Maximum Allowable Gate Opening Regression Equations

The maximum allowable gate openings for each S-65 structures are needed to determine the maximum flow in each reach. Values from the Maximum Allowable Gate Openings curves (Central and Southern Florida Project, Master Water Control Manual, Kissimmee River-Lake Istokpoga Basin, USACE Jacksonville District, August 1994) were picked off by hand: the data points are provided in Table E-1 below.

Two-dimensional regression equations were developed based on the data in Table E-1. The results for four different equations are shown in Table E-2. Part A shows the form of the equation used in UKISS for the upper basin: this form does a poor job for S-65A and E (R^2 = 0.9798 and 0.3447). A number of other equations were tried, three of which are shown in Table E-2. The equation shown in Table E-2, Part D performed the best for all structures, with a maximum deviation from the data of 0.77 ft.

Table E-1: Values from the Maximum Allowable Gate Opening Curves, Aug 1994

A) S-65A

TW (ft)	HW (ft)	GO (ft)
38	44.2	3.5
38	46.1	3
38	50.9	2
39	44.6	4.5
39	45.9	4
39	48.7	3
39	51	2.5
40	45.4	6
40	46.5	5
40	48.6	4
40	51.5	3
41	45.8	8
41	45.6	8.5
41	46.2	7.5
41	46.7	7
41	47.8	6
41	48.4	5.5
41	49.2	5
41	51.3	4
42	46	10.5
42	46.3	10
42	46.6	9.5
42	47	9
42	47.7	8
42	48.3	7.5
42	48.8	7
42	49.9	6
42	50.9	5.5
43	46.7	11.5
43	47.1	11
43	47.8	10
43	48.6	9
43	49.5	8
43	50.1	7.5
43	50.8	7
44	47.4	12.5
44	47.7	12
44	48.1	11.5
44	48.5	11
44	49.3	10
44	50.2	9
44	51.4	8
45	48.8	12.5
45	49.1	12
45	49.9	11

B) S-65B

TW (ft)	HW (ft)	GO (ft)
31	38.15	8
31	38.55	7
31	39.25	6
31	41.6	5
32	38.1	10
32	38.45	9
32	39	8
32	39.75	7
32	42.3	6
33	38.8	10
33	39.4	9
33	40.7	8
33	42.7	7
34	39.1	11
34	39.8	10
34	41	9
35	40.45	11
35	41.5	10
36	40.25	13
36	40.85	12
36	42	11
37	41.85	13
37	42.55	12
38	41.65	14
38	43.1	13
39	42.2	15
40	42.8	16

45	50.8	10
45	51.3	9.5
46	50.2	12.5
46	50.6	12
46	51.2	11

C) S-65C

TW (ft)	HW (ft)	GO (ft)
24	30.8	6
24	32	5
24	34.1	4
25	31.6	7
25	32.8	6
25	34.4	5
26	32.2	8
26	33.5	7
26	35	6
27	33.2	9
27	34	8
27	35.5	7
28	33.2	11
28	34.1	10
28	34.9	9
29	33.9	12
29	34.7	11
29	35.7	10
30	34.5	13
30	35.4	12

D) S-65D

TW (ft)	HW (ft)	GO (ft)
18	25.9	7
18	27.4	6
18	30	5
19	26.8	8
19	28	7
19	29.1	6
20	26.7	10
20	27.9	9
20	28.9	8
20	30.3	7
21	27.7	11
21	28.7	10
21	29.8	9
21	31	8
22	27.9	13
22	28.8	12
22	29.7	11

E) S-65E

TW (ft)	HW (ft)	GO (ft)
10	18.9	7
10	20	6
10	21.5	5
11	20	7.5
11	20.7	7
11	21.5	6.5
11	22.2	6
11	22.9	5.5
11	23.6	5
12	20.4	8.5
12	21	8
12	22.6	7
12	23.8	6
13	21.4	8.5
13	22.1	8
13	23	7.5
13	23.7	7
14	21.4	9
14	23	8
15	21.4	9.5
15	22	9
15	23.7	8
16	22	9.5
16	22.6	9
16	23.4	8.5
17	22	10
17	22.5	9.5
17	23.1	9
17	23.9	8.5
18	22.5	10
18	23	9.5
18	23.6	9
19	23	10
19	23.5	9.5
20	23.5	10

22	30.6	10
23	28.7	14
23	29.6	13
23	30.6	12
24	29.3	15
24	30.1	14
24	31.1	13

Table E-2: Regression equations for maximum allowable gate openings

A)	STRUCTURE				
	S-65A	**S-65B**	**S-65C**	**S-65D**	**S-65E**
	GO_max = a(HW-TW)^b * TW^c + d				
A	-844.880867	-208.251174	15.1410709	14.6892716	16569.4362
B	0.007179342	0.280378598	-0.121743281	-0.17189912	-0.0001668
C	-0.046288082	-0.806772244	0.424504125	0.44901081	0.000131675
D	727.58653	30.1618874	-40.2023821	-30.6132134	-16561.5108
E					
R^2	0.9798	0.986	0.9979	0.9946	0.8463
deviation from data (ft)					
ave	0.32	0.27	0.09	0.16	0.48
max	1.6	0.95	0.23	0.53	1.2

B)	**GO_max = a(HW-TW)^b + cHW + dTW + e**				
A	-20.6306078	-187.750999	-60.2851974	-79.8303576	76.1658988
B	0.903146577	0.998278379	0.978871028	0.98206612	0.989300192
C	14.6706984	185.953756	55.7767001	74.64116711	-74.169894
D	-13.866838	-185.477614	-55.0084906	-73.7721079	74.2746104
E	-10.2641445	1.1989653	1.98216073	9.52967352	4.34207245
R^2	0.9905	0.9848	0.9982	0.9954	0.9399
deviation from data (ft)					
ave	0.23	0.27	0.08	0.16	0.3
max	0.97	0.97	0.23	0.39	0.81

C)	**GO_max = aHW^b + cTW^d + e**				
A	-4.91155E-06	-49.2013014	-2.12486E-06	-2.1559E-06	-1.506E-07
B	3.72033577	0.259630899	4.23934577	4.38401978	5.38210706
C	2.04704936	1.05106416	0.039390387	0.169211807	390.75762
d	0.937643199	1.05456449	1.92652738	1.6062093	0.019924982
e	-51.2671614	95.0028777	-7.61230071	-7.06982079	-400.960883
R^2	0.9509	0.9841	0.9947	0.9894	0.955
deviation from data (ft)					
ave	0.55	0.28	0.15	0.21	0.25
max	2.3	0.96	0.41	0.95	0.91

D)	GO_max = a(HW*TW)^b + cHW + dTW + e				
a	-4.72066988	-4.74754332	-5.49788092	-6.33317538	-1.6591E-05
b	0.674371415	0.536129506	0.60262226	0.586094038	2.17462761
c	10.2932362	2.1452248	5.04104706	4.55811145	-0.29463541
d	14.5903463	4.9688841	9.12843668	9.35287177	1.33262822
e	-300.081385	-17.4329468	-74.0904385	-47.4172074	0.618537704
R^2	0.9921	0.9846	0.998	0.9965	0.9692
deviation from data (ft)					
ave	0.21	0.27	0.09	0.13	0.22
max	0.77	0.99	0.29	0.44	0.65

APPENDIX F

Effect of Lateral Inflows in OKISS Results

Effect of Lateral Inflows in OKISS Results

In an effort to assess the effects that variations in lateral inflows would have on the results obtained from OKISS, an exercise was performed where lateral inflows were modified by a 10%. This analysis was performed during the initial stages of the OKISS development, and was done to assess the response of the model under different scenarios, verifying the robustness of the internal formulation. This exercise did not intend to provide information on the model uncertainty or sensitivity since it did not follow the standards required for that type of analysis. The results obtained are given in Figures F-1 through F-25, which show stages and arcflows with the original lateral inflow (green lines), lateral inflows increased by 10% (white lines), and lateral inflows decreased by 10% (yellow lines). The target stage specified by the current regulation schedule is shown in blue.

When target stages could be maintained with the original lateral inflows, they were also maintained with the inflow changes, and the arcflows were altered accordingly. This can be seen, for example, in Alligator Lake. From July to October, the target stage is maintained. The arcflow out of Alligator increases or decreases accordingly during these months. Under the increased lateral inflow condition, the maximum flow through this arc (010.120) is reached occasionally; on these days, excess water is released through arc010.060 to maintain the target stage in Alligator Lake.

The same behavior occurs in the lower basin, where target stages were maintained with the original inflows: the stages stay the same and the volume difference is seen in the arcflows. The one exception is in Pool A which shows small drawdowns in the spring when inflows are reduced, and one day of increased stage when inflows are increased.

At times when the stage was below the target stage, the change in lateral inflows results in a shift in the stage. During these times periods, OKISS maintains the highest stage that can be supported by the lateral inflows. This can be seen in Alligator Lake from October to July: the stages shift and the arcflows remain zero.

Similarly, at times when the stage was above the target stage, the change in lateral inflows results in a shift in the stage. During these times periods, OKISS maintains the lowest stage allowable by the maximum flows in the arcs. This can be seen in Lake Myrtle, for example, in August and September: the stages shift and the arcflow remains at its maximum value.

The results are summarized in Table F- 1.

Table F- 1: Summary of results from inflow sensitivity analysis.

Original Inflows	Increased Inflows	Decreased Inflows
Target stage met	Target stage met until arcflow out of lake reaches maximum; then, stage increases	Target stage met until arcflow out of lake drops to zero; then, stage decreases
Stage below target	Stage increases as far as target	Stage decreases further
Stage above target	Stage increases, since arcflow is already at maximum under original inflows	Stage decreases as low as target

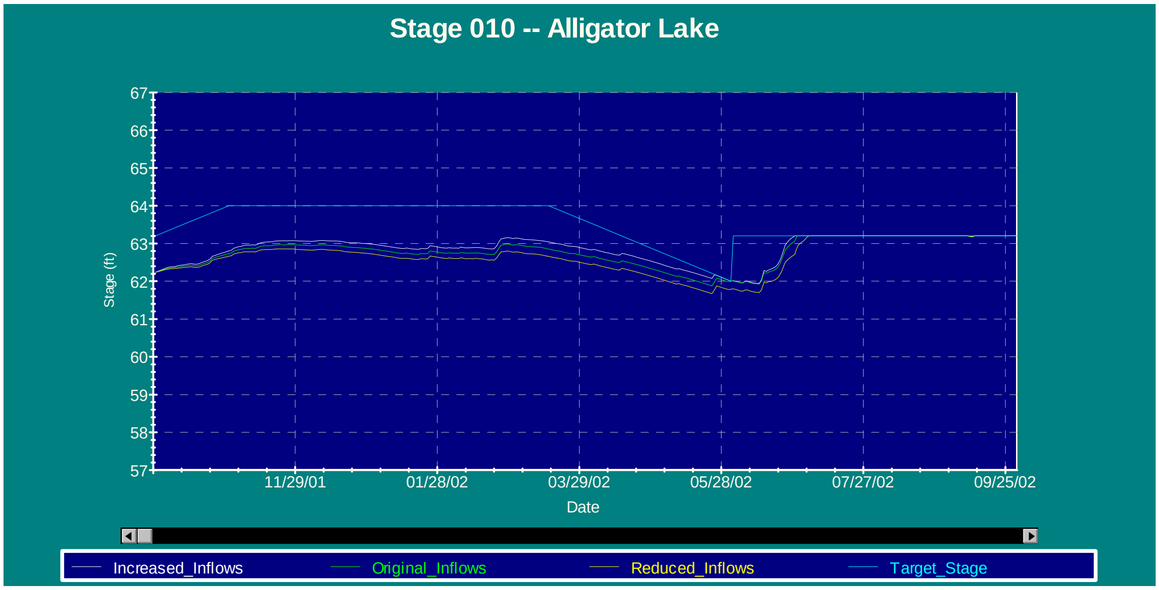


Figure F- 1: Simulated stage in node 010 with the original lateral inflows, lateral inflows increased by 10%, and lateral inflows reduced by 10%.

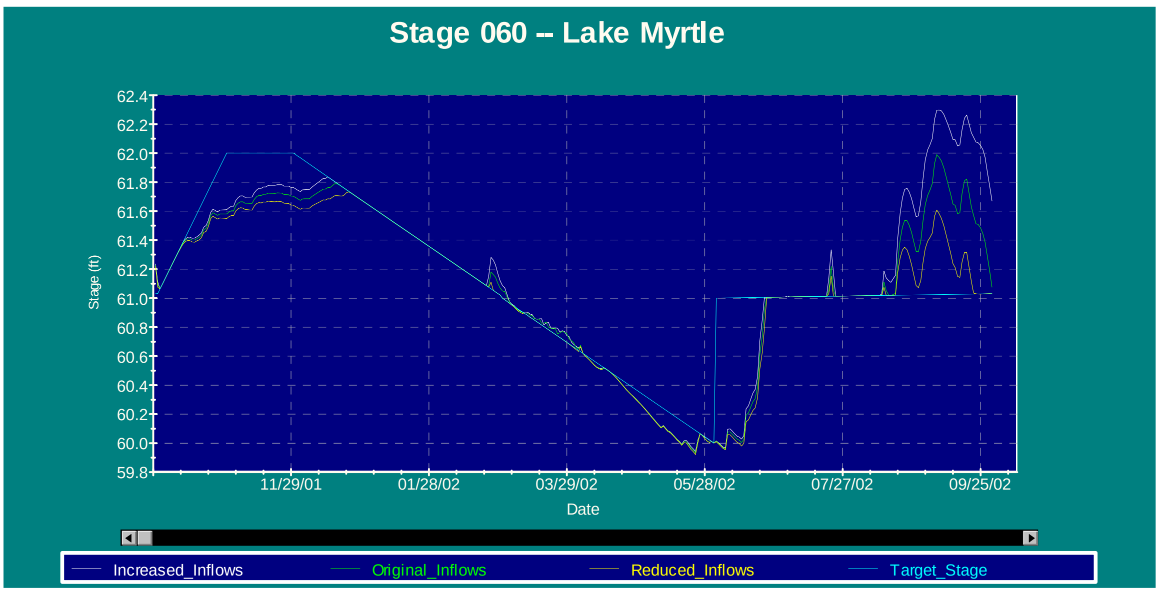


Figure F- 2: Simulated stage in node 060 with the original lateral inflows, lateral inflows increased by 10%, and lateral inflows reduced by 10%.

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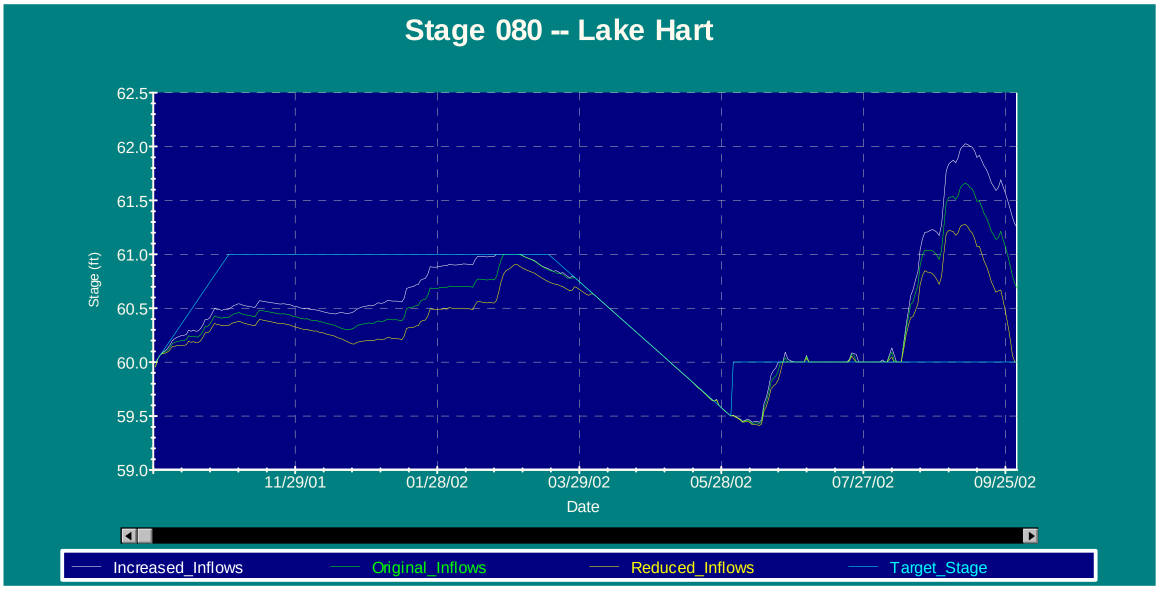

Figure F- 3: Simulated stage in node 080 with the original lateral inflows, lateral inflows increased by 10%, and lateral inflows reduced by 10%.

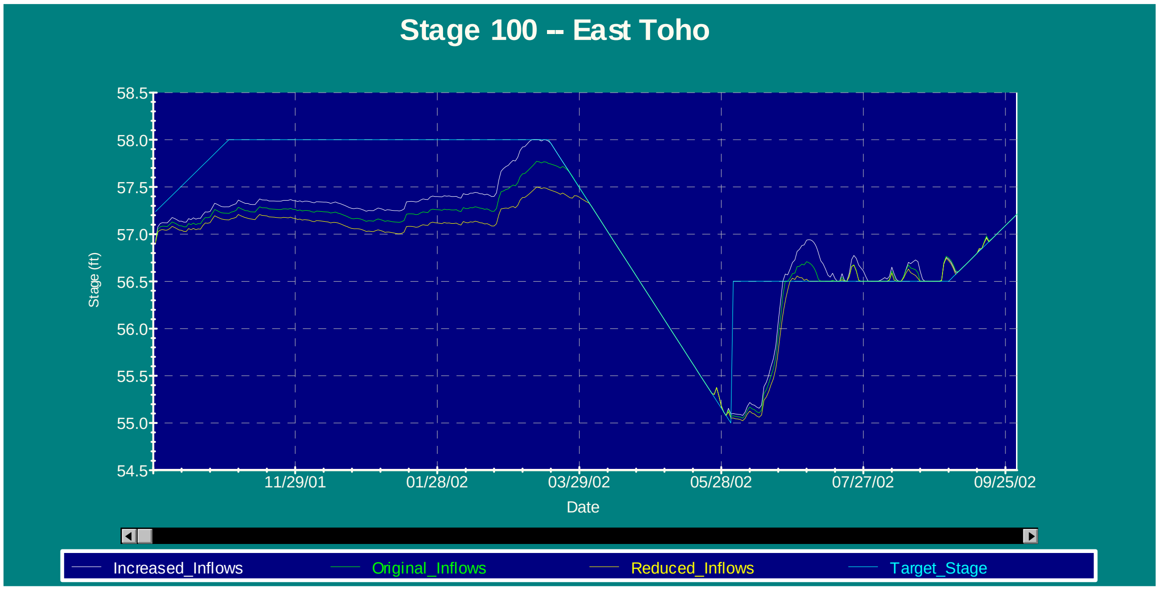

Figure F- 4: Simulated stage in node 100 with the original lateral inflows, lateral inflows increased by 10%, and lateral inflows reduced by 10%.

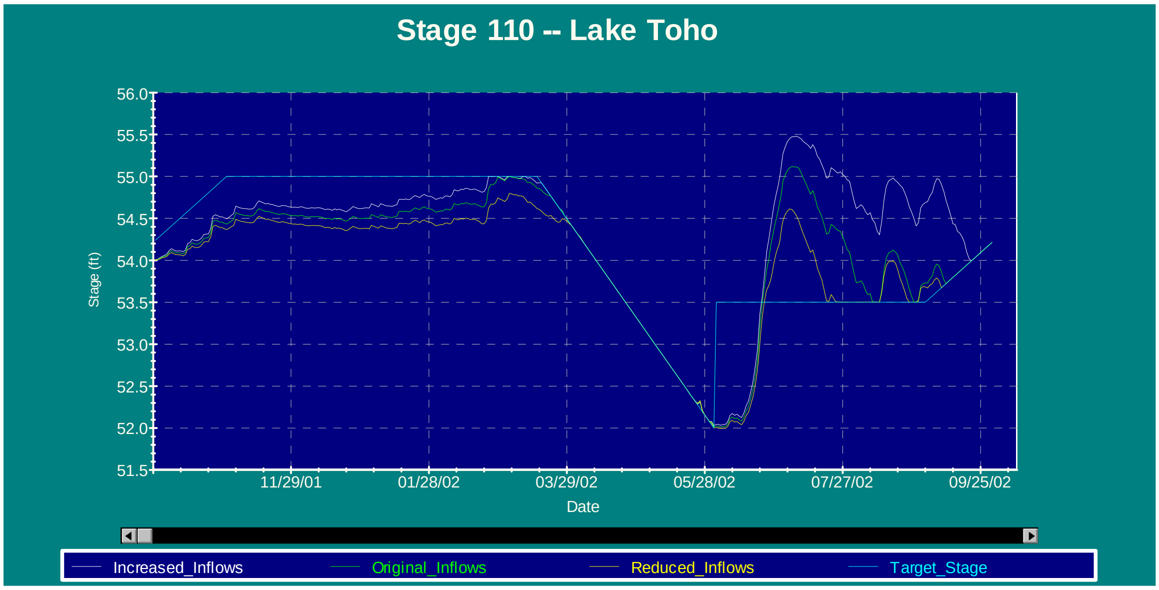

Figure F- 5: Simulated stage in node 110 with the original lateral inflows, lateral inflows increased by 10%, and lateral inflows reduced by 10%.

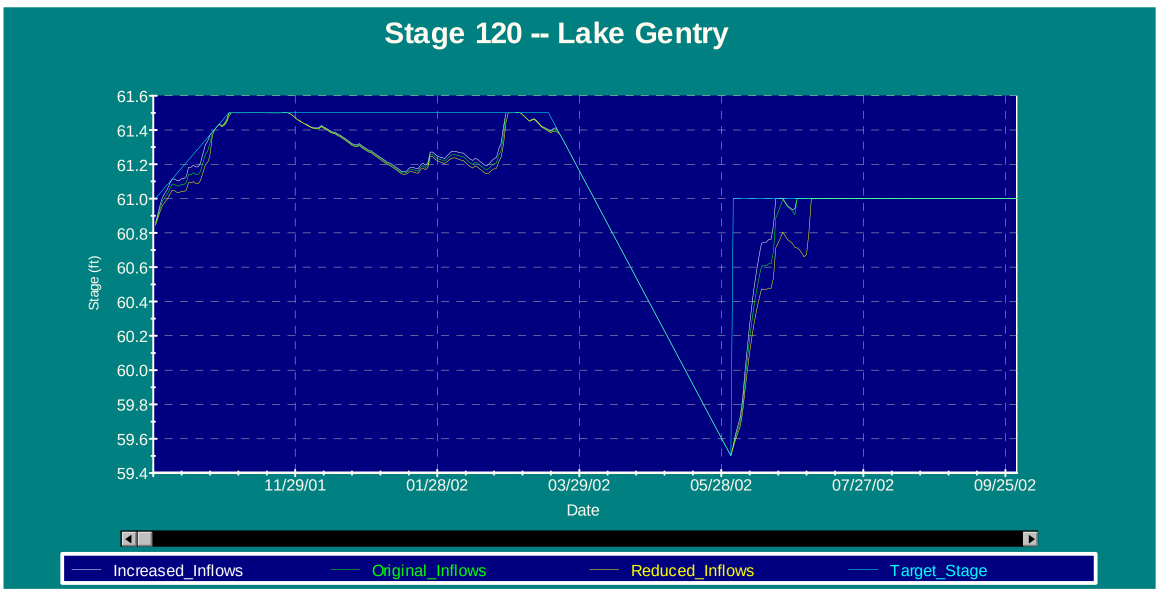

Figure F- 6: Simulated stage in node 120 with the original lateral inflows, lateral inflows increased by 10%, and lateral inflows reduced by 10%.

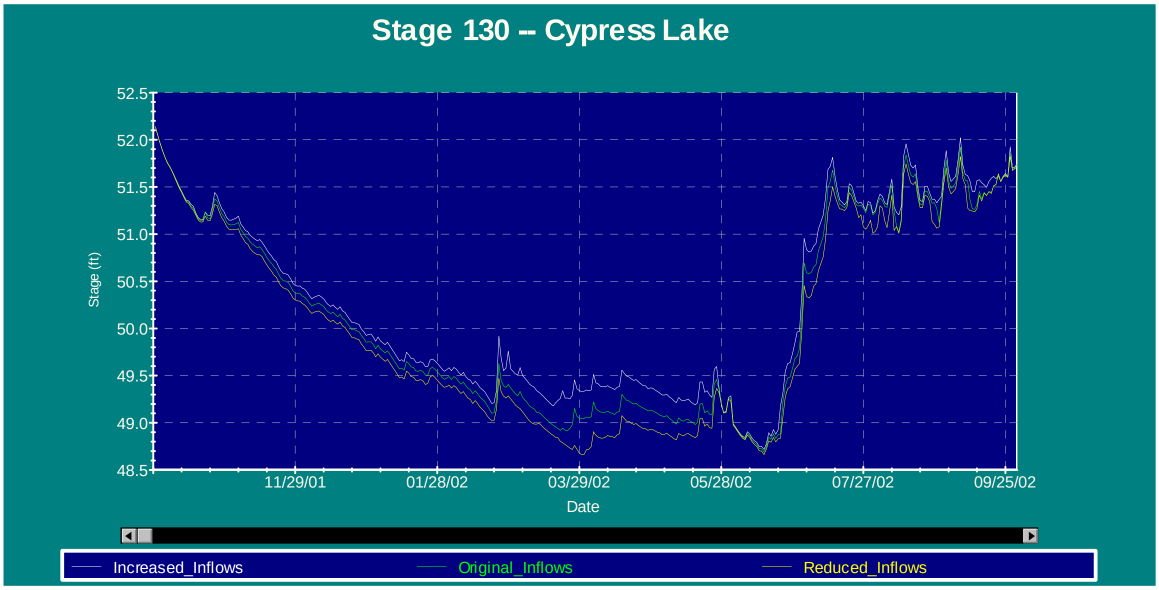

Figure F- 7: Simulated stage in node 130 with the original lateral inflows, lateral inflows increased by 10%, and lateral inflows reduced by 10%.

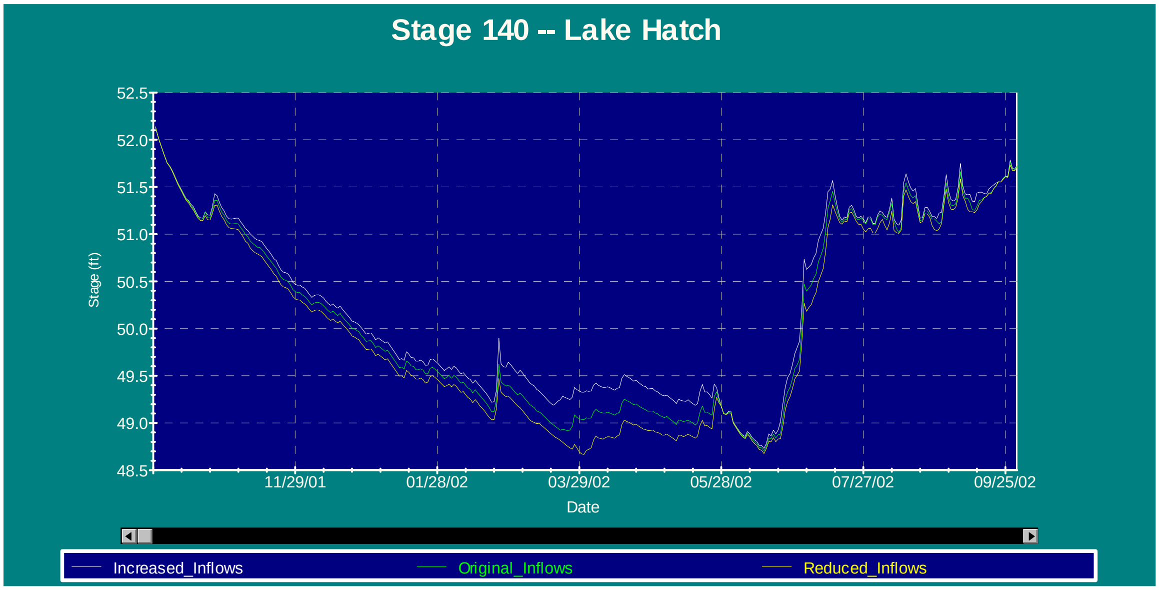

Figure F- 8: Simulated stage in node 140 with the original lateral inflows, lateral inflows increased by 10%, and lateral inflows reduced by 10%.

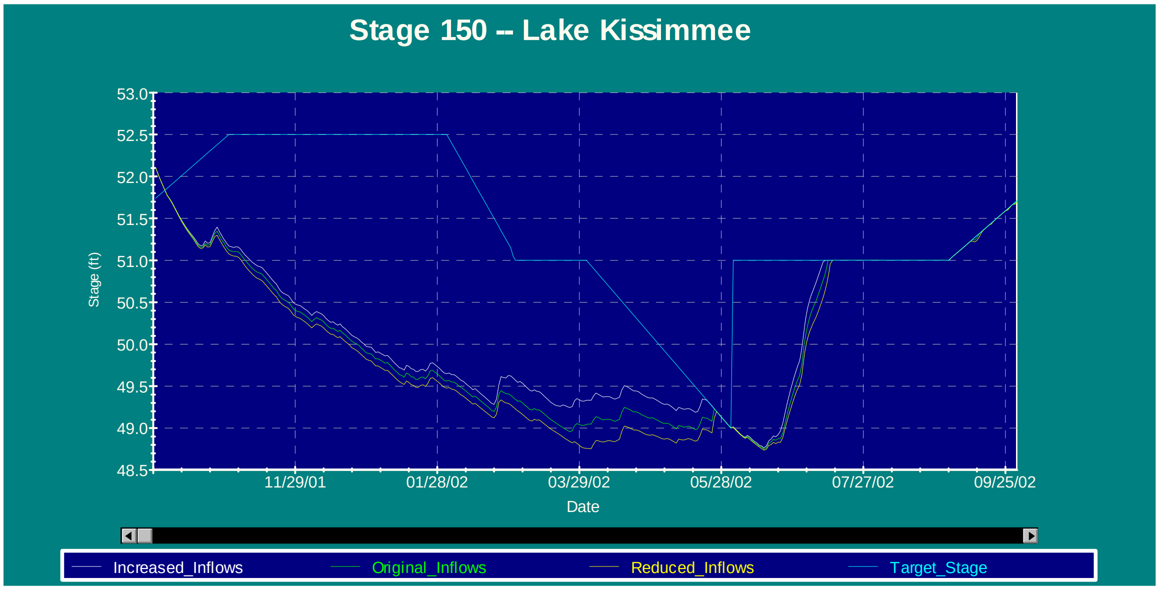

Figure F- 9: Simulated stage in node 150 with the original lateral inflows, lateral inflows increased by 10%, and lateral inflows reduced by 10%.

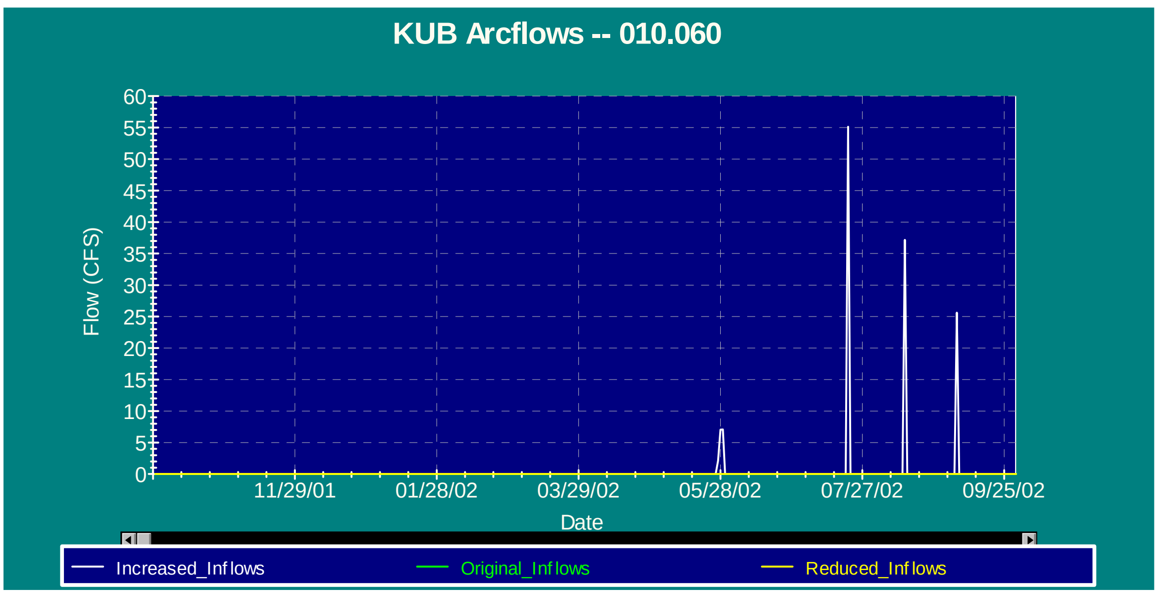

Figure F- 10: Simulated arcflows in arc010.060 with the original lateral inflows, lateral inflows increased by 10%, and lateral inflows reduced by 10%.

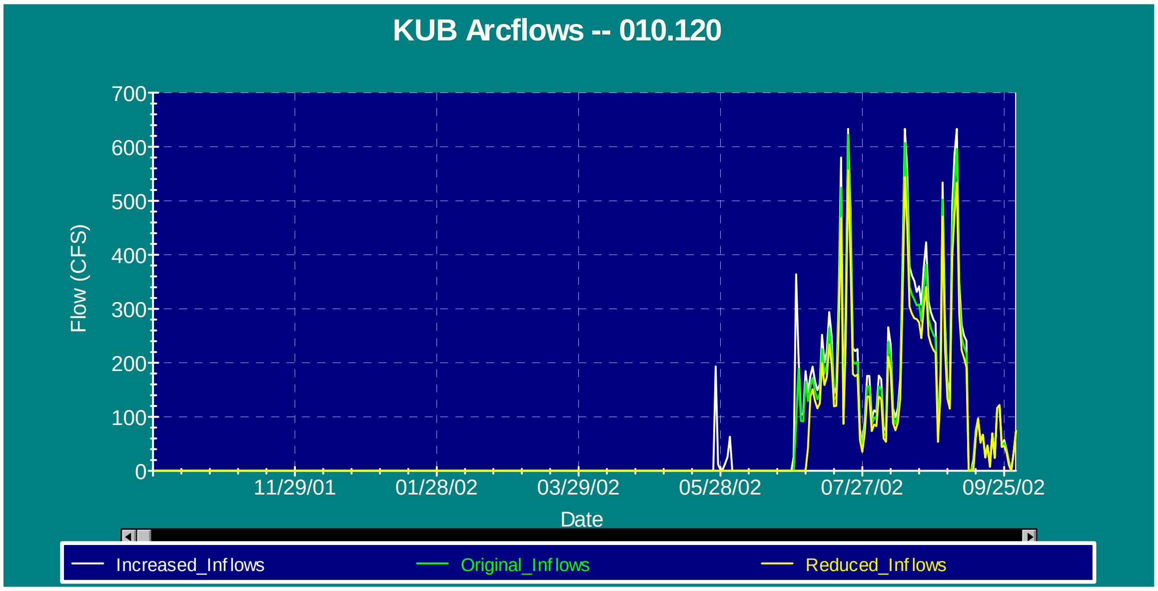

Figure F- 11: Simulated arcflows in arc010.120 with the original lateral inflows, lateral inflows increased by 10%, and lateral inflows reduced by 10%.

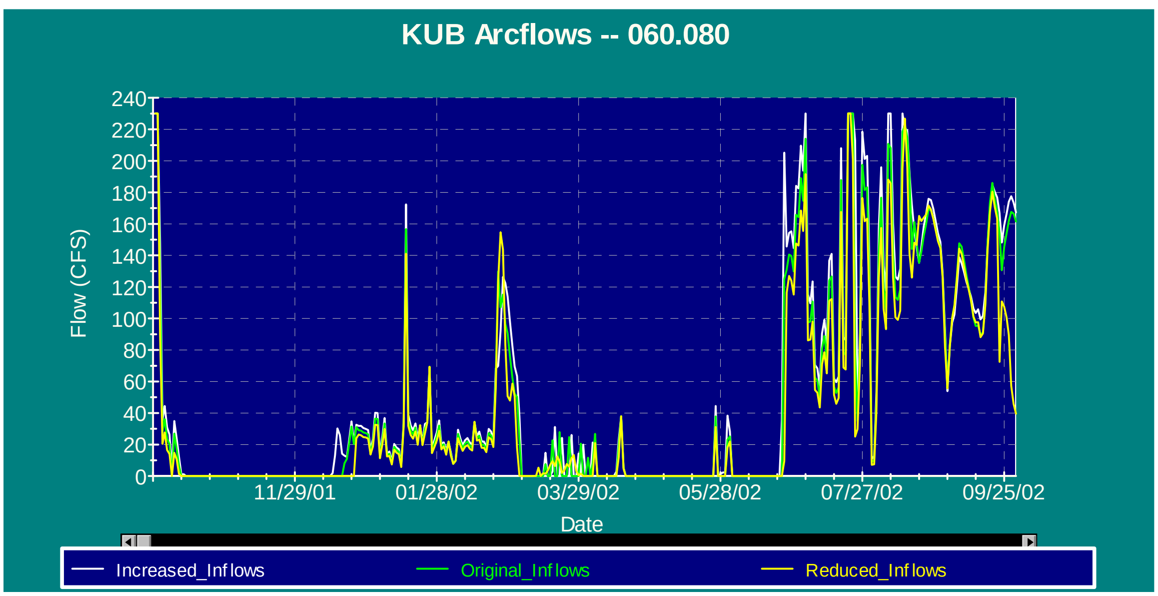

Figure F- 12: Simulated arcflows in arc060.080 with the original lateral inflows, lateral inflows increased by 10%, and lateral inflows reduced by 10%.

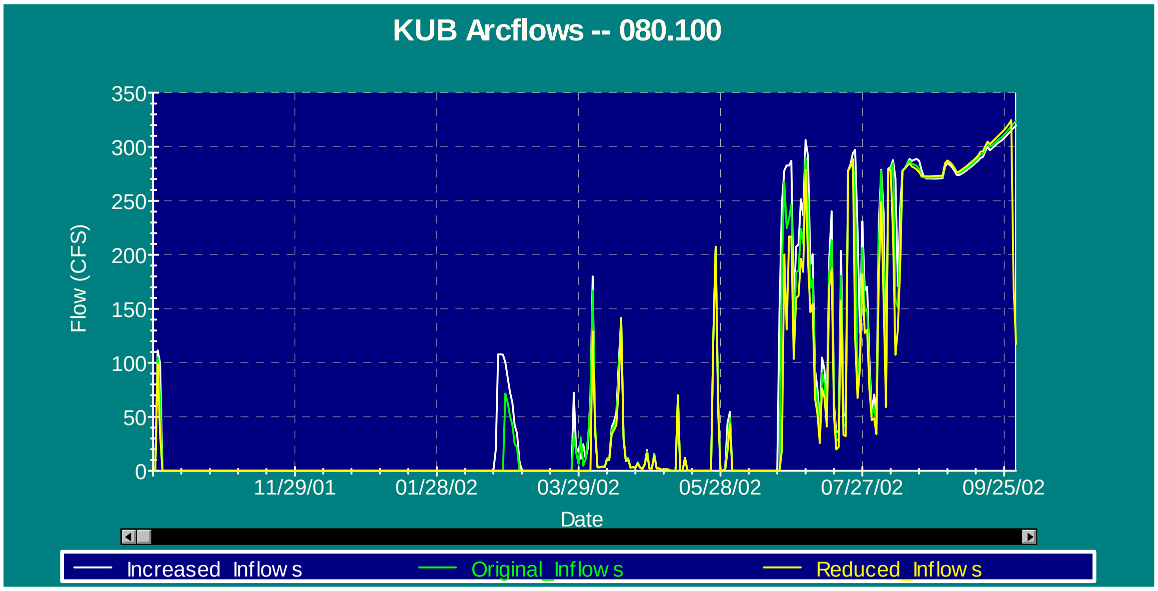

Figure F- 13: Simulated arcflows in arc080.100 with the original lateral inflows, lateral inflows increased by 10%, and lateral inflows reduced by 10%.

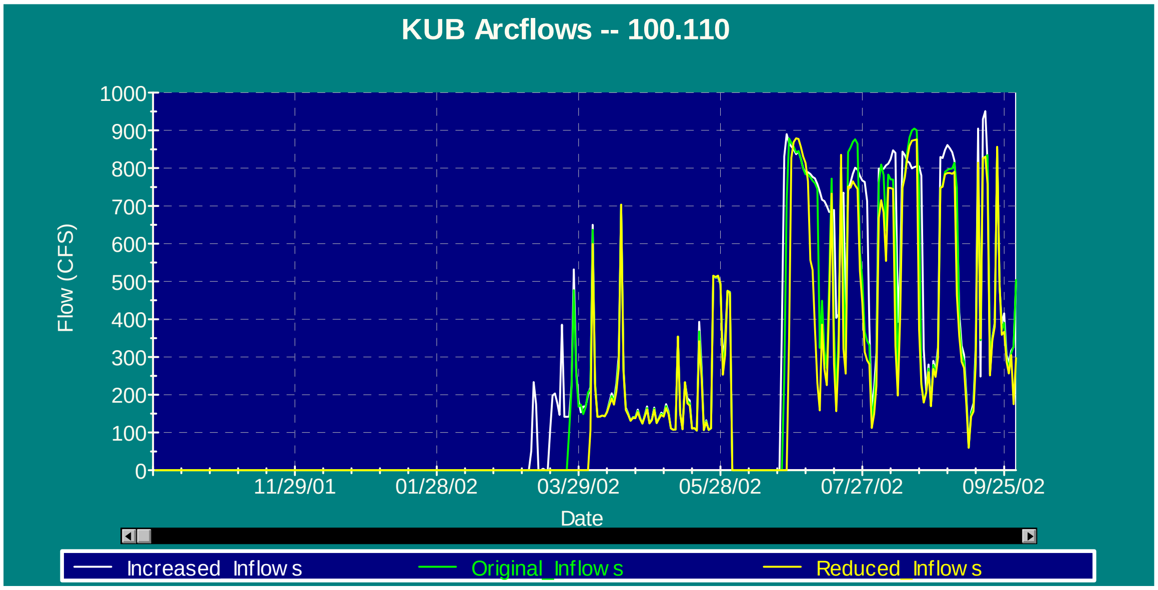

Figure F- 14: Simulated arcflows in arc100.110 with the original lateral inflows, lateral inflows increased by 10%, and lateral inflows reduced by 10%.

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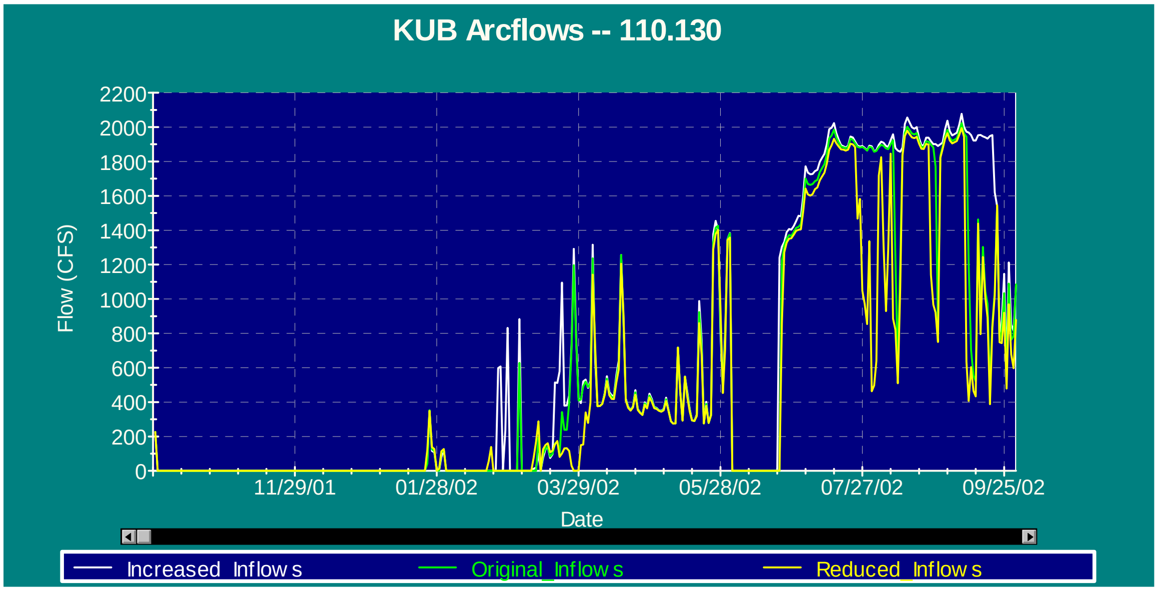

Figure F- 15: Simulated arcflows in arc110.130 with the original lateral inflows, lateral inflows increased by 10%, and lateral inflows reduced by 10%.

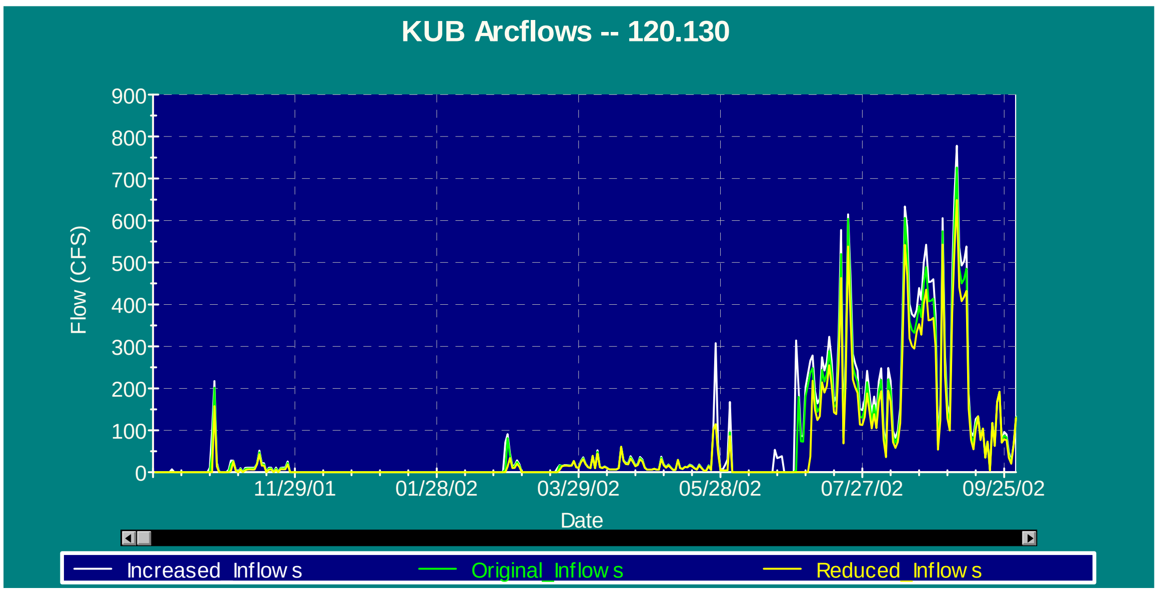

Figure F- 16: Simulated arcflows in arc120.130 with the original lateral inflows, lateral inflows increased by 10%, and lateral inflows reduced by 10%.

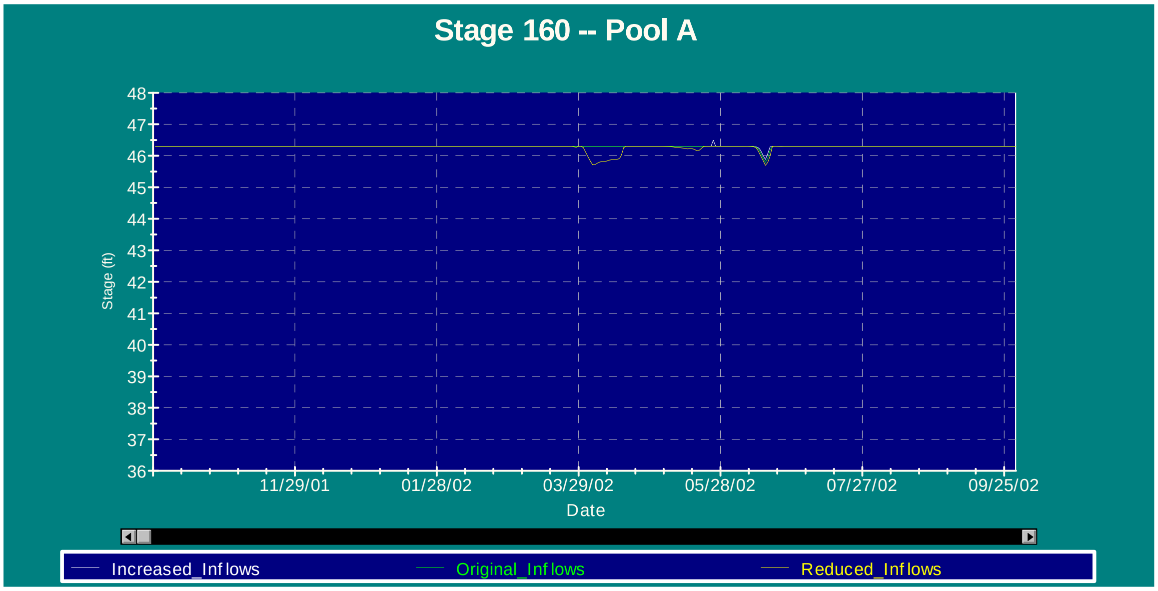

Figure F- 17: Simulated HW at node 160 with the original lateral inflows, lateral inflows increased by 10%, and lateral inflows reduced by 10%.

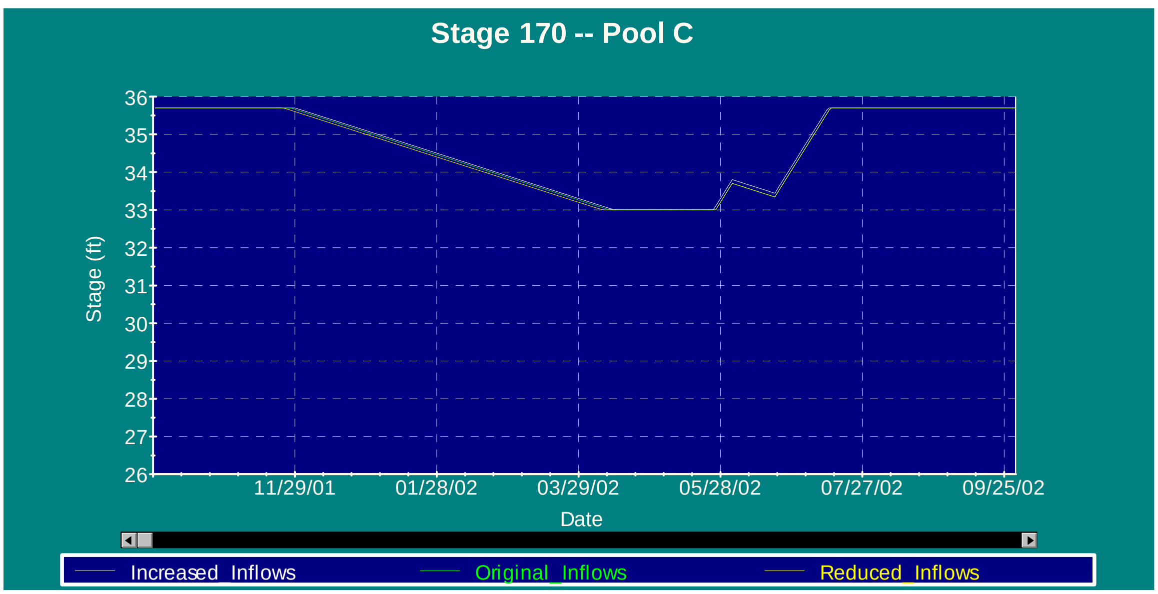

Figure F- 18: Simulated HW at node 170 with the original lateral inflows, lateral inflows increased by 10%, and lateral inflows reduced by 10%.

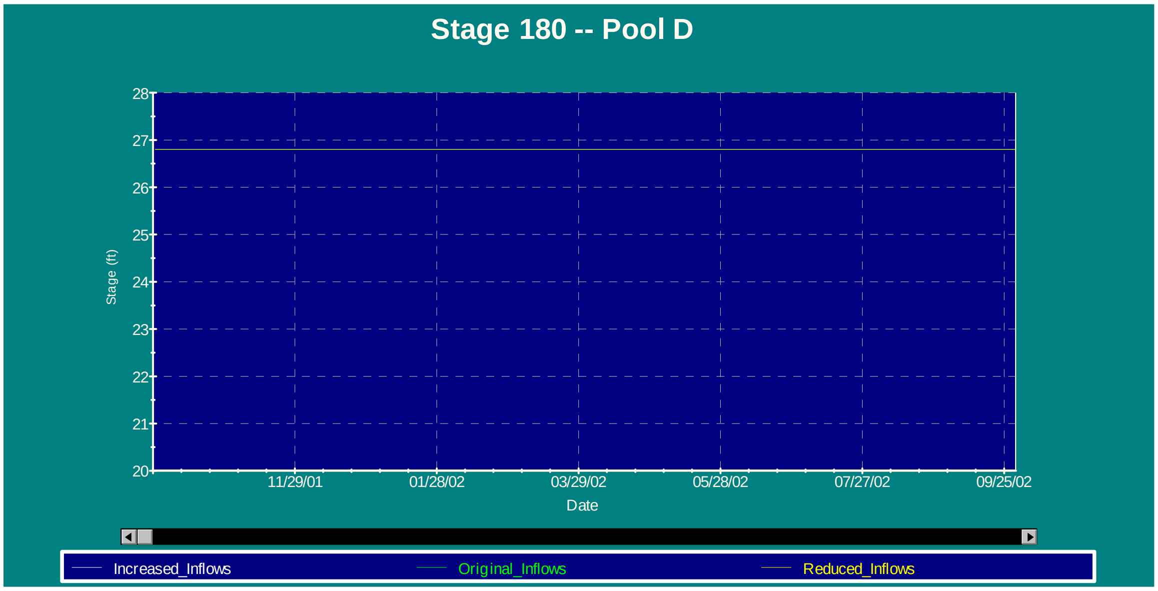

Figure F- 19: Simulated HW at node 180 with the original lateral inflows, lateral inflows increased by 10%, and lateral inflows reduced by 10%.

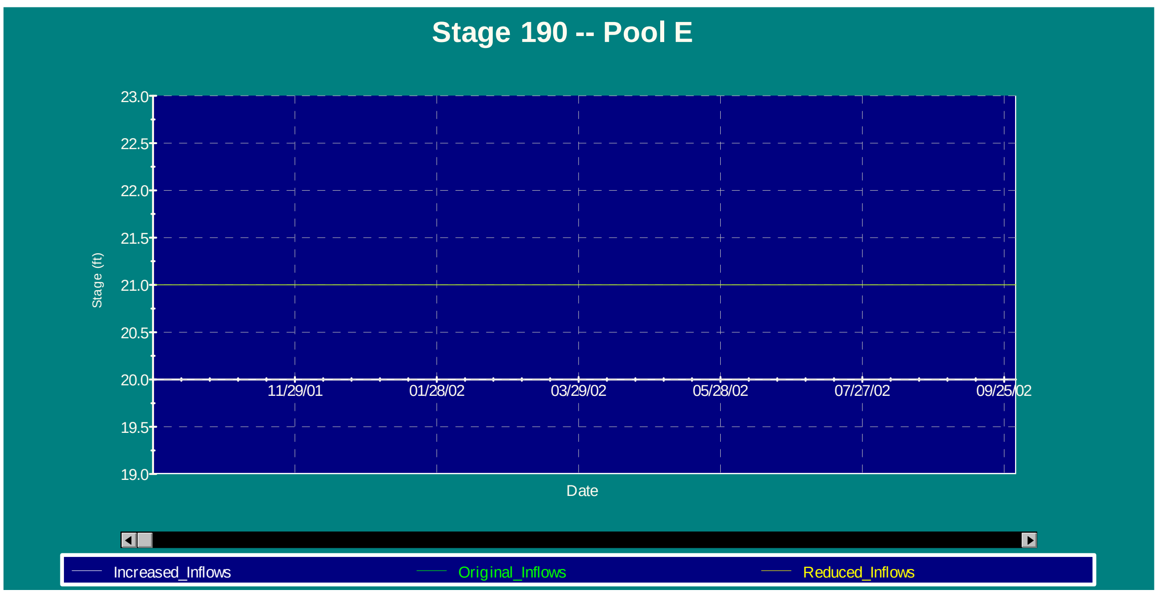

Figure F- 20: Simulated HW at node 190 with the original lateral inflows, lateral inflows increased by 10%, and lateral inflows reduced by 10%.

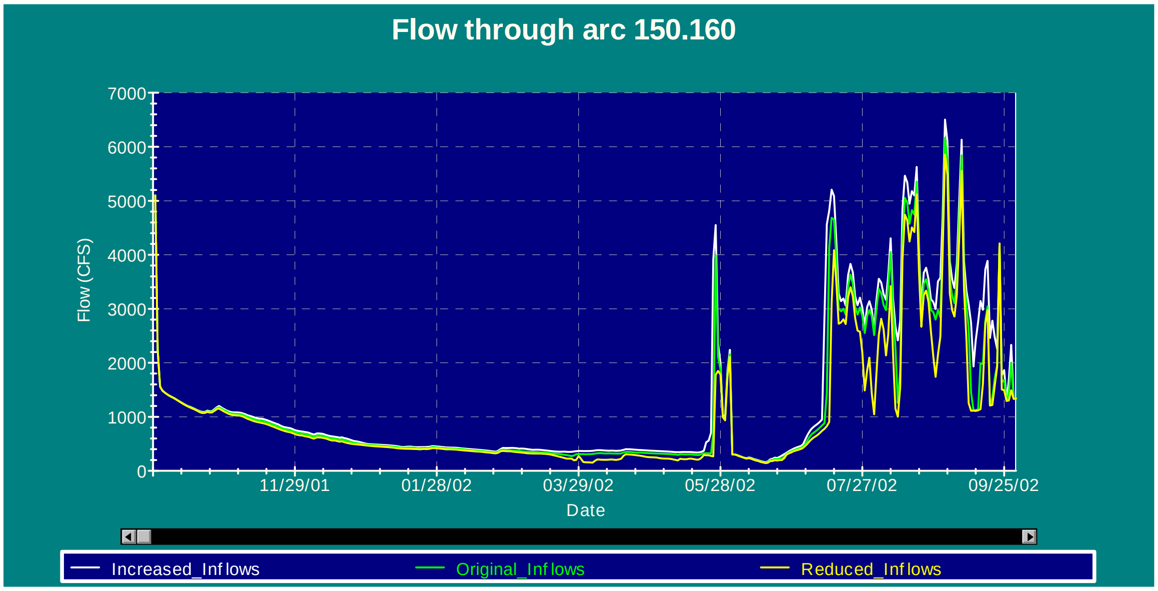

Figure F- 21: Simulated arcflows in arc150.160 with the original lateral inflows, lateral inflows increased by 10%, and lateral inflows reduced by 10%.

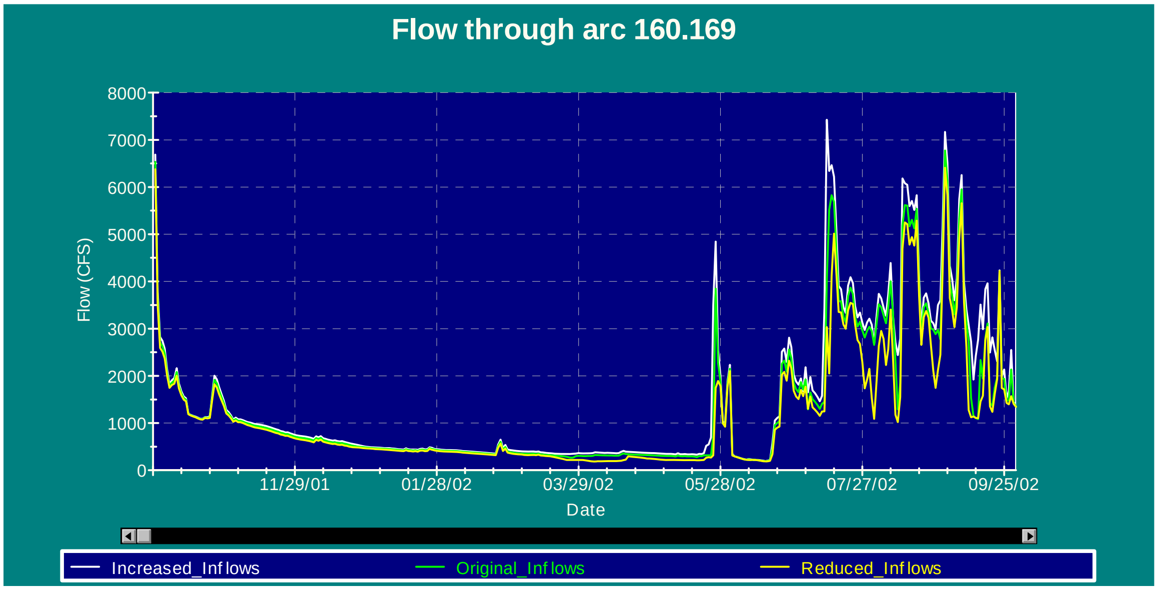

Figure F- 22: Simulated arcflows in arc160.169 with the original lateral inflows, lateral inflows increased by 10%, and lateral inflows reduced by 10%.

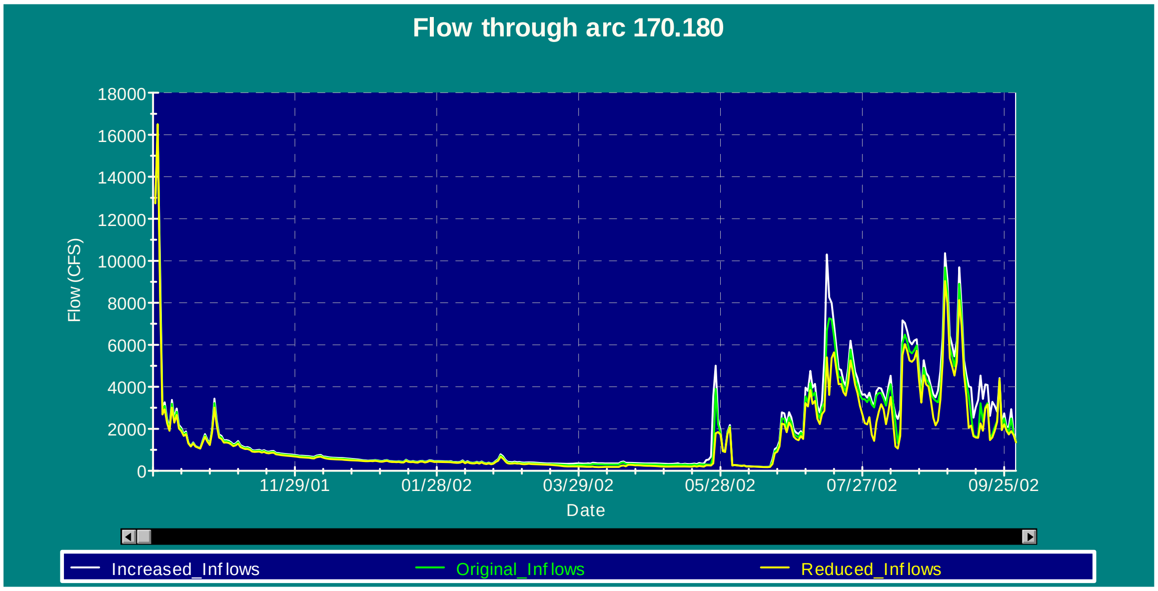

Figure F- 23: Simulated arcflows in arc170.180 with the original lateral inflows, lateral inflows increased by 10%, and lateral inflows reduced by 10%.

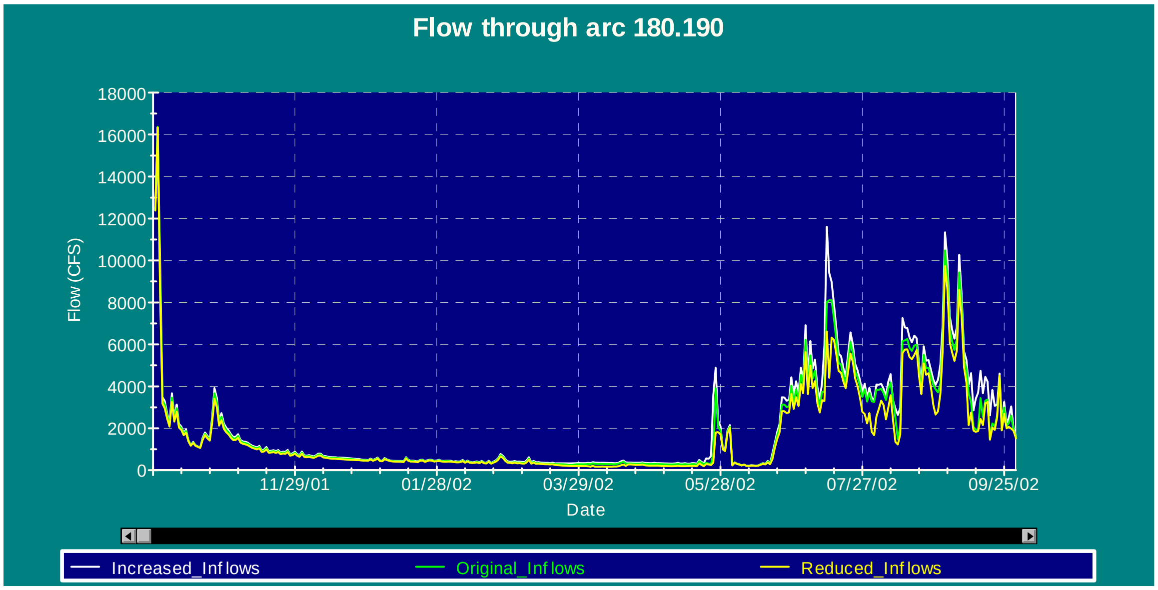

Figure F- 24: Simulated arcflows in arc180.190 with the original lateral inflows, lateral inflows increased by 10%, and lateral inflows reduced by 10%.

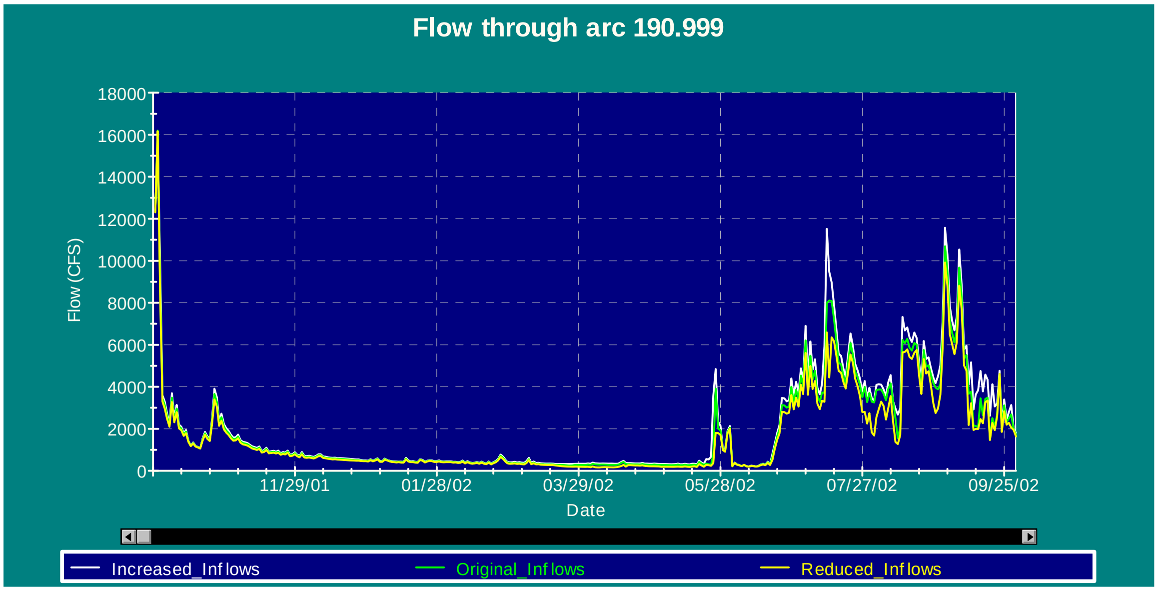

Figure F- 25: Simulated arcflows in arc190.999 with the original lateral inflows, lateral inflows increased by 10%, and lateral inflows reduced by 10%.