RESTORING THE ROOKERY BAY ESTUARY

A PROJECT CONNECTING PEOPLE AND SCIENCE FOR LONG-TERM COMMUNITY BENEFIT

Rookery Bay National Estuarine Research Reserve

Henderson Creek Watershed Engineering Research Project

Task 2.5 – Interim Technical Memorandum

Henderson Creek Weir and Gate Operation Scenario Simulation

Prepared for Rookery Bay National Estuarine Research Reserve
October 29, 2014

Prepared by Interflow Engineering LLC
14499 N. Dale Mabry Highway, Suite 290
Tampa, FL 33618

INTERFLOW ENGINEERING LLC

In association with Taylor Engineering, Inc.
10151 Deerwood Park Boulevard Building 300, Suite 300
Jacksonville FL 32256

TAYLOR ENGINEERING, INC.

FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION · Rookery Bay National Estuarine Research Reserve · NOAA · National Estuarine Research Reserve System Science Collaborative · University of New Hampshire

Funding for this project was provided to the Rookery Bay National Estuarine Research Reserve in 2011-2015 by the National Estuarine Research Reserve System's (NERRS) Science Collaborative which is a cooperative agreement between the National Oceanic and Atmospheric Administration (NOAA) and the University of New Hampshire under NOAA grant NA09NOS4190153. The NERRS Science Collaborative puts Reserve-based science to work for coastal communities by engaging the people who need the science in the research process—from problem definition and project design through implementation of the research and use of its results in coastal decisions. For more information about this project please visit www.rookerybay.org/restoreRB or contact Principal Investigator Tabitha Whalen Stadler at the Rookery Bay National Estuarine Research Reserve in Naples, Florida at 239-530-5940.

Certification

<table>
<tr><td colspan="2">Not valid unless stamped or embossed with Engineer's Seal, signed and dated in contrasting color ink.</td></tr>
<tr><td>This report titled Henderson Creek Watershed Engineering Research Project Task 2.5, Interim Technical Memorandum, Henderson Creek Weir and Gate Operation Scenario Simulation was prepared under the responsible charge of John E. Loper, P.E.

Interflow Engineering, L.L.C.
14499 N. Dale Mabry Hwy, Suite 290
Tampa, FL 33618
www.interfloweng.com

Certificate of Authorization No. 26901</td><td>John E. Loper, FL P.E. 54623

6/19/2015
Date</td></tr>
</table>

Table of Contents

Executive Summary 1

1.0 Introduction 1

2.0 Methodology 4

3.0 Results and Discussion 6

3.1 MIKE-11: Surface Water Results 6

3.2 MIKESHE: Overland Flow Results 17

3.3 MIKESHE: Groundwater Results 19

4.0 Conclusion 23

Figure 1. LSM Domain and Location of HENDTAMI and TAMIHEND Control Structures 3
Figure 2. Average Monthly Flow: Henderson Creek Basin 7
Figure 3. Henderson Creek Coastal Transect and Belle Meade Flow-Way Comparison Points. 8
Figure 4. Flow Duration Curves: Henderson Creek Basin 9
Figure 5. Henderson Creek Cumulative Flow 10
Figure 6.Location of MIKESHE/MIKE-11 Comparison Points 12
Figure 7. Stage Duration Curve Marco Lake A: Existing vs Alternative 13
Figure 8. Water Level Upstream of HENDTAMI Control Structure 14
Figure 9. Stage Duration Curve: U.S.-41 Canal Water Level Upstream of TAMIHEND 15
Figure 10. Stage Duration Curve: U.S.-41 Canal Water Level Downstream of TAMIHEND 15
Figure 11. Stage Duration Curve: Henderson Creek E. Branch Downstream of TAMIHEND 16
Figure 12. Stage Duration Curve: Wetland Area North of US-41 Canal. 17
Figure 13. Belle Meade Flow-Way Depth-Duration: North Comparison Point 18
Figure 14. Belle Meade Flow-Way Depth-Duration: South Comparison Point 19
Figure 15. Belle Meade Flow-Way Water Table Stage-Duration: North Comparison Point 20
Figure 16. Belle Meade Flow-Way Water Table Stage-Duration: South Comparison Point 21
Figure 17. Water Table Stage-Duration: Wetland Area North of U.S.-41 Canal 22

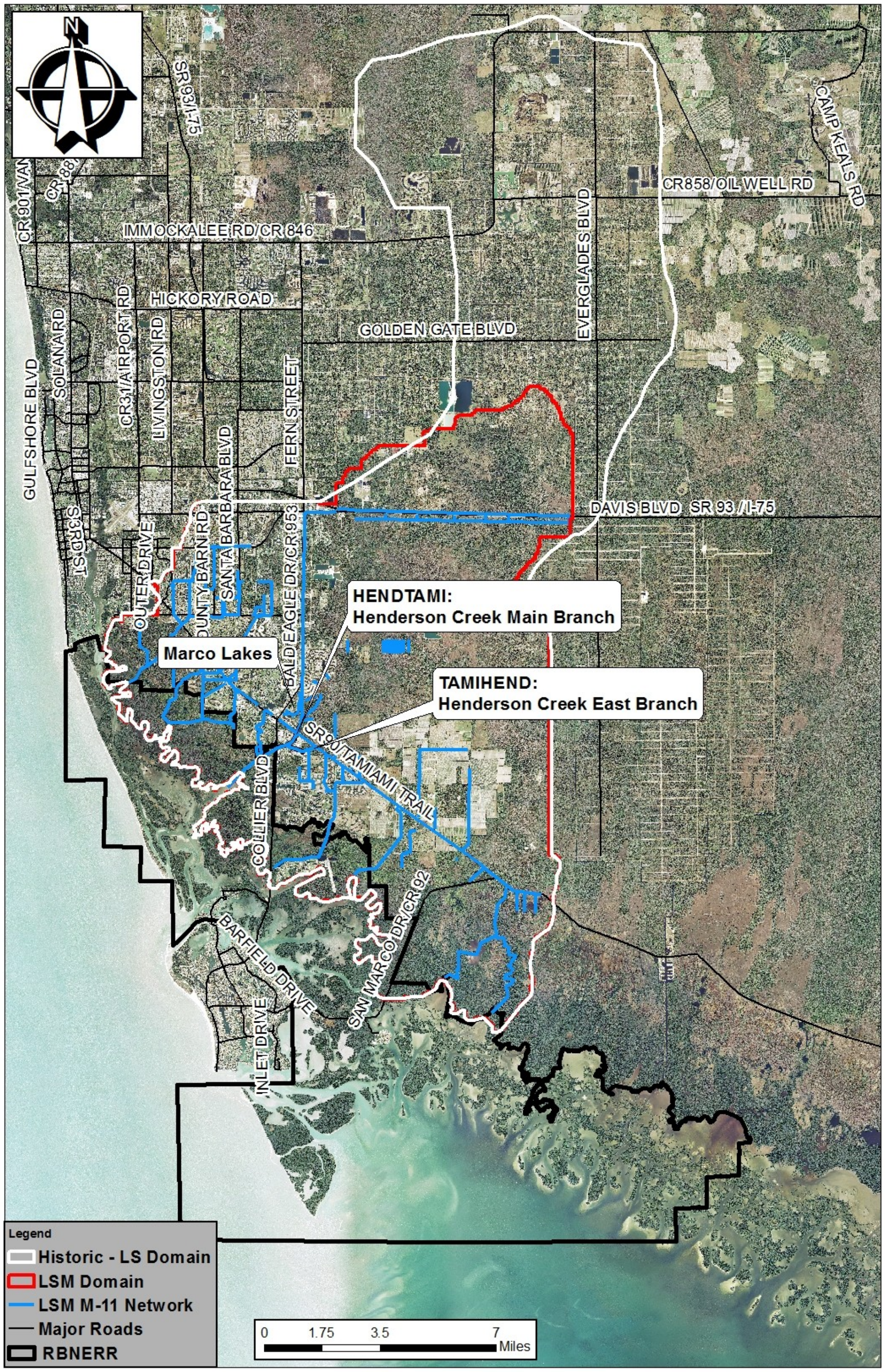
Table 1. Alternative 1: Proposed Gate Operations at HENDTAMI and TAMIHEND Structures 5
Table 2. Average Monthly Flow and Percent Difference Comparisons 11

Executive Summary

The results of modeling efforts conducted under **Task 2.5 - Henderson Creek weir and gate operation scenario simulation**, of the Henderson Creek Watershed Engineering Research Project (HCWERP) are presented in this memo. The starting point for the **Task 2.5** modeling effort was the Existing Conditions-Local Scale Model (LSM) developed and documented in **Task 2.3** and Historical Conditions-LSM developed and documented in **Task 2.4.** The results of previous modeling efforts conducted in **Tasks 2.3** and **2.4** suggested that the cumulative overall volumes of fresh water delivered to the Rookery Bay Estuary from the Rookery Bay/Henderson Creek Watershed are nearly the same between Existing and Historical conditions. However, these simulations revealed significant changes have occurred in the seasonal distribution of flows, with a decrease in dry season flows and an increase in wet season flows from historical to current conditions from the Henderson Creek sub-basins.

The purpose of this task is to evaluate potential options to determine if historical condition flows could be better approximated by changing the operation and / or configuration of the HENDTAMI and TAMIHEND structures on Henderson Creek in an effort to address the differences found in the seasonal flow distribution. These structures provide the main conveyance of water from the Henderson Creek sub-Basin to the Rookery Bay National Estuarine Research Reserve (RBNERR). In an effort to better represent the seasonal pattern, especially the low flows to RBNERR from the Henderson Creek sub-basin, the simulated gate operations were revised in a manner that allowed more water to flow through the structures during the dry season, while storing as much as possible in the wet season without creating adverse upstream or downstream impacts. Through an iterative simulation process, many simulations were performed to ensure the most defensible model was built to provide reasonable results in an effort to answer the question of whether or not gate operations alone could provide an improvement in low flows to the RBNERR at this location.

This memo presents the methodology used to develop the scenario and the results produced from the proposed gate operations at the HENDTAMI and TAMIHEND control structures. From the results of the simulations, it was concluded that a revised gate operation schedule would provide a better representation of the dry season flow when compared to the Historical conditions. Furthermore, the proposed operations would not create negative impacts within the Henderson Creek sub-basin for surface water (including overland flow) and ground water. **Figure ES 1** presents the Existing and Historical Local Scale model domains, RBNERR boundary, as well as the location of Marco Lakes, and HENDTAMI and TAMIHEND control structures within the study area.



ES 1. LSM Domains, RBNERR Boundary and Selected Watershed Feature Notations

1.0 Introduction

The National Estuarine Research Reserve System (NERRS) Science Collaborative puts Reserve-based science to work for coastal communities coping with the impacts of land use change, stormwater, nonpoint source pollution, and habitat degradation in the context of a changing climate. A multidisciplinary team led by Florida's Rookery Bay National Estuarine Research Reserve (RBNERR) has received an $815,000 grant for a three-year project to help local communities manage freshwater flows in the Rookery Bay/Henderson Creek watershed. In consultation with an advisory group consisting of hydrological engineers, social researchers, resource managers, and community stakeholders, the team will generate science to better understand the fresh water flows needed to maintain the health of the watershed's Rookery Bay Estuary and the perspectives of water users and decision makers. As part of this project, investigators will create a framework that stakeholders can use to collaborate and make decisions about water issues into the future.

Taylor Engineering holds the prime contract with the Florida Department of Environmental Protection to provide the RBNERR with engineering services to develop a local-scale hydrologic model for the Rookery Bay/Henderson Creek watershed. Interflow Engineering, as a subconsultant to Taylor Engineering, has developed the existing conditions local-scale hydrologic model described herein.

The RBNERR has identified the following objectives for work.

A. Develop a local-scale hydrodynamic model for the Henderson Creek watershed
B. Establish target flows, defined as the amount of freshwater flow needed to sustain a balanced Rookery Bay Estuary, where volumes and timing of water at specific locations are set aside from consumptive uses for the protection of fish, wildlife, or public health and safety as defined in Section 373.223 (4) Florida Statutes, if deemed necessary by research results
C. Analyze probable freshwater inflow quantity and timing of water management projects and water use scenarios
D. Communicate science to water stakeholders of this project and integrate their perspectives and recommendations into research efforts of this project.

To understand the hydrologic conditions of the Rookery Bay Estuary system — and, specifically, freshwater flows to the estuary —Existing and Historical Conditions local-scale hydrologic and hydraulic models with MIKE SHE were built during **Tasks 2.3** and **2.4** respectively.

This memo serves to describe the process and results for **Task 2.5 - Henderson Creek weir and gate operation scenario simulation** of the Team's scope of work. **Task 2.5** is an alternative scenario model, and is the first of several potential alternatives. When this memo was written future alternatives were still under development and not contracted. The scope of **Task 2.5** was to optimize the control logic of Henderson Creek gated control structures HENDTAMI and TAMIHEND within the framework of the Existing Conditions-LSM.

Figure 1 presents the alignment of the MIKE-11 network for the HENDTAMI and TAMIHEND control structures within the study area. Both HENDTAMI and TAMIHEND are compound structures and include operational gates and a fixed crest weir at a single location.

HENDTAMI is a combination of three structures:

- Fixed crest weir
- Variable weir – two sluice gates (vertical lift 4 feet high x 6 feet wide)
- Box culvert with upstream sluice gate

TAMIHEND is comprised of a fixed crest weir with an operational 4 feet high x 4 feet wide slide gate.

HENDTAMI was designed to prevent saltwater intrusion and provide water level control to prevent over drainage of the Rookery Bay/Henderson Creek watershed. TAMIHEND was similarly designed to provide seasonal control of water deliveries to RBNERR as well as water level control for the U.S.-41 canal. For a complete description of the aforementioned structures please refer to the memo prepared for **Task 2.2 - Recalibrate Existing BCB Model**.

The simulation result comparisons between existing and historical conditions were performed and documented in **Task 2.3/2.4 - Local Scale Model (Existing Conditions-LSM/Historical Conditions-LSM) Development**, and will not be discussed in detail within this memo. The **Task 2.3** and **2.4** analyses presented evidence that Henderson Creek now delivers less flow to the RBNERR during the dry season, and substantially higher flows during the wet season, with accumulated flows for the simulation period (2003 to 2012) being approximately equal for existing and historical simulations. The results from the prior tasks indicate that a possible scenario to provide freshwater deliveries that approximate historical conditions could be achieved through a revision of the operating schedules at the control structure (gates) HENDTAMI and TAMIHEND.

This memo describes the work conducted in an effort to better represent historical dry season flows by optimizing the control logic of the Henderson Creek HENDTAMI and TAMIHEND control structures. This alternative provides a scenario analysis of the simulations to determine if the goal of restoring historical dry season inflows was achieved through simulated gate logic differences and no infrastructure modifications. The alternative would be considered successful if the simulated flows better represented the dry season Historical conditions.

Model simulations for this alternative started from the Existing Conditions-LSM model built for **Task 2.3/2.4**, using MIKESHE/MIKE-11 Release 2011 SP7. Many simulations were conducted through an iterative process to assess differences between model simulations to arrive at the conclusions presented in this memo. The simulations were analyzed based upon the following criteria:

- The ability to better represent Historical condition dry season freshwater inflows to Rookery Bay
- The ability to provide wet season flood control through gate operations
- The avoidance of negative impacts

The following sections provide a narrative to what was accomplished through the simulations and analyses conducted as part of this alternative, including results and conclusions drawn from this effort.

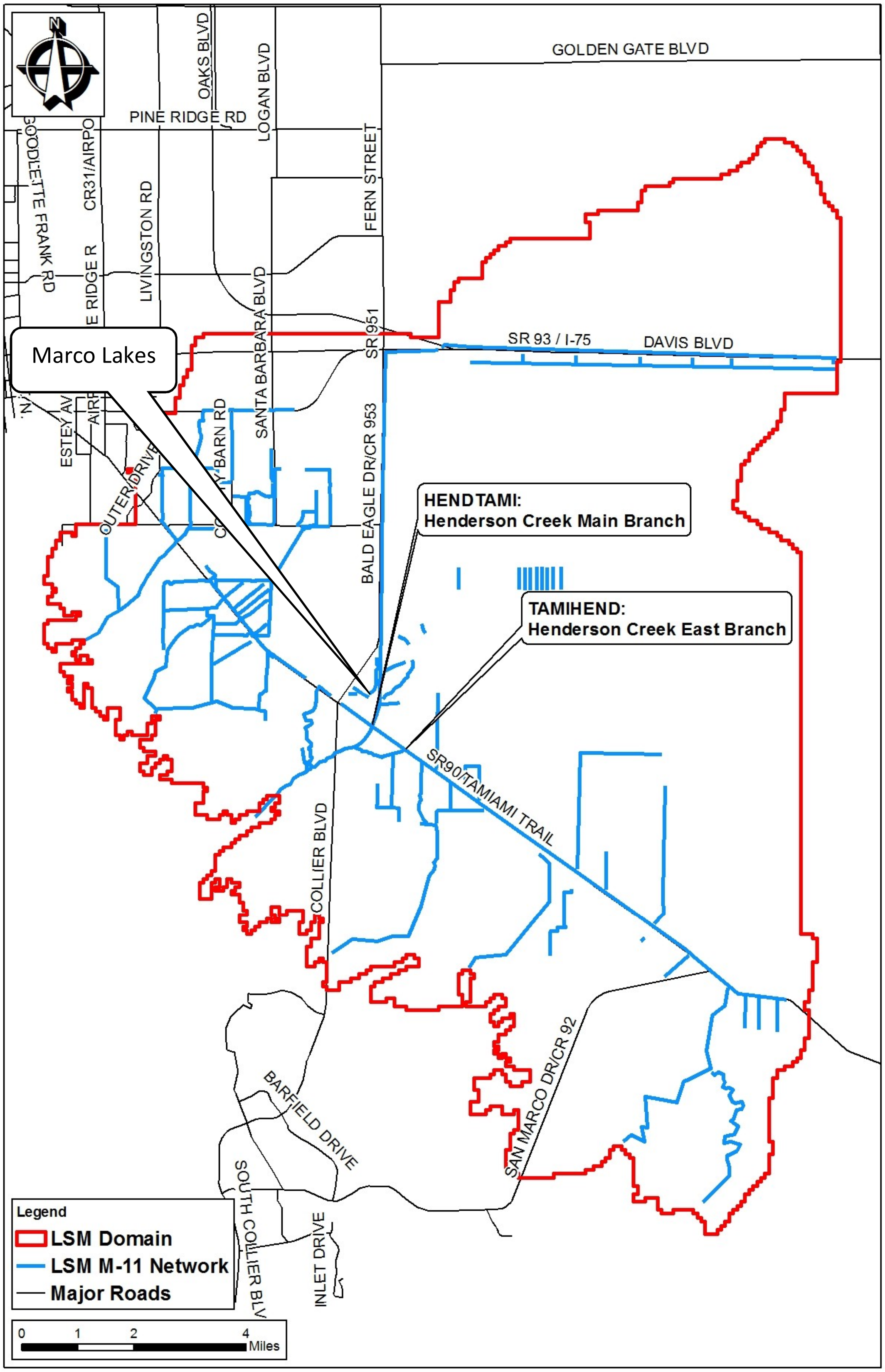


Figure 1. LSM Domain and Location of HENDTAMI and TAMIHEND Control Structures

2.0 Methodology

The alternative simulation was completed by starting with the Existing Conditions-LSM MIKESHE/MIKE-11 model developed in **Task 2.3/2.4** and modifying the control operations at HENDTAMI and TAMIHEND structures (**Fig. 1**) within the MIKE-11 surface water network. Several iterative simulations were run in an effort to approximate the Historical condition flows to Rookery Bay. The results of each iteration were evaluated with respect to Historical condition flows to Rookery Bay, and the potential for negative impacts.

Previous result comparisons between simulated dry season flows (December through June) for existing and Historical conditions showed Historical existing condition dry season flows were non-existent (See **Task 2.3/2.4** memo for a complete discussion). The absence of flow to Rookery Bay via the Henderson Creek structures was hypothesized to be a function of gate operations under existing conditions, where upstream water was not allowed to pass until water levels reached a significant stage.

Under this current task, Interflow Engineering developed a modified gate operation schedule that would allow water to pass through the structure during the dry season and provide the same level of flood control as simulated under Existing Conditions. The focus of the simulations completed for this alternative was to provide dry season flows to RBNERR (via Henderson Creek), ensuring no negative/harmful effects were brought about by this modification. It was initially believed this could be done largely through the HENDTAMI structure, but early simulation results indicated that the reconfiguration of gate operations may lead to unacceptable impacts to Marco Lakes, which is a municipal water supply source. Therefore, the operations at HENDTAMI were modified to ensure for minimal head loss (dH) between Henderson Creek and Marco Lakes. Through this process the proposed gate operations provided a logical operation schedule to allow less water through the HENDTAMI structure and more water through TAMIHEND structure to better represent simulated historical condition dry season flows.

In addition to evaluating the potential impacts of the proposed gate operations on Marco Lakes, existing conditions stages were examined in conjunction with historical condition flows to develop the proposed gate operations schedule as part of this alternative. **Table 1** presents the logical gate operations of the HENTAMI and TAMIHEND structures developed for this alternative. **Table 1** shows that the main delivery mechanism of dry season flow is the operable gate at the TAMIHEND structure. Please note that the On/Off Trigger is based upon the water level or head upstream (Hups) of the structure in question.

Table 1. Alternative 1: Proposed Gate Operations at HENDTAMI and TAMIHEND Structures

HENDTAMI† Structure	Seasonal Trigger	Trigger On Hups (ft)	Trigger Off Hups (ft)	Gate Opening (ft)
Flap Gate	None - Hups	> 5	< 5	Fully Open
	Dry	> 2	< 0.5	0.05
	Wet	> 3.0	< 1.5	0.02
Overflow Gate 1	Dry	> 5.0	< 5.0	1.1
	Wet	> 5.0	< 5.0	Fully Open
Overflow Gate 2	Dry	> 5.0	< 5.0	1.2
	Wet	> 5.0	< 5.0	Fully Open
TAMIHEND‡ Structure	**Seasonal Trigger**	**Trigger On Hups (ft)**	**Trigger Off Hups (ft)**	**Gate Opening (ft)**
Underflow Gate	None - Hups	> 3.8	< 3.8	Fully Open
	Dry	> -0.29	< -0.29	0.44
	Wet	> -0.29	< -0.29	0.34

Notes: †HENDTAMI is a compound structure: weir and three gates, ‡TAMIHEND is a compound structure: weir and single gate.

The proposed alternative gate operations provide flood control and allows dry season flow through the gate when conditions are met. The proposed operations, shown in **Table 1**, include a provision to avoid over draining the Henderson Creek canal. This is essential to maintaining the ecology of the surrounding area as well as water levels in the nearby Marco Island Utilities Lakes A/B utilized for water supply. Additionally, the proposed gate operations allow for water to be held back in the wet season to the maximum extent possible, again providing flood control and stored water at the onset of the dry season which is bled out as per the operations in **Table 1**. Several measures were evaluated during the simulation process to ensure the final proposed alternative would:

- Better represent historical condition dry season freshwater inflows to Rookery Bay
- Provide wet season flood control through gate operations
- Not cause negative impacts to water supply sources, nearby roads and buildings, and wetland hydroperiods.

These measures included:

- Simulated monthly average flow comparisons (Historical, Existing, Alternative)
- Upstream water level checks against measured data and Existing-LSM simulated water levels

- Overland depth and groundwater elevation difference maps providing localized and watershed scale information
- Overland depth and groundwater elevation duration curves in Belle Meade Flow-way to provide point analyses
- Water level comparisons between existing and proposed conditions at Marco Lakes

Section 3 presents the results of the successful alternative simulation and a discussion relating to the aforementioned simulation measures.

3.0 Results and Discussion

This section will focus on the MIKE-11 (1-D surface water), and MIKE SHE (overland and groundwater) results, where each component will be individually presented and discussed in the following subsections. For the analyses presented in this section and following subsection, all statistical comparisons were made for the period of 2003 through 2012.

3.1 MIKE-11: Surface Water Results

The MIKE-11 surface water results were analyzed to ensure that Henderson Creek and the U.S.-41 canal were not experiencing abnormal stages as compared to the Existing Conditions-LSM model, as well as to ensure upstream flooding or over drainage of both canals was not being caused by the gate optimizations described in **Section 2.0** of this memo. The following figures and tables present the results of the MIKE-11 analysis conducted for the Alternative 1 simulation.

Figure 2 presents a comparison between Historical, Existing and Alternative 1 simulations for average monthly flow from Henderson Creek at the coast. That is, the flows in the Henderson Creek canal have been added to flows in the Henderson Creek east branch, the Eagle Creek branch to the north, and the 2-D overland flows across the coastal transect shown in **Figure 3**. Additionally, **Figure 3** presents the locations of the north (green) and south (red) comparison locations within the Belle Meade Flow-way. The differences illustrated in **Figure 2** demonstrate the average monthly flow simulated in Alternative 1 provides a much better approximation of Historical condition flows. This is attributed to the proposed gate operations logic (**Table 1**) at the TAMIHEND control structure.

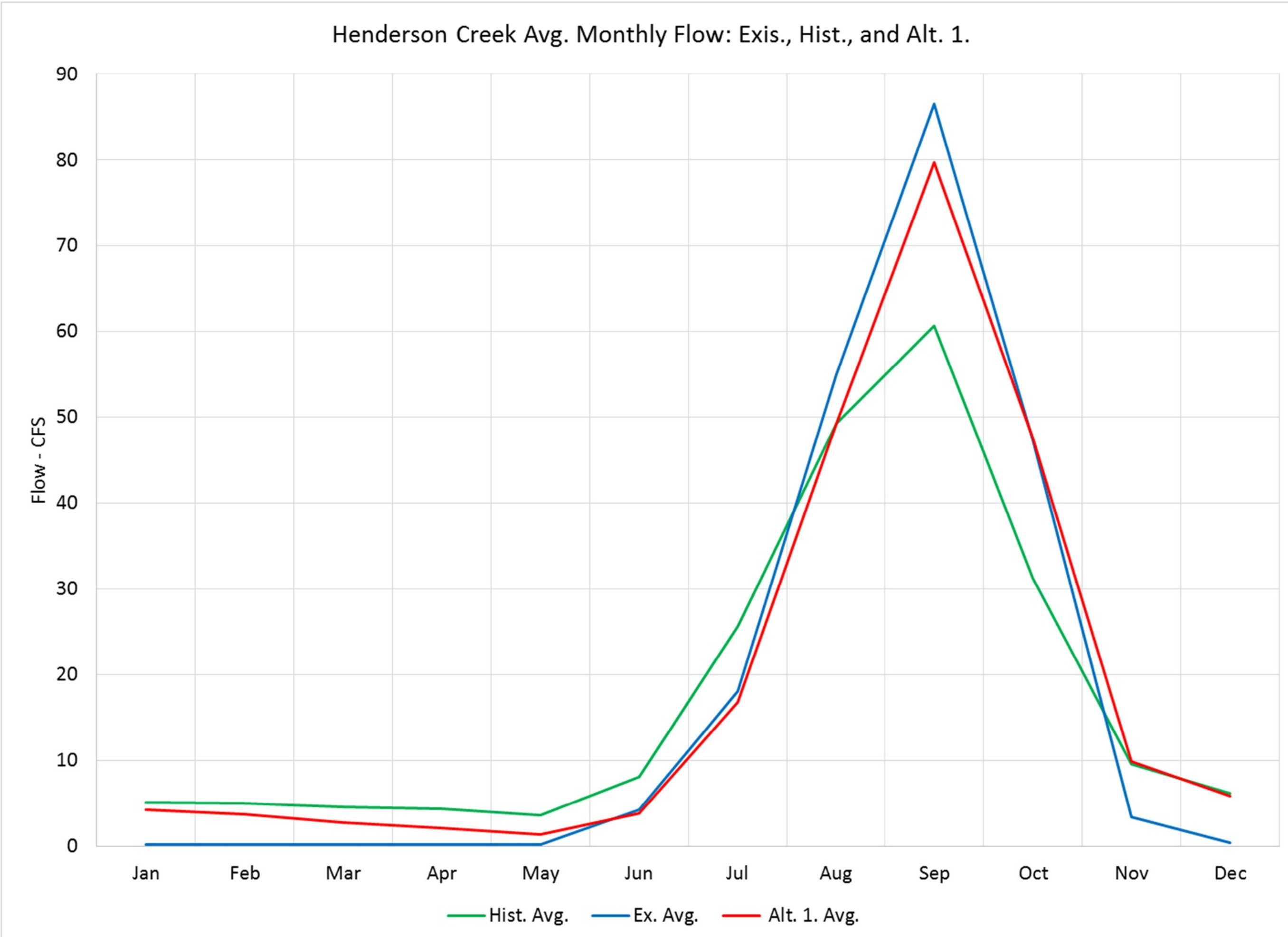


Figure 2. Average Monthly Flow: Henderson Creek Basin

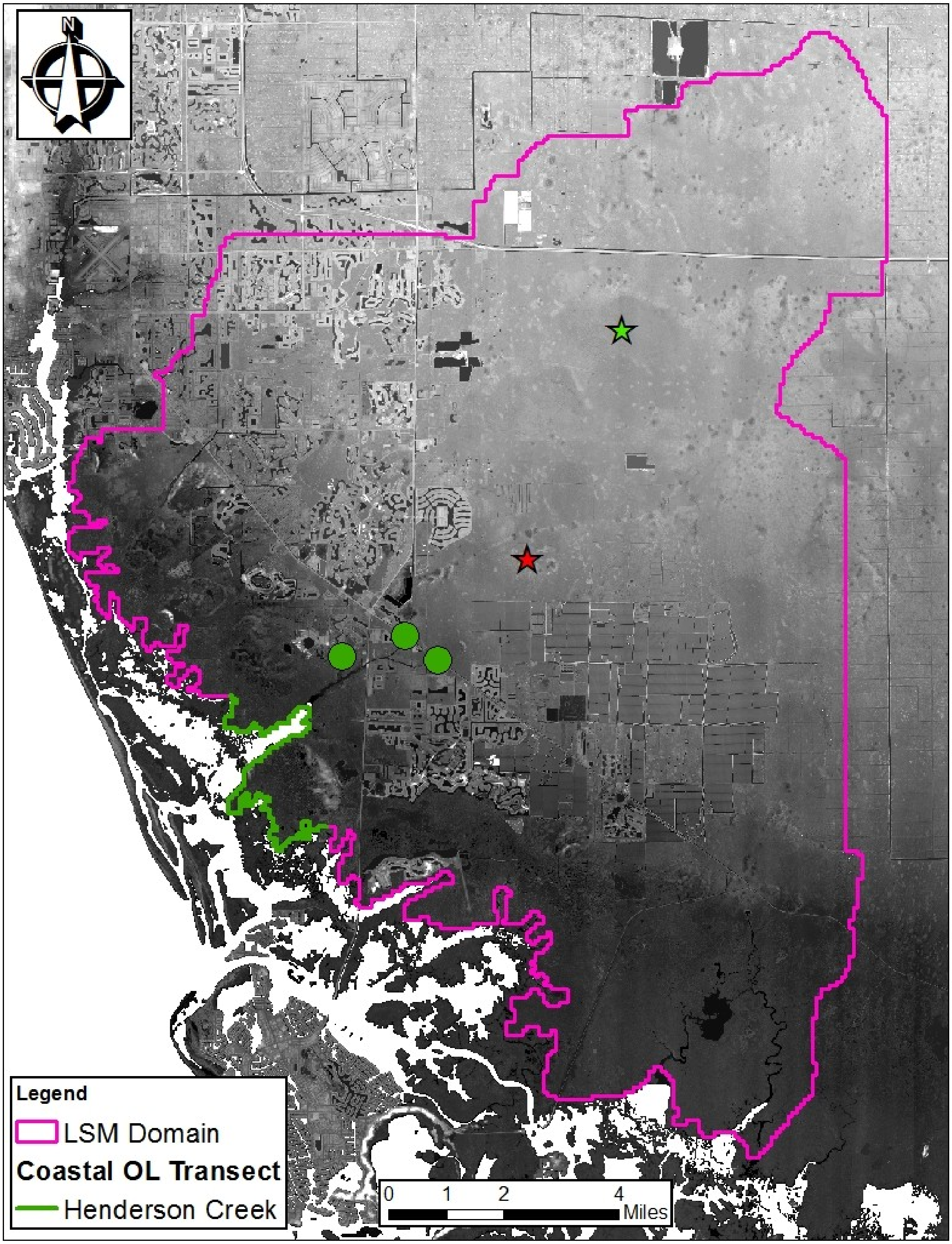


Figure 3. Henderson Creek Coastal Transect and Belle Meade Flow-Way Comparison Points.

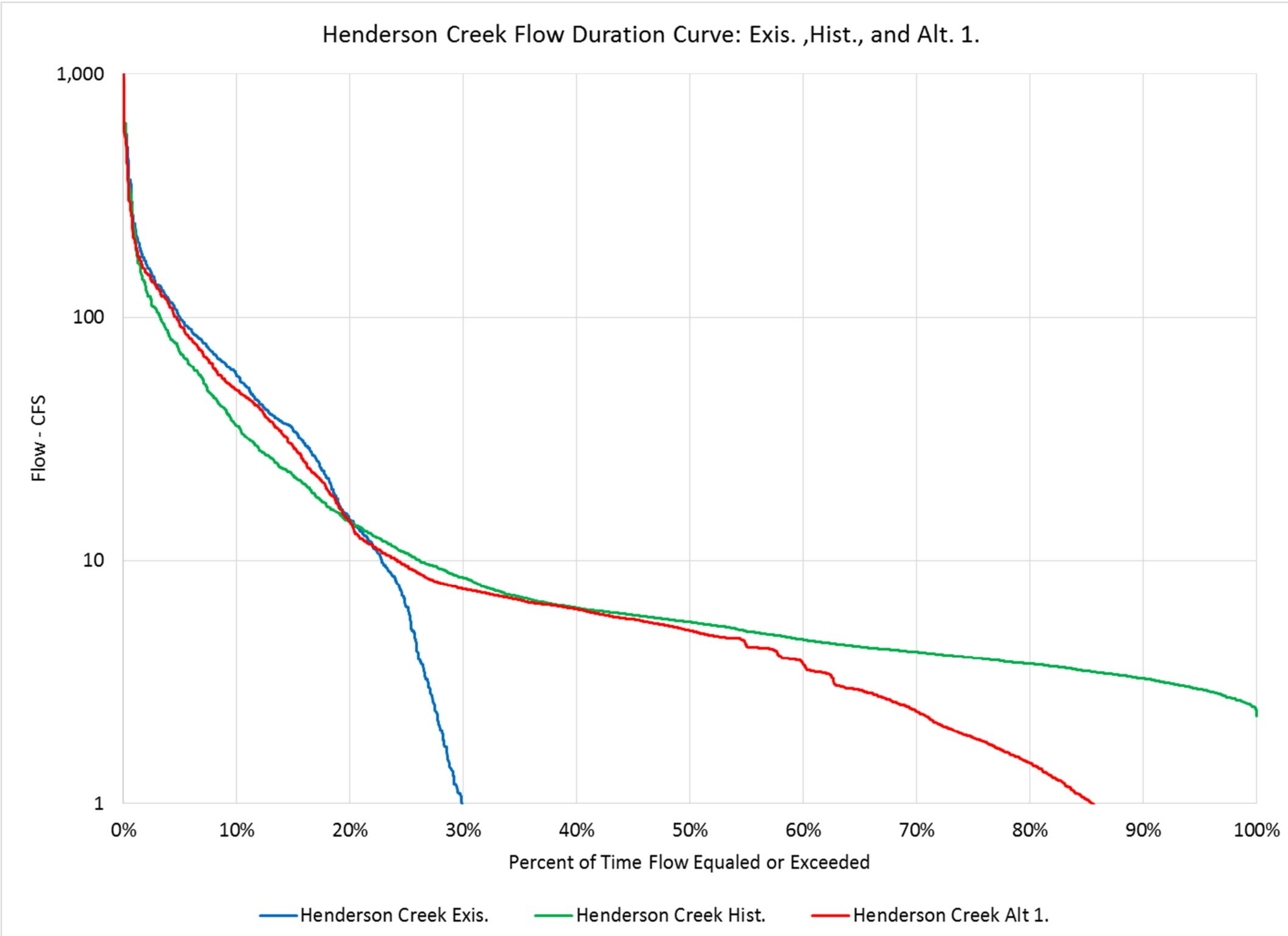


Figure 4. Flow Duration Curves: Henderson Creek Basin

As previously discussed in **Task 2.7 – Interim Hydrodynamic Modeling Report**, simulation results show more flow during the dry season months in the historical condition compared to the existing condition (**Figures 2** and **4**). This could be explained by a regulation schedule at the "HENDTAMI" structure that prevents flow until upstream stages reach a threshold for the gates to open. The purpose of this structure is to prevent over-drainage of the system and to conserve water in the dry season, and is the impetus for the simulations conducted as part of this alternative. While Alternative 1 shows a better approximation of Historical dry season flows to Rookery Bay, there is an obvious departure from Historical conditions that could not be as closely approximated from March through May (**Figure 2**). Many iterations (twelve) were conducted in an effort to optimize the gates at HENDTAMI to prevent adverse impacts to Marco Lakes water levels. These iterations proved that gate operations at HENDTAMI could create variations in the head differential between Henderson Creek and Marco Lakes that cause an unacceptable drop in Marco Lakes stage. Therefore, Alternative 1 results presented here were the best case scenario for providing a significant improvement in the approximation of Historical dry season deliveries to Rookery Bay and not causing adverse impacts to existing legal users or sensitive wetland areas nearby (e.g. Belle Meade Flow-way).

Cumulative volume between Existing and Historical simulations shows very little difference (**Figure 5**), indicating that under existing conditions the simulated freshwater deliveries from Henderson Creek do not deviate substantially from historical conditions on an annual or long term basis. However, under the proposed gate operations from this alternative, the cumulative flow from the Henderson Creek Basin is about 4.7% higher than Existing Conditions. This is attributed to the slight increase in dry season flows shown in **Figures 2** and **4** with the same magnitude of wet season flow**.** While this alternative delivers slightly more water to Rookery Bay via the Henderson Creek Coastal Basin, the seasonality of flows have been greatly improved. **Table 2** presents the average monthly flow in cubic feet per second (cfs), average dry season (DS) flow for the Existing, Historical and Alternative 1 model simulations.

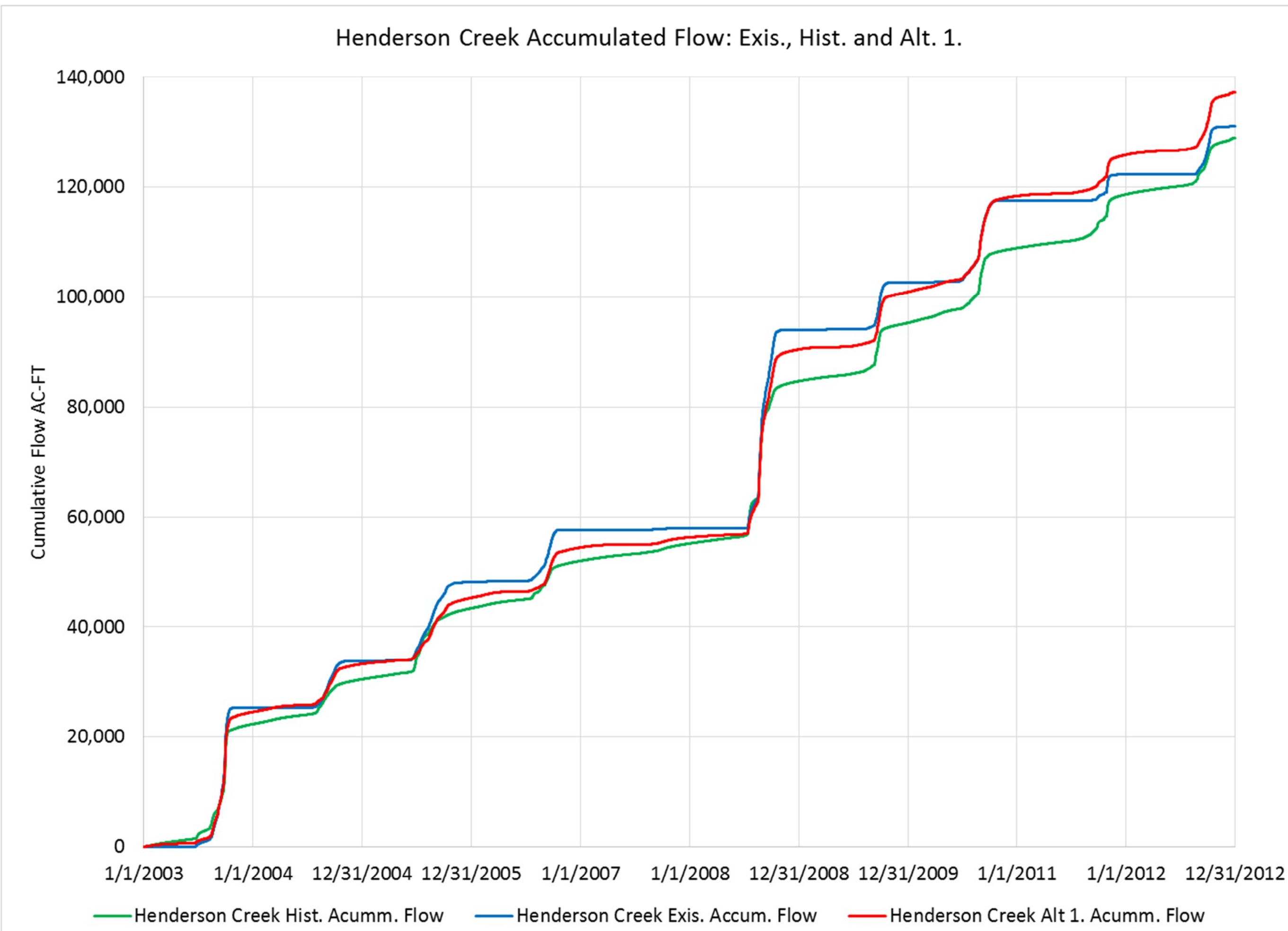


Figure 5. Henderson Creek Cumulative Flow

Table 2. Average Monthly Flow and Percent Difference Comparisons

Month	Avg. Monthly Flow - CFS		
	Existing	Historical	Alt. 1.
Jan	0.2	5.1	4.2
Feb	0.2	5	3.7
Mar	0.2	4.6	2.8
Apr	0.2	4.4	2.1
May	0.2	3.6	1.3
Jun	4.2	8	3.8
Jul	18.1	25.6	16.9
Aug	55	49.3	49.2
Sep	86.5	60.7	79.7
Oct	47.4	31.3	47.6
Nov	3.4	9.5	9.9
Dec	0.4	6.1	5.8
°Avg. DS Q	0.7	5.5	4.3

Note: ° Avg. DS flow calculated as the average dry season flow: DS Q = Avg.[(Jan – May: Nov. – Dec.)]

Considering the dry season flows presented in **Table 2**, it is clear that Alternative 1 better simulates the seasonal patterns of the historical freshwater deliveries to Rookery Bay on a monthly basis. This fact combined with the previous results indicate that this alternative is a viable solution to better represent the historical condition dry season flow to Rookery Bay.

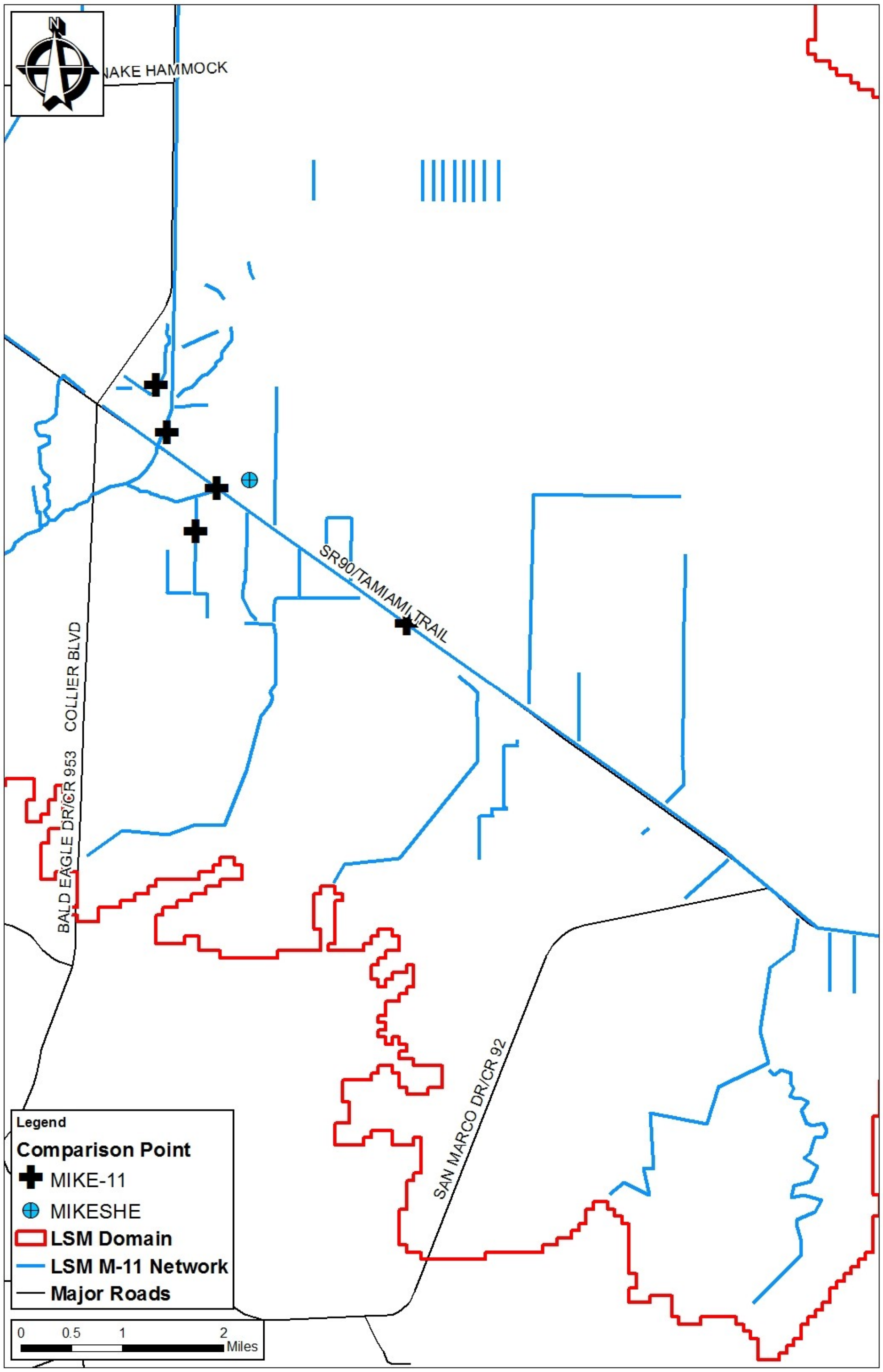


Figure 6. Location of MIKESHE/MIKE-11 Comparison Points

Additional checks were made comparing the Existing and Alternative simulation results to ensure the proposed gate operations did not create any negative effects upstream or downstream of the gate. Figure 6 presents the location of comparison points used to evaluate model performance between Existing Conditions the proposed Alternative 1 for surface water (MIKE-11) and overland flow/groundwater (MIKESHE) simulation results and includes the north and south comparison points within the Belle Meade Flow-way. For example, the water levels within Marco Lakes were compared between simulations and shown to have insignificant differences. **Figure 7** presents a stage duration curve at Marco Lakes which shows that for wet season stages the water level is higher under the Alternative 1 simulation and during the dry season months stages show an insignificant (≤ 0.05ft) decrease between simulations (Existing vs Alternative).

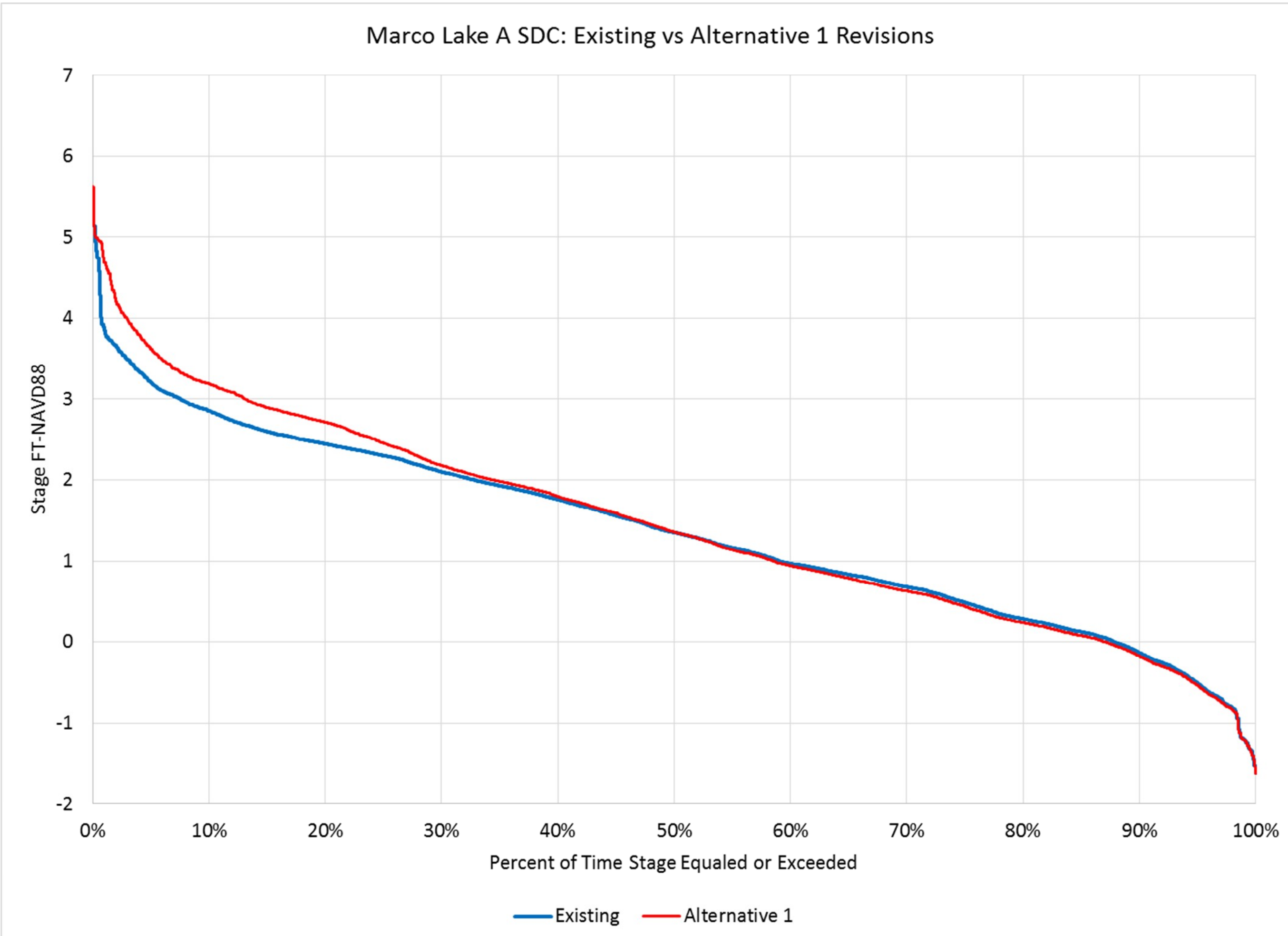


Figure 7. Stage Duration Curve Marco Lake A: Existing vs Alternative

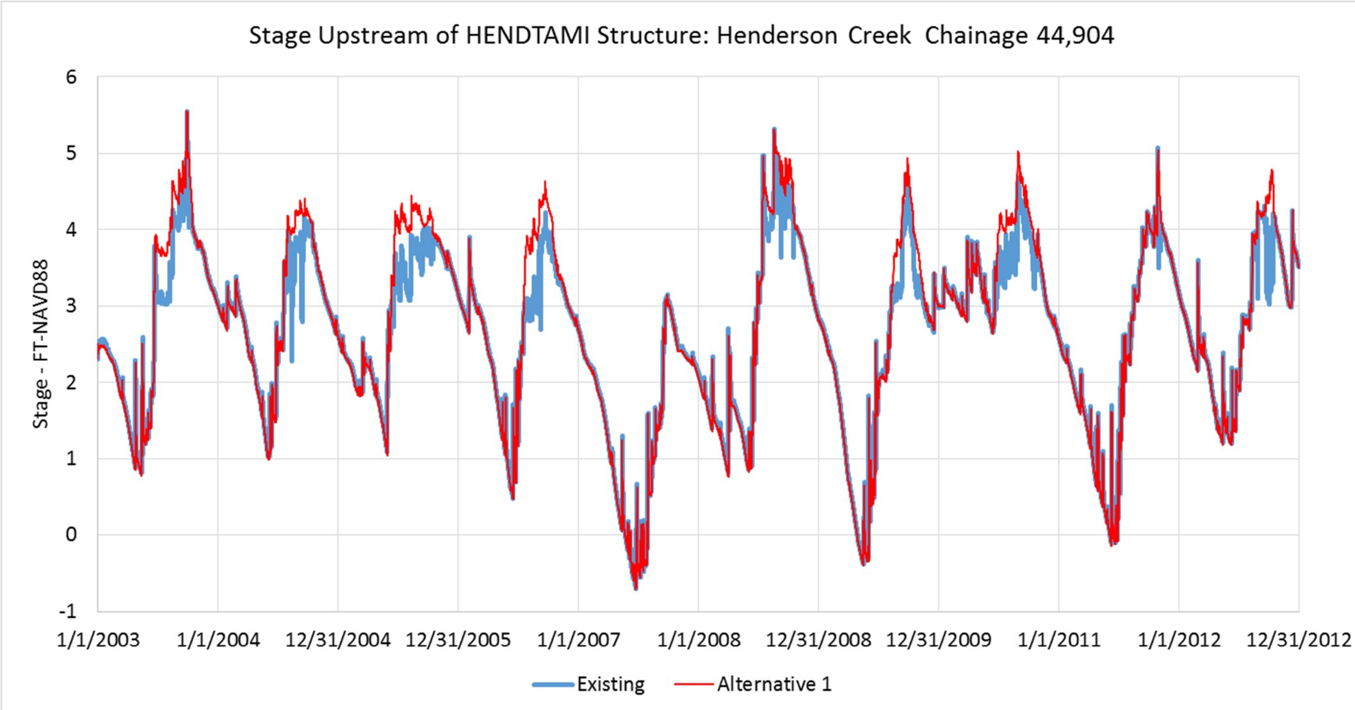


Figure 8. Water Level Upstream of HENDTAMI Control Structure

Figure 8 presents a comparison of water levels upstream of the HENDTAMI control structure, showing that gate operations proposed for Alternative 1 created no differences in the maximum stage. From **Figure 8** it is shown that two large events occur in the watershed (9/30/2013 and 8/20/2008), with no difference in upstream stage between Existing and Alternative 1 simulations. The proposed gate operations did not cause flooding, therefore simulation has been deemed successful considering no negative effects were created.

Additional water level checks were made along the U.S.-41 canal upstream (**Fig. 9**) and downstream (**Fig. 10**) of the TAMIHEND structure, and directly downstream of the structure on the east branch of Henderson Creek (**Fig. 11**). These analyses were performed to ensure that the U.S.-41 canal was not being overdrained and to ensure downstream flooding was not being created from the proposed gate operations.

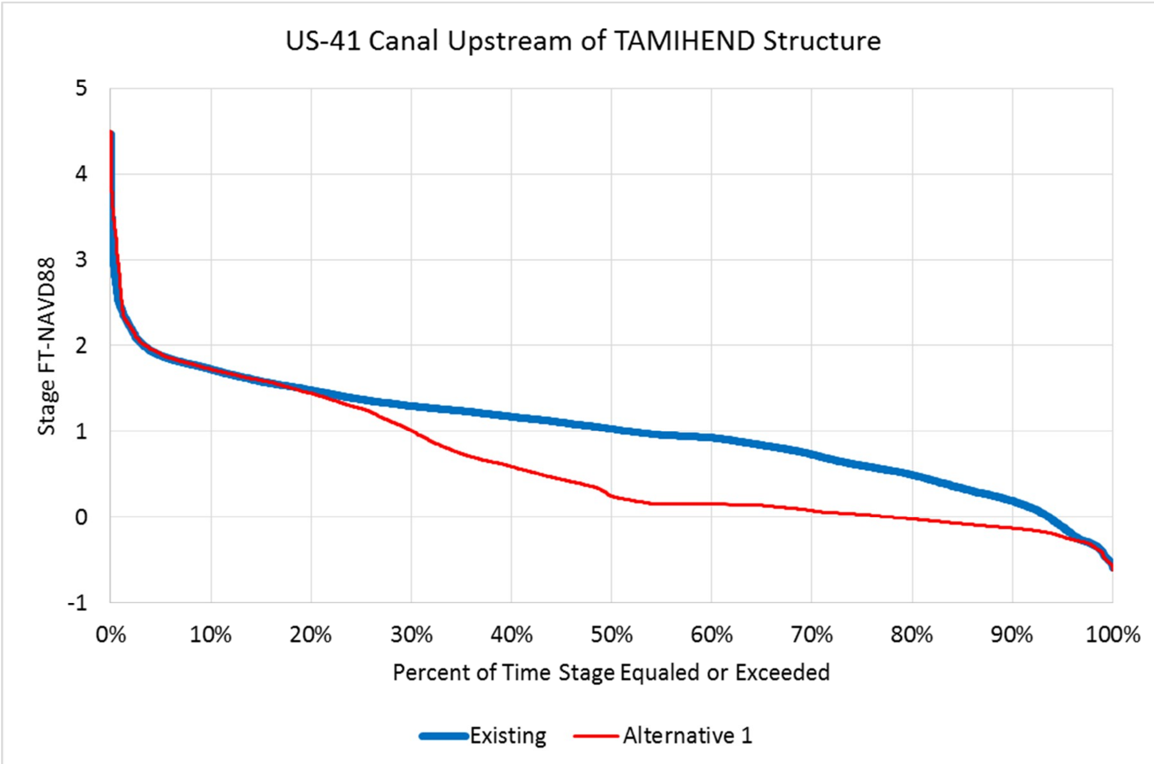


Figure 9. Stage Duration Curve: U.S.-41 Canal Water Level Upstream of TAMIHEND

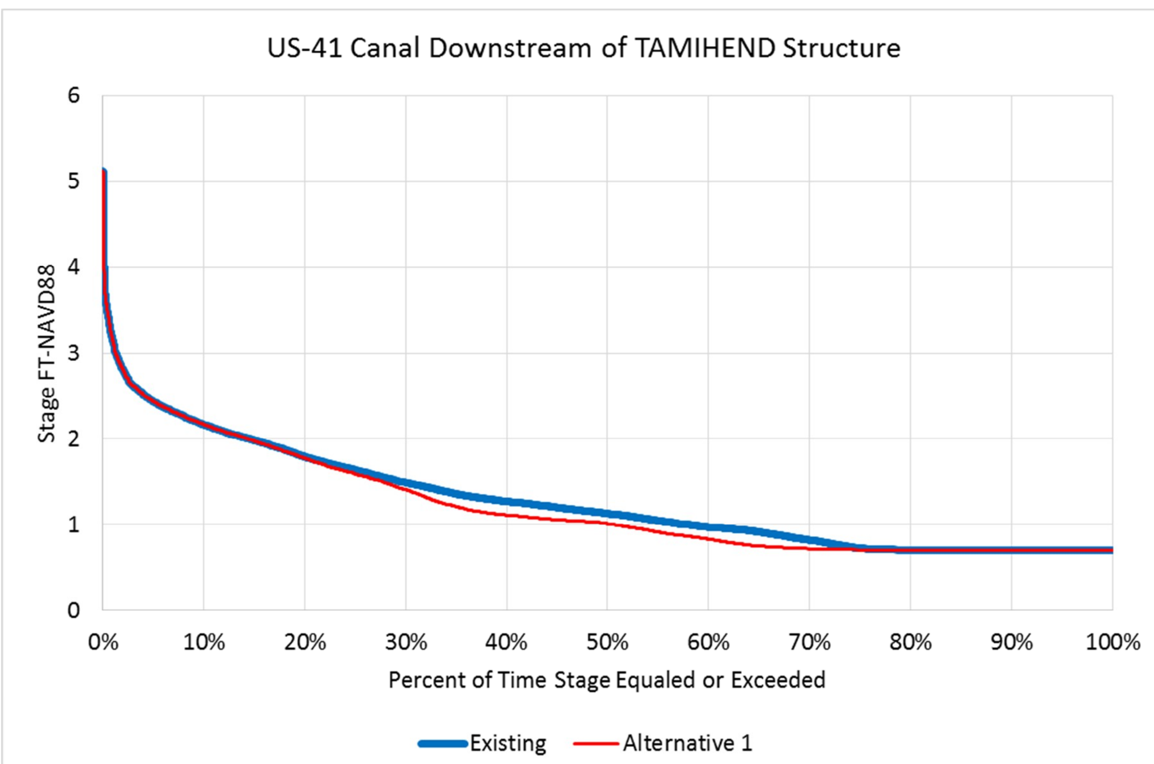


Figure 10. Stage Duration Curve: U.S.-41 Canal Water Level Downstream of TAMIHEND

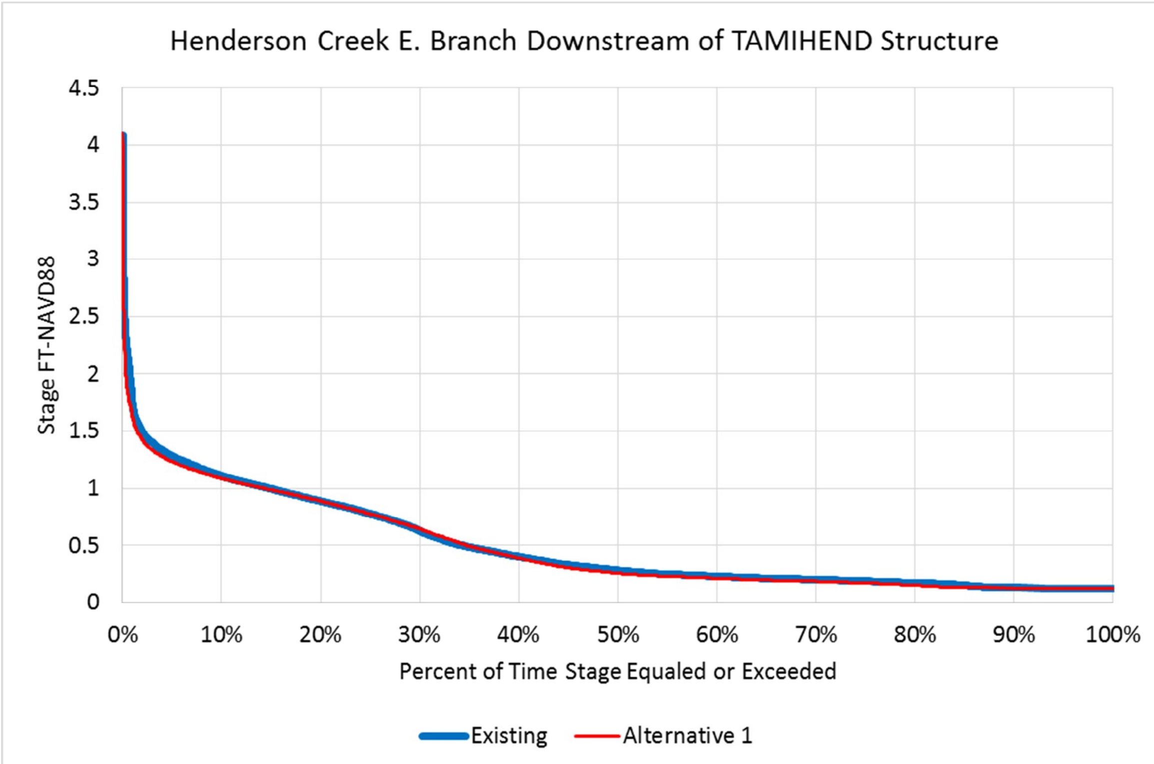


Figure 11. Stage Duration Curve: Henderson Creek E. Branch Downstream of TAMIHEND

Stage duration curves presented in **Figures 9** thru **11** illustrate that the U.S.-41 canal would experience some drawdown during the dry season months when compared to Existing Conditions. Additionally, stages in the U.S.-41 canal just upstream of the TAMIHEND structure (**Fig. 8**), show no difference when comparing the maximum stage to existing conditions. While differences of about 0.8-foot are shown in **Figure 9**, these drawdowns are attributed to the proposed gate operations (50-60 percentile) during the dry season and are not thought to create negative impacts to the surrounding area. **Figure 10** presents U.S.-41 canal stages downstream of the TAMIHEND structure and show no difference in minimum or maximum water levels, and slight differences (0.1-foot) in the median difference (50 percentile). This 0.1-foot of difference between Existing Conditions and Alternative 1 simulated water levels is seen as insignificant and does not represent a negative impact. Thus upstream and downstream canal stages (within the U.S.-41 canal) resulting from the proposed gate operations are not expected to cause flooding to downstream residents nor would the proposed gate operations drop U.S.-41 canal stages to unacceptable levels (**Figures 9 and 10**). Based on the analysis, there would be no deleterious effects created by the proposed gate operations as the drawdowns would not affect the minimum water levels within the canal, nor create an increase in water level in the canal network downstream of the structure (**Fig. 10**). Further checks were made with respect to overland flow and groundwater levels and are discussed in the following subsections.

3.2 MIKESHE: Overland Flow Results

To assess the proposed gate operations with respect to overland flow, the Existing Conditions and Alternative 1 simulations were compared using the maximum depth of overland flow as well stage duration curves at the points within the Belle Meade Flow-way (**Fig 3**). The maximum depth was used to create a difference map, where the Existing Conditions were subtracted from the Alternative 1 simulation results for each model grid cell, showing any increase or decrease in the depth of overland water. An examination of the maximum and median statistic depth of overland water difference maps between Existing and Alternative 1 simulations, shows no difference in overland flow depths for the maximum statistic and minimal differences (about 0.2-foot) for the median statistic in areas south of the U.S.-41 canal near the TAMIHEND structure. These minimal differences south of the U.S.-41 canal were shown in areas of topographic lows associated with small ponds (less than one grid cell in size) and are considered to be within the range of possible error associated with the model. **Figure 12** presents the stage duration curve (Existing Conditions vs Alternative 1) for the wetland area north of U.S.-41 canal (the blue hashed dot **Fig 6**.) and shows a slight difference (0.1-foot) in the maximum depth of overland flow and no differences over the remaining exceedance probabilities.

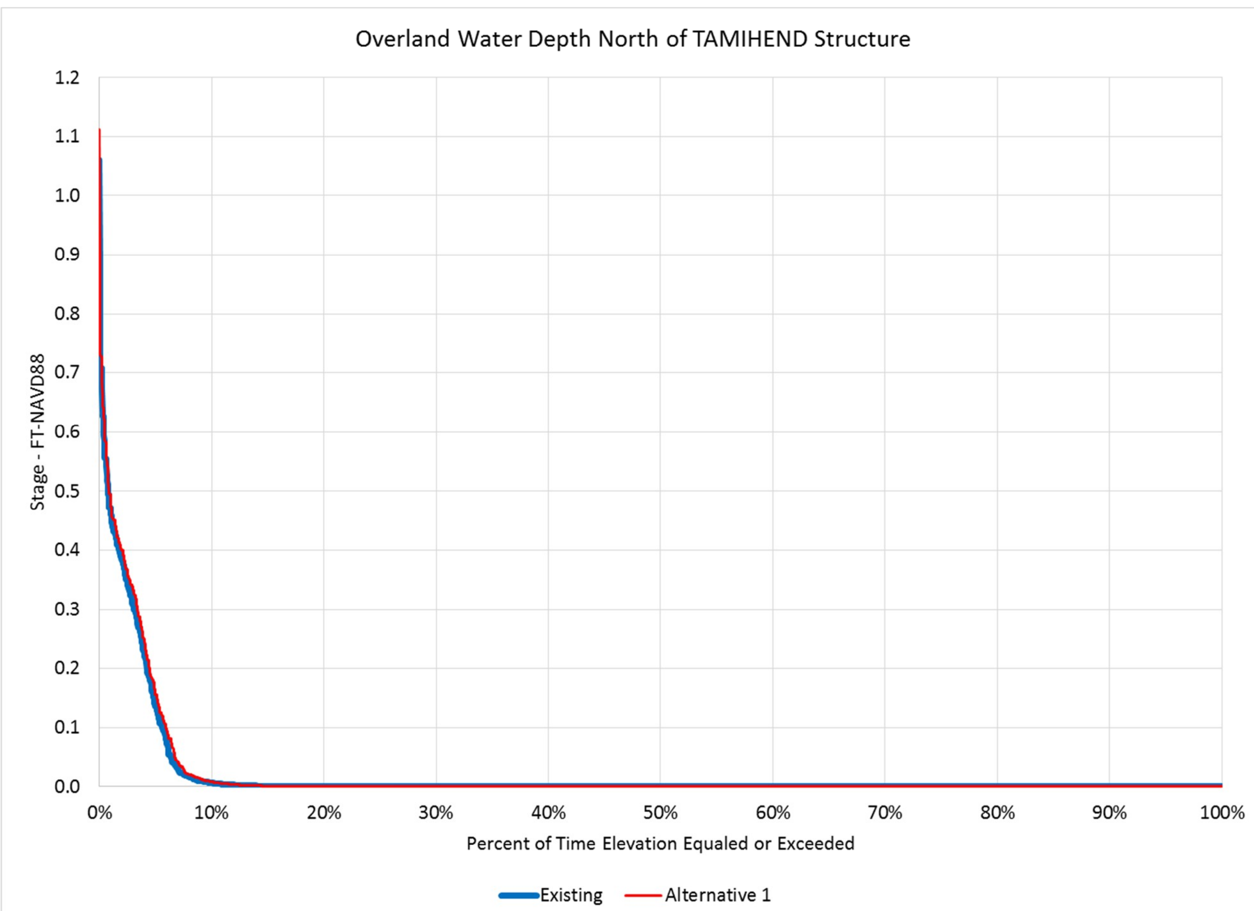


Figure 12. Stage Duration Curve: Wetland Area North of US-41 Canal.

In **Task 2.7 – Interim Hydrodynamic Modeling Report,** comparisons between Historical and Existing conditions were made at two locations within the Belle Meade Flow-way (**Fig 3**). The same comparison was made between the Existing Conditions and Alternative 1 simulated overland flow depths which are presented here. **Figure 13** presents the north comparison point and **Figure 14** presents the south comparison point within the Belle Meade Flow-way. These figures show that for the proposed gate operations associated with Alternative 1, there are no differences in depth of overland water for either location within the Belle Meade Flow-way.

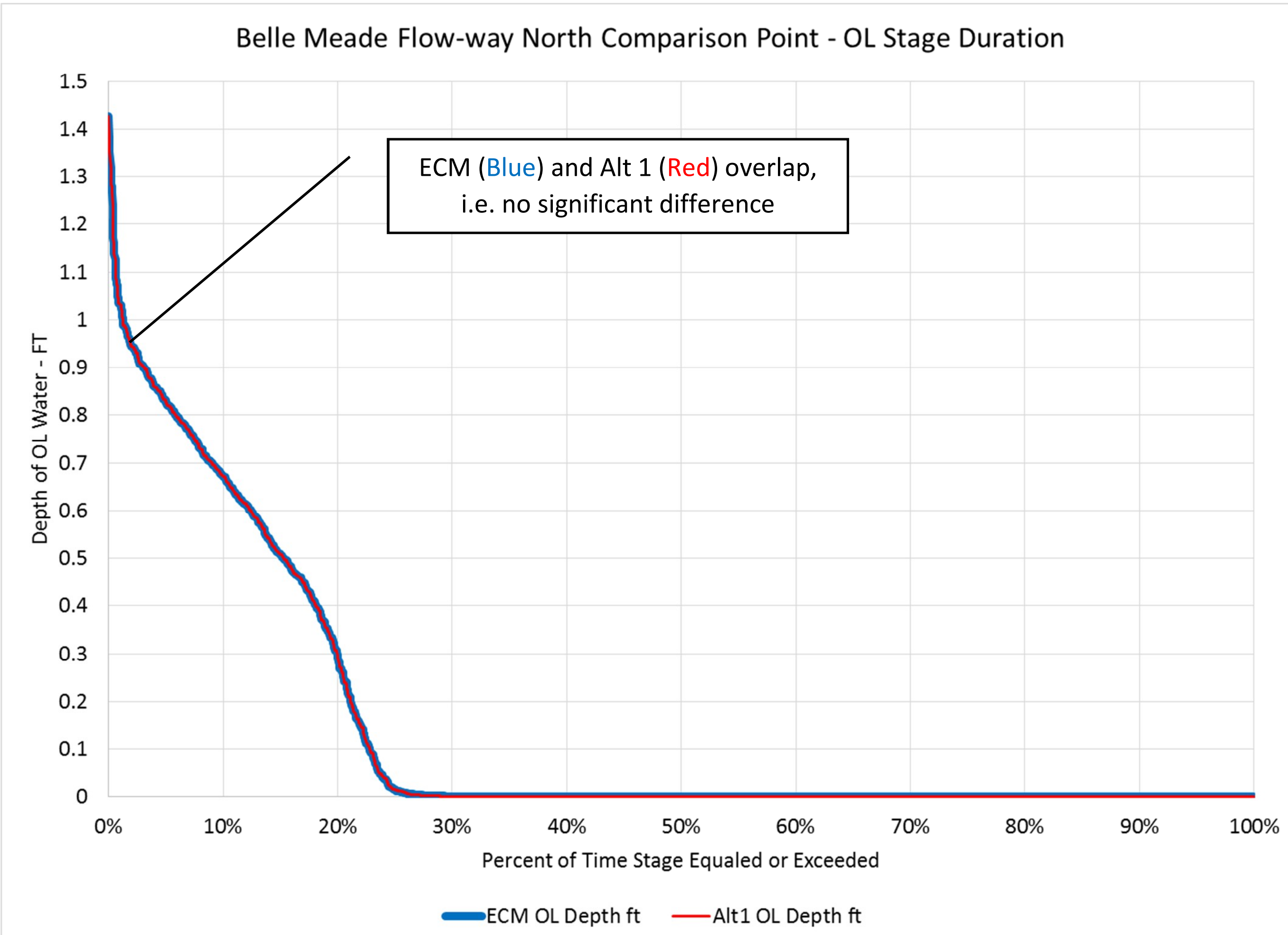


Figure 13. Belle Meade Flow-Way Depth-Duration: North Comparison Point

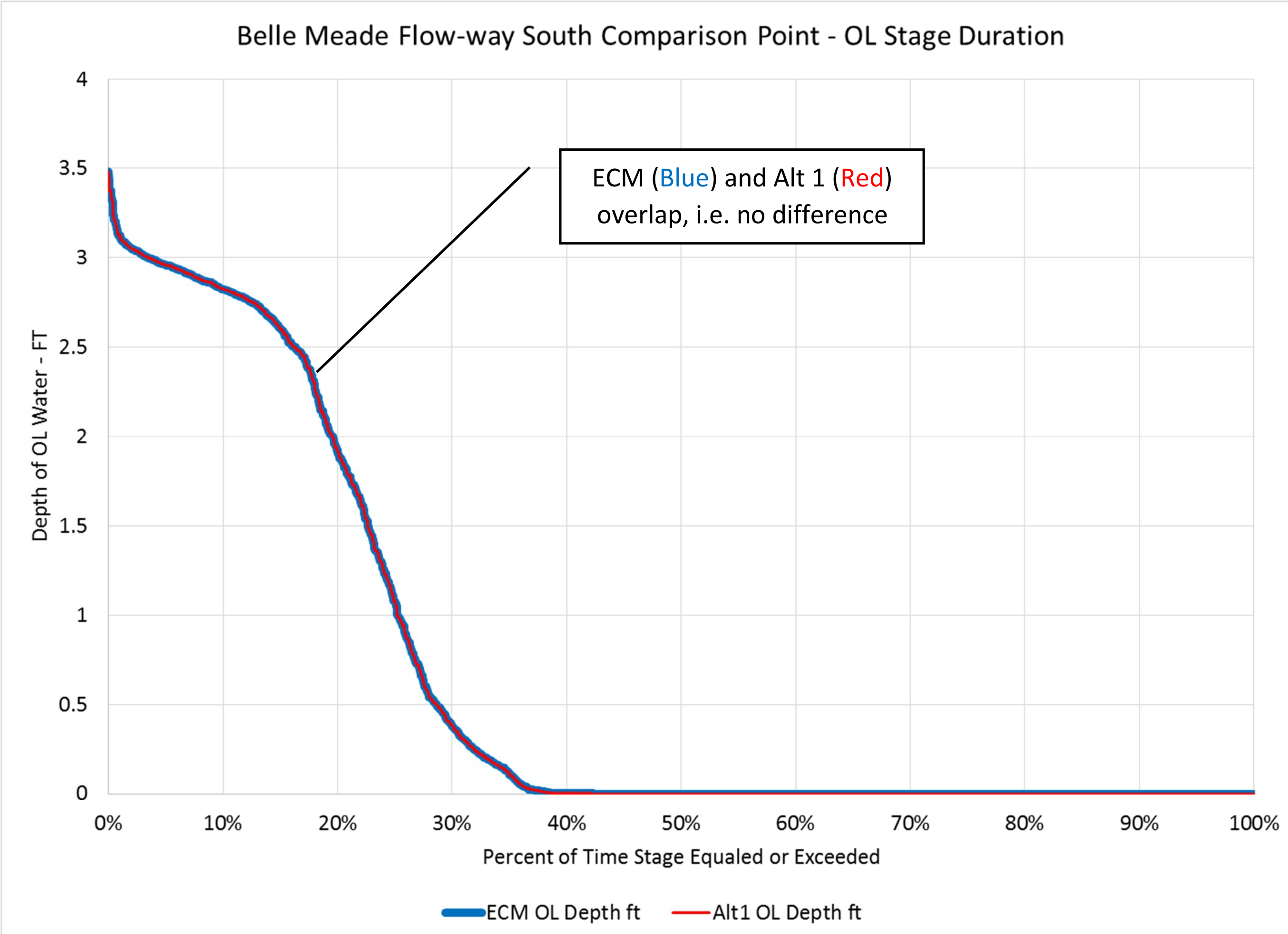


Figure 14. Belle Meade Flow-Way Depth-Duration: South Comparison Point

Based on the analyses presented in this subsection, it is the opinion of the modeling team that the proposed gate operations would not induce any negative impacts to the overland flow depths.

3.3 MIKESHE: Groundwater Results

Groundwater impact assessments were accomplished by first comparing difference maps of the maximum and median statistic elevation of the water table aquifer between the Existing Conditions and Alternative 1 simulations and elevation duration curves at the previously mentioned locations within the Belle Meade Flow-way and wetland area north of the U.S.-41 canal in a similar manner to the results presented in **subsection 3.2**. The maximum groundwater elevation difference map was developed in the same manner as the overland flow depth comparisons. Difference calculations were made by subtracting the Existing Conditions results from Alternative 1 to create a spatially distributed map of the maximum difference. An examination of the difference in maximum groundwater elevations between Alternative 1 and Existing conditions showed there to be no significant difference between simulations resulting from the proposed gate modifications, while the median statistic shows a minus 0.2-foot difference in ground water elevations. The proposed gate operations are not thought to adversely affect the maximum groundwater elevation in the water table aquifer and the impact to groundwater for the median statistic shows a slight lowering of water table elevations, within a range that may be considered acceptable. The impact would not extend into the Belle Mead Flow-way, as indicated in Figures **15** and **16**.

Figures 15 and **16** present the stage duration curves of the water table aquifer for the same points of comparison within the Belle Meade Flow-way as presented in **subsection 3.2**. It is shown from these curves that the simulated water table aquifer elevations have not been affected for the comparison points within the flow-way. This is seen as a positive result in that no negative effects (i.e. over drainage) have been simulated for the sensitive wetland areas within the Belle Meade Flow-way.

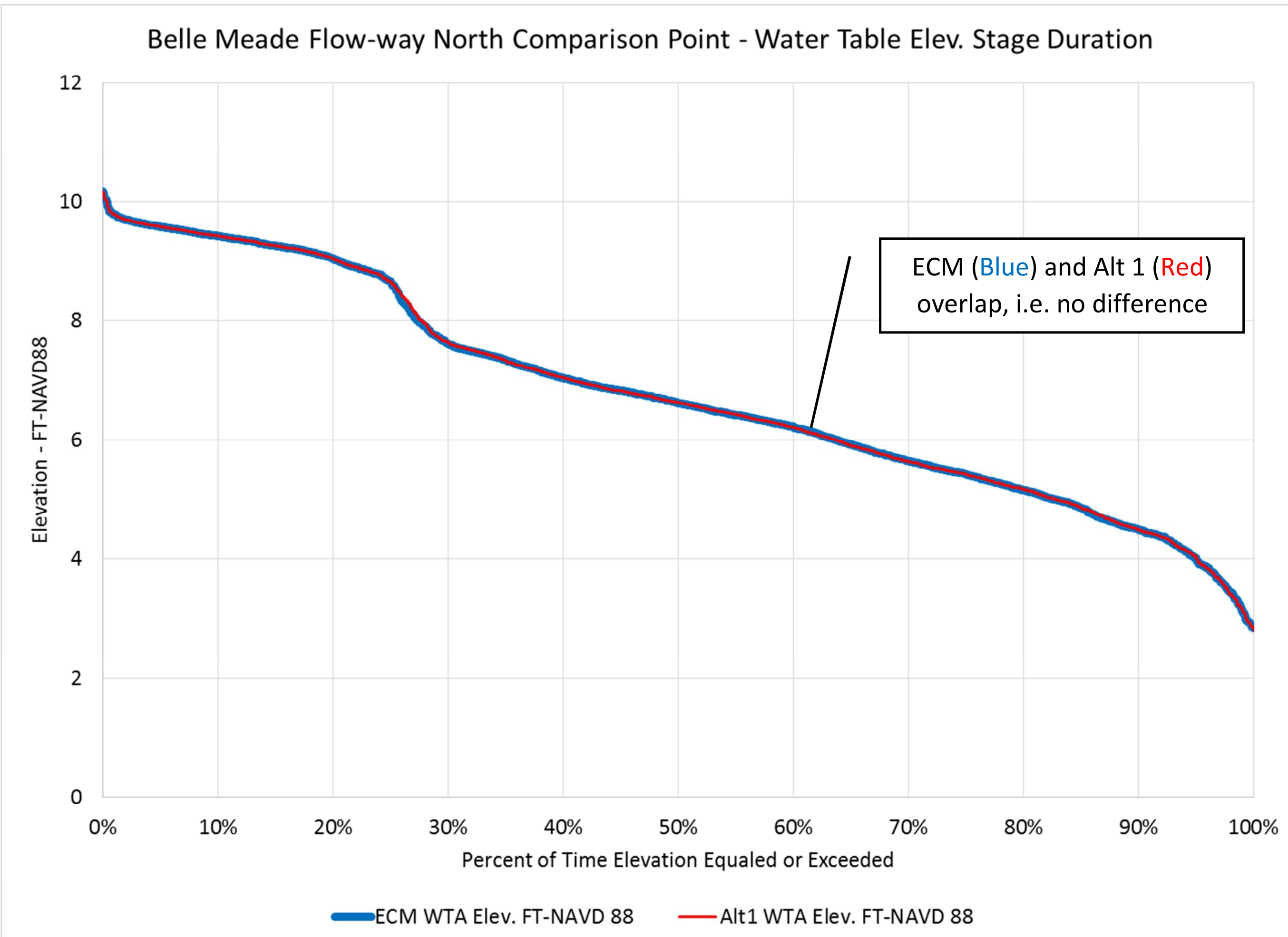


Figure 15. Belle Meade Flow-Way Water Table Stage-Duration: North Comparison Point

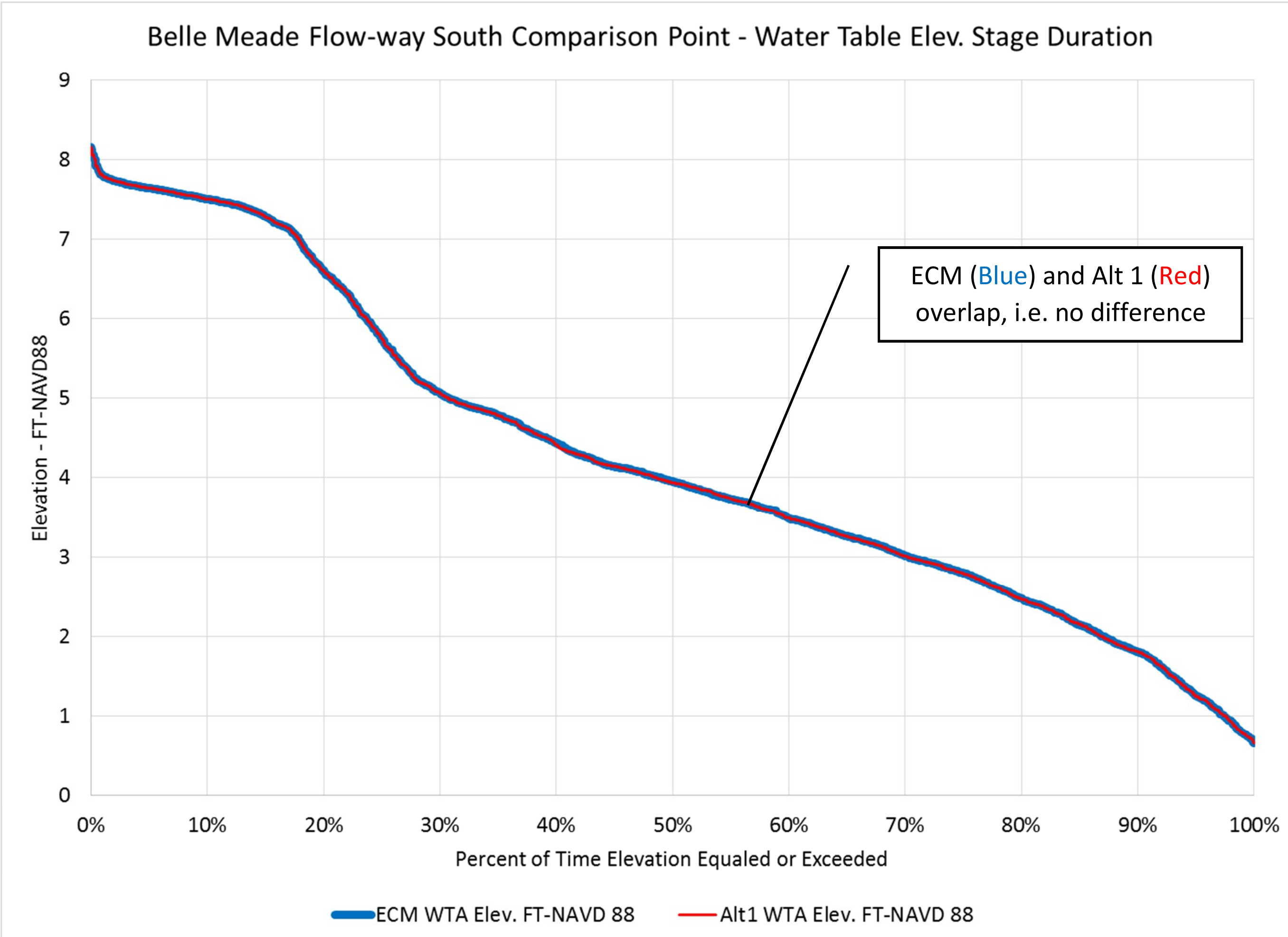


Figure 16. Belle Meade Flow-Way Water Table Stage-Duration: South Comparison Point

Figure 17 presents the stage duration of water table aquifer elevation at the same wetland north of the U.S.-41 Canal shown in **Figure 6** and discussed in the previous subsection. Evidenced in **Figure 17**, the maximum and minimum groundwater elevations remain unchanged with a median difference (50^{th} percentile) of about 0.2-foot. This difference may be within an acceptable range and occurs over a relatively small geographic area, as it does not extend into the environmentally sensitive Belle Meade Flow-way.

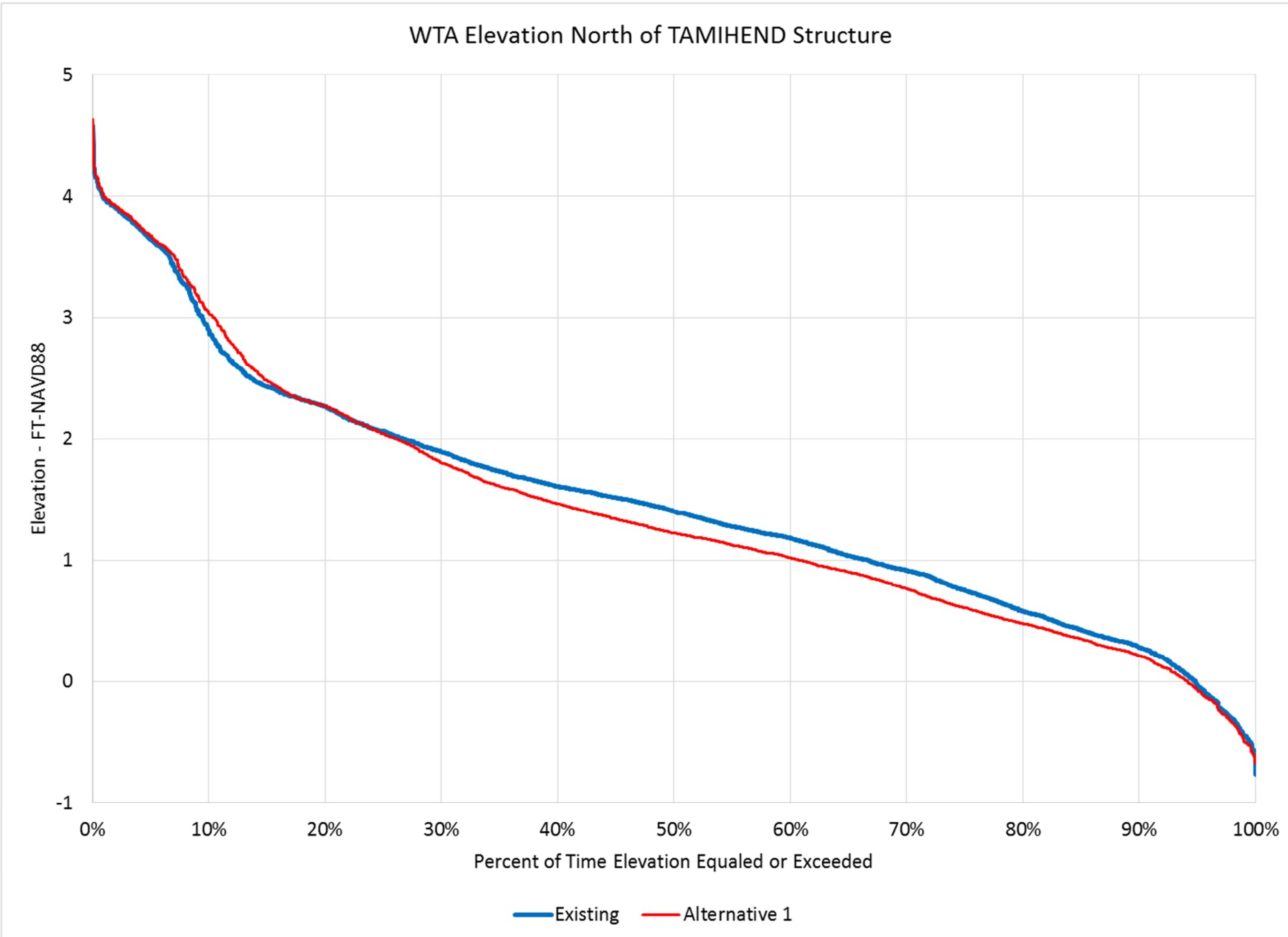


Figure 17. Water Table Stage-Duration: Wetland Area North of U.S.-41 Canal

4.0 Conclusion

From the analyses presented herein, it is clear that the objectives of the model have been met in that the proposed alternative would:

- Provide a better representation of the Historical condition dry season flows to the Rookery Bay Estuary
- Avoid negative impacts within the surface water network
- Not exacerbate any existing overland flooding
- Not create negative impacts within the adjacent wetlands and water table aquifer

From these objectives being met, the results of the Alternative 1 simulation show that it could be a viable scenario:

- By providing a better representation of historical dry season flows to the Rookery Bay Estuary
- Accomplishing these goals without the need for a new structure or the costs associated with infrastructure changes.

In summary, the proposed gate operations developed in Alternative 1 provide a mechanism to better approximate historical condition dry season flows to the Rookery Bay Estuary. The simulation results presented herein show that no negative impacts would be created within the surface water network, and impacts to depth of overland flow and water table aquifer elevations are considered minimal and within the possible error range associated with the model.