Savannah Harbor Expansion Project

Evaluation of Marsh/Wetland Impacts with Proposed Mitigation Plan

November 2007

Introduction

This report summarizes the results of marsh impacts with implementation of the proposed mitigation plan to alter flows in the estuary at each alternative channel depth (44 ft, 45 ft, 46 ft, and 48 ft). The two proposed plans are: Plan 6b for the 44 ft depth, and Plan 6a for the 45 ft, 46 ft, and 48 ft depths. Details of each of the mitigation plans are shown in Figures 1 and 2. For details on how these plans were developed and selected, please see the main report document for this project. It should be noted that these plans are not considered the Selected Mitigation Plan, but will be a component of the Selected Plan.

Figure 1: Plan 6a (proposed mitigation for 45 ft, 46 ft and 48 ft channel depths)

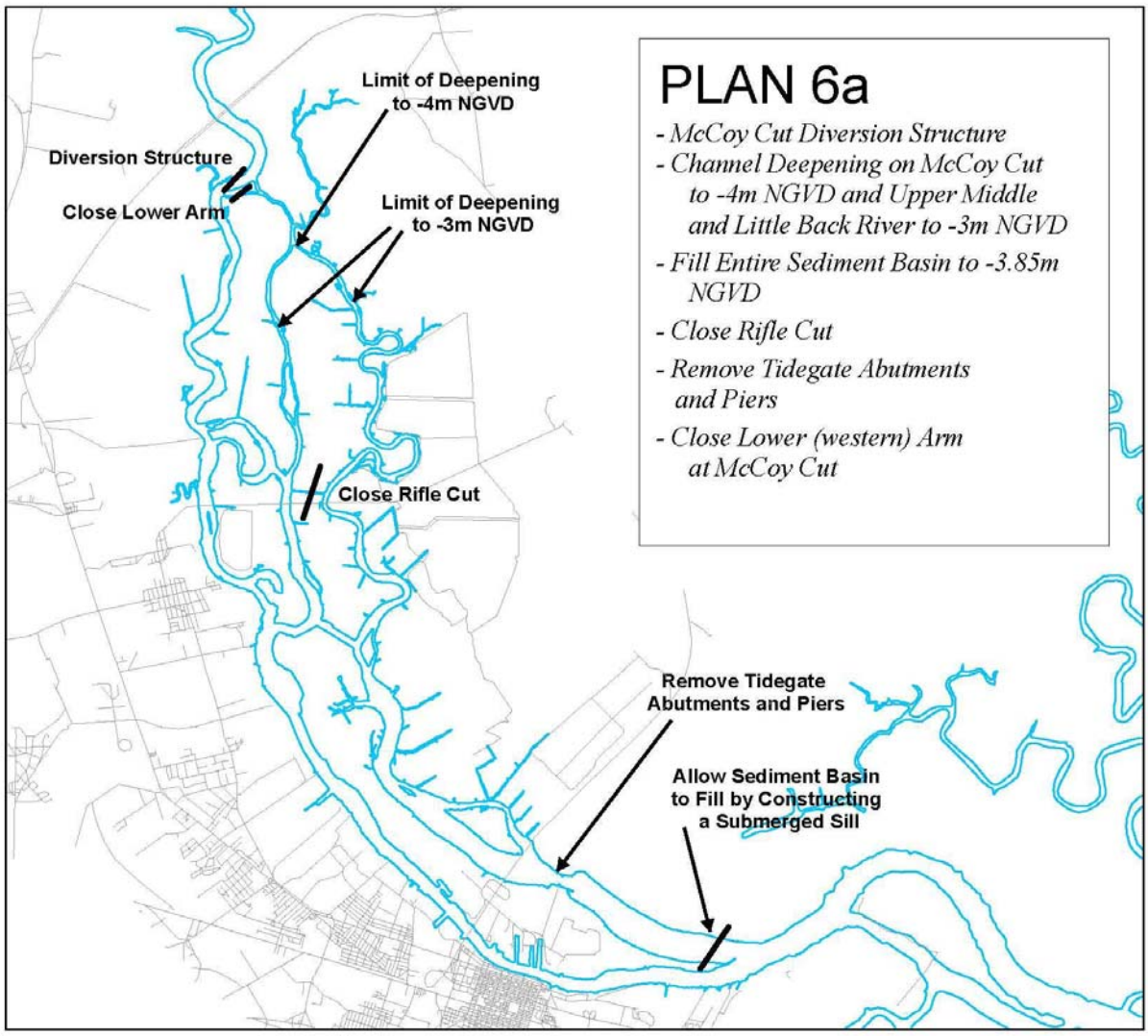
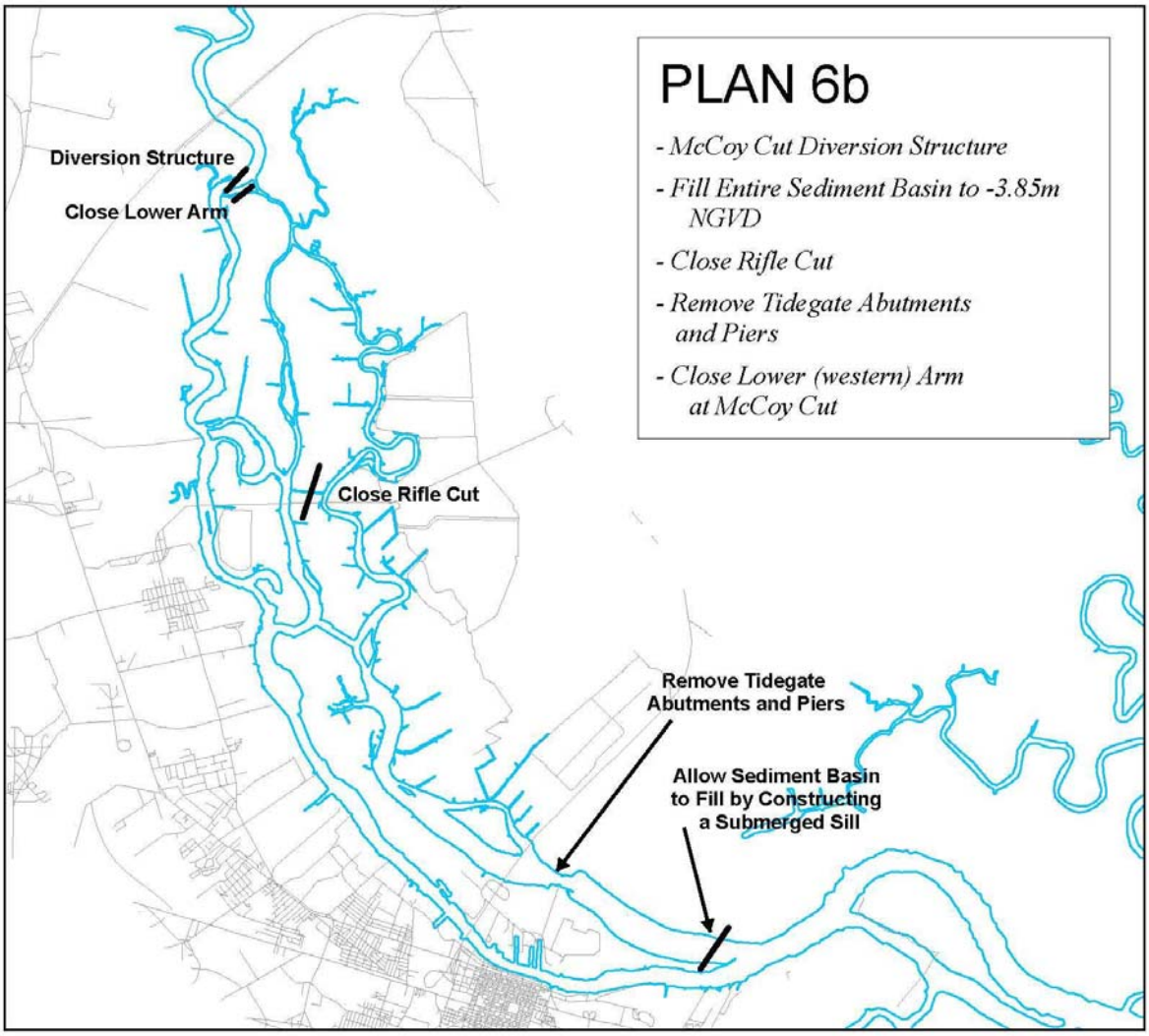


Figure 2: Plan 6b (proposed mitigation for 44 ft channel depth)



Hydrodynamic Model Input

The plans were evaluated using the 3D hydrodynamic model EFDC. The run period and flow parameters are shown below and were specified by the Savannah Harbor Expansion Wetland Interagency Coordination Team and have been consistent throughout the study process. The group developed four model input scenarios for evaluation (See Table 1).

Table 1: Model Input Conditions

Run Scenario	*River Flow*	*Sea Level Rise**	*Evaluation Period*
Basic Evaluation	*Average/Typical*	*Existing Sea Level*	*1-March to 1-November*
Sensitivity Analysis #1	*Low Flow/Dry*	*Existing Sea Level*	*1-March to 1-November*
Sensitivity Analysis #2A	*Average/Typical*	*25 cm Sea Level Rise*	*1-March to 1-November*
Sensitivity Analysis #2B	*Average/Typical*	*50 cm Sea Level Rise*	*1-March to 1-November*

**25 and 50 cm sea level rise conditions were specified by the Interagency Coordination Team and are based on EPA and NOAA projections.*

Average/typical river flows needed for the Basic Evaluation and Sensitivity Analysis #2A and B were determined using recorded gage data for Savannah River at Clyo, GA. The EFDC model has continuous input boundary conditions for a 7 year period (1997 - 2003) available for simulation. 1997 was found to have flow conditions representative of the long term average flows. The flow boundary conditions for Sensitivity Analysis #1 are low flow or dry year conditions. Using the recorded gage data at Clyo, GA, 2001 (March through October) was considered to be a low flow/dry period.

The two sea level rise conditions used in Sensitivity Analysis #2A and B were modeled by adding an additional 25 or 50 cm, depending on the run scenario, to the water surface elevations on the open ocean boundary cells. The sea level rise sensitivity analyses are based only on a change in the ocean boundary water surface elevation. There was no consideration of any potential change in the ocean boundary salinity density in this modeling effort.

All other model boundary inputs remain unaltered and correspond to the run time of 1 March to 1 November for 1997 or 2001, depending on the run scenario being modeled.

Output Presented

There are three types of maps presented in this report:

1- *Surface Salinity Difference Maps*- Maps show the change in riverine salinity at each EFDC grid cell between the existing condition and each mitigation plan. Salinity values are predicted using the hydrodynamic model (EFDC) and were computed for the 10% and 50% exceedance values. The grid cells are color coded to show the salinity differences. The grey shading is used to show cells that have lower salinity values than the existing condition (i.e.

deepening impacts have been reduced to 0, and, in fact, show improvement over the existing condition).

2- *Bottom Salinity Difference Maps*- Maps show the change in riverine salinity at each EFDC grid cell between the existing condition and each mitigation plan. Salinity values are predicted using the hydrodynamic model (EFDC) and were computed for the 10% and 50% exceedance values. The grid cells are color coded to show the salinity differences. The grey shading is used to show cells that have lower salinity values than the existing condition (i.e. deepening impacts have been reduced to 0, and, in fact, show improvement over the existing condition).

3- *Freshwater Threshold Maps*- Maps show the change in the freshwater threshold in the river. The threshold is based on the EFDC modeling 50% exceedance, surface salinity value. The threshold marks the line where salinity values change from below 0.5ppt to above 0.5ppt and vice versa.

4- *Predicted River Salinity from the Hydrodynamic Model (EFDC)*- The EFDC model grid is shown with 50% exceedance surface salinities broken into 5 categories: 0-0.5 ppt, 0.6-1.0 ppt, 1.1-2.0 ppt, 2.1-4.0 ppt, 4.0-32.5 ppt.

5- *Estimated Marsh Salinity Contour Lines*- Marsh salinity contour lines are shown that break the marsh into 5 categories: 0-0.5 ppt, 0.6-1.0 ppt, 1.1-2.0 ppt, 2.1-4.0 ppt, > 4.0 ppt. The first category 0-0.5 ppt represents freshwater marsh. The contour lines were extrapolated into the marsh from the riverine hydrodynamic model results shown in the maps described above *4- Predicted River Salinity from the Hydrodynamic Model*.

Because of the subjectivity of developing the contour lines for this set of maps, two measures were taken to ensure the results are valid. First, all of the maps were developed by the same person to eliminate bias due to the possibility of different perspectives. Second, verification was done to determine a level of confidence in comparing the results. The verification was done by testing the repeatability of drawing the contour line for the freshwater zone (0-0.5 ppt) for three randomly selected maps. For the repeatability test, first the same person redrew the freshwater zone. Second a different person redrew the freshwater zone. Both of these tests produced acreages with less than a 2% difference from the original acreages. From this test, the results are considered valid within +/- 50 acres.

Results

In viewing and discussing the results of the mitigation plans it is important to remember the following:

1- The marsh impacts are evaluated by looking at the *net* acreage. This is especially important when discussing the impacts to freshwater marshes. The net acreage value is based on the conditions of the marsh after the project is in place. It does not take into consideration what the marsh salinity is under current conditions. For example, a mitigation plan may gain freshwater marsh on Back River and lose freshwater marsh on Front River. The net acreage

may meet the impact criteria, but in reality, it may take some time for a marsh to convert from a brackish marsh to a freshwater marsh.

2- The model has a limited ability to evaluate specific design parameters of a true diversion structure. The diversion structure described in each of the plans was modeled by altering the Front River width just downstream of McCoys Cut. By narrowing the passage on Front River the water surface elevation at the mouth of McCoys Cut was increased. The rise in elevation encourages more water to go down McCoys Cut. EFDC does not have options for inserting a defined diversion structure but narrowing the River channel in this area is essentially what a diversion structure will do.

   Several different "sizes" of diversion structures were evaluated during the development of the mitigation plans by varying the widths of the narrow passage on Front River. This allowed us to vary the amount of flow diverted down McCoys Cut. The structure modeled in Mitigation Plan 3, and each of the additional plans in this report, was found to be the most effective at diverting freshwater flows through McCoys Cut of the several different "sizes" evaluated. A future design task will be required to develop specifications for a diversion structure that performs as in the model simulation.

The evaluation of each of the mitigation plans included review of the effects the plan has on the tide range and velocities. It was concluded that both of the selected plans do not reduce the tide range significantly in Back River, Little Back River, or Middle River. Velocities for all the additional plans are close to existing conditions. However, as expected, removing the abutments and piers in the two plans do increase velocities in Back River and Little Back River slightly above the existing condition.

Results from the modeling are presented in the following tables. Table 2 shows estimated marsh salinity impacts based on the mapping described in 5-*Estimated Marsh Salinity Contour Lines* above. The contour line verification described in the previous section suggests the acreages are valid within +/- 50 acres. Table 3 shows the predicted salinities (on Little Back River at the entrance of Lucknow Canal.

Table 2: Estimated Marsh Salinity Acreage Impacts

All values listed are in acres and are based on the Salinity Contour Maps derived from EFDC output.

Basic Evaluation1997 (avg flow) NO Sea Level Rise

Salinity Range	***Existing No Deepening No Mitigation***	***44 ft Depth & Mitigation Plan 6b***	***45 ft Depth & Mitigation Plan 6a***	***46 ft Depth & Mitigation Plan 6a***	***48 ft Depth & Mitigation Plan 6a***
0-0.5 ppt	4072	4394	4040	3871	3735
0.6-1.0 ppt	864	1137	1781	1650	1340
1.1-2.0 ppt	555	749	588	862	1191
2.1-4.0 ppt	834	855	745	700	790
>4 ppt	2506	1698	1678	1749	1776

Sensitivity Analysis #1 2001 (low flow) NO Sea Level Rise

Salinity Range	***Existing No Deepening No Mitigation***	***44 ft Depth & Mitigation Plan 6b***	***45 ft Depth & Mitigation Plan 6a***	***46 ft Depth & Mitigation Plan 6a***	***48 ft Depth & Mitigation Plan 6a***
0-0.5 ppt	2208	3128	3111	2886	2570
0.6-1.0 ppt	767	459	674	825	845
1.1-2.0 ppt	1322	1342	981	822	786
2.1-4.0 ppt	1076	1564	1848	2009	2236
>4 ppt	3458	2339	2218	2291	2394

Sensitivity Analysis #2A 1997 (avg flow) 25cm Sea Level Rise

Salinity Range	***Existing No Deepening No Mitigation***	***44 ft Depth & Mitigation Plan 6b***	***45 ft Depth & Mitigation Plan 6a***	***46 ft Depth & Mitigation Plan 6a***	***48 ft Depth & Mitigation Plan 6a***
0-0.5 ppt	3507	3659	3740	3594	3536
0.6-1.0 ppt	1118	1401	1500	1400	713
1.1-2.0 ppt	551	972	1098	1283	1790
2.1-4.0 ppt	969	1000	758	796	977
>4 ppt	2687	1799	1737	1760	1815

Sensitivity Analysis #2B 1997 (avg flow) 50cm Sea Level Rise

Salinity Range	***Existing No Deepening No Mitigation***	***44 ft Depth & Mitigation Plan 6b***	***45 ft Depth & Mitigation Plan 6a***	***46 ft Depth & Mitigation Plan 6a***	***48 ft Depth & Mitigation Plan 6a***
0-0.5 ppt	2809	3462	3554	3512	3297
0.6-1.0 ppt	1255	1099	793	484	558
1.1-2.0 ppt	927	1305	1641	1909	1874
2.1-4.0 ppt	977	785	988	1139	896
>4 ppt	2864	2181	1855	1787	2208

Table 3: Predicted Salinity Values at Lucknow Canal Entrance

50 / 10 percent exceedance salinity values (ppt)

	Existing *No Deepening No Mitigation*	**44 ft Depth & Mitigation Plan 6b**	**45 ft Depth & Mitigation Plan 6a**	**46 ft Depth & Mitigation Plan 6a**	**48 ft Depth & Mitigation Plan 6a**
Basic Evaluation 1997 (avg flow) NO Sea Level Rise	0.02 / 0.14	0.00 / 0.04	0.00 / 0.04	0.00 / 0.04	0.00 / 0.05
Sensitivity Analysis #1 2001 (low flow) NO Sea Level Rise	0.15 / 0.57	0.05 / 0.33	0.05 / 0.36	0.06 / 0.42	0.09 / 0.55
Sensitivity Analysis #2A 1997 (avg flow) 25cm Sea Level Rise	0.05 / 0.26	0.01 / 0.08	0.01 / 0.08	0.01 / 0.10	0.01 / 0.12
Sensitivity Analysis #2B 1997 (avg flow) 50cm Sea Level Rise	0.11 / 0.45	0.03 / 0.17	0.02 / 0.17	0.02 / 0.19	0.03 / 0.24

All Salinities taken at EFDC grid cell 39_114 located on Little Back River at the entrance of Lucknow Canal

Conclusion

In summary, Mitigation Plans 6a and 6b are the proposed flow altering mitigation plans to reduce salinity impacts in the harbor. The model results show that the mitigation plans do reduce the salinity impacts due to deepening the navigation channel, and in some areas the plans provide suitable conditions for freshwater marsh where it currently does not exist.

It is interesting to note, that depending on which flow condition is focused on, the impacts are variable. The three Sensitivity Analysis show that Plans 6a and 6b reduce the net freshwater marsh loss to zero under the four depth scenarios when compared to the existing conditions. The Basic Evaluation output shows some of the depths continue to have impacts on freshwater marsh and will require other measures, outside of what is presented here, to fully mitigate for the loss of freshwater wetlands. The range of flow conditions modeled, provides a broad overview of the current harbor conditions and how they will be changed with the deepening project.

Existing Conditions

No Deepening No Mitigation

Basic Evaluation

1997 (Average) Flow Conditions- No Sea Level Rise

Sensitivity Analysis #1

2001 (Low) Flow Conditions- No Sea Level Rise

Sensitivity Analysis #2A

1997 (Average) Flow Conditions- 25cm Sea Level Rise

Sensitivity Analysis #2B

1997 (Average) Flow Conditions- 50cm Sea Level Rise

44 ft Channel Depth

Mitigation Plan 6b

Basic Evaluation

1997 (Average) Flow Conditions- No Sea Level Rise

Sensitivity Analysis #1

2001 (Low) Flow Conditions- No Sea Level Rise

Sensitivity Analysis #2A

1997 (Average) Flow Conditions- 25cm Sea Level Rise

Sensitivity Analysis #2B

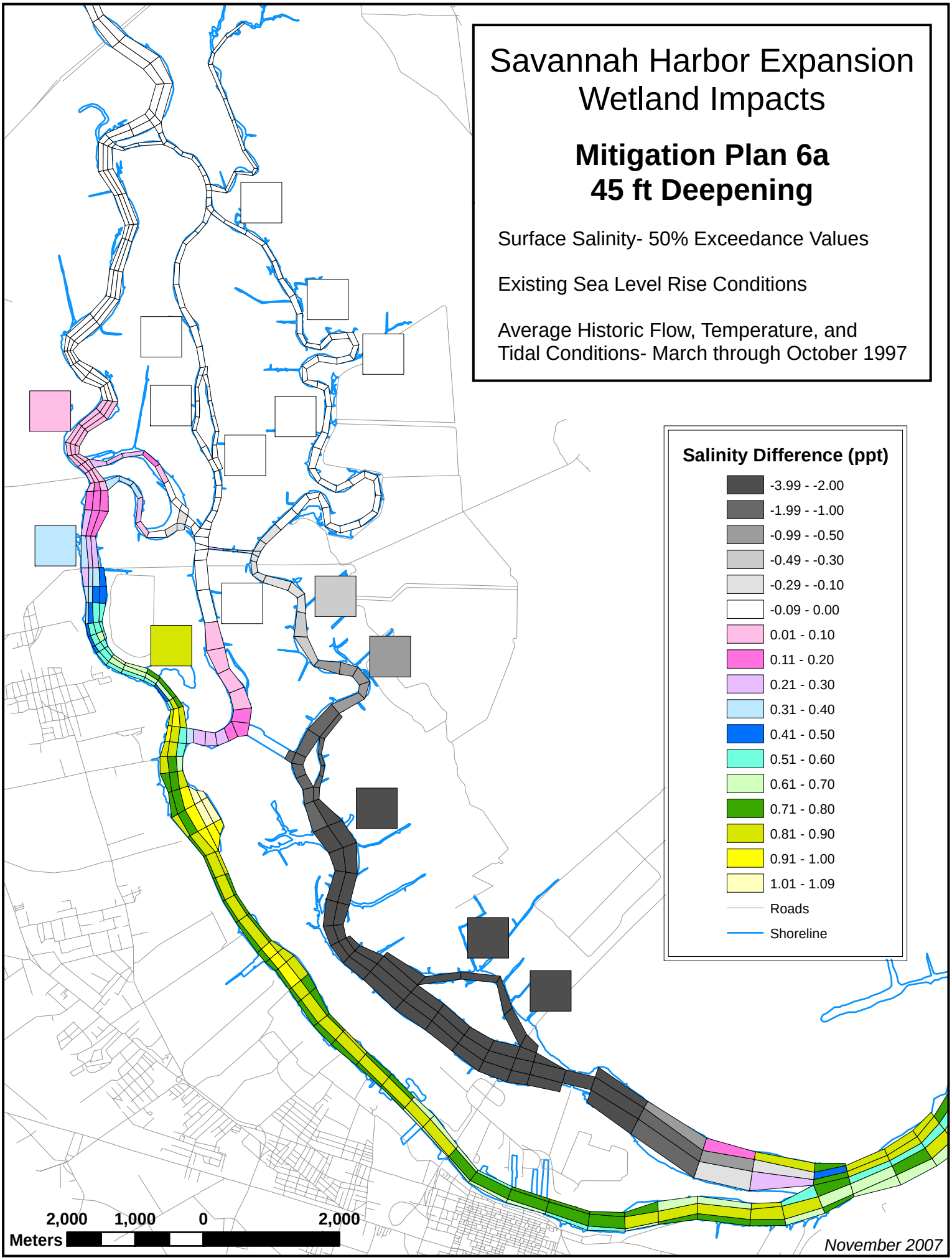
1997 (Average) Flow Conditions- 50cm Sea Level Rise

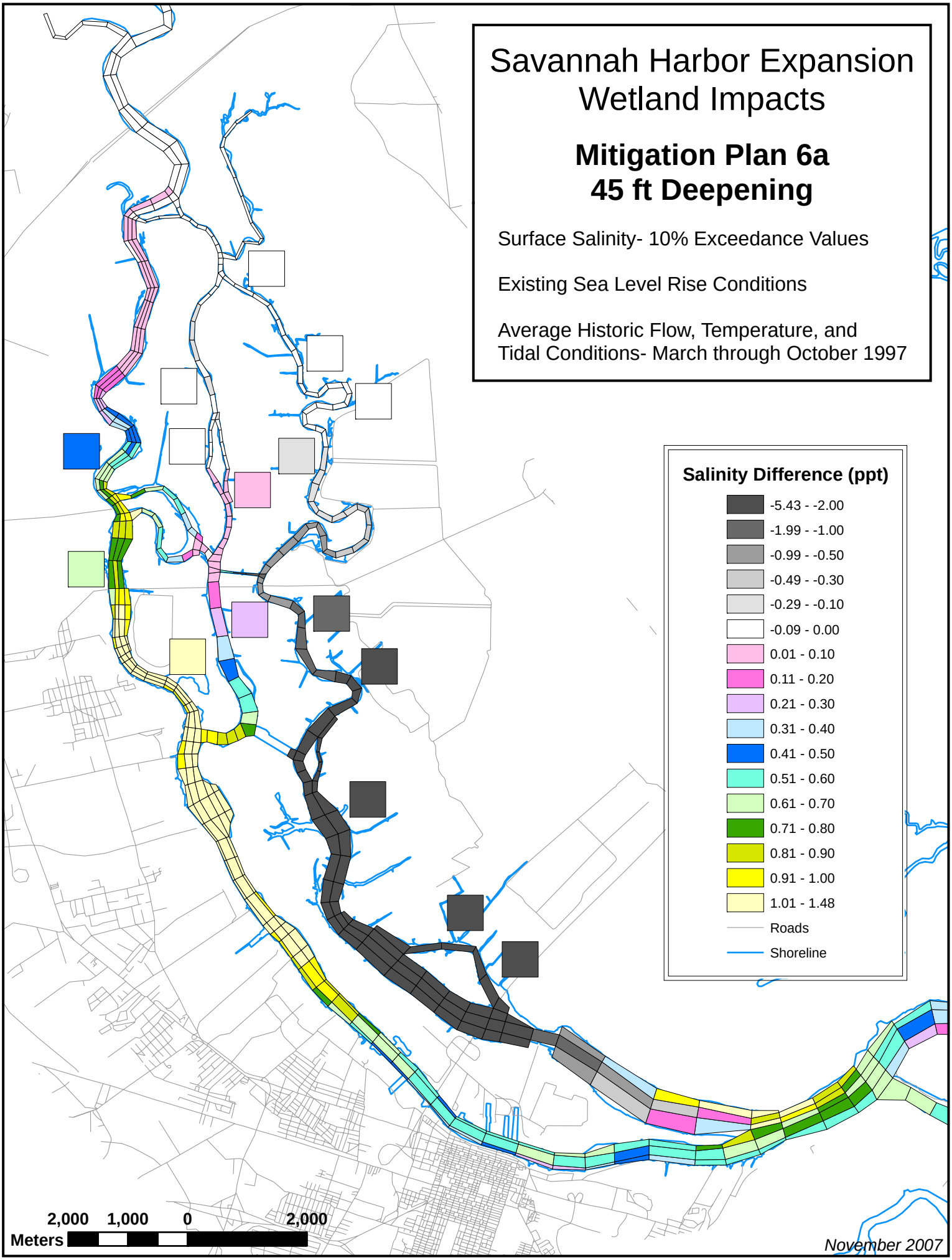
45 ft Channel Depth

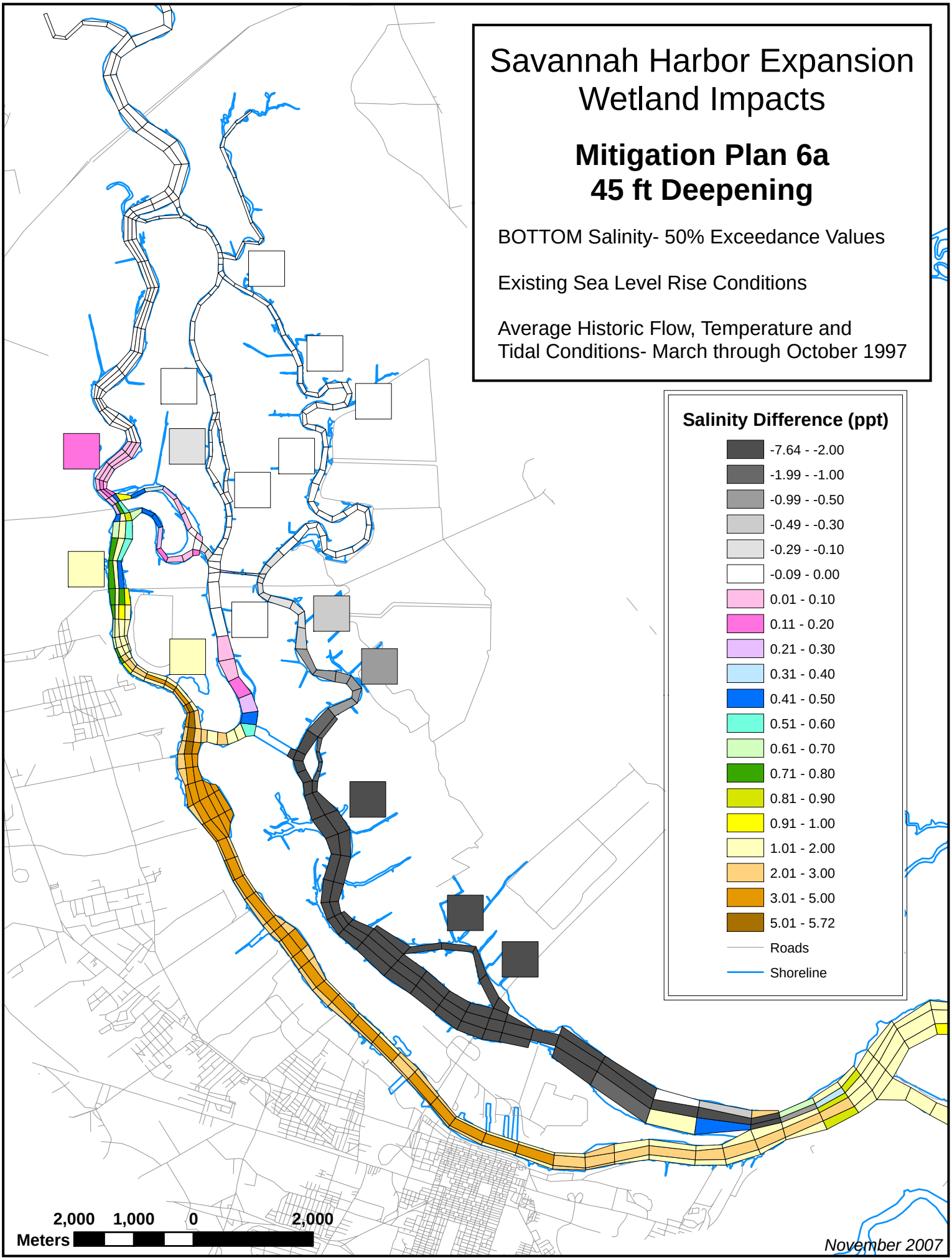
Mitigation Plan 6a

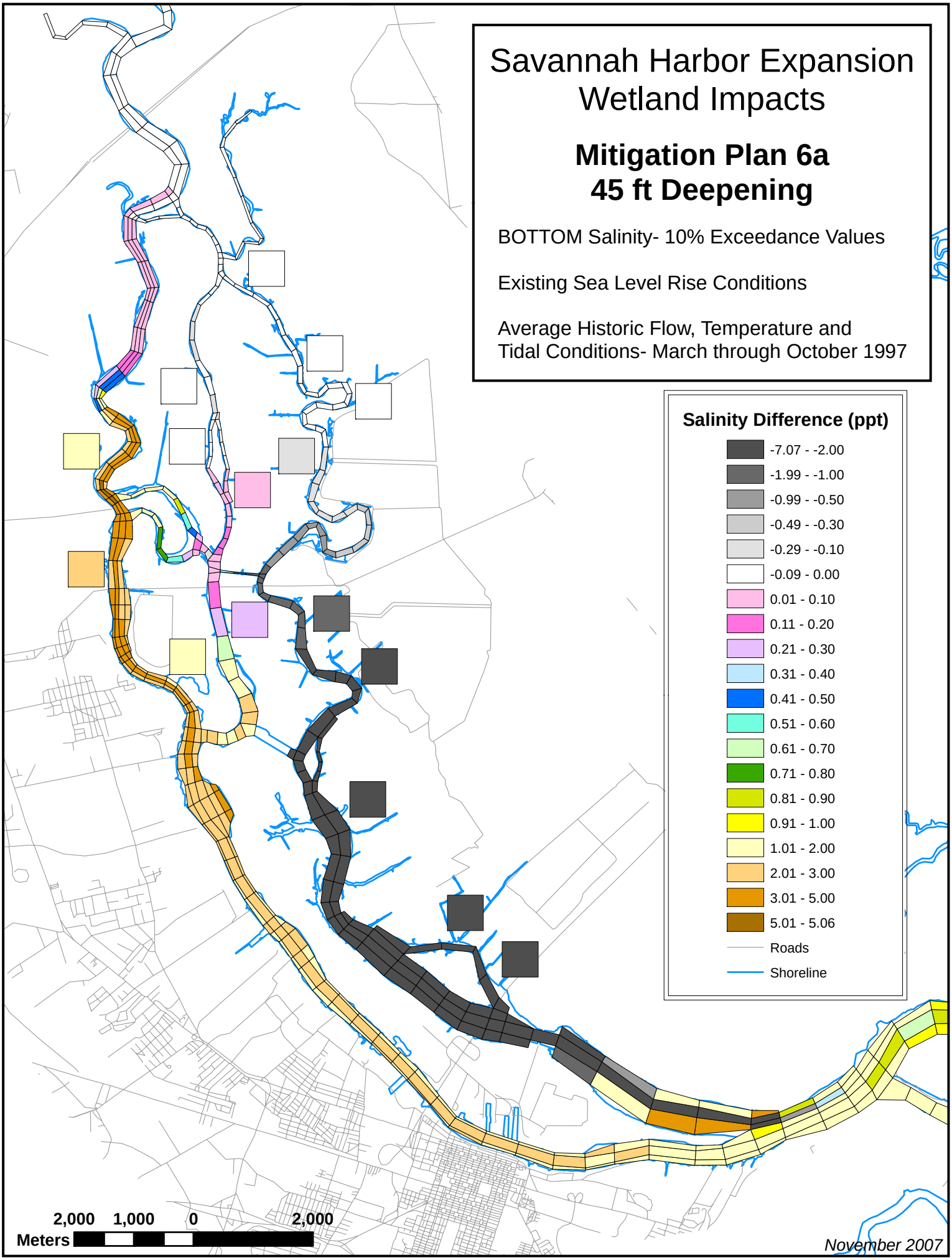
Basic Evaluation

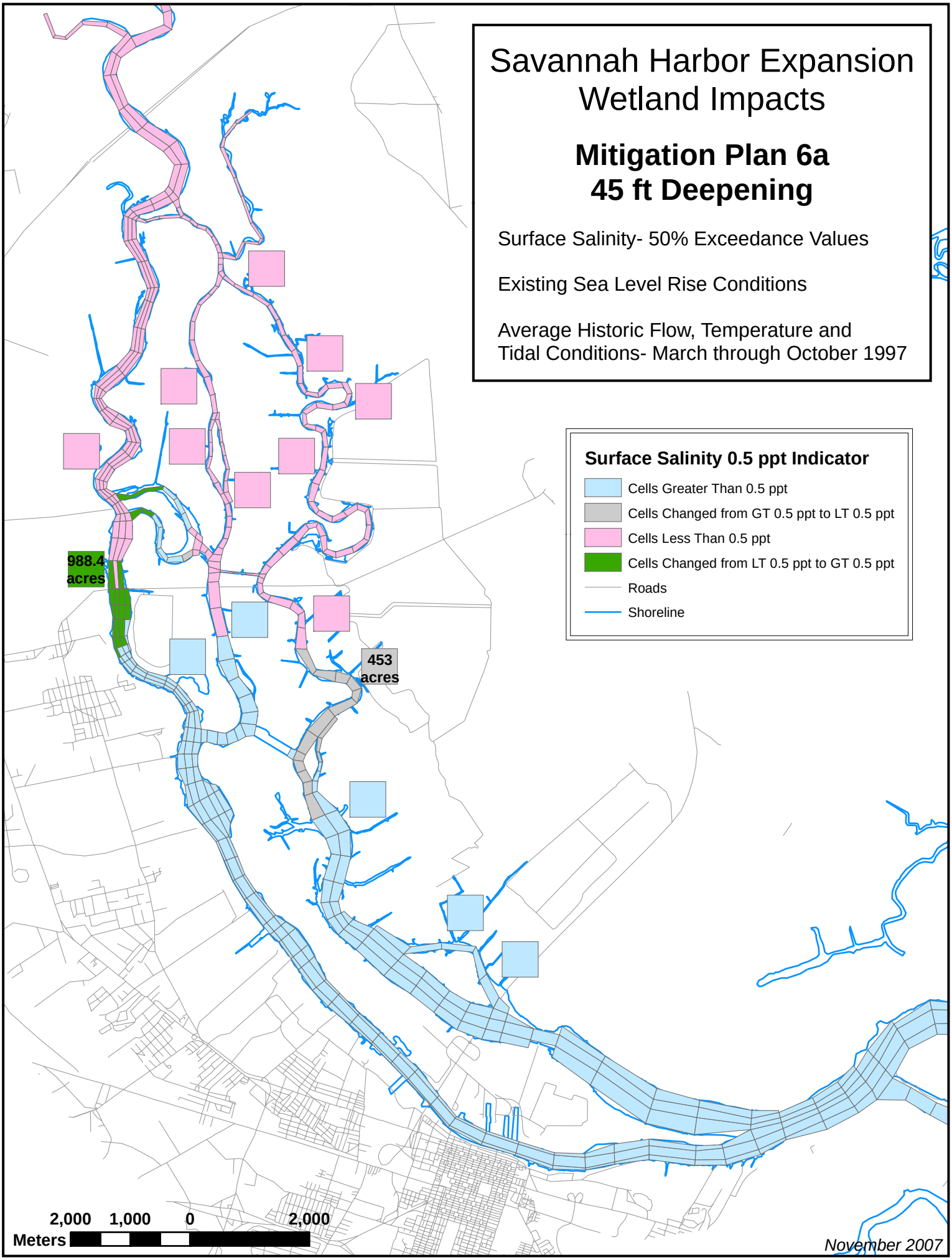
1997 (Average) Flow Conditions- No Sea Level Rise

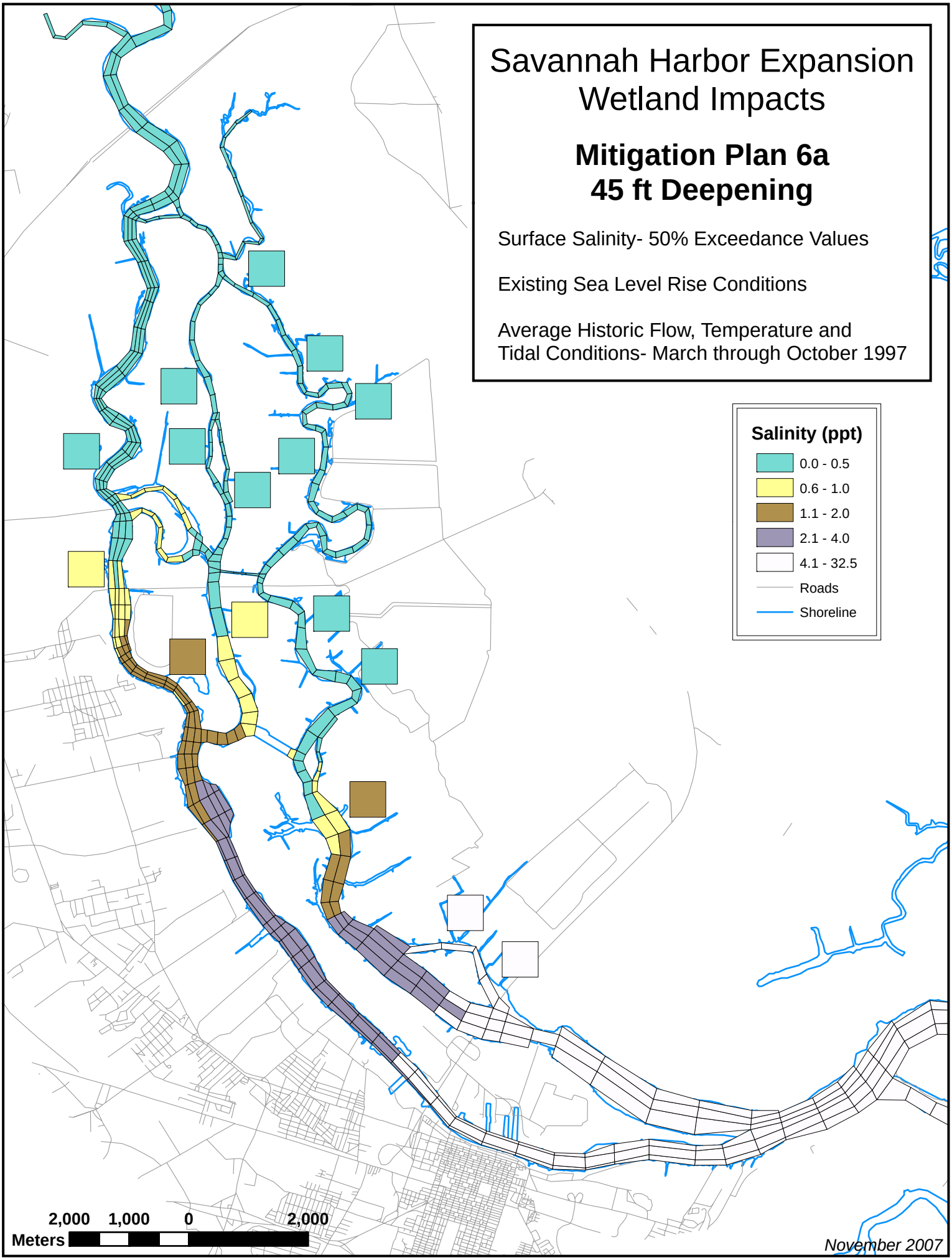

Savannah Harbor Expansion
Wetland Impacts
Mitigation Plan 6a
45 ft Deepening
Surface Salinity- 50% Exceedance Values
Existing Sea Level Rise Conditions
Average Historic Flow, Temperature, and
Tidal Conditions- March through October 1997
Salinity Difference (ppt)
-3.99 - -2.00
-1.99 - -1.00
-0.99 - -0.50
-0.49 - -0.30
-0.29 - -0.10
-0.09 - 0.00
0.01 - 0.10
0.11 - 0.20
0.21 - 0.30
0.31 - 0.40
0.41 - 0.50
0.51 - 0.60
0.61 - 0.70
0.71 - 0.80
0.81 - 0.90
0.91 - 1.00
1.01 - 1.09
Roads
Shoreline
2,000 1,000 0 2,000
Meters
November 2007

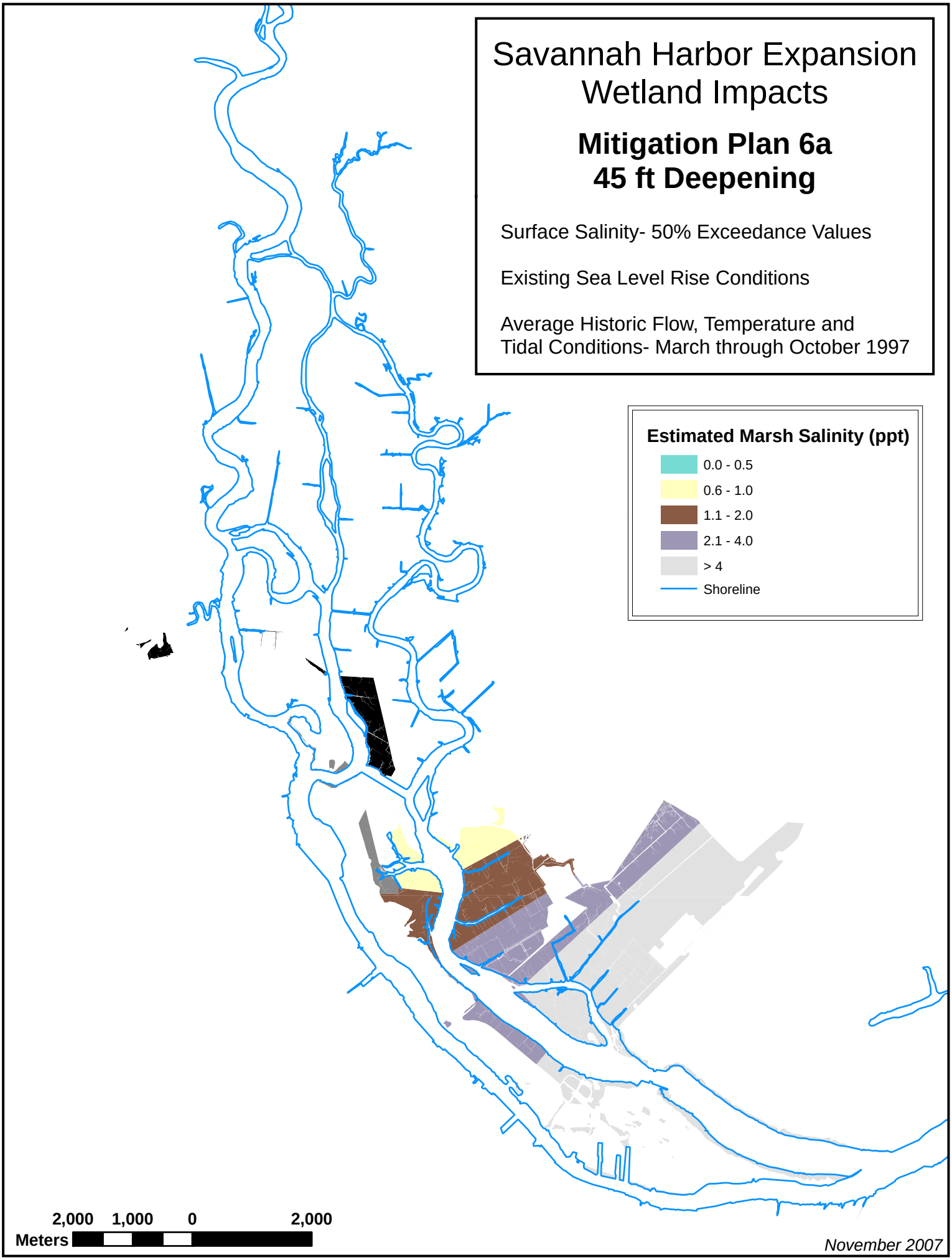

Savannah Harbor Expansion
Wetland Impacts
Mitigation Plan 6a
45 ft Deepening
Surface Salinity- 10% Exceedance Values
Existing Sea Level Rise Conditions
Average Historic Flow, Temperature, and
Tidal Conditions- March through October 1997
Salinity Difference (ppt)
-5.43 - -2.00
-1.99 - -1.00
-0.99 - -0.50
-0.49 - -0.30
-0.29 - -0.10
-0.09 - 0.00
0.01 - 0.10
0.11 - 0.20
0.21 - 0.30
0.31 - 0.40
0.41 - 0.50
0.51 - 0.60
0.61 - 0.70
0.71 - 0.80
0.81 - 0.90
0.91 - 1.00
1.01 - 1.48
Roads
Shoreline
2,000 1,000 0 2,000
Meters
November 2007


Savannah Harbor Expansion
Wetland Impacts
Mitigation Plan 6a
45 ft Deepening
BOTTOM Salinity- 50% Exceedance Values
Existing Sea Level Rise Conditions
Average Historic Flow, Temperature and
Tidal Conditions- March through October 1997
Salinity Difference (ppt)
-7.64 - -2.00
-1.99 - -1.00
-0.99 - -0.50
-0.49 - -0.30
-0.29 - -0.10
-0.09 - 0.00
0.01 - 0.10
0.11 - 0.20
0.21 - 0.30
0.31 - 0.40
0.41 - 0.50
0.51 - 0.60
0.61 - 0.70
0.71 - 0.80
0.81 - 0.90
0.91 - 1.00
1.01 - 2.00
2.01 - 3.00
3.01 - 5.00
5.01 - 5.72
Roads
Shoreline
2,000 1,000 0 2,000
Meters
November 2007


Savannah Harbor Expansion
Wetland Impacts
Mitigation Plan 6a
45 ft Deepening
BOTTOM Salinity- 10% Exceedance Values
Existing Sea Level Rise Conditions
Average Historic Flow, Temperature and
Tidal Conditions- March through October 1997
Salinity Difference (ppt)
-7.07 - -2.00
-1.99 - -1.00
-0.99 - -0.50
-0.49 - -0.30
-0.29 - -0.10
-0.09 - 0.00
0.01 - 0.10
0.11 - 0.20
0.21 - 0.30
0.31 - 0.40
0.41 - 0.50
0.51 - 0.60
0.61 - 0.70
0.71 - 0.80
0.81 - 0.90
0.91 - 1.00
1.01 - 2.00
2.01 - 3.00
3.01 - 5.00
5.01 - 5.06
Roads
Shoreline
2,000 1,000 0 2,000
Meters
November 2007


Savannah Harbor Expansion
Wetland Impacts
Mitigation Plan 6a
45 ft Deepening
Surface Salinity- 50% Exceedance Values
Existing Sea Level Rise Conditions
Average Historic Flow, Temperature and
Tidal Conditions- March through October 1997
Surface Salinity 0.5 ppt Indicator
Cells Greater Than 0.5 ppt
Cells Changed from GT 0.5 ppt to LT 0.5 ppt
Cells Less Than 0.5 ppt
Cells Changed from LT 0.5 ppt to GT 0.5 ppt
Roads
Shoreline
988.4 acres
453 acres
2,000 1,000 0 2,000
Meters
November 2007


Savannah Harbor Expansion
Wetland Impacts
Mitigation Plan 6a
45 ft Deepening
Surface Salinity- 50% Exceedance Values
Existing Sea Level Rise Conditions
Average Historic Flow, Temperature and
Tidal Conditions- March through October 1997
Salinity (ppt)
0.0 - 0.5
0.6 - 1.0
1.1 - 2.0
2.1 - 4.0
4.1 - 32.5
Roads
Shoreline
2,000 1,000 0 2,000
Meters
November 2007


Savannah Harbor Expansion
Wetland Impacts
Mitigation Plan 6a
45 ft Deepening
Surface Salinity- 50% Exceedance Values
Existing Sea Level Rise Conditions
Average Historic Flow, Temperature and
Tidal Conditions- March through October 1997
Estimated Marsh Salinity (ppt)
0.0 - 0.5
0.6 - 1.0
1.1 - 2.0
2.1 - 4.0
> 4
Shoreline
2,000 1,000 0 2,000
Meters
November 2007

Sensitivity Analysis #1

2001 (Low) Flow Conditions- No Sea Level Rise

Sensitivity Analysis #2A

1997 (Average) Flow Conditions- 25cm Sea Level Rise

Sensitivity Analysis #2B

1997 (Average) Flow Conditions- 50cm Sea Level Rise

46 ft Channel Depth

Mitigation Plan 6

Basic Evaluation

1997 (Average) Flow Conditions- No Sea Level Rise

Sensitivity Analysis #1

2001 (Low) Flow Conditions- No Sea Level Rise

Sensitivity Analysis #2A

1997 (Average) Flow Conditions- 25cm Sea Level Rise

Sensitivity Analysis #2B

1997 (Average) Flow Conditions- 50cm Sea Level Rise

48 ft Channel Depth

Mitigation Plan 6a

Basic Evaluation

1997 (Average) Flow Conditions- No Sea Level Rise

Sensitivity Analysis #1

2001 (Low) Flow Conditions- No Sea Level Rise

Sensitivity Analysis #2A

1997 (Average) Flow Conditions- 25cm Sea Level Rise

Sensitivity Analysis #2B

1997 (Average) Flow Conditions- 50cm Sea Level Rise