Savannah Harbor Expansion Project

Sensitivity Analysis of Proposed Navigation Meeting Areas

September 2009

Introduction

This report summarizes the results of impacts to freshwater marshes/wetlands and to water quality (dissolved oxygen, D.O.) within the Savannah River estuary due to two proposed navigation meeting areas. A meeting area is an area within the navigation channel that has been widened to allow two-way ship traffic to meet and pass safely. The two proposed areas are located in the Long Island Range and Oglethorpe Range (See Table 1 and Figure 1). They were evaluated using the ERDC Ship Simulator and economically justified using HarborSym. Results of those two analyses are provided separately. The ERDC Ship Simulator Meeting Areas Analysis dated March 31, 2009 is located in the Engineering Appendix, Digital Supplement, and the HarborSym results are located in the Economics Appendix.

Table 1: Meeting Area Dimensions and Locations

Meeting Area	Length (ft)	Width* (ft)	Stationing
Long Island	8,000	100	14+000 to 22+000
Oglethorpe	4,000	100	54+800 to 58+800

** Width is in addition to the width of the navigation channel at the toe.*

Figure 1: Meeting Area Locations

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Hydrodynamic & Water Quality Model Input

The two meeting areas were incorporated into the EFDC and WASP model grids by adjusting the widths of several grid cells along the navigation channel. The cells that have been widened are representative channel cells; cells that have been reduced in width represent adjacent bank and sideslope transition cells. See Table 2.

Table 2: Meeting Area Model Parameters

Meeting Area	EFDC Model Grid Adjustments*
Long Island	widen cell **14_28** by 100 feet (30.5 m) -- from 153.75m to 184.25m reduce width of cell **13_28** by 100 feet (30.5m) -- from 265.81m to 235.31m widen cell **14_27** by 100 feet (30.5 m) -- from 154.4m to 184.9m reduce width of cell **13_27** by 100 feet (30.5m) -- from 245.15m to 214.65m widen cell **14_26** by 25 feet (7.62m) -- from 175.28m to 182.9m reduce width of cell **13_26** by 25 feet (7.62m) -- from 208.99m to 201.37m
Oglethorpe	widen cell **14_50** by 85 feet (25.9 m) -- from 163.43m to 189.33m reduce width of cell **15_50** by 85 feet (25.9 m) -- from 143.61m to 117.71m widen cell **14_49** by 100 ft (30.5 m) -- from 150.85m to 181.35m reduce width of cell **15_49** by 100 ft (30.5 m) -- from 94.36m to 63.86m widen cell **14_48** by 100 ft (30.5 m) -- from 165.93m to 196.43m reduce width of cell **15_48** by 100 ft (30.5 m) -- from 88.2m to 57.7m

**Adjustments made by changing the DX value in the dxdy.inp file.*

Several model run scenarios were analyzed to determine if there are any additional impacts as a result of the two proposed meeting areas. Two scenarios for freshwater marsh/wetland impacts one during an average freshwater flow year, considered the "Basic Evaluation", and also one during a low freshwater flow year, considered "Sensitivity Analysis #1". See Table 3. For more information on how these run scenarios were developed see the report titled *Evaluation of Marsh/Wetland Impacts with Proposed Mitigation Pla*n dated November 2007, which is included in the Engineering Appendix, Digital Supplement.

Table 3: Model Input Conditions for Freshwater Marsh/Wetland Impacts

Run Scenario	River Flow	Evaluation Period	Parameters Evaluated
Basic Evaluation	Average/Typical	1-March to 1-November	Surface & Bottom Salinity
Sensitivity Analysis #1	Low Flow/Dry	1-March to 1-November	Surface Salinity Only

In addition to the analysis performed for marsh/wetland impacts, an analysis was also done to determine water quality (i.e. D.O.) impacts. One time-period scenario was analyzed for this purpose. The run period is August of 1997, an average flow summer-month period.

All run scenarios incorporate the 48 ft project depth (considered a worse case scenario for the sensitivity analysis) along with the proposed mitigation plan for that depth (Plan 6a and D.O. injection). The details of Plan 6a are shown in Figure 2. Locations of the D.O. injection are selected to be at the former tide gate site and Mulberry Grove (near the confluence of Steamboat

River and Front River). See Figure 3. Details of the D.O. injection system can be found in the report titled *Design of Dissolved Oxygen Improvement Systems in Savannah Harbor* dated April 2008, which is included in the Engineering Appendix, Digital Supplement.

Figure 2: Mitigation Plan 6a

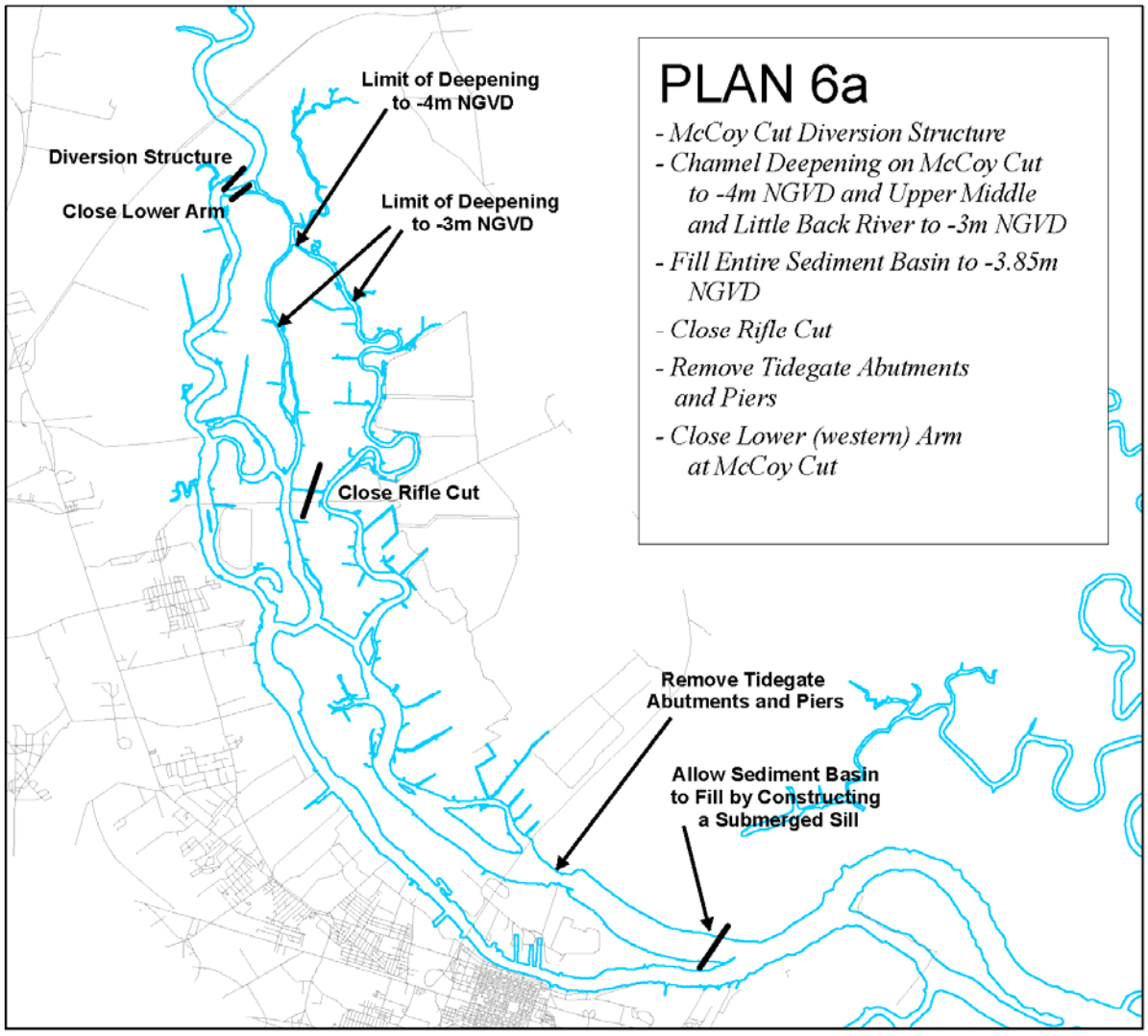

Figure 3: D.O. Mitigation Locations

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Results

Marsh/Wetland Impact Analysis

Impacts to Tidal Fluctuations

Impacts to tidal fluctuations within the estuary due to inclusion of the meeting areas were examined at several grid cell locations on Back and Middle Rivers, shown highlighted in Figure 4. Details of tidal variability are shown by water depth in Figures 5-11. None of these seven locations along Middle and Back River show an impact to tidal depth or timing as a result of inclusion of the meeting lanes within the model geometry. Comparisons are made between the 48 ft depth alternative with Mitigation Plan 6a in place with and without the meeting areas modeled.

Figure 4: EFDC Grid Cell Locations Examined for Impacts to Tidal Fluctuations

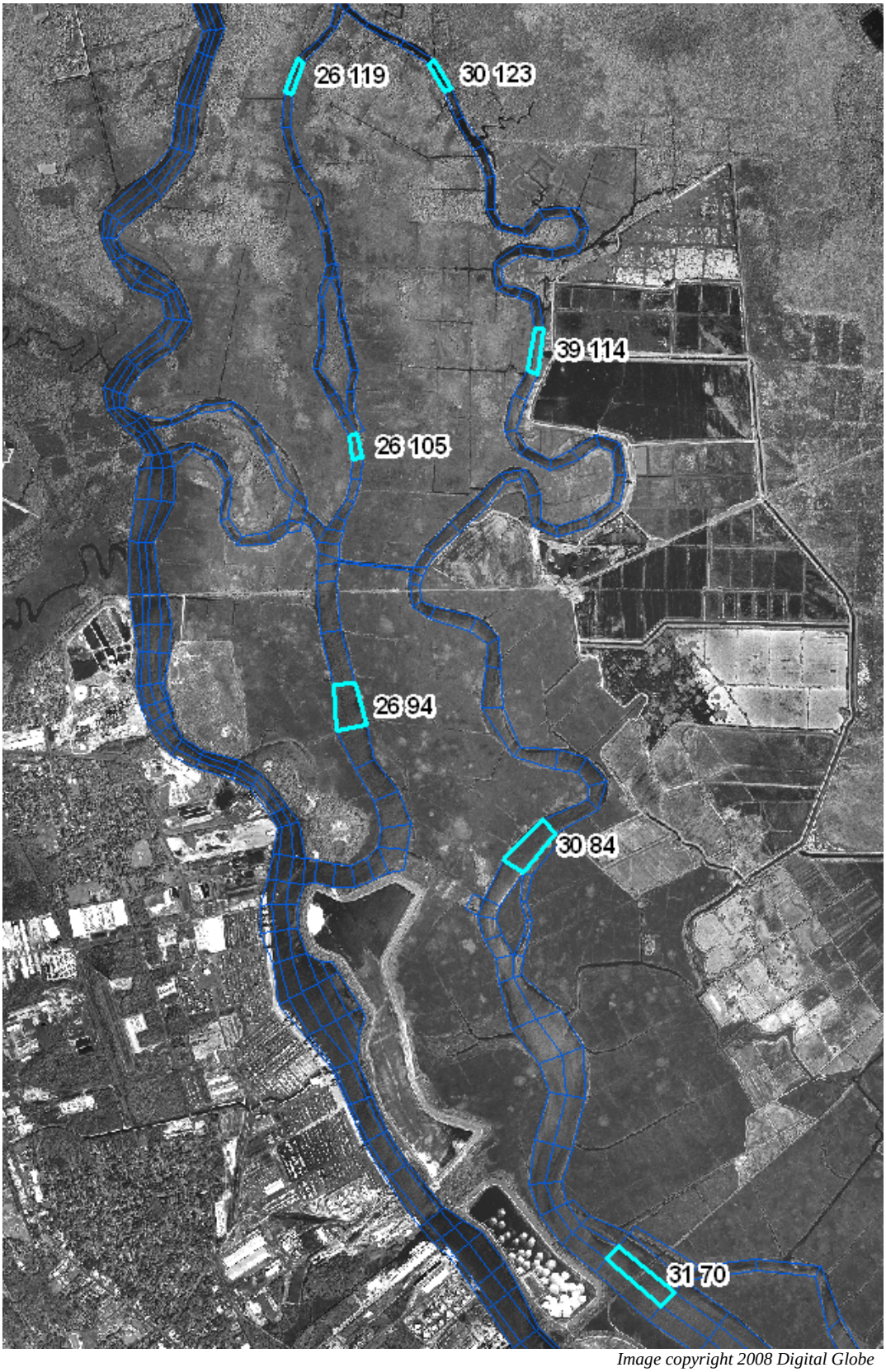
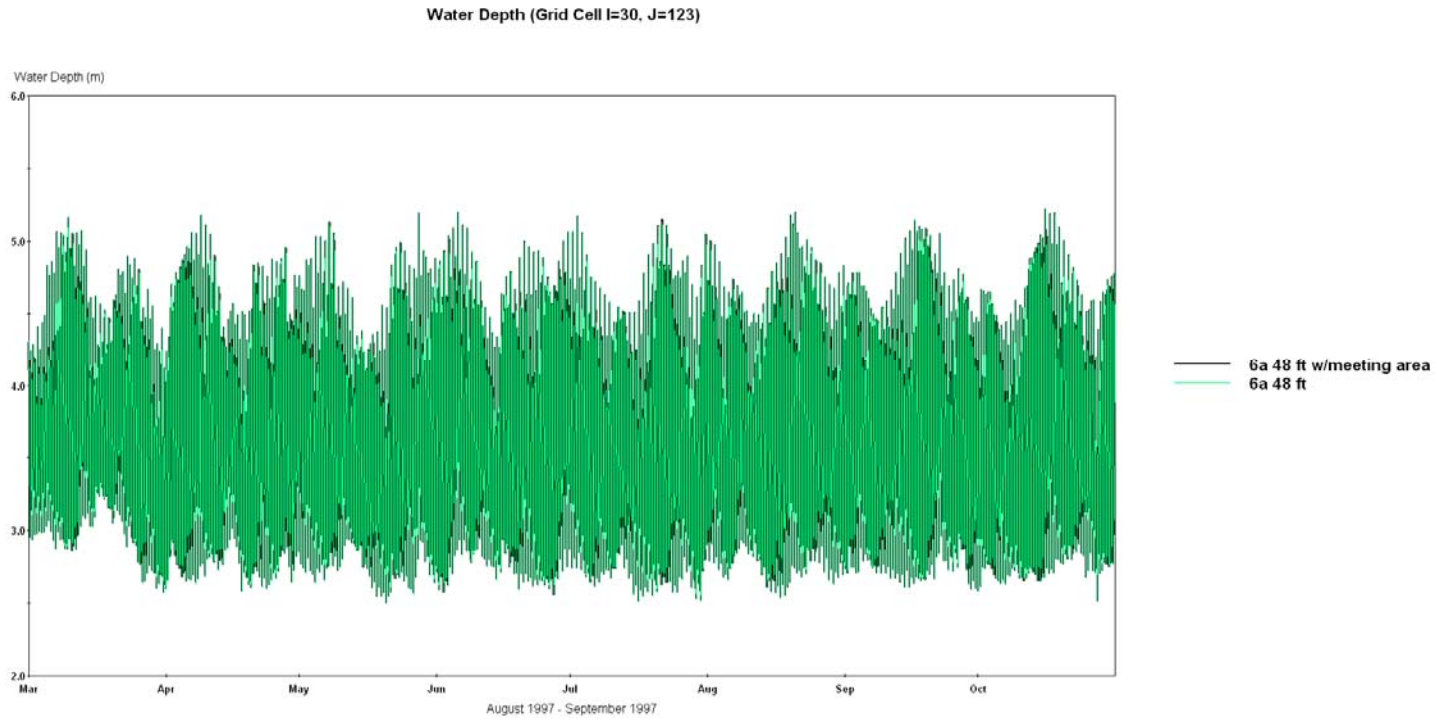


Image copyright 2008 Digital Globe

Figure 5: Water Depth Comparison at EFDC Grid Cell 30 123

A: full run period March through October 1997



B: zoomed run period August 1997

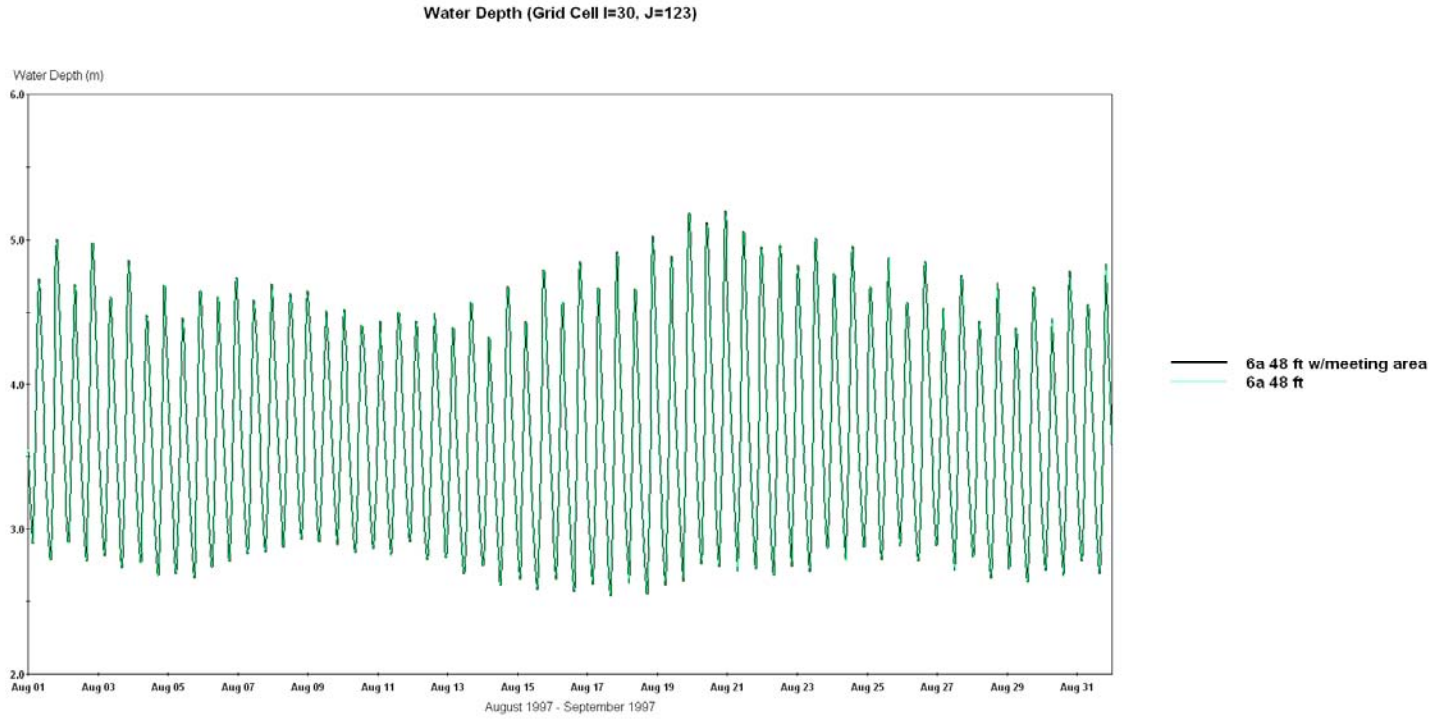
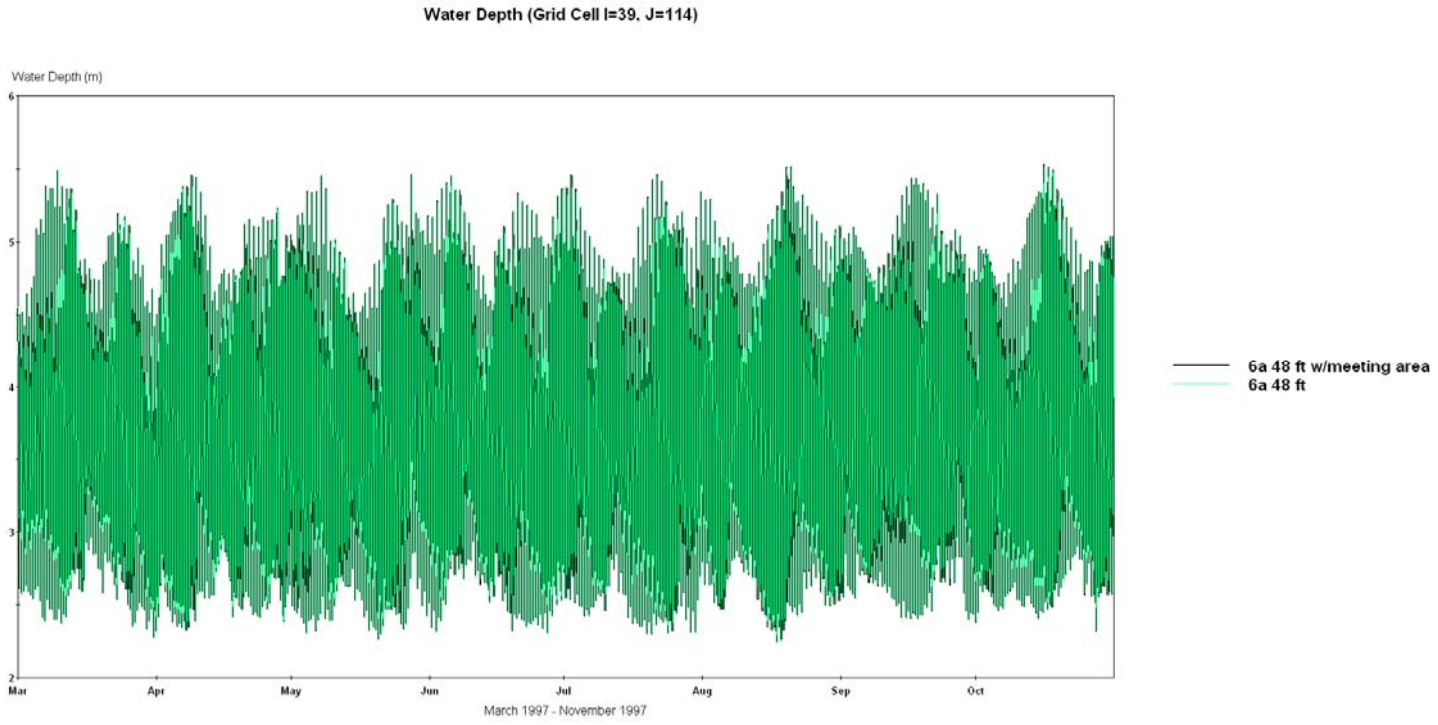


Figure 6: Water Depth Comparison at EFDC Grid Cell 39 114

A: full run period March through October 1997



B: zoomed run period August 1997

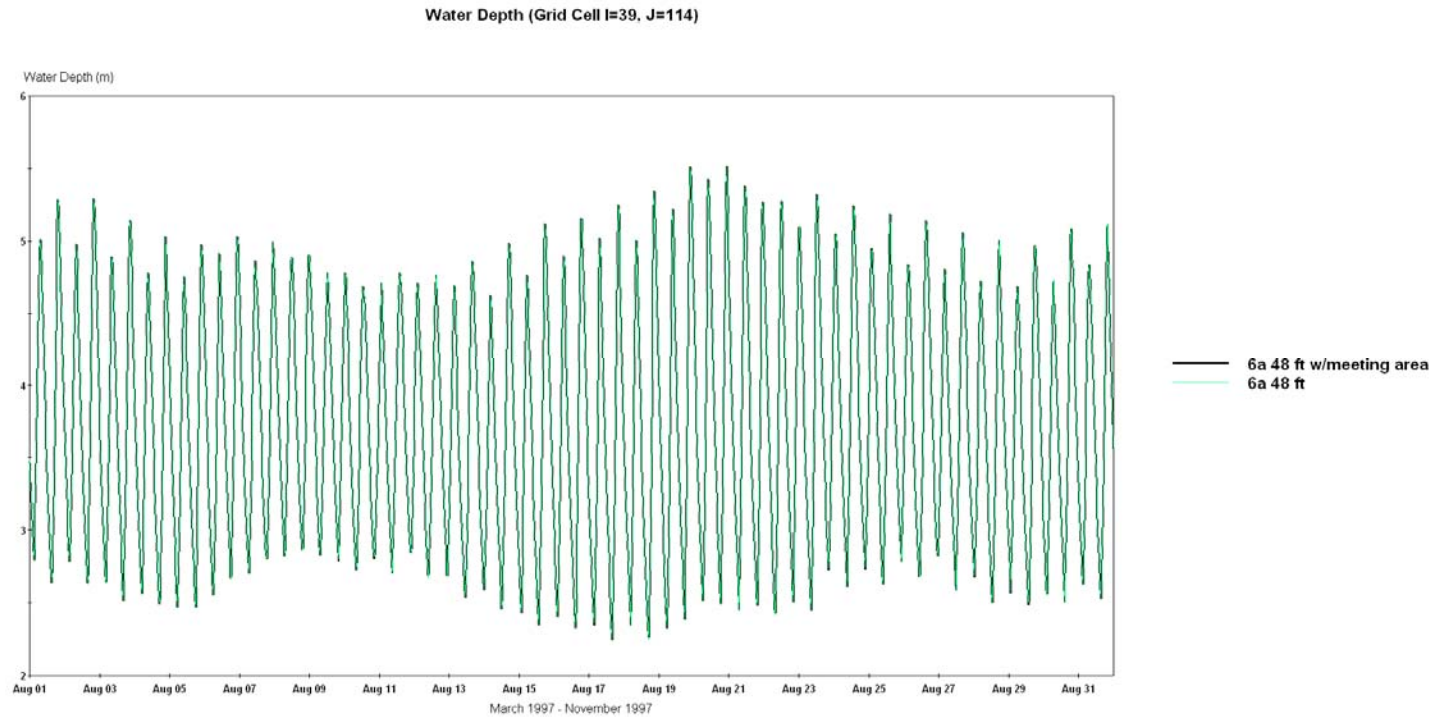
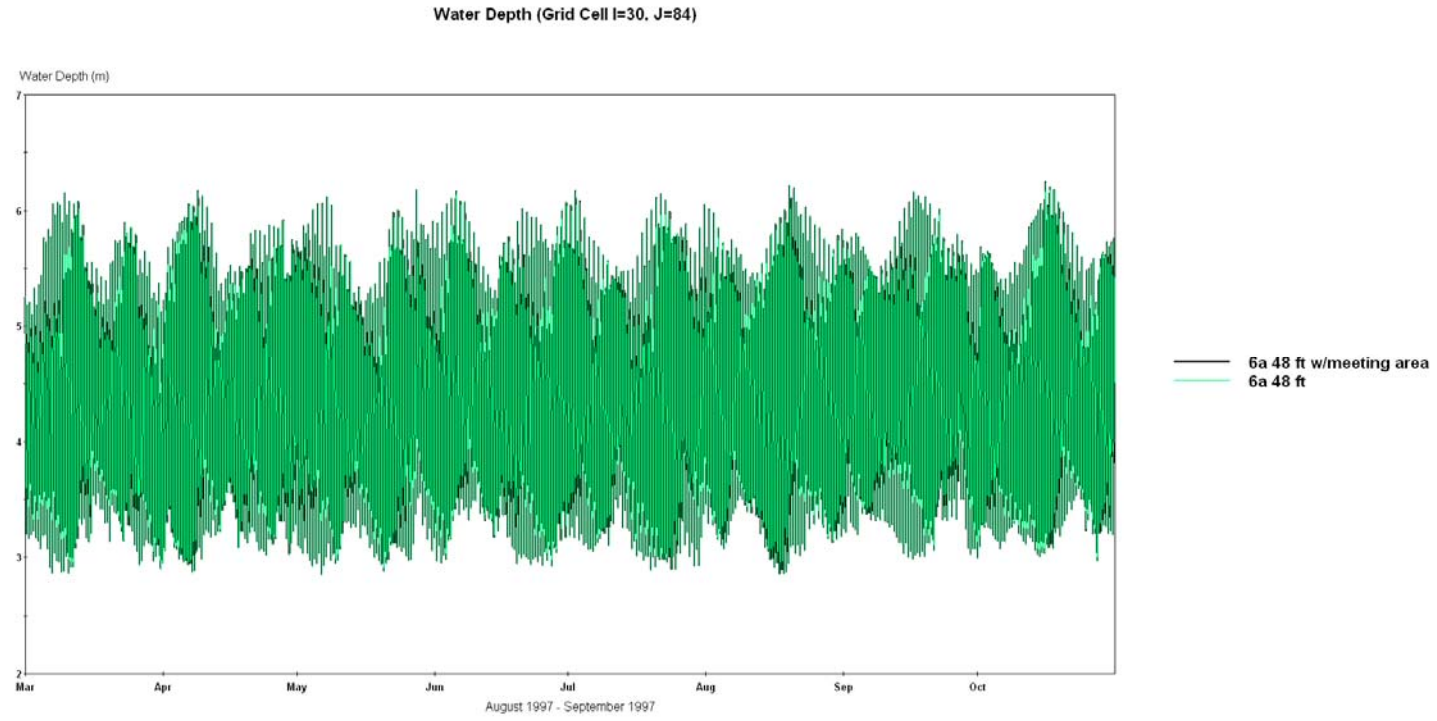


Figure 7: Water Depth Comparison at EFDC Grid Cell 30 84

A: full run period March through October 1997



B: zoomed run period August 1997

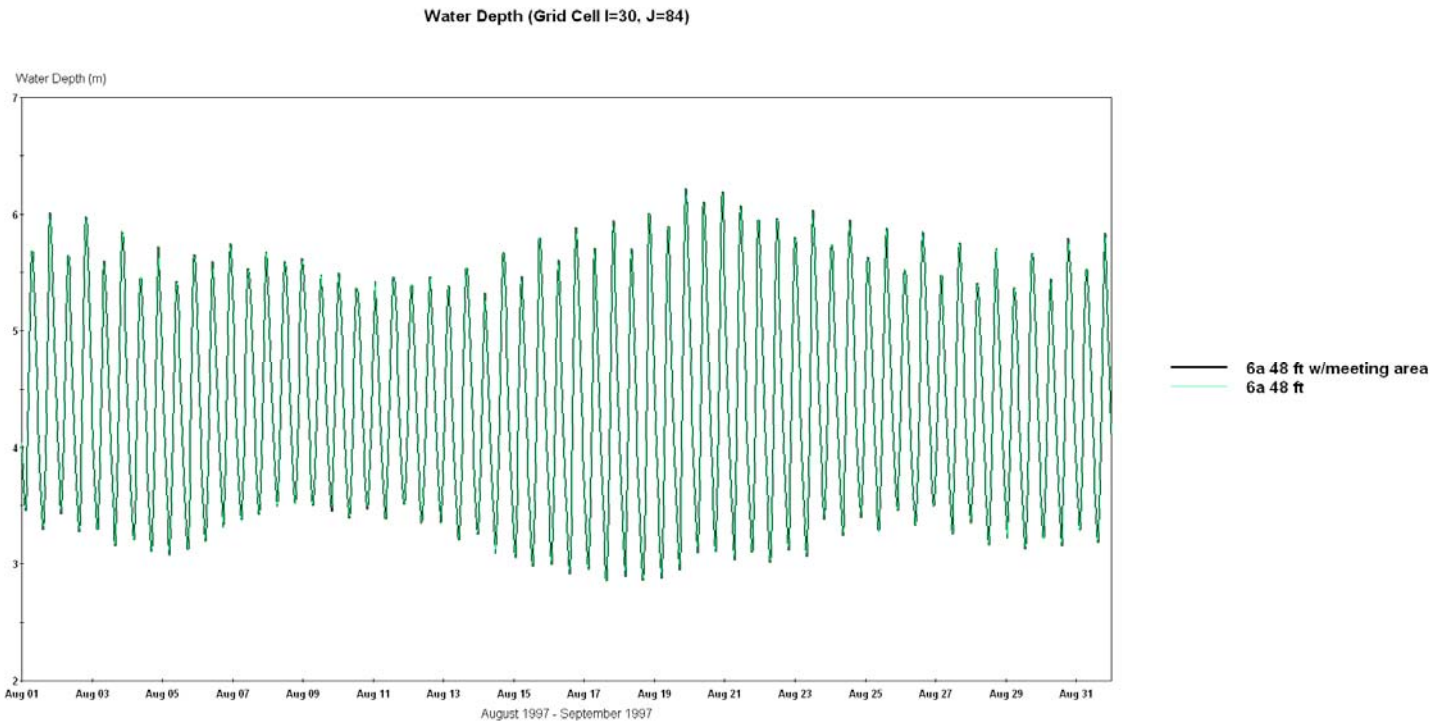
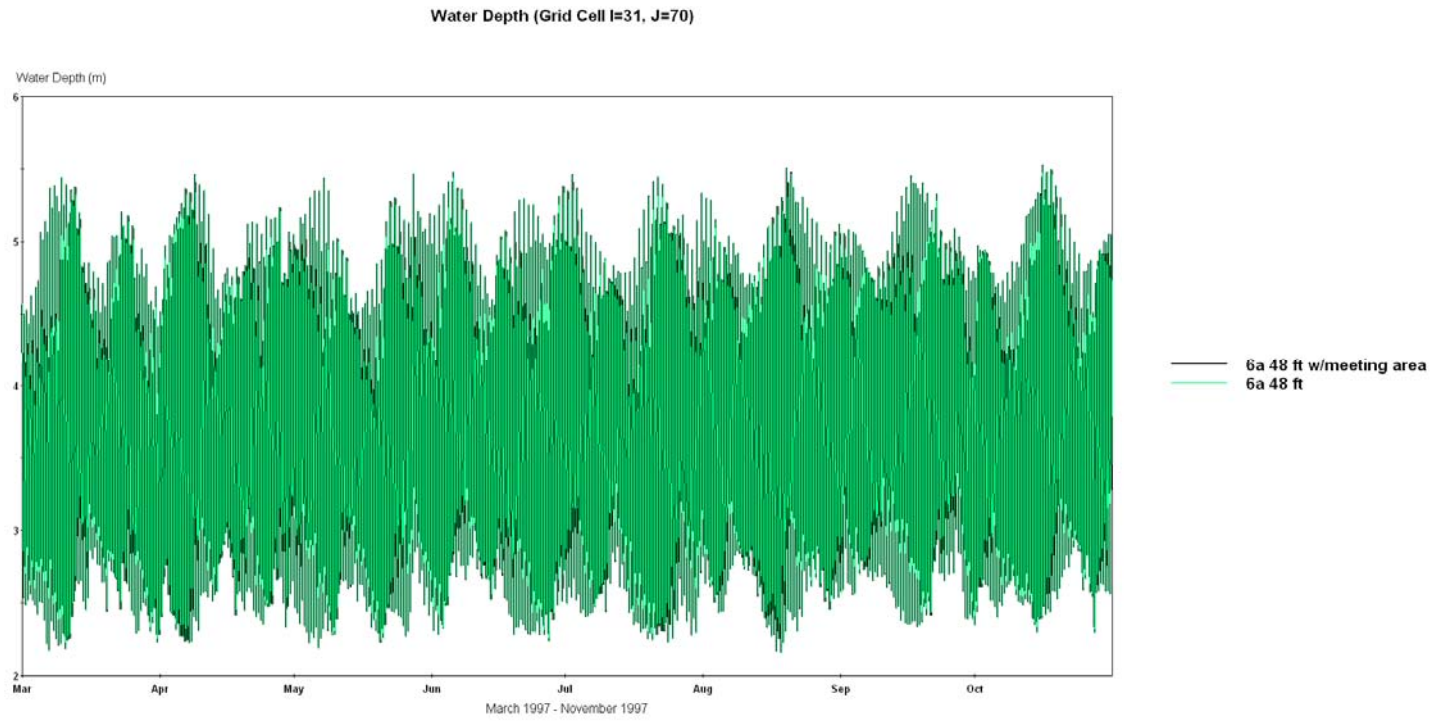


Figure 8: Water Depth Comparison at EFDC Grid Cell 31 70

A: full run period March through October 1997



B: zoomed run period August 1997

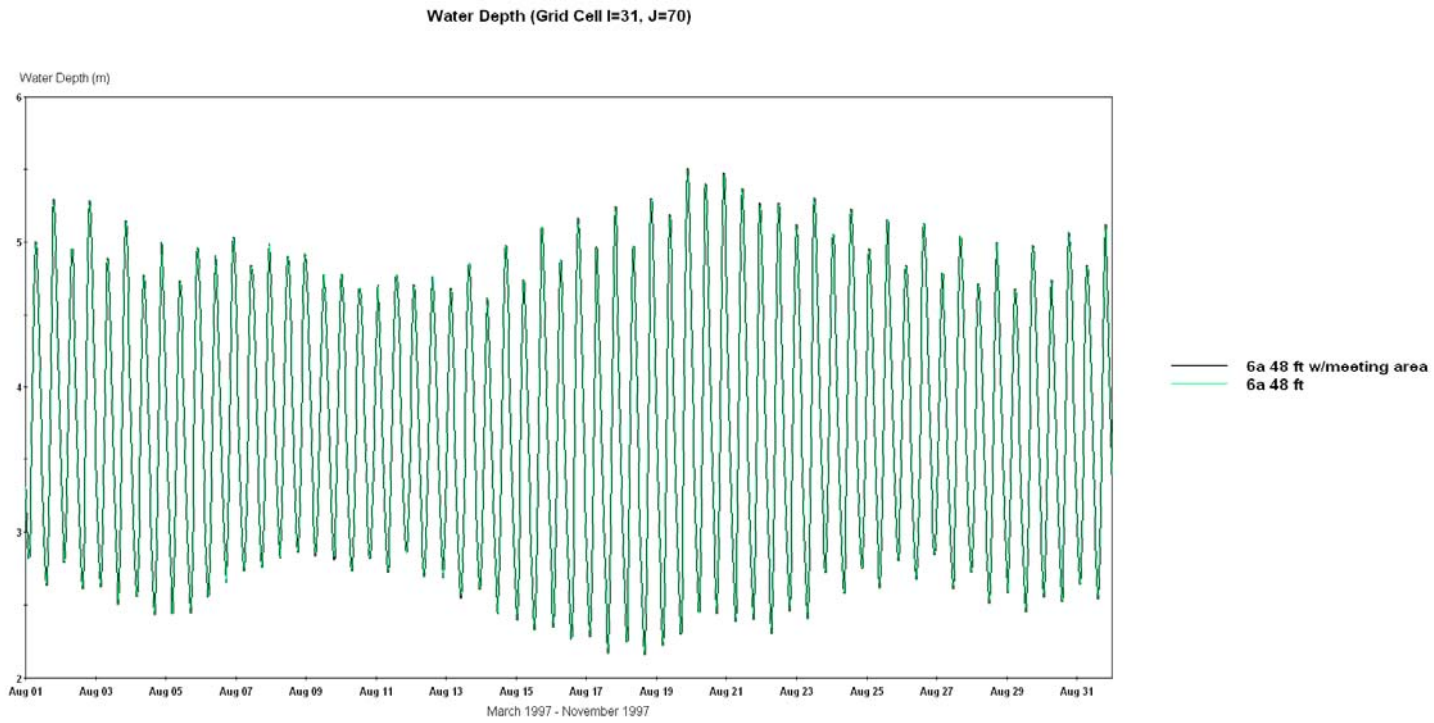
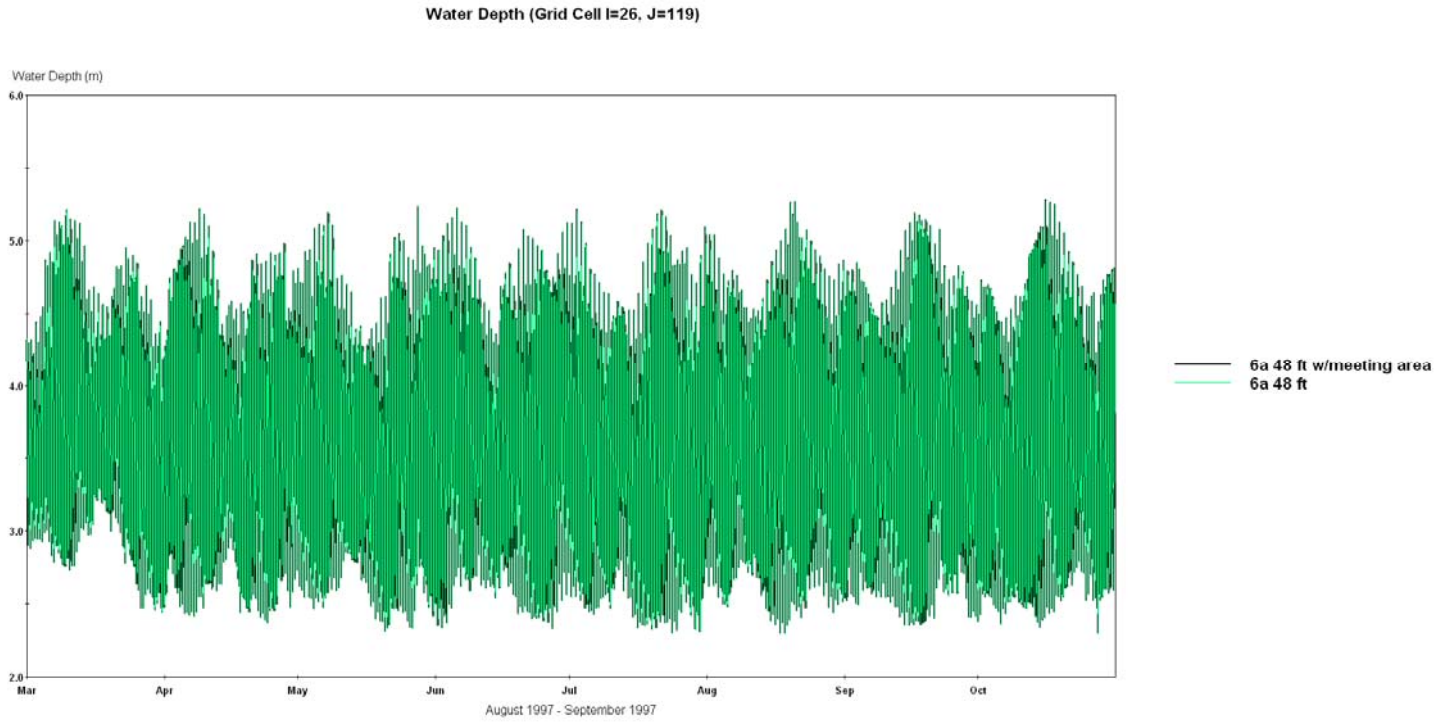


Figure 9: Water Depth Comparison at EFDC Grid Cell 26 119

A: full run period March through October 1997



B: zoomed run period August 1997

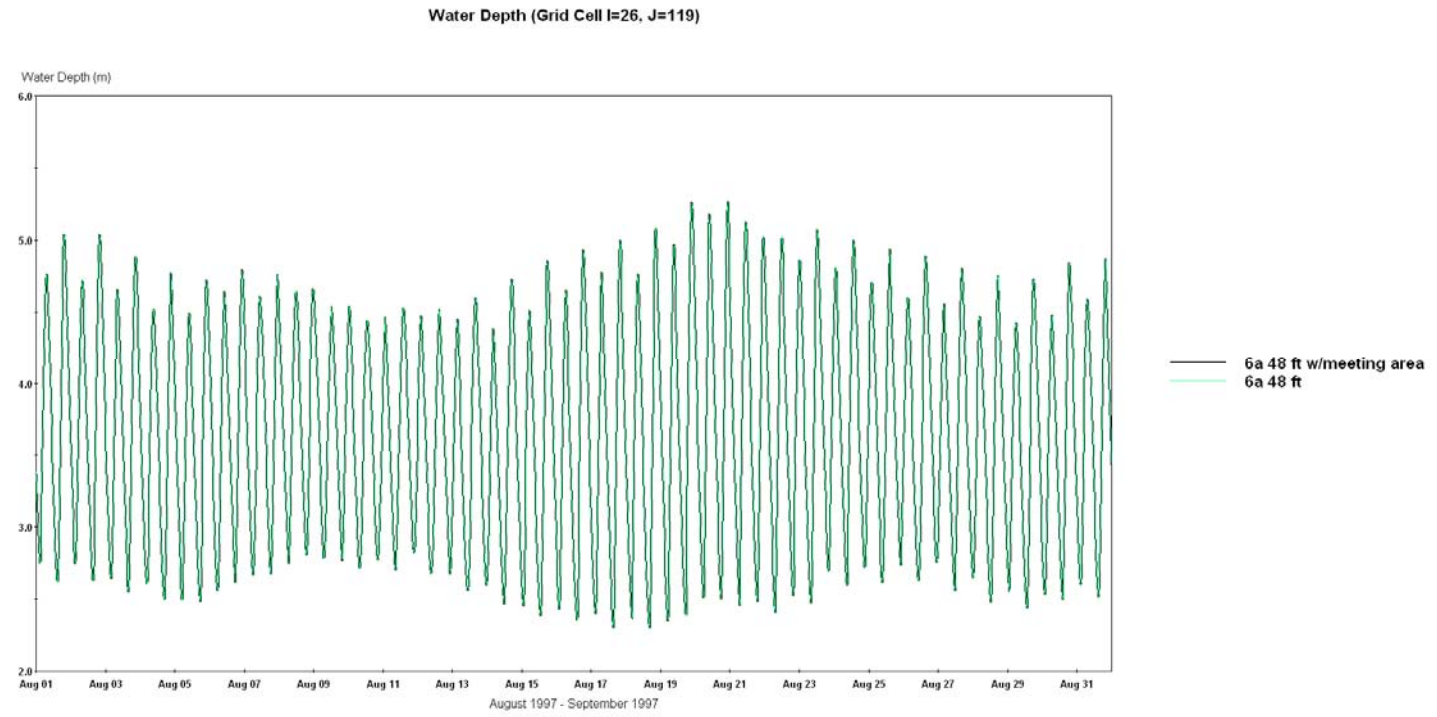
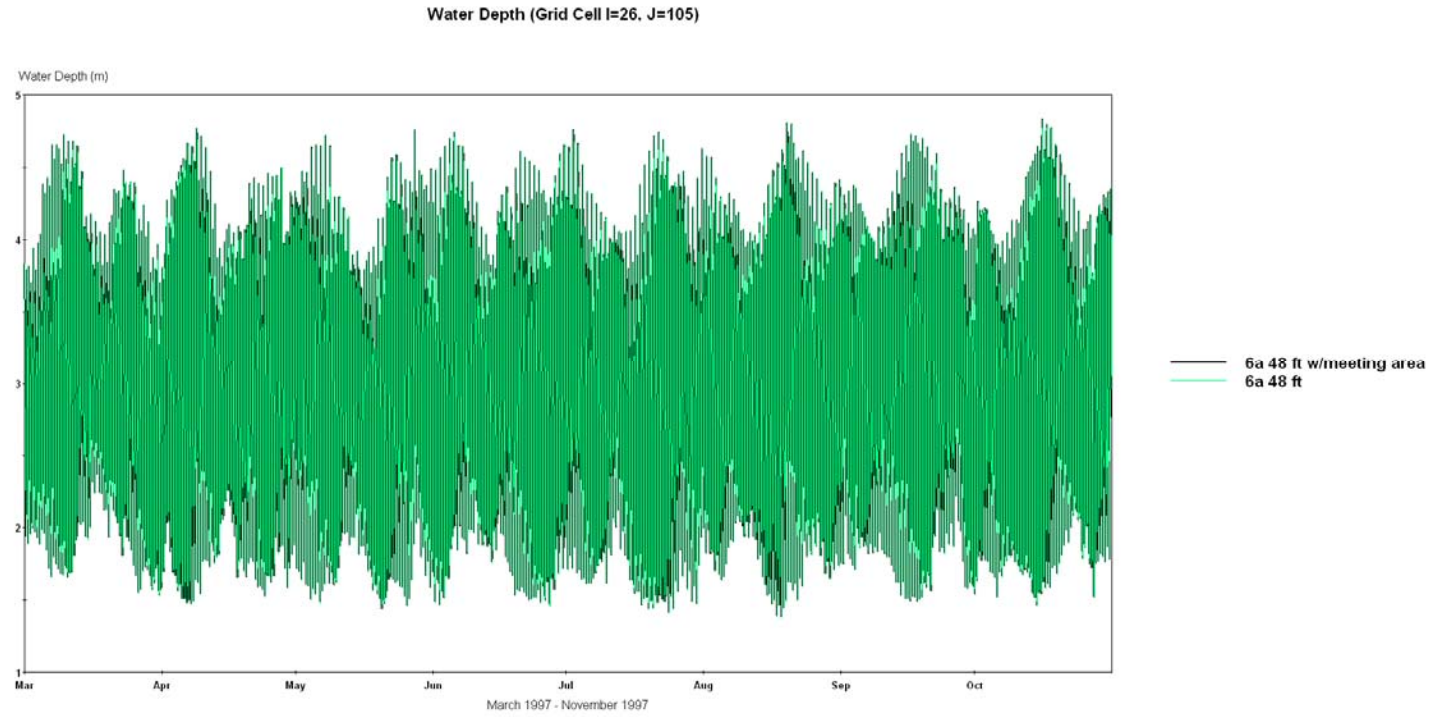


Figure 10: Water Depth Comparison at EFDC Grid Cell 26 105

A: full run period March through October 1997



B: zoomed run period August 1997

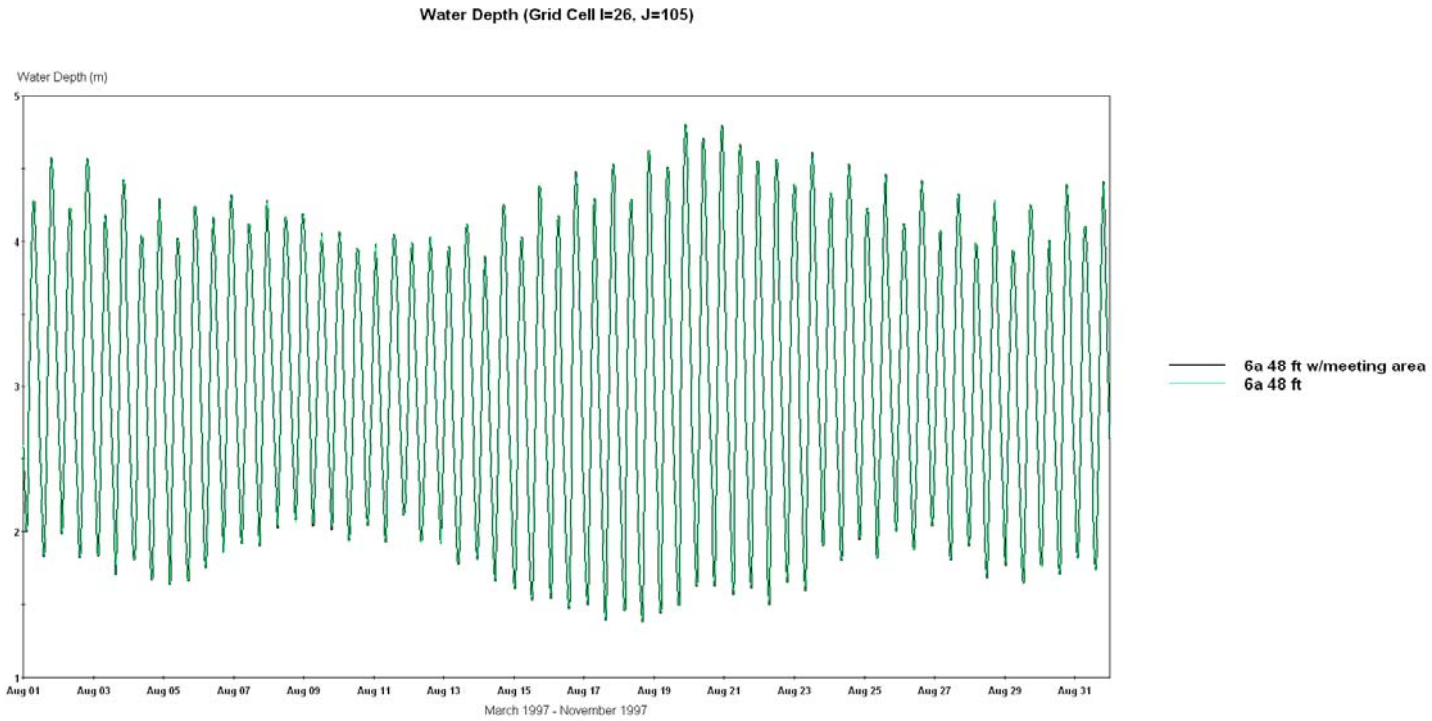
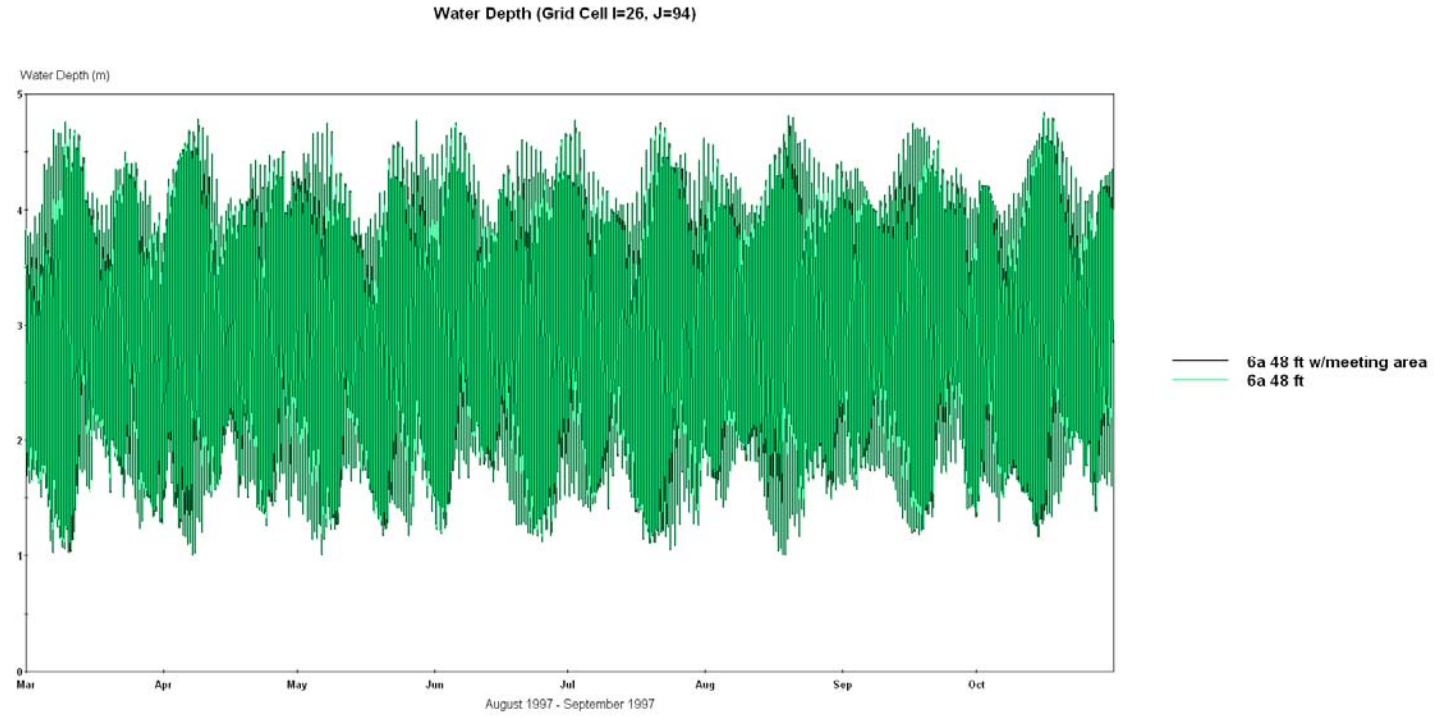
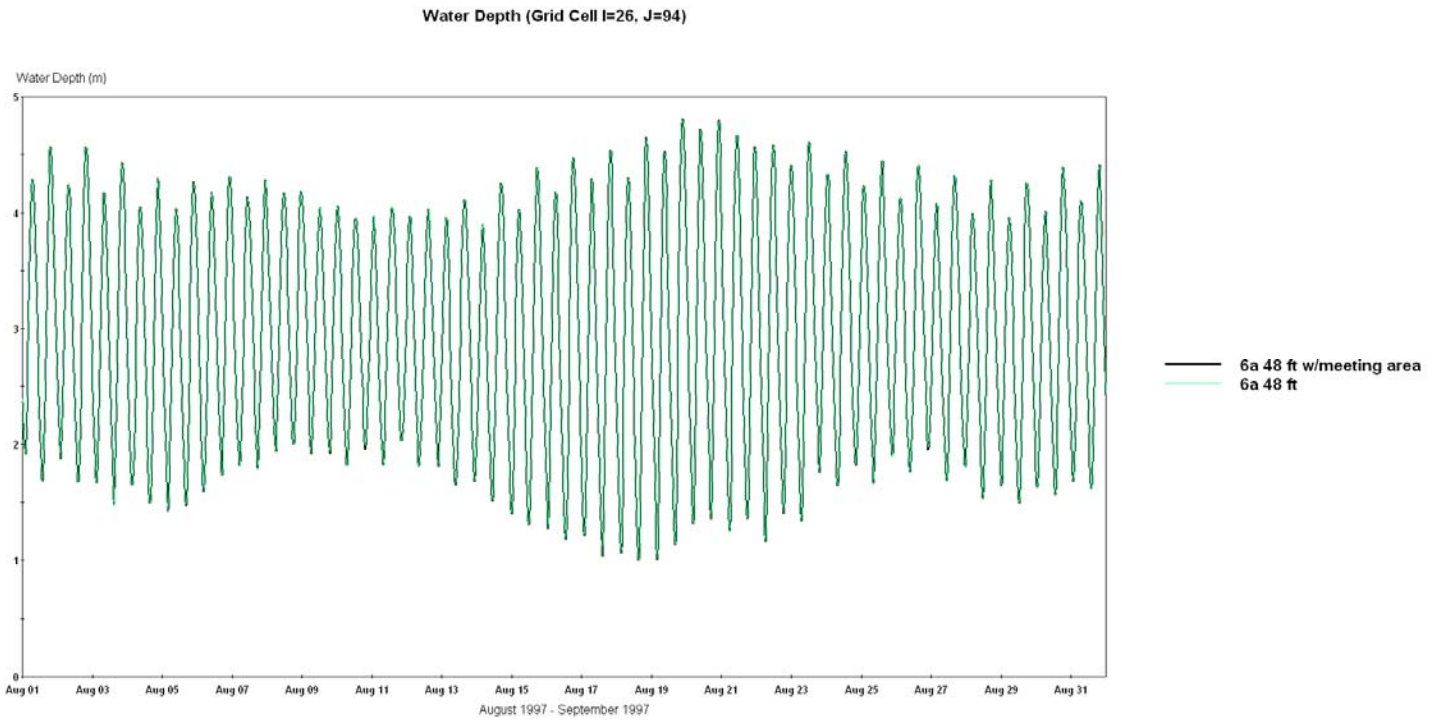


Figure 11: Water Depth Comparison at EFDC Grid Cell 26 94

A: full run period March through October 1997



B: zoomed run period August 1997



Impacts to Salinity Regime

Impacts to the salinity regime within the estuary due to inclusion of the meeting areas in the model grid geometry were examined and results are shown in Figures 12-14. Comparisons are made between the 48 ft depth alternative with Mitigation Plan 6a in place with and without the meeting areas modeled.

Figures 12 and 13 show the changes in salinity for both the model grids surface and bottom salinity predictions for the Basic Evaluation run period. The Basic Evaluation occurs from March through October in 1997 which is considered an average flow year. These would be conditions experienced within the estuary on an average basis.

The maximum change in the surface salinity prediction for the Basic Evaluation is 0.14 ppt. This change occurs just upstream of the tide gate on Back River and causes an increase in the salinity prediction from 5.88 ppt to 6.02 ppt. Surface salinity changes under the Basic Evaluation conditions extend up to New Cut on Back River. However, the increases in prediction values in that area are quite minor, 0.01 ppt. Additionally, the change in salinity regime causes a decrease in predicted surface salinity values on Front River up to 0.44 ppt.

Comparatively the maximum change in the bottom salinity prediction during Basic Evaluation conditions is 0.33 ppt and occurs on Front River just upstream of Elba Island. The addition of the meeting areas within the model cause the bottom salinity to increase from 19.25 ppt to 19.58 ppt. Changes in bottom salinity for the Basic Evaluation, although very small (less than 0.1 ppt) are seen as far upstream as New Cut on Back River. However, this change or shift in the salinity regime causes a decrease in predicted bottom salinity values on Front River up to almost 0.5 ppt.

Figure 14 shows surface salinity changes under the Sensitivity Analysis #1 (low flow/drought conditions). Increases are seen throughout Front, Middle and Back Rivers. However, the increases are minor (under 0.17 ppt).

Figure 12: Surface Salinity Difference Comparison – with and without meeting areas modeled

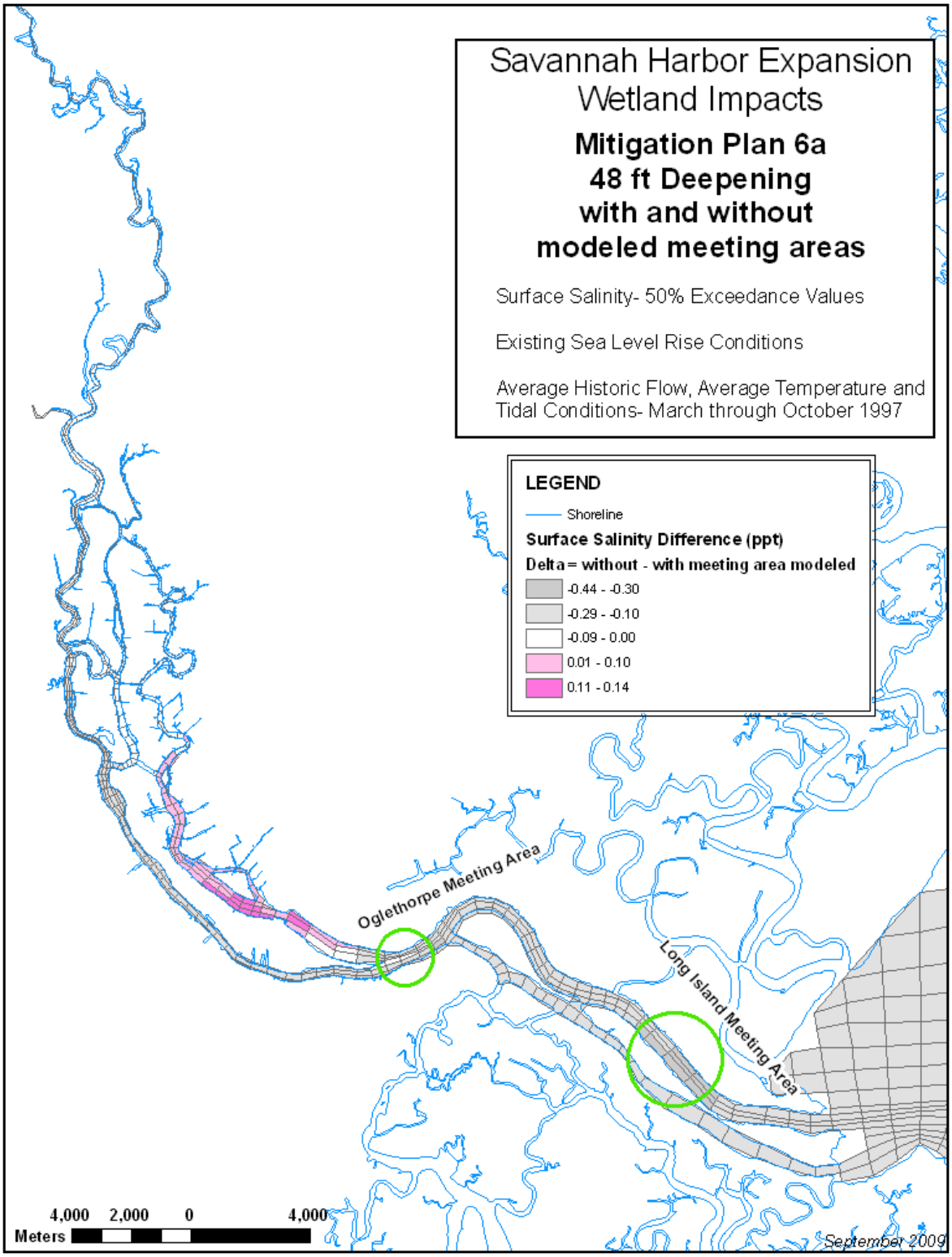


Figure 13: Bottom Salinity Difference Comparison – with and without meeting areas modeled

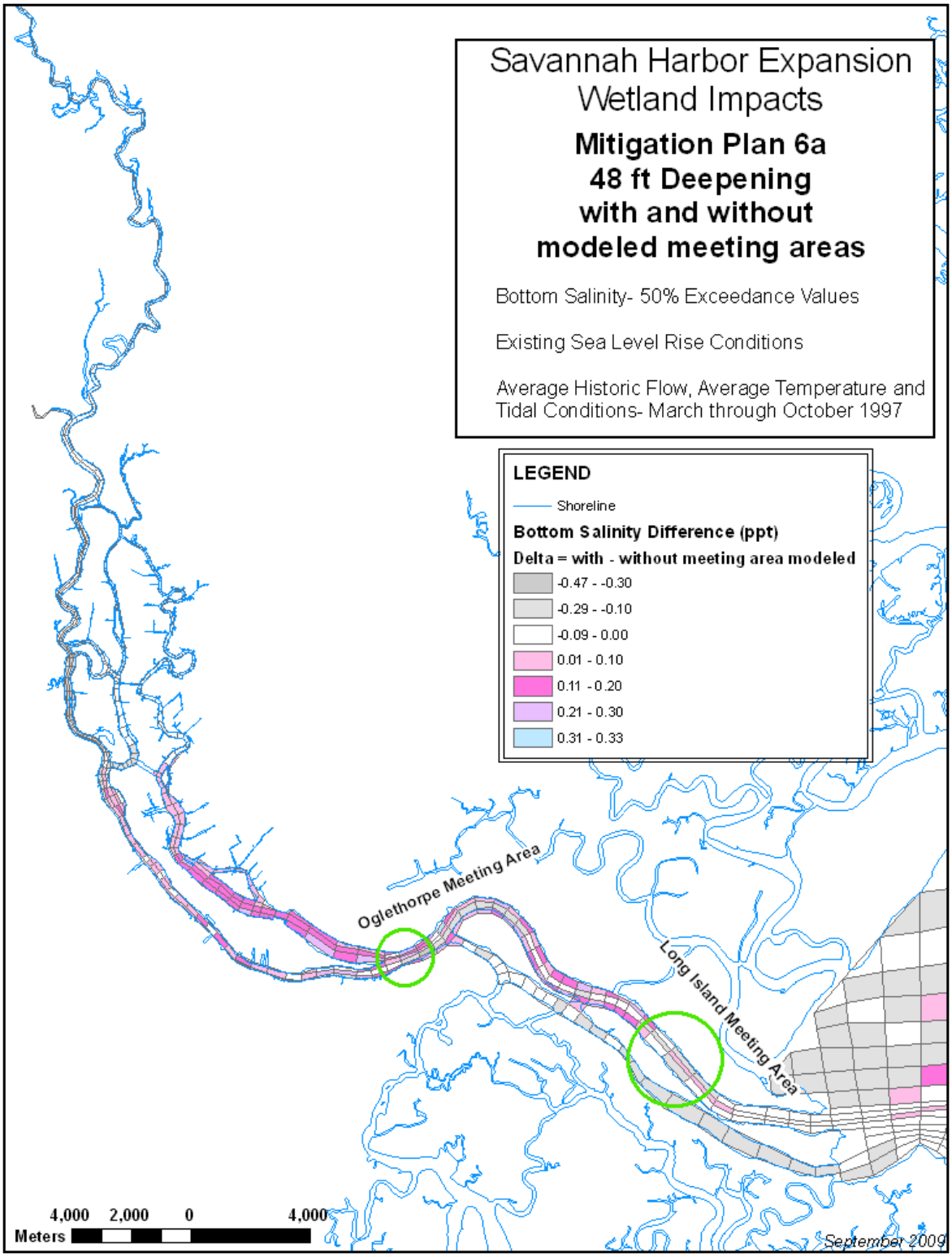
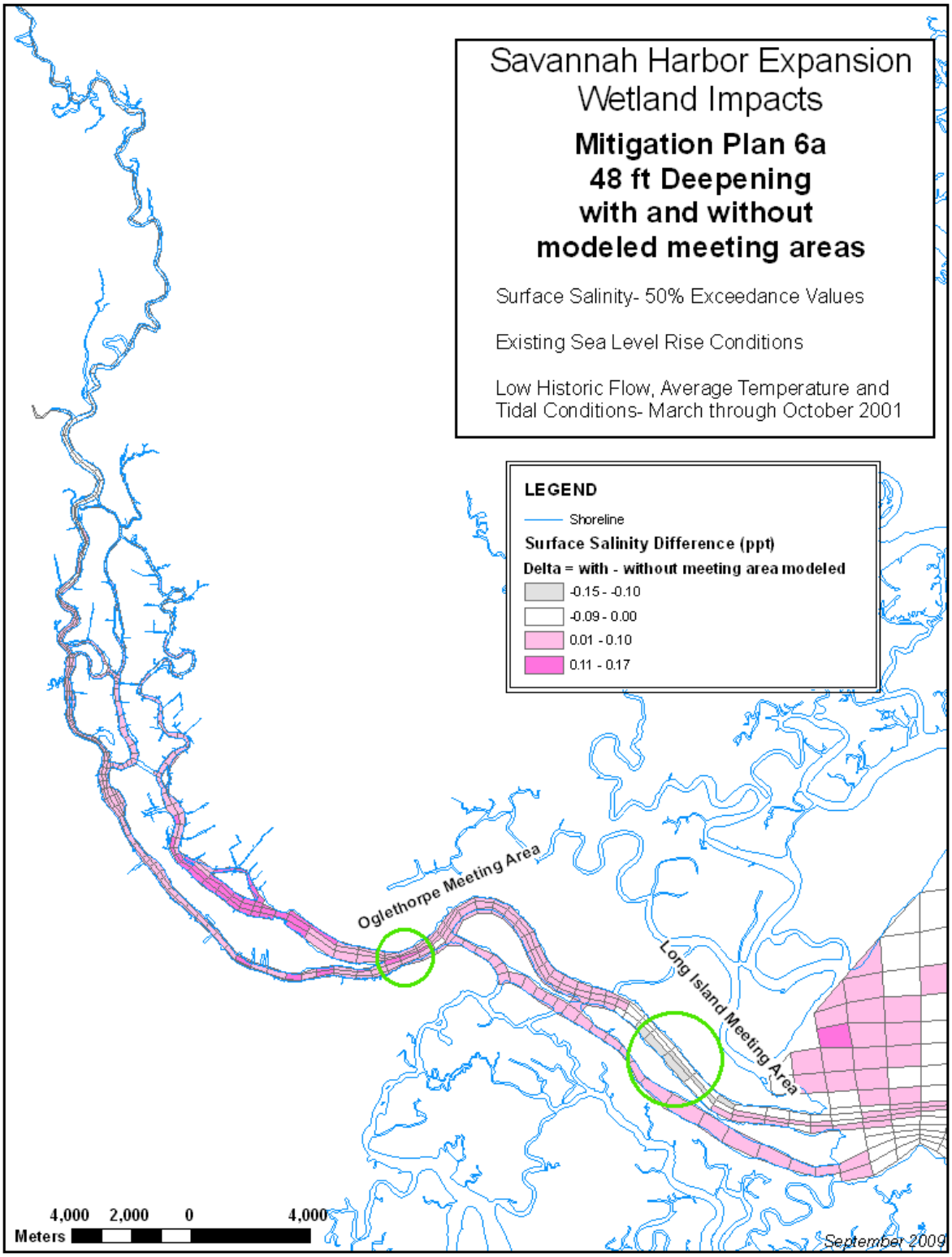


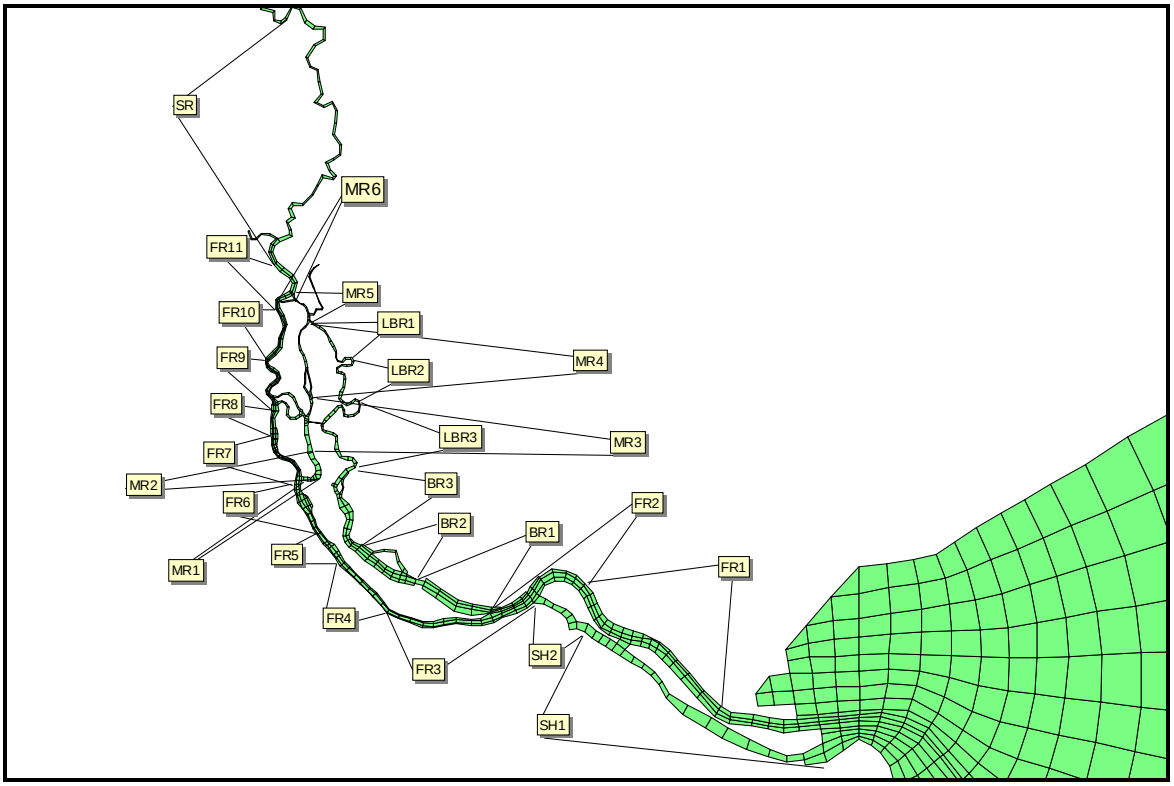
Figure 14: Surface Salinity Difference Comparison – with and without meeting areas modeled



Impacts to D.O.

Impacts to D.O. within the estuary due to inclusion of the meeting areas in the model grid are shown in Tables 4 and 5. Table 4 shows the change in D.O. percentiles for critical cells. A critical cell is the cell with the lowest D.O. concentrations during the simulation. The critical cell is found within each Zone. Table 5 shows the change in D.O. percentiles for each zone. A zone is an assemblage of cells that is limited by specified horizontal and vertical boundaries. The extents of each zone are shown in Figure 15.

Figure 15: Spatial Zones for D.O. Impact Evaluation



The maximum decrease in the critical cells for D.O. (shown in Table 4) as a result of modification to the model grid occurs on Back River in Zone BR3, which is located near New Cut. The change is 0.26 mg/L, which is a 7% decrease in the predicted D.O. value. Conversely, there are some increases in D.O. as a result of the model grid modification as well, which occurs on Front River in Zone FR9. The change is 1.47 mg/L, which is a 16.2% increase.

Table 5 shows that the maximum decrease in the zones for D.O. as a result of modification to the model grid occurs on Front River in Zone FR8 at the 95th percentile. The relative difference for this change in prediction is 1.2%. Comparatively, the maximum increase in D.O. as a result of modification to the grid is 0.13 mg/L for the 1st percentile and occurs on Back River in Zone BR1 and has a relative difference of 3%.

For both tables the 50th percentile differences are very minor with D.O. changes less than 0.1 mg/L.

Table 4: Changes in D.O. Percentiles for Critical Cells With and Without the Meeting Areas Included in the Model Grid.

Delta D.O. Percentiles for Critical Cells

Baseline: Scenario: 6A6ft-withDOmitigation
Project: Scenario: 6A6ftpasslane-withDOmitigation

Zone	Delta D.O. Percentile																	
	1%		5%		10%		25%		50%		75%		90%		95%		99	
	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%
FR1	0	0.0	-0.01	-0.2	0	0.0	-0.01	-0.2	-0.02	-0.4	-0.01	-0.2	-0.02	-0.4	-0.03	-0.6	-0.09	-1.9
FR2	-0.01	-0.3	-0.03	-0.8	-0.03	-0.7	-0.04	-0.9	-0.05	-1.1	-0.04	-0.9	0	0.0	0.01	0.2	0.02	0.4
FR3	-0.02	-0.5	-0.02	-0.5	-0.02	-0.5	-0.04	-1.0	-0.03	-0.7	-0.03	-0.7	-0.06	-1.2	0	0.0	-0.01	-0.2
FR4	-0.04	-1.1	-0.03	-0.8	-0.02	-0.5	-0.05	-1.2	-0.03	-0.7	-0.04	-0.9	-0.01	-0.2	-0.04	-0.7	0	0.0
FR5	-0.02	-0.5	-0.01	-0.3	-0.01	-0.2	-0.03	-0.7	-0.03	-0.7	-0.03	-0.6	-0.03	-0.6	-0.02	-0.4	-0.01	-0.2
FR6	-0.02	-0.5	-0.03	-0.7	-0.04	-1.0	-0.06	-1.4	-0.03	-0.7	-0.03	-0.6	-0.03	-0.6	-0.02	-0.4	-0.02	-0.3
FR7	-0.02	-0.5	-0.01	-0.2	-0.02	-0.4	-0.03	-0.6	-0.03	-0.6	-0.02	-0.4	-0.02	-0.3	-0.03	-0.4	-0.02	-0.3
FR8	-0.02	-0.4	-0.02	-0.4	-0.04	-0.8	-0.03	-0.5	-0.05	-0.7	-0.02	-0.2	-0.12	-1.3	-0.08	-0.8	-0.09	-0.9
FR9	0.23	4.1	0.05	0.8	0.05	0.8	0.02	0.3	0.09	1.2	0.81	9.9	1.1	12.5	1.47	16.2	0.94	8.8
FR10	-0.01	-0.2	-0.01	-0.2	0	0.0	0	0.0	0	0.0	-0.01	-0.2	0	0.0	0.01	0.1	0.01	0.1
FR11	-0.02	-0.5	0	0.0	0	0.0	-0.01	-0.2	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
MR1	-0.02	-0.4	-0.03	-0.6	-0.03	-0.6	-0.02	-0.4	-0.02	-0.4	-0.02	-0.3	-0.01	-0.2	-0.01	-0.2	-0.04	-0.6
MR2	0	0.0	0	0.0	-0.01	-0.2	0	0.0	0	0.0	0.01	0.2	0.02	0.3	0	0.0	-0.01	-0.2
MR3	-0.01	-0.2	0.03	0.7	0.01	0.2	0	0.0	0	0.0	-0.01	-0.2	0.02	0.3	-0.01	-0.2	0	0.0
MR4	0	0.0	0.01	0.2	0.02	0.4	0	0.0	0.01	0.2	0.01	0.2	-0.01	-0.2	0	0.0	-0.01	-0.2
MR5	0	0.0	-0.02	-0.7	0	0.0	0.02	0.5	0	0.0	0	0.0	-0.01	-0.2	0	0.0	0	0.0
MR6	0	0.0	-0.01	-0.2	0	0.0	0	0.0	0	0.0	0	0.0	-0.01	-0.1	0.01	0.1	0	0.0
LBR1	0.03	0.7	-0.04	-0.8	-0.01	-0.2	0.01	0.2	0.01	0.2	0.01	0.2	0	0.0	0	0.0	-0.01	-0.1
LBR2	0.19	4.4	0.02	0.4	0.01	0.2	0.01	0.2	0.01	0.2	0.01	0.2	0.02	0.4	0.04	0.7	0.45	7.7
LBR3	0.01	0.4	0.02	0.8	0	0.0	0	0.0	0	0.0	-0.02	-0.5	-0.01	-0.3	-0.03	-0.8	-0.01	-0.2
BR1	0.03	1.0	0.1	2.8	0.21	5.4	0.03	0.7	0.04	0.8	0.04	0.8	0.03	0.5	0.03	0.5	0.01	0.2
BR2	0.07	3.0	0.06	2.3	0.04	1.4	0.16	4.6	0.09	2.1	0.04	0.9	0.06	1.2	0.01	0.2	0.05	1.0
BR3	0.06	2.6	0.03	1.2	0	0.0	0.06	2.4	0.02	0.7	-0.01	-0.3	-0.17	-5.2	-0.2	-5.7	-0.26	-7.0
SCH1	-0.02	-0.8	-0.02	-0.7	-0.02	-0.7	-0.01	-0.3	-0.02	-0.6	0.02	0.5	0.02	0.5	-0.05	-1.1	-0.05	-1.1
SCH2	-0.01	-0.3	-0.05	-1.2	-0.01	-0.2	-0.03	-0.7	-0.02	-0.4	0	0.0	0.01	0.2	-0.04	-0.8	-0.01	-0.2
SR	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
StbR	-0.03	-0.7	-0.01	-0.2	0	0.0	0	0.0	-0.05	-0.7	-0.01	-0.1	-0.04	-0.5	0	0.0	-0.06	-0.7

Table 5: Changes in D.O. Percentiles for Zones With and Without the Meeting Areas Included in the Model Grid.

Difference of D.O. %-tiles for zones of Savannah Estuary

Simulation Period: Year 1997 AUGUST 1 -AUGUST 31

Baseline Scenario: 6A6ft-withDOmitigation

Project 6A6ftpasslane-withDOmitigation

Zone	Project - Baseline Difference (mg/l)									Project - Baseline Relative Difference (%)								
Name	1%	5%	10%	25%	50%	75%	90%	95%	99%	1%	5%	10%	25%	50%	75%	90%	95%	99%
FR1	-0.01	-0.02	-0.02	-0.05	-0.04	-0.01	0.01	-0.02	-0.05	-0.3	-0.4	-0.6	-1.2	-1.0	-0.2	0.2	-0.4	-1.0
FR2	-0.01	-0.01	-0.02	-0.05	-0.04	-0.04	0.03	0.02	0.02	-0.2	-0.3	-0.4	-1.2	-0.8	-0.7	0.6	0.3	0.4
FR3	-0.02	-0.02	-0.02	-0.03	-0.03	-0.03	0.00	0.02	0.02	-0.5	-0.4	-0.4	-0.8	-0.6	-0.6	0.0	0.3	0.3
FR4	-0.02	-0.01	-0.01	-0.04	-0.03	-0.03	0.00	-0.01	-0.02	-0.5	-0.4	-0.3	-0.9	-0.7	-0.6	0.0	-0.2	-0.4
FR5	-0.02	-0.02	-0.02	-0.03	-0.05	-0.03	-0.01	-0.01	-0.01	-0.5	-0.4	-0.4	-0.6	-1.1	-0.5	-0.2	-0.1	-0.2
FR6	-0.02	-0.02	-0.03	-0.04	-0.03	-0.02	-0.02	-0.03	-0.02	-0.5	-0.4	-0.6	-1.0	-0.6	-0.4	-0.3	-0.4	-0.3
FR7	-0.02	-0.02	-0.01	-0.02	-0.04	-0.02	-0.05	-0.02	0.01	-0.3	-0.4	-0.1	-0.5	-0.7	-0.4	-0.7	-0.3	0.1
FR8	0.00	-0.03	-0.04	-0.02	-0.05	-0.03	-0.06	-0.11	-0.03	0.1	-0.6	-0.7	-0.4	-0.7	-0.4	-0.7	-1.2	-0.3
FR9	0.05	0.04	-0.01	0.01	0.00	-0.01	0.00	0.02	0.02	0.8	0.6	-0.1	0.2	-0.1	-0.1	0.0	0.3	0.2
FR10	0.00	0.00	-0.01	0.00	0.00	0.00	0.01	0.00	0.01	-0.1	0.0	-0.1	0.0	0.0	0.0	0.1	0.1	0.2
FR11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MR1	-0.02	-0.01	-0.03	-0.03	-0.01	-0.02	0.01	-0.02	-0.01	-0.5	-0.3	-0.6	-0.6	-0.3	-0.3	0.2	-0.4	-0.1
MR2	0.01	0.02	0.00	0.01	-0.01	-0.02	-0.03	-0.01	-0.01	0.2	0.4	0.1	0.1	-0.2	-0.4	-0.5	-0.2	-0.1
MR3	0.00	0.01	0.01	0.02	0.01	0.00	0.00	0.00	0.00	-0.1	0.2	0.1	0.3	0.2	0.0	-0.1	0.1	-0.1
MR4	0.01	0.00	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.3	0.0	0.3	0.2	0.2	0.1	0.0	0.0	0.0
MR5	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.2	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.0
MR6	-0.01	0.01	-0.01	0.00	0.01	0.00	0.00	0.00	0.00	-0.3	0.2	-0.3	0.1	0.2	0.0	0.0	0.0	0.1
LBR1	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	0.00	-0.01	0.0	0.0	0.0	-0.1	0.0	-0.1	-0.1	0.0	-0.1
LBR2	0.00	0.00	0.00	0.00	-0.02	0.00	0.00	0.02	-0.02	0.0	0.0	0.0	-0.1	-0.3	0.0	0.1	0.3	-0.4
LBR3	0.00	0.00	-0.01	-0.01	-0.02	-0.01	0.00	0.00	0.00	-0.1	0.0	-0.2	-0.2	-0.5	-0.2	0.0	0.0	0.1
BR1	0.13	0.01	0.01	0.01	0.00	0.02	0.01	0.04	0.05	3.0	0.2	0.2	0.3	0.1	0.3	0.2	0.8	0.9
BR2	0.07	0.05	0.04	0.07	0.08	0.03	0.02	0.02	0.02	2.7	1.8	1.2	1.9	1.8	0.7	0.4	0.5	0.4
BR3	0.03	0.03	0.03	0.04	0.04	0.04	0.03	0.04	0.07	1.0	1.1	1.0	1.2	1.4	1.2	0.8	1.1	2.0
SCh1	-0.05	-0.03	-0.03	-0.01	0.00	-0.02	-0.01	-0.02	-0.04	-1.5	-1.0	-0.7	-0.2	-0.1	-0.5	-0.3	-0.5	-0.9
SCh2	0.01	-0.01	0.00	-0.02	-0.01	0.01	0.00	0.01	0.00	0.1	-0.2	0.0	-0.5	-0.3	0.2	0.1	0.1	0.1
SR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
StbR	-0.01	0.00	-0.01	0.02	0.00	0.00	-0.03	-0.03	-0.04	-0.2	0.1	-0.2	0.3	0.0	0.0	-0.4	-0.4	-0.6

Conclusions

In summary, the changes due to model grid modification with addition of the meeting area geometries are minor. The impacts to tidal fluctuations and the salinity regime as shown by Figures 5 through 15 are minor. The largest changes in salinity occur on the bottom of the river and are not expected to pose an impact to adjacent wetlands.

The largest impacts to D.O. as a result of the model grid occur at the extreme percentiles, 1st and 95th while the 50th percentile salinities changes are very minor.

For completeness, these features could be incorporated into the project conditions model grid. However, it is currently unknown whether these navigation features will be economically justified and incorporated into the final selected plan. Also, as shown by this sensitivity analysis, the changes are likely to have little to no impact on the previous estimates to freshwater marsh/wetland or water quality impacts and therefore no bearing on the mitigation plan or project cost estimates.