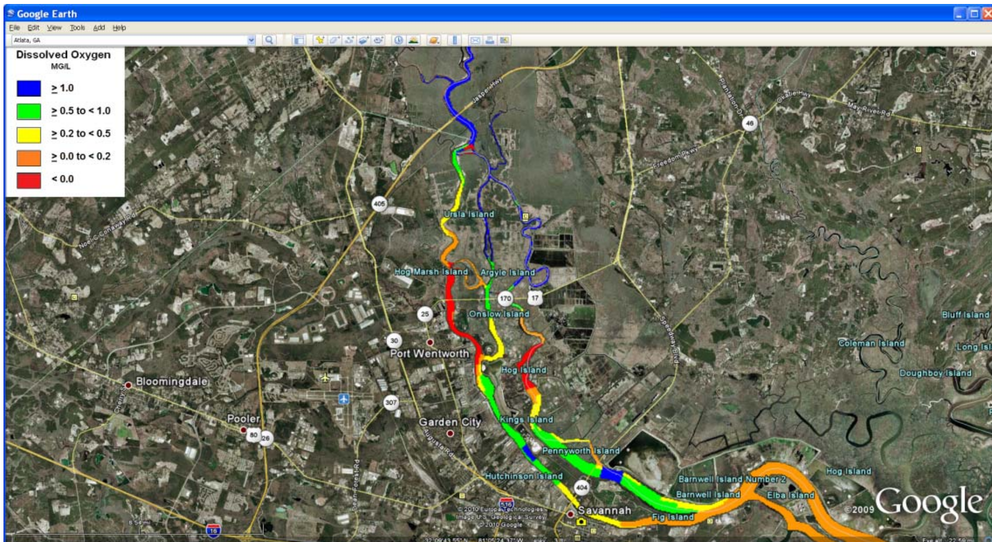
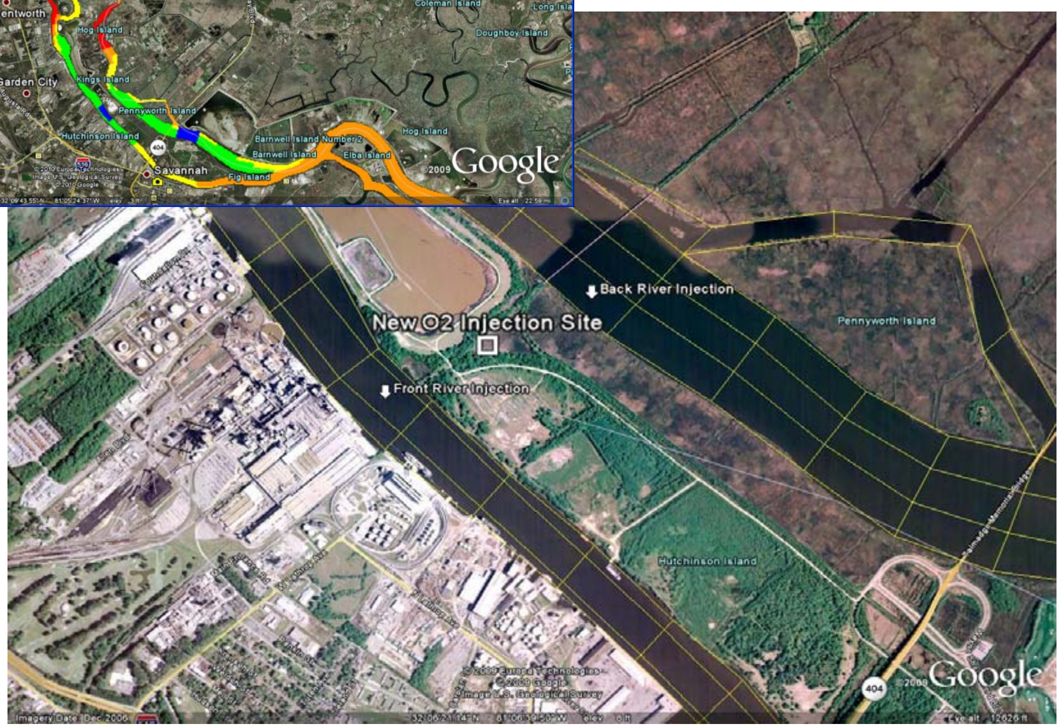
Oxygen Injection Design Report
Savannah Harbor Expansion Project
Savannah, Georgia





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1.0 INTRODUCTION

The United States Army Corps of Engineers (USACE), Savannah District is working with the Georgia Ports Authority (GPA) to evaluate the deepening of the navigation channel in Savannah Harbor. This effort is called the Savannah Harbor Expansion Project (SHEP). The project is intended to identify the impacts and mitigation strategies of deepening the harbor from its presently authorized 42-foot depth Mean Lower Low Water (MLLW), up to a depth of 48-feet MLLW.

Hydrodynamic and water quality models were developed and determined to be acceptable in March 2006 by the United States Environmental Protection Agency (USEPA), United States Fish and Wildlife Services (USFWS), Georgia Environmental Protection Division (GAEPD), and South Carolina Department of Health and Environmental Control (SCDHEC) to identify dissolved oxygen (D.O.) levels throughout Savannah Harbor. Studies have identified a dissolved oxygen injection system as being the most cost effective method to improve dissolved oxygen levels in the harbor (MACTEC 2005).

The SHEP is examining ways to mitigate for potential adverse effects on dissolved oxygen levels from proposed harbor deepening alternatives and will use oxygen injection systems for that mitigation. To meet those mitigation requirements, designs for an oxygen injection system were needed. This work effort uses the models to size and locate the system components and ensure the dissolved oxygen effectively mixes throughout the portions of the harbor that have the critical dissolved oxygen impacts.

The dissolved oxygen improvement designs are based on use of an off-stream (land-side) system to improve the dissolved oxygen of waters obtained from the harbor, and then reintroduce those oxygenated waters back into the harbor. The designs are based on the Speece cones to increase the oxygen levels.

The basic tasks included in this *Oxygen Injection Design Report* are as follows:

- Review siting of D.O. Injection Systems
- Optimize the D.O. discharge for mitigation purposes
- Accomplish near-field plume modeling for discharge sites
- Accomplish all necessary additional far-field model runs

2.0 TECHNICAL APPROACH

In developing the models for the Savannah River Estuary (Savannah Harbor), the Environmental Fluid Dynamics Code (EFDC) was selected for the hydrodynamic model. The Water Quality Analysis Simulation Program Version 7.0 (WASP7) was used for the water quality model development.

The EFDC model is part of the USEPA TMDL Modeling Toolbox due to its application in many TMDL-type projects. As such, the code has been peer reviewed and tested and has been freely distributed for public use. EFDC was developed by Dr. John Hamrick and is currently supported by Tetra Tech for USEPA Office of Research and Development (ORD), USEPA Region 4, and USEPA Headquarters. EFDC has proven to capture the complex hydrodynamics in Savannah Harbor and similar systems. The EFDC hydrodynamic and sediment transport model linked with the WASP water quality model provided the most appropriate combination of features necessary for this study. EFDC is a multifunctional, surface-water modeling system, which includes hydrodynamic, sediment-contaminant, and eutrophication components. The EFDC model is capable of 1, 2, and 3-D spatial resolution. The model employs a curvilinear-orthogonal horizontal grid and a sigma, or terrain following, vertical grid. The EFDC model's hydrodynamic component employs a semi-implicit, conservative finite volume-finite difference solution scheme for the hydrostatic primitive equations with either two or three-level time stepping (Hamrick 1992).

The EFDC hydrodynamic model can run independently of a water quality model. For this Savannah Harbor application the EFDC model simulates the hydrodynamic and constituent (salinity and temperature) transport and then writes a hydrodynamic linkage file for the water quality model WASP7 code. This model linkage, from EFDC hydrodynamics to WASP7 water quality, has been applied on many USEPA Region 4 projects in support of TMDLs and has been well tested (Wool 2003).

WASP7 is the new version of WASP with many upgrades to the user's interface and the model's capabilities. The major upgrades to WASP have been the addition of multiple BOD components, addition of sediment diagenesis routines, and addition of periphyton routines. WASP is an enhanced Windows version of the USEPA Water Quality Analysis Simulation Program (WASP), nonetheless, uses the same algorithms to solve water quality problems as those used in the DOS version. WASP is a dynamic compartment-modeling program for aquatic systems, including both the water column and the underlying benthos. The time-varying processes of advection, dispersion, point and diffuse mass loading, and boundary exchange are represented in the basic program.

2.1 EFDC Application to the Savannah River Estuary

The EFDC model was developed to run for seven years – from January 1, 1997 through December 31, 2003. The model grid, which includes 931 horizontal cells, extends upstream to Clyo, Georgia (~ 61 miles from Fort Pulaski) and downstream to the Atlantic Ocean (~17 miles offshore from Fort Pulaski). The model also includes marsh cells, to simulate the extensive intra-tidal marsh areas in the system, increasing the number of total cells to 947. The man-made connections affecting the system were included in the model. These included McCoy Cut, Rifle Cut, Drakie's Cut, New Cut as closed, and the sill of the Tide Gate.

Figure 2-1 shows the grid, while Figure 2-2 shows a closer view of the upper estuary. The Savannah Harbor EFDC model was calibrated with graphical time series comparisons (qualitative) and statistical calculations (quantitative). The statistical calculations included percentiles at 5% intervals. It included: water surface elevation, currents, flow, temperature, and salinity.

The calibration objectives for the hydrodynamic model were to appropriately represent the transport processes by propagating momentum and energy through the system based upon freshwater inflow from the Savannah River and tidal energy from the Atlantic Ocean. Since vertical stratification plays a major role in the water quality of the lower harbor area, it was imperative to capture the effect of tides and fresh water flows on salinity and temperature over the appropriate spatial and temporal scales. The primary objective was to simulate the salinity and temperature stratification events and to demonstrate that the duration and magnitude of the events were appropriately represented in the model. The calibration period was the summer of 1999. The confirmation period was the summer of 1997. Long-term United States Geological Survey (USGS) data was also used for confirmation. The two summer periods were both low-flow conditions with several spring/neap tide events occurring throughout the period.

The model calibration and validation results are presented in the report "Development of the Hydrodynamic and Water Quality Models for the Savannah Harbor Expansion Project", January of 2006, prepared by Tetra Tech, Inc. for the USACE Savannah District.

Kinetic Analysis Corporation (KAC) performed a sensitivity/uncertainty analysis to quantify the sensitivity of the model simulations to uncertainty in values of model input data or calibration parameters. The results are presented in the January 2006 report as an appendix.

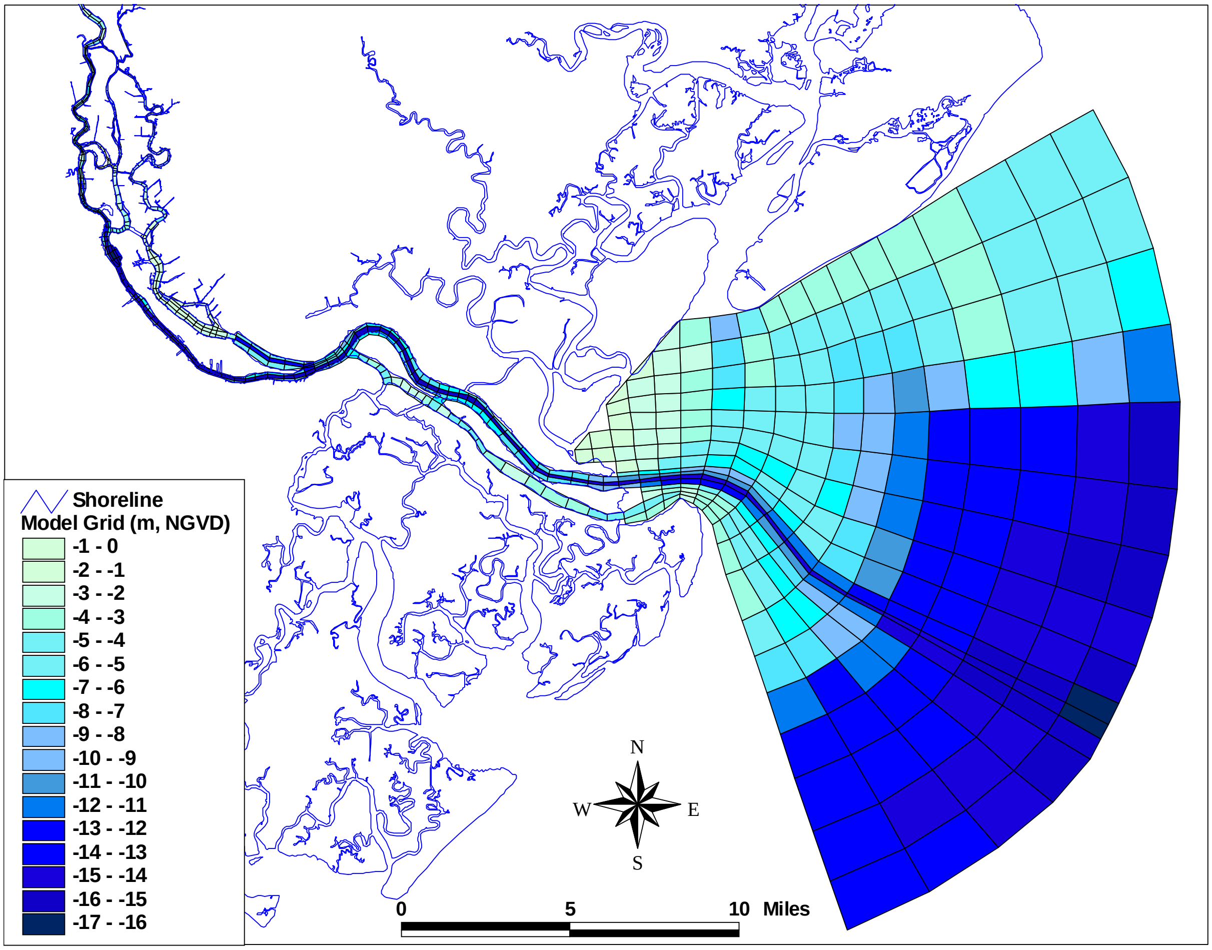

Figure 2-1 Model Grid and Bathymetry

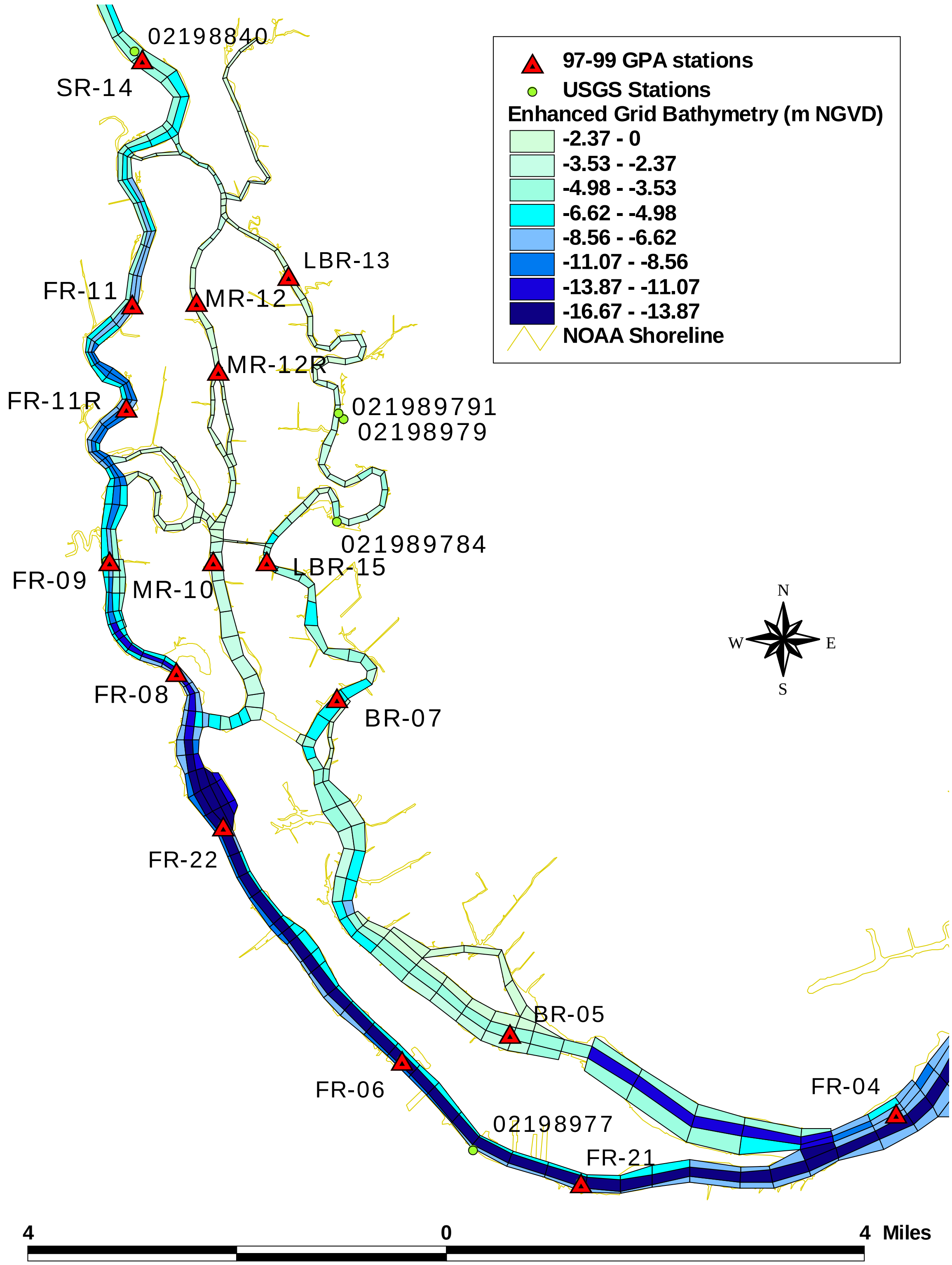

Figure 2-2 Model Grid and Bathymetry in the Upper Estuary

2.2 WASP Application to the Savannah River Estuary

The water quality model incorporated oxygen dynamics, including: reaeration, sediment oxygen demand (SOD), carbonaceous Biochemical Oxygen Demand (CBOD) and uptake, and Nitrogenous Biochemical Oxygen Demand (NBOD) and uptake. Since there is limited algal activity or primary production in the harbor, EPA Region 4 determined that nutrients were not a significant issue and they were not included in the water quality modeling scenarios.

The EFDC hydrodynamic model provides WASP with the flows between cells, the flows between cells and boundaries, cell volume, salinity, and temperature. This information is incorporated into the WASP model through the hydrodynamic linkage file.

The calibration was performed using the summer 1999 dataset. The WASP model was run from July 21, 1999 to October 13, 1999 with a 10-day spin up time. The measured values from the data collected during the 1999 summer survey were used for calibration of the WASP water quality model. Specifically, dissolved oxygen, BOD, and ammonia data were used for the calibration.

The time period for the WASP model confirmation was from July 5, 1997 through October 13, 1997. In addition to the 1999 summer data collection, the 1997 summer data collection represented the most recent dissolved oxygen and water chemistry data for the system.

Model calibration and validation results, as well as the sensitivity analysis for the water quality model, are also presented in the January 2006 report (Tetra Tech 2006a).

2.3 An Approach to Evaluation of Deepening Impacts and Mitigation Measures

The results of simulations that were performed under the project’s Design of Dissolved Oxygen Improvement Systems in Savannah Harbor, Tasks I and II (Tetra Tech 2006b and 2006c) and their combination in Task III (Tetra Tech 2008) were used to develop the methodology to determine mitigation. This current work examines the impacts of the harbor deepening, Corps’ mitigation plans, and the effects of oxygen injection system implementation based on average (August 1997) river flow conditions. The 2006 report identified average river flows as requiring more supplemental oxygen to meet harbor deepening mitigation requirements than do low river flow (August 1999) conditions (Tetra Tech 2006b and 2006c).

Figure 2-3 shows 27 spatial zones that delineate the estuary’s simulated area. The zones cover the estuary area that can be affected by the harbor deepening. There are 11 zones for Front River (FR), 6 zones for Middle River (MR), 3 zones for Back River (BR), 3 zones for Little Back River (LBR), 2 zones for South Channel (SH), 1 zone for Steamboat River (StbR), and 1 zone for Savannah River (SR). The grid coordinates (I, J) zone boundaries are presented in Table 2-1.

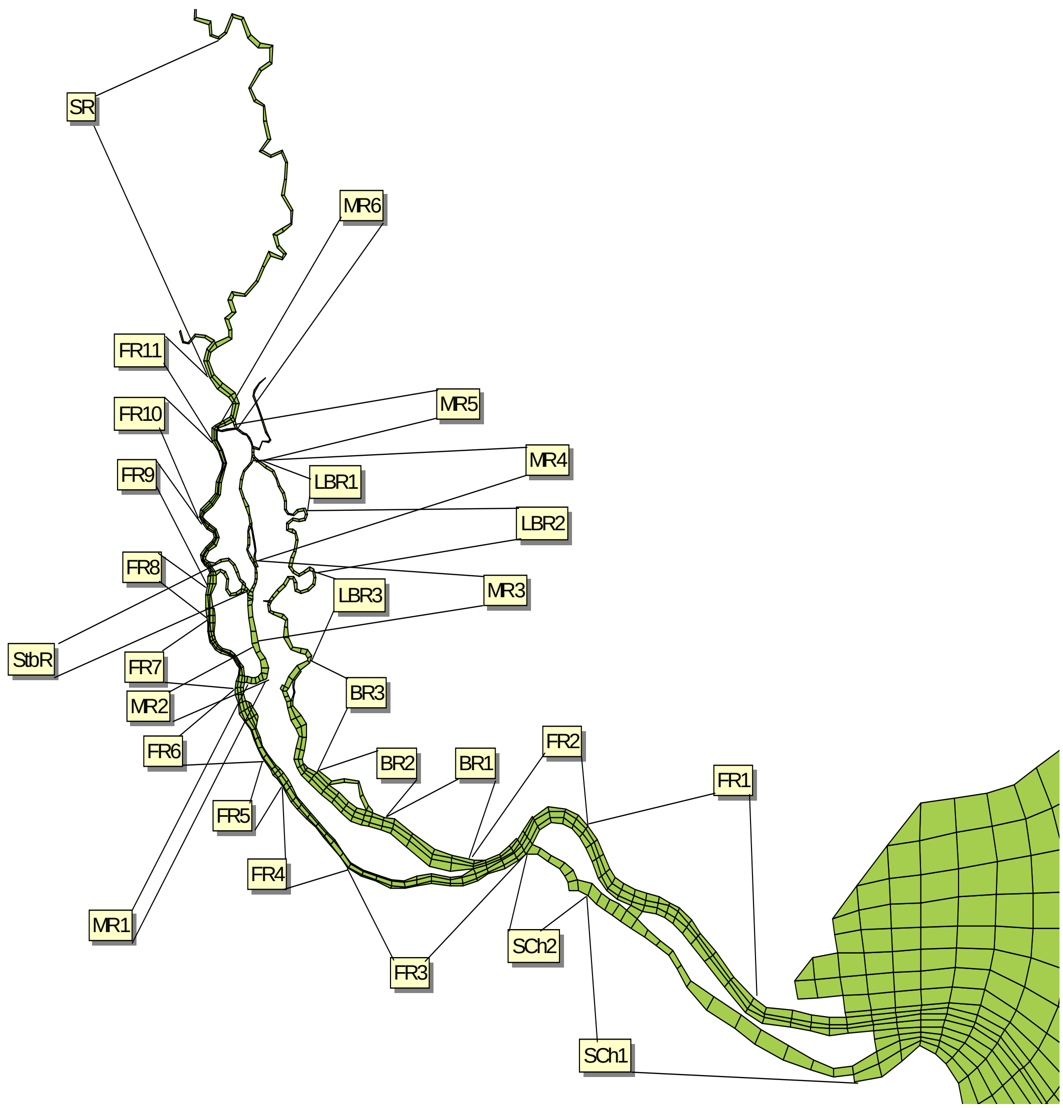

Figure 2-3 Zones' Delineation of Savannah Estuary Computational Grid

Table 2-1 Grid Coordinates and Volumes of Delineating Zones

Zone #	Zone Name	Grid Coordinates				Volume km3*1000	Relative Volume (%)
		I beg	J beg	I end	J end		
1	FR1	13	26	17	40	54.816	23.94
2	FR2	13	41	17	52	37.067	16.19
3	FR3	13	53	17	59	15.172	6.63
4	FR4	13	60	17	66	10.517	4.59
5	FR5	13	67	17	72	7.066	3.09
6	FR6	13	73	17	80	13.481	5.89
7	FR7	13	81	17	93	6.352	2.77
8	FR8	13	94	17	97	2.429	1.06
9	FR9	13	98	15	111	5.624	2.46
10	FR10	13	112	15	120	4.39	1.92
11	FR11	13	121	14	127	3.455	1.51
12	MR1	18	82	21	82	0.714	0.31
13	MR2	21	83	21	86	0.967	0.42
14	MR3	26	94	26	104	1.237	0.54
15	MR4	26	105	26	122	0.951	0.42
16	MR5	15	123	26	123	0.294	0.13
17	MR6	20	118	20	119	0.029	0.01
18	LBR1	27	123	38	123	0.401	0.18
19	LBR2	39	106	39	123	0.805	0.35
20	LBR3	30	86	30	109	2.766	1.21
21	BR1	30	59	34	63	8.16	3.56
22	BR2	30	64	34	70	4.988	2.18
23	BR3	30	71	32	85	5.572	2.43
24	SCh1	9	20	11	38	24.384	10.65
25	SCh2	7	45	12	46	4.761	2.08
26	SR	13	128	15	166	11.728	5.12
27	StbR	16	99	25	101	0.833	0.36

The model's postprocessor is described in Appendix D. The postprocessor outputs information for the following harbor's spatial objects:

- Critical Cell – cell with lowest D.O. concentrations during specified simulation period
- Critical Segment – an assemblage of cross section cells located at the critical cell's j-coordinate
- Zone – an assemblage of cells that are limited by specified horizontal and vertical boundaries

The postprocessor outputs allow evaluation of the impact and mitigation effects by:

- Comparing critical cells' D.O. concentrations for existing and project scenarios
- Comparing zones' volume-weighted D.O. concentrations for existing and project scenarios
- Calculating the percentage of water volume with the projected D.O. concentration that do not meet the existing bathymetry D.O. concentrations during the selected simulation periods

The basic criteria for assessing the success of mitigation measures was proposed by the USACE Savannah District based on results of numerous meetings and discussions with federal and local environmental agencies. The criteria require 97% of the estuary waters have D.O. concentrations equal or higher than the concentrations at existing (pre-project) conditions.

The selection of vertical boundaries of zones is the important factor of mitigation success calculations. The one boundary layer (1BL) and a mean of three boundary layers (3BL) criteria were selected and applied for the project. The 1BL is just the bottom layer and the 3BL is the three bottom layers of the model.

3.0 MITIGATION PLANS FOR SALINITY AND WETLANDS

The USACE Savannah District used the EFDC model to determine the appropriate measures to mitigate for salinity and wetland impacts. Based on analysis of the model output, the flow-altering mitigation plans that were found to be the most effective at reducing salinity impacts and protecting fresh water tidal marshes are Plan 6A for the 48-, 47-, 46-, and 45-foot channel depths and 6B for the 44-foot channel depth. Although the plans do not fully mitigate for all impacts to the estuary, they are expected to provide substantial benefits to the fresh water marsh ecosystems adjacent to the Back and Little Back Rivers.

Plan 6B is the proposed flow-altering mitigation plan for the 44-foot channel depth. The features of this plan include a diversion structure on Front River, closure of the lower (western) arm at McCoy Cut, closure of Rifle Cut, filling of the Sediment Basin, and removal of the tide gate abutments and piers. This plan provides potential for additional fresh water flows to enter the Back River System at McCoy Cut, without exiting through the lower (western) arm, and flow downstream through Middle, Back, and Little Back Rivers. It also has features that will limit saltwater intrusion to the Back River area through the sediment basin and Rifle Cut.

Plan 6A is the proposed mitigation plan for the 45-, 46-, 47-, and 48-foot channel depths. This plan includes all the features of Plan 6B and one additional feature, channel deepening on McCoy Cut, upper Middle, and Little Back Rivers. This additional feature in combination with the features in Plan 6B maximizes the potential for additional fresh water flows to enter the Back River System at McCoy Cut and flow downstream through Middle, Back, and Little Back Rivers.

Plan 6A includes the enlarged McCoy Cut only to the junction of Middle and Little Back Rivers. Plan 6B includes Plan 6A plus extending the enlargement 1,700 feet downstream of the junction of the two rivers. Figures 3-1 and 3-2 were provided by the USACE Savannah District and depict the different features for Plan 6A and 6B, respectively.

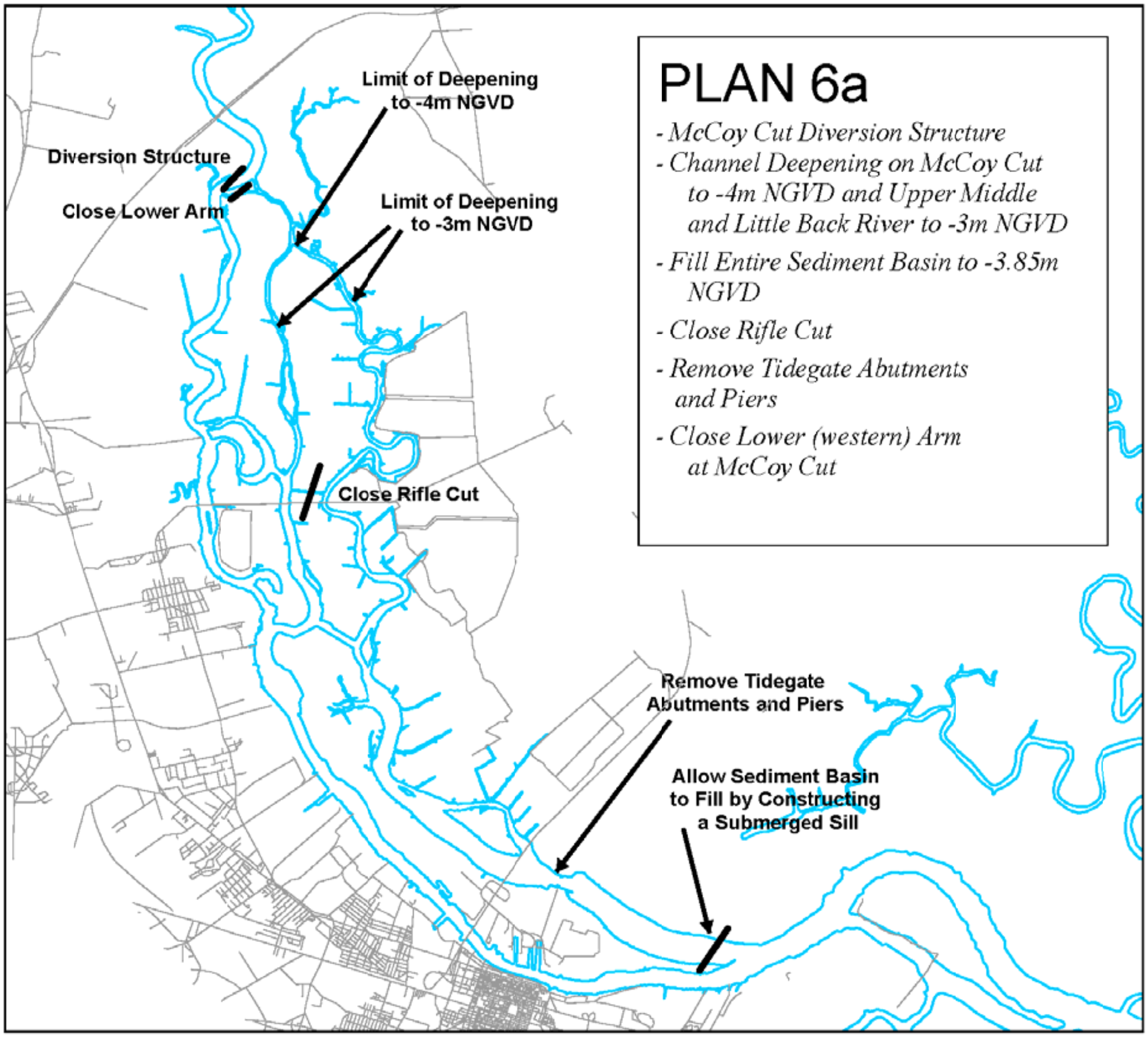

Figure 3-1 Mitigation Plan 6A (courtesy of the USACE Savannah District)

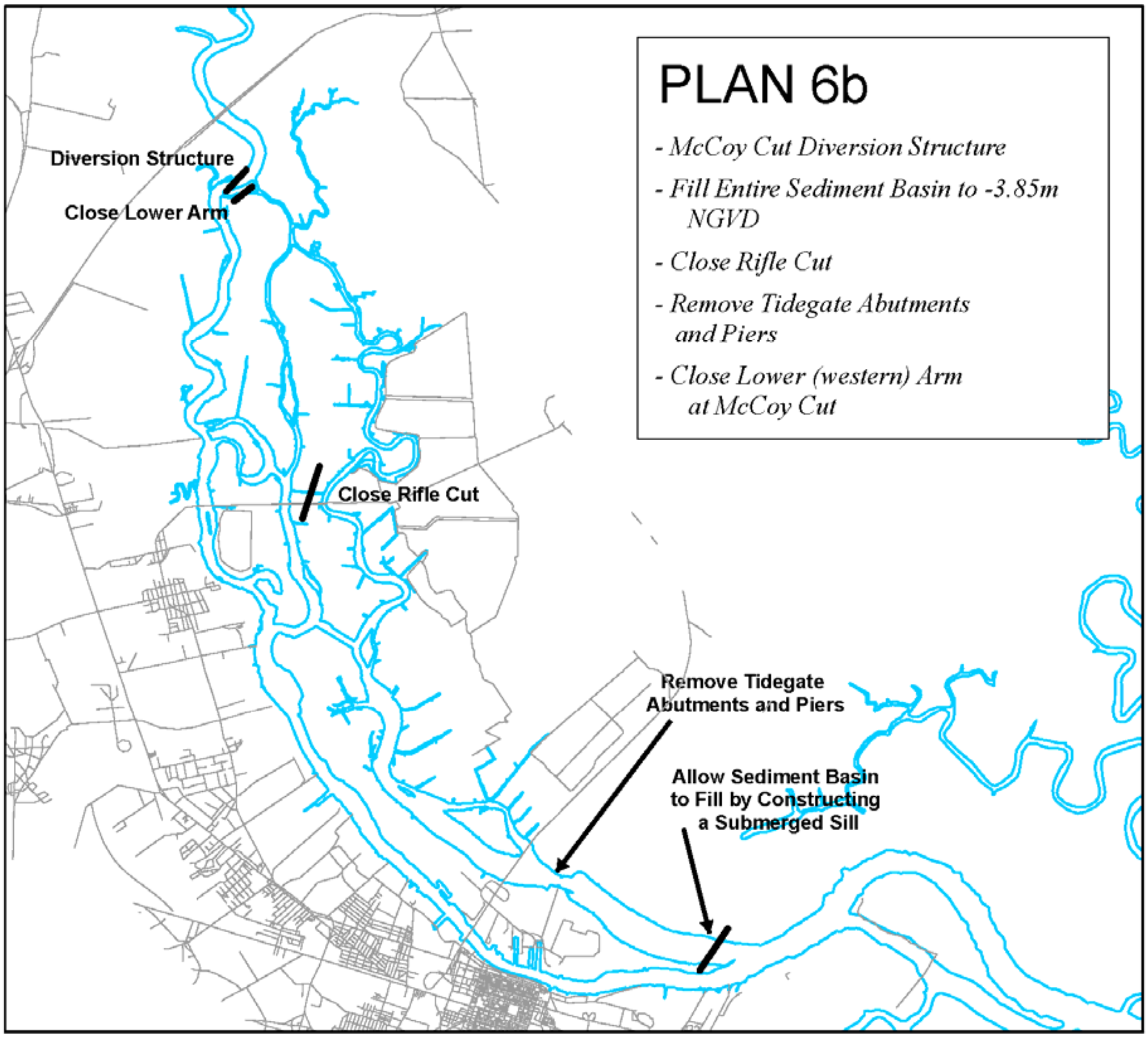

Figure 3-2 Mitigation Plan 6B (courtesy of the USACE Savannah District)

3.1 *Impact of alternative deepening and mitigation plans on D.O. regime*

Results of D.O. delta that were calculated by subtraction of existing bathymetry scenario outputs from the proposed mitigation plans alternative scenarios are presented in Table 3-1 and Appendix A.

Table 3-1 shows the percentage of water volumes where D.O. is not adversely affected by the proposed harbor deepening. The tables and figures presented in Appendix A allow identification of the harbor areas that are most affected by the deepening. These are zones F7, FR8, FR11, MR1, BR1, BR2, BR3, and LBR3 for mitigation plan 6A, and zones FR8, FR11, MR1, MR5, BR1, BR2, BR3, and LBR3 for mitigation plan 6B.

Such identification helps in selection of projected locations of components of the Oxygen Injection System.

Table 3-1 Volume of the harbor's water that was mitigated by plans 6A and 6B

Scenario Description	Injection	Volume mitigation (%) for the percentiles			
	kg/day	5%	10%	25%	50%
Plan 6A 6 ft deepening	0	68.1	73	68.8	43.8
Plan 6A 5 ft deepening	0	71	74.2	69.5	58.5
Plan 6A 4 ft deepening	0	71.2	73.4	72.9	10.4
Plan 6A 3 ft deepening	0	73.3	75.4	75.2	69.7
Plan 6B 2 ft deepening	0	65.1	68.7	63.1	68.4

4.0 OXYGEN INJECTION TECHNOLOGY

In order to inject oxygen into the system and to mitigate dissolved oxygen concentrations in the Savannah River Estuary that are below the standard, the technology developed by Dr. Richard Speece was used for design purposes. Dr. Speece invented the Speece Cone, a device originally used to add oxygen to the bottom of lakes to enhance downstream fisheries.

ECO2 SuperOxygenation systems (www.eco2tech.com) for water and wastewater treatment are designed and produced by Eco-Oxygen Technologies, LLC, an independent company headquartered in Indianapolis, Indiana.

The ECO2 SuperOxygenation method is a simple process based upon the scientific principle of Henry's Law. No chemicals and no moving parts other than standard municipal wastewater pumps are used. The result is a robust, reliable, economically competitive, and environmentally friendly technology.

This technology is appropriate when dissolved oxygen standards in the river are not attained, even if the industrial and municipal dischargers use the most advanced effluent treatments available. By superoxygenating directly to the river, water quality standards can be reached or maintained (Speece 2004).

This technology pulls a small sidestream of water from the river, superoxygenates it (using pure oxygen) and dilutes it back in the main river to satisfy dissolved oxygen deficiencies without treating the entire river. The sidestream is superoxygenated to achieve concentrations of 40 to 140 mg/L. Contrary to popular misconception, these high dissolved oxygen concentrations do not spontaneously effervesce, but can be kept in solution.

Cost comparisons with other traditional methods of oxygenation favor the use of this technology. Because pure oxygen and smaller sidestream flows used, less civil works and energy consumption are required than generally needed for aeration. Because the technology facilitates long residence times of gaseous oxygen in the oxygen transfer reactor, oxygen absorption efficiencies of 90 to 98% can be achieved.

The oxygen being dissolved can be supplied to the ECO 2 SuperOxygenation system in two ways:

1. Onsite oxygen generation either by Pulse Swing Absorption (PSA) or Vacuum Swing Absorption (VSA). Oxygen generation is a mature technology that has been used for decades and is widely used for wastewater treatment, medical facilities, and manufacturing. Oxygen generators operate by passing an air stream through a molecular sieve, which traps the nitrogen and discharges high purity oxygen for use. The nitrogen is then discharged into the atmosphere. The advantage to generating oxygen onsite is that oxygen is generated as it is being used, so there is no onsite bulk oxygen storage and it produces oxygen as a gas, not liquid. This eliminates issues centered on bulk liquid oxygen storage and truck delivery.
2. Bulk liquid oxygen (LOX). Bulk Liquid Oxygen is also widely used at wastewater treatment plants, manufacturing facilities and most noticeable medical hospitals. LOX systems are provided by a third party vendor that services, monitors, and delivers oxygen. LOX systems are comprised of a bulk oxygen storage tank and an evaporator. Liquid oxygen is trucked to the site and stored in the bulk oxygen tank. The liquid oxygen is piped through an evaporator that changes the liquid oxygen to gaseous oxygen.

High purity oxygen has been injected in water bodies in the past by various methods, such as pressurized sidestream, venturi aspirator, or turbine mixers, but inefficiently. The Downflow Bubble Contact Oxygenation equipment (Speece Cone) combines high oxygen absorption efficiency (>90%) with low unit energy consumption (<400 kwhr/ton D.O.), producing a superoxygenated discharge of >70 mg/L of D.O. The system can be placed out of the river channel without disrupting the water body, unlike aerators, or scouring the bottom.

Figure 4-1 shows a Speece Cone being installed at Newman Lake near Spokane, Washington. This cone was designed to add 3,300 pounds of oxygen per day (lbs/day) to a side stream of 13 million gallons per day (MGD) withdrawn from the hypolimnion of the lake.

Figure 4-2 shows a pictured of the Georgia Ports Authority (GPA) demonstration project managed by MACTEC. The results of the study are in the “Savannah Harbor Reoxygenation Demonstration Project, Savannah, Georgia” (MACTEC 2008) and, in summary, improve the dissolved oxygen levels in the mid-channel, average low-tide by about 0.6 mg/L along the three-mile-long target segment.

Figure 4-1 Speece Cone Being Installed in Newman Lake (from www.eco2tech.com)

Figure 4-2 Summer 2007 GPA Demonstration Project (MACTEC, 2008)

5.0 INJECTION QUANTITIES AND LOCATIONS

The SHEP model was used to determine the optimal quantities and locations of the oxygen injection facilities needed to mitigate for harbor deepening impact on dissolved oxygen. The problems with selection of optimal locations are complicated by limited availability of potential injection sites with easy transport and access.

5.1 Injection for Harbor Deepening Mitigation (IP site)

The USACE proposed the site on Hutchinson Island (near the International Paper (IP) aeration lagoon) as an oxygen injection facility for discharging oxygen into Front and Back Rivers. The results of D.O. mitigation for 6 ft deepening (Plan 6A) are presented in Table 5-1. The scenarios labeled m1 through m4 in Table 5-1 are different magnitudes of the 1BL (bottom layer only) criteria.

Table 5-1 Oxygen loads and mitigation results for IP facilities: 1BL criteria

Scenario		Coordinates	Injection	Sum	Mitigation (%) for the percentiles			
	Cell Location	(I, J)	(kg/day)	(kg/day)	5%	10%	25%	50%
	IP	FR (14,66)	30,000					
m1	IP	BR (31,70)	7,000	37,000	89.8	90.4	89.8	89.6
	IP	FR (14,66)	40,000					
m2	IP	BR (31,70)	17,000	57,000	91	91.7	90.9	91.7
	IP	FR (14,66)	50,000					
m3	IP	BR (31,70)	27,000	77,000	91.8	92.8	92.4	92.5
	IP	FR (14,66)	80,000					
m4	IP	BR (31,70)	60,000	140,000	93.3	93.9	93.7	93.6

The results of simulations under scenarios m1, m2, m3, and m4 demonstrate an inability of the Oxygen Injection Systems located only at the IP site to achieve the required 97% mitigation success criteria. So the IP Front and Back River injection sites alone do not mitigate all of harbor deepening impacts.

5.2 Injection for Harbor Deepening Mitigation (IP and GP sites)

The specifics of water circulation in Savannah River Estuary make oxygen discharge upstream of Savannah River very important. The Georgia Pacific (GP) site has high potential as an addition to the IP location for a combined Oxygen Injection System. Table 5-2 shows the results of D.O. mitigation for alternative deepening and 1BL criteria of success for locations near IP and GP.

Comparisons of results of Tables 5-1 and 5-2 demonstrate strong effect of upstream oxygen injection (GP) for FR and LBR zones. Such effect was not achievable by simply increasing of loads at the IP facility.

The Corps met with federal and state environmental agencies in February 2010 to discuss Tetra Tech's ongoing redesign of the oxygen injection systems. The agencies agreed that an upstream location appeared to be needed (in addition to the mid-harbor IP location) to meet the mitigation goals. The agencies agreed that the analysis could examine the effects in the lower half of the water column (bottom 3 layers of the model grid) rather than the bottom grid layer. D.O. generally decreases with channel depth, so analysis of conditions at the river bottom would represent worst-case conditions. Analysis of the bottom half of the water column would be more representative (but still somewhat conservative) of average conditions throughout the water column.

The results of simulations and assessment of D.O. improvement on the basis of the 3 bottom layer (3BL) criteria are presented in Table 5-3.

Table 5-2 Oxygen loads and mitigation results for IP and GP facilities: 1BL criteria

Scenario Description	D.O. Discharge Location	Cell (I,J,K) Coordinates	Load (kg/day)	Sum (kg/day)	Volume mitigation (%) for the percentiles 5%	10%	25%	50%
Plan 6A	IP (FR)	14, 66, 6	10,000					
6 ft deepening	IP (BR)	31,70, 6	7,000	27,000	98.4	98.6	98.4	97.1
(GP+IP_5)	Georgia-Pacific	14, 171, 6	10,000					
Plan 6A	IP (FR)	14, 66, 6	9,000					
5 ft deepening	IP (BR)	31,70, 6	3,000	22,000	97.3	97.3	98.1	97.3
(5F-7)	Georgia-Pacific	14, 171, 6	10,000					
Plan 6A	IP (FR)	14, 66, 6	6,000					
4 ft deepening	IP (BR)	31,70, 6	3,000	19,000	97.5	97.3	97.3	97.4
(4F-3)	Georgia-Pacific	14, 171, 6	10,000					
Plan 6A	IP (FR)	14, 66, 6	3,000					
3 ft deepening	IP (BR)	31,70, 6	3,000	18,000	97.1	98.2	98.5	98.8
(3F-13)	Georgia-Pacific	14, 171, 6	12,000					
Plan 6B	IP (FR)	14, 66, 6	6,000					
2 ft deepening	IP (BR)	31,70, 6	3,000	19,000	97.2	97.4	97	97.8
(2B-1)	Georgia-Pacific	14, 171, 6	10,000					

Table 5-3 Oxygen loads and mitigation results for IP and GP facilities: 3BL criteria

Scenario Description	D.O. Discharge Location	Cell (I,J,K) Coordinates	Load (kg/day)	Sum (kg/day)	Volume mitigation (%) for the percentiles 5%	10%	25%	50%
Plan 6A	IP (FR)	14, 66, 6	7,000					
6 ft deepening	IP (BR)	31,70, 6	2,000	18,000	97.9	97.8	98.1	97.3
(GP+IP_13m)	Georgia-Pacific	14, 171, 6	9,000					
Plan 6A	IP (FR)	14, 66, 6	3,000					
5 ft deepening	IP (BR)	31,70, 6	2,000	16,000	98.2	97.5	97.9	97.3
(5F-5m)	Georgia-Pacific	14, 171, 6	11,000					
Plan 6A	IP (FR)	14, 66, 6	2,000					
4 ft deepening	IP (BR)	31,70, 6	2,000	14,000	97.6	97.2	97.4	97.7
(4F-3m)	Georgia-Pacific	14, 171, 6	10,000					
Plan 6A	IP (FR)	14, 66, 6	1,000					
3 ft deepening	IP (BR)	31,70, 6	2,000	13,000	98.1	97.4	97.7	98.5
(3F-3m)	Georgia-Pacific	14, 171, 6	10,000					
Plan 6B	IP (FR)	14, 66, 6	1,000					
2 ft deepening	IP (BR)	31,70, 6	4,000	15,000	97.2	97.3	97.6	97.8
(2B-6m)	Georgia-Pacific	14, 171, 6	10,000					

Table 5-3 shows the percent of the water volume where D.O. is at least as high as in the pre-project condition. The tables that show mitigation effect of Table 5-3 scenarios for every zone D.O. average and D.O. concentrations for critical cells are presented in Appendix B. The figures in Appendix B display 50th percentile of D.O. delta (Project minus Existing scenarios).

Appendix C contains tables that demonstrate mitigation success (required for 5th, 10th, 25th, and 50th percentiles) for surface, middle, and bottom layers.

Table 5-4 displays depths and statistics of oxygen saturation using oxygen injection facilities near IP and GP. This information is necessary for the design of oxygen injection in the harbor using Speece supersaturating cones.

Table 5-4 D.O. Saturation (%) in locations of GP and IP facilities

Scenario Description	D.O. Discharge Location	Cell (I,J,K) Coordinates	Depth (m)	D.O. Saturation (%)		
				10 %ile	50 %ile	90 %ile
Plan 6A	IP (FR)	14, 66, 6	16.92	53	56	60
6 ft deepening	IP (BR)	31,70, 6	3.33	30	38	49
(GP+IP_13m)	Georgia-Pacific	14, 171, 6	3.62	65	74	80
Plan 6A	IP (FR)	14, 66, 6	16.61	53	56	61
5 ft deepening	IP (BR)	31,70, 6	3.33	29	36	48
(5F-5m)	Georgia-Pacific	14, 171, 6	3.62	65	74	80
Plan 6A	IP (FR)	14, 66, 6	16.31	53	56	62
4 ft deepening	IP (BR)	31,70, 6	3.33	28	35	48
(4F-3m)	Georgia-Pacific	14, 171, 6	3.62	65	74	80
Plan 6A	IP (FR)	14, 66, 6	16	53	56	63
3 ft deepening	IP (BR)	31,70, 6	3.33	27	35	48
(3F-3m)	Georgia-Pacific	14, 171, 6	3.62	65	74	80
Plan 6B	IP (FR)	14, 66, 6	15.7	52	57	65
2 ft deepening	IP (BR)	31,70, 6	3.33	19	29	45
(2B-6m)	Georgia-Pacific	14, 171, 6	3.62	65	74	80

The location of the injection facilities for mitigation of deepening impacts are shown in Figure 5-1. Figure 5-2 shows a close-up view of the IP Hutchinson Island location with injection sites on the Front and Back Rivers.

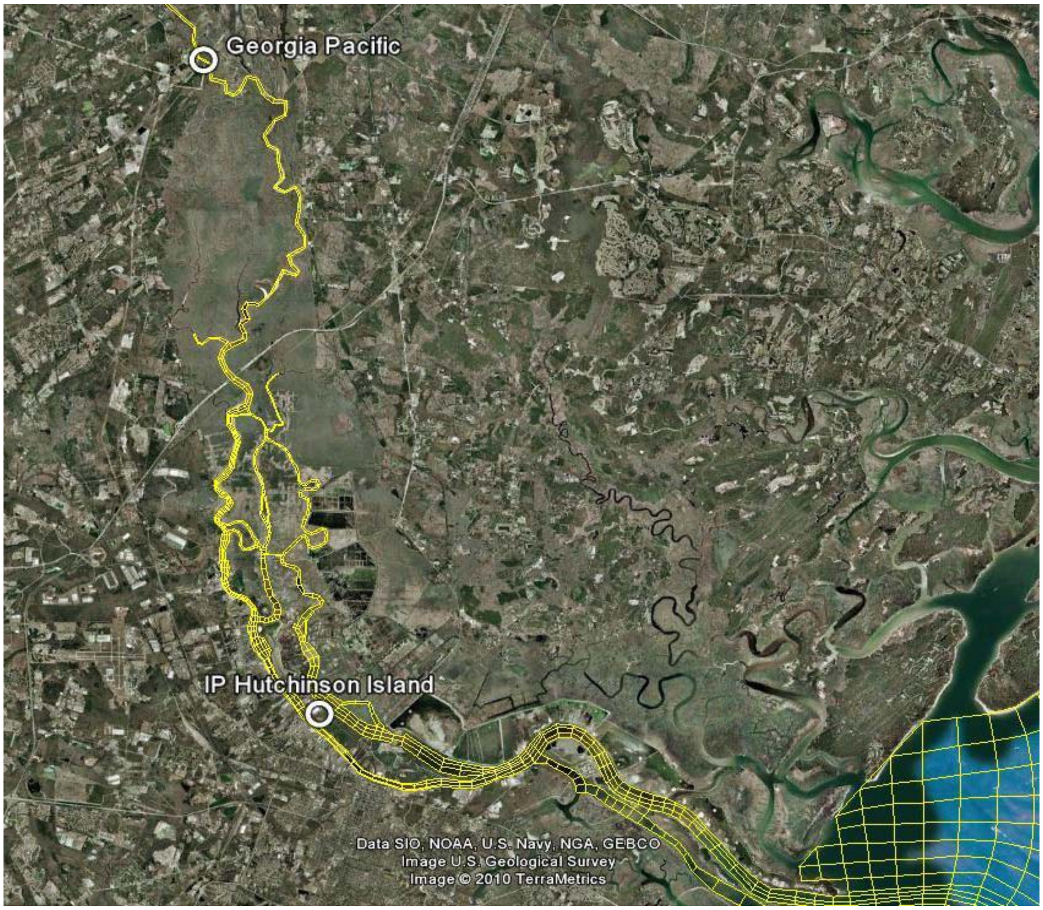

Figure 5-1 Location of Components of Dissolved Oxygen Injection System

Figure 5-2 Location at IP Hutchinson Island

6.0 NEAR-FIELD MODELING RESULTS

A mixing zone analysis was performed at each of the three locations to simulate the near-field results. A request was made by South Carolina DHEC to perform a similar mixing zone analysis to the one in the 2007 Demonstration Project report (Tetra Tech 2009). The analysis for the 2007 Demonstration Project showed a small plume and a relatively short mixing zone. DHEC desired this analysis to occur for the designed locations as well.

In order to predict the near-field plume dynamics so that accurate estimates of height of rise and fall and initial dilution can be calculated, near-field plume numerical descriptive models have to be used. One of the most widely used choices over the past several years have been Visual Plumes. Visual Plumes (VP) is a family of mixing zone models to simulate surface water jets and plumes for a range of temperature, depth, discharge buoyancy, and ambient velocity conditions.

The VP model is a Windows-based mixing zone modeling application designed to replace the DOS-based PLUMES program (Baumgartner et al. 1994). VP was developed by the USEPA and supports initial dilution models that simulate single and merging submerged plumes in arbitrarily stratified ambient flow. Predictions include dilution, rise and sink, diameter, and other plume variables. A more detailed description of the VP model is included in Appendix E of the 2007 injection modeling report (Tetra Tech 2009) and can be viewed at http://www.epa.gov/ceampubl/swater/vplume/. There are presently five recommended models in VP: DKHW, NRFIELD/FRFIELD, UM3, PDSW, and DOS PLUMES. For the present work the model UM3 was used. Figure 6-1 shows the output capabilities within the model after running scenarios (typical output).

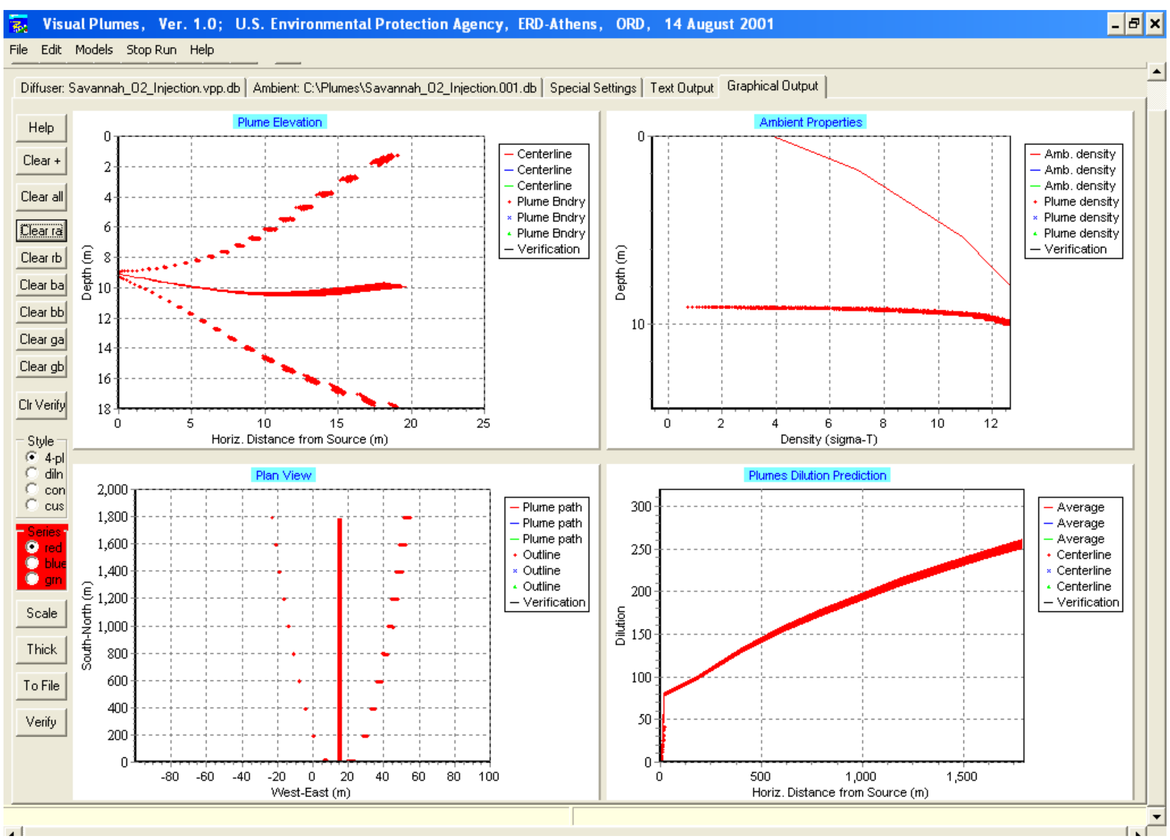

Figure 6-1 Typical Output using Visual Plumes Model

6.1 Plume Model

UM3 is an acronym for the three-dimensional Updated Merge (UM) model for simulating single and multi-port submerged discharges. UM3 is a Lagrangian model that features the projected-area entrainment (PAE) hypothesis. This established hypothesis quantifies forced entrainment, the rate at which mass is incorporated into the plume in the presence of current. In UM3, it is assumed that the plume is in steady state; in the Lagrangian formulation this implies that successive elements follow the same trajectory (Baumgartner et al. 1994). The plume envelope remains invariant while elements moving through it change their shape and position with time. To make UM three-dimensional, the PAE forced entrainment hypothesis has been generalized to include an entrainment term corresponding to the third-dimension: a cross-current term. As a result, single-port plumes are simulated as truly three-dimensional entities. Merged plumes are simulated less rigorously by distributing the cross-current entrainment over all plumes.

The average dilution factor, S_a , used in the UM model is the reciprocal of the volume fraction of effluent, v_e , contained in the diluted plume. An equivalent way of expressing this term is the ratio of effluent volume plus volume of ambient dilution water, v_a , to the effluent volume, as in the following equation:

$$S_a = 1 / (v_e / (v_e + v_a)) = (v_e + v_a) / v_e$$

Thus, in the region immediately outside the discharge orifice the volumetric dilution factor is very nearly 1. In some discussions of this term in other works, the factor is considered to be the ratio of the volume of ambient dilution water, v_a , to the volume of effluent discharged, v_e. In this definition, the volumetric dilution factor approaches zero near the orifice. Above a value of 30, the difference in the two definitions is progressively less than 3 %, an inconsequential amount for most regulatory purposes.

6.2 Near-Field Simulation Results

Tetra Tech used the three-dimensional EFDC Savannah Harbor model (Tetra Tech 2006a) to develop the flow and velocity field under which the simulations were performed. The three-dimensional model was run for the 1997 summer conditions based on earlier results that showed more oxygen is needed the summer of 1997 versus summer of 1999 due to slightly higher levels of flows (Tetra Tech 2006b, 2006c, and 2008). The ambient river time series of velocity, salinity, and temperature were obtained from the EFDC simulation results.

Other input information required by the near field model included the following:

- Physical setup of the discharge
- Physical schematization of the channel cross section at the injection location.

For each of the three locations, a VP model was developed and results presented in this section. The ambient conditions were developed by the EFDC model at each location by simulating the 6-feet deepening with mitigation Plan 6A.

For the effluent conditions of the effluent, the following parameters were assigned:

- Flow = 12,500 gallons per minute (gpm) for each cone
- Salinity = ambient conditions (intake = discharge)
- Temperature = ambient conditions (intake = discharge)
- Dissolved Oxygen = 140 mg/L (based on 2007 Demonstration Project)
- Depth = time series based water surface elevation (tides)

The salinity and temperature conditions for the effluent were set to the ambient conditions because we assumed the intake and discharge depth were equal. In the 2007 Demonstration Project, the intake was 10 feet below the surface and the discharge was 30 feet below the surface. The modeling of the Demonstration Project showed that the mixing zone of the plume was short (~ 60 feet) and was not buoyant because of the short distance. For the purposes of this design report, we assumed the intake and discharge depths would be the same depth but separated by a horizontal distance of 600 feet.

Ambient conditions were based on the following parameters:

- Salinity = time series from EFDC model
- Temperature = time series from EFDC model
- Dissolved Oxygen = time series from EFDC model
- Velocity = time series from EFDC model

Pipe conditions were based on the following parameters:

- Diameter = 18 inches
- Angle = varies
- Port Depth = varies
- Number of Ports = one
- Port Spacing (intake to effluent) = minimum of 600 feet

Table 6-1 summarizes the details of each of the three effluent designs and Figures 6-2 through 6-4 show the vertical mixing zone results for all three locations.

Table 6-1 Design parameters for each of the three locations

Location	Effluent Flow (MGD)	Effluent DO (mg/L)	Port Elevation* (m)	Pipe Diameter (inches)	Horizontal Angle (degrees)	Vertical Angle (degrees)
Front River IP	108	140	2	18	0	20
Back River IP	72	140	1	18	0	0
Savannah River GP	108	140	1	18	0	0

* Port Elevation is the distance from the bottom of the channel to the effluent pipe, so it is measured from the bottom.

At all three locations, the dissolved oxygen concentrations are close to background within 20 meters of the effluent discharge.

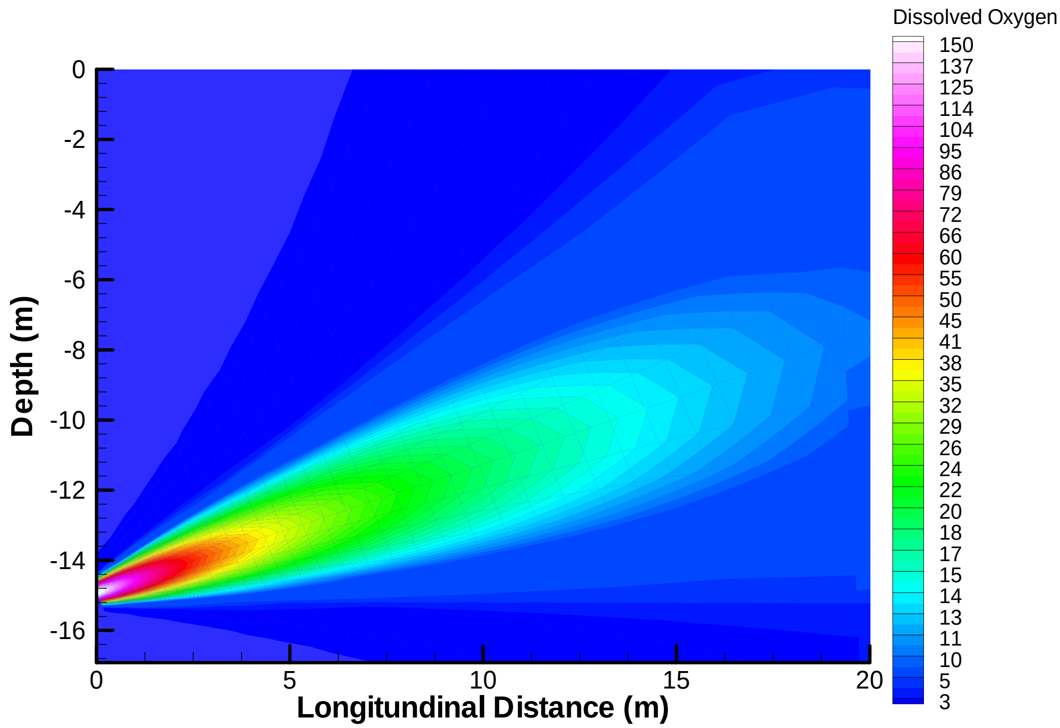

Figure 6-2 Visual Plume Model Results for Front River at International Paper

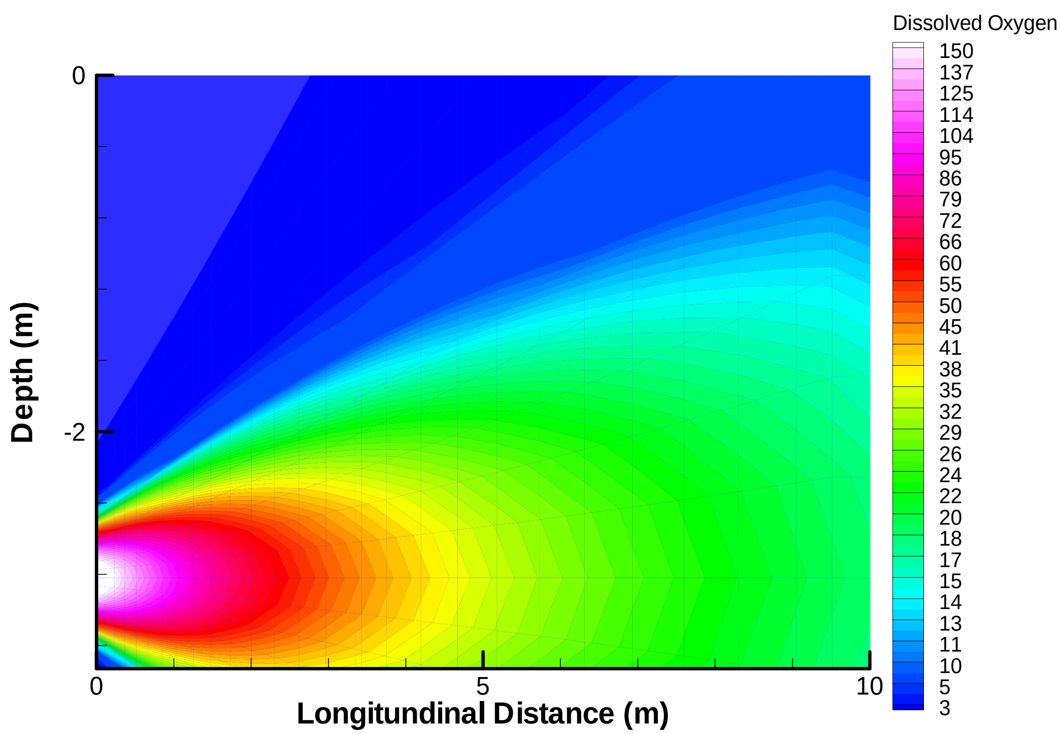

Figure 6-3 Visual Plume Model Results for Back River at International Paper

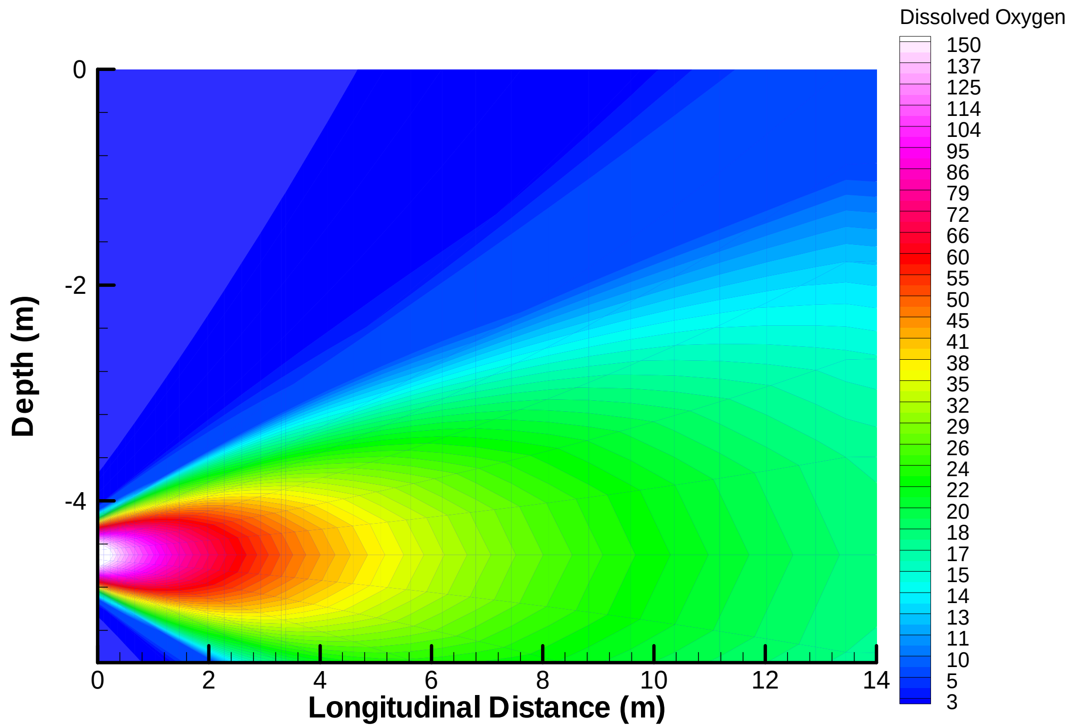

Figure 6-4 Visual Plume Model Results for Savannah River at Georgia Pacific

7.0 COST CONSIDERATIONS

This section describes cost considerations of installing and maintaining the oxygen injection systems. Capital costs include the purchasing, design, installing, and construction of the systems. Operating costs include the long-term maintenance of the systems. Tables 7-1 and 7-2 were developed to produce a cost estimate and summarize the installation and maintenance of one Speece Cone.

Table 7-1 Installation Cost Estimate of Speece Cone Land-Side Installation

Description of Work	Cost
One Speece Cone	$748,474
Design with Plans & Specs of grading, road, pad, house, & piping	$225,000
Construction (installation) of pumps, pipes, house, & cone	$342,500
Oxygen generator & compressor	$170,000
Subtotal	$1,485,974
Contingency (10%)	$148,597
TOTAL	$1,634,571

Table 7-2 Maintenance Cost Estimate of Speece Cone Land-Side Installation

Description of Work	Cost
Operating and energy cost (includes electrical, O&M, license)	$48,100
Maintenance of cone (labor of field technicians)	$43,000
TOTAL	$91,100

Therefore, the total cost of one cone is $1,634,571 (including contingency) and $91,100 per year in maintenance costs. Costs supplied by Eco2 (Eco2 2010) and previous MACTEC report (MACTEC 2008). See Appendix E for Eco2's quotation from March 17, 2010. These costs are based on generating oxygen on-site and supplying oxygen as needed. Therefore, no storage will be required.

Several assumptions were included and listed as the following:

- Above ground, land-side installation
- Oxygen generation on-site
- Speece Cone provides 5,000 lbs/day of oxygen
- Designed to consider 80% efficiency which is 4,000 lbs/day (regulators requested 80%)
- There would be a cost savings with more than one cone installed at a site (i.e., concrete pad, building, and piping may be overestimated)
- Design and construction considerations will be the elevation and soil conditions of the land, road and piping distances, and size of concrete pad
- Cones would run for approximately 180 days each year during the summer months

These costs do not include land procurement, utility installation, support building construction, or roadway construction as these are highly dependent on the sites selected. The support building would house equipment, control panels, oxygen generation equipment, and provide offseason storage of pumps, Speece Cone(s), and other equipment. Building costs will vary depending on the type (prefabricated, block, or concrete) and the finish required (some areas may have specific design requirements, i.e. brick, rock, etc.) for a specific location selected. These costs range from $150,000 to $300,000 or more. The below ground installation is more expensive because sheet piling and dewatering would be required during installation (MACTEC 2008).

8.0 CONCLUSIONS

The hydrodynamic and water quality models provided a tool to determine the amount of oxygen needed to mitigate for the deepening impacts on dissolved oxygen. With the expertise of Eco2, the designs were generated and summarized in Tables 8-1. The costs discussed in Section 7.0 were used to generate the cost at each of the three sites for each of the deepening scenarios. For each scenario, a mitigation plan (6A or 6B) was included.

Table 8-1 Summary of Dissolved Oxygen Loads and Cost (MITIGATION)

Scenario	Discharge Location	Load (kg/day)	Load (lb/day)	Cones	Cones (rounded)	Sum (kg/d)	Sum (lbs/d)	Cost at Each Site	Cost for Each Scenario
6 feet, Plan 6A	IP (FR)	7,000	15,432	3.86	4	18,000	39,683	$ 6,538,284	$ 16,345,710
	IP (BR)	2,000	4,409	1.10	1			$ 1,634,571	
	Georgia-Pacific	9,000	19,842	4.96	5			$ 8,172,855	
5 feet, Plan 6A	IP (FR)	3,000	6,614	1.65	2	16,000	35,274	$ 3,269,142	$ 14,711,139
	IP (BR)	2,000	4,409	1.10	1			$ 1,634,571	
	Georgia-Pacific	11,000	24,251	6.06	6			$ 9,807,426	
4 feet. Plan 6A	IP (FR)	2,000	4,409	1.10	1	14,000	30,865	$ 1,634,571	$ 13,076,568
	IP (BR)	2,000	4,409	1.10	1			$ 1,634,571	
	Georgia-Pacific	10,000	22,046	5.51	6			$ 9,807,426	
3 feet, Plan 6A	IP (FR)	1,000	2,205	0.55	1	13,000	28,660	$ 1,634,571	$ 13,076,568
	IP (BR)	2,000	4,409	1.10	1			$ 1,634,571	
	Georgia-Pacific	10,000	22,046	5.51	6			$ 9,807,426	
2 feet, Plan 6B	IP (FR)	1,000	2,205	0.55	1	15,000	33,069	$ 1,634,571	$ 14,711,139
	IP (BR)	4,000	8,818	2.20	2			$ 3,269,142	
	Georgia-Pacific	10,000	22,046	5.51	6			$ 9,807,426	

*Three bottom layer criteria (3BL) were used to generate final results.

The costs for operating the dissolved oxygen injection systems are based on their continued operation for a period of 180 days per year. The operational costs are assumed to be uniform throughout that 180-day period. The operating costs would be less if the systems were operated for a shorter duration.

9.0 REFERENCES

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APPENDICES

APPENDIX A

DISSOLVED OXYGEN REGIME OF SAVANNAH ESTUARY: AUGUST 1997 (AVERAGE FLOW), ALTERNATIVE DEEPENING WITH MITIGATION PLANS 6A AND 6B, NO D.O. INJECTION

TABLES AND FIGURES

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Table A-1 Delta (Project – Existing) D.O. Percentiles for Critical Cells: Plan 6a, 6 ft deepening, No injections

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	0.02	0.5	0.02	0.5	0.01	0.2	0	0.0	-0.03	-0.7	-0.05	-1.1	-0.09	-1.9	-0.11	-2.3	-0.1	-2.1
FR2	-0.06	-1.6	0.26	6.9	0.4	10.4	0.44	10.9	0.4	9.5	0.38	8.6	0.28	6.1	0.4	8.5	0.23	4.5
FR3	0.12	3.4	0.07	1.9	0.06	1.6	0.06	1.6	-0.03	-0.7	-0.13	-3.0	-0.25	-5.2	-0.11	-2.2	-0.24	-4.3
FR4	0.12	3.4	0.1	2.8	0.1	2.8	0.01	0.3	-0.02	-0.5	-0.16	-3.6	-0.38	-7.7	-0.31	-5.8	-0.03	-0.5
FR5	0.12	3.3	0.04	1.1	-0.04	-1.0	-0.06	-1.5	-0.16	-3.7	-0.61	-12.5	-0.75	-13.8	-0.79	-14.0	-0.75	-13.0
FR6	0.03	0.8	0.05	1.3	0	0.0	-0.06	-1.5	-0.08	-1.9	-0.45	-9.4	-0.83	-14.9	-0.84	-14.6	-0.76	-12.9
FR7	-0.18	-4.3	-0.13	-3.1	-0.14	-3.2	-0.29	-6.3	-0.54	-10.7	-1.11	-18.6	-0.65	-10.4	-0.31	-4.9	-0.19	-2.9
FR8	-0.3	-6.4	-0.3	-6.3	-0.42	-8.3	-0.62	-11.3	-0.4	-6.5	-0.12	-1.9	-0.15	-2.2	-0.13	-1.9	-0.27	-3.8
FR9	0.24	4.9	0.46	9.1	0.31	5.8	0.26	4.5	0.06	1.0	0.02	0.3	0.06	0.9	0.12	1.7	0.3	4.2
FR10	0.38	8.8	0.26	5.4	0.29	5.9	0.23	4.3	-0.01	-0.2	-0.1	-1.6	-0.09	-1.3	-0.16	-2.3	-0.06	-0.8
FR11	-1.46	-35.0	-1.99	-42.3	-2.21	-44.8	-2.5	-47.7	-2.89	-51.0	-3.25	-52.9	-3.47	-53.4	-3.53	-53.2	-3.95	-55.4
MR1	-0.23	-5.2	-0.21	-4.6	-0.21	-4.5	-0.25	-5.1	-0.26	-5.0	-0.44	-7.9	-0.46	-7.8	-0.46	-7.7	-0.25	-4.0
MR2	0.19	4.7	0.2	4.8	0.14	3.2	0.08	1.7	-0.12	-2.4	-0.33	-6.0	-0.29	-5.0	-0.29	-4.9	-0.29	-4.8
MR3	0.49	13.2	0.45	11.6	0.44	11.0	0.42	10.0	0.42	9.3	0.08	1.6	-0.33	-5.8	-0.37	-6.2	-0.41	-6.6
MR4	0.46	11.8	0.41	10.2	0.45	10.9	0.37	8.4	0.44	9.5	0.43	8.8	0.53	10.5	0.52	10.0	0.58	10.7
MR5	0.71	47.7	0.73	35.8	0.71	29.5	0.82	26.9	0.39	7.8	-0.03	-0.5	-0.05	-0.8	-0.11	-1.6	-0.08	-1.1
MR6	0.53	25.1	0.16	6.4	-0.35	-11.6	-0.81	-23.1	-2.8	-49.9	-3.34	-52.5	-3.54	-52.1	-3.67	-52.0	-3.83	-52.3
LBR1	0.5	14.0	0.47	10.8	0.35	7.4	0.37	7.2	0.37	6.8	0.46	8.2	0.35	5.9	0.38	6.2	0.23	3.6
LBR2	0.6	16.3	0.71	18.4	0.72	18.1	0.77	18.5	0.76	17.3	0.79	17.2	0.79	16.6	0.82	16.8	0.55	10.5
LBR3	-0.38	-13.1	-0.62	-18.9	-0.67	-19.3	-0.66	-17.9	-0.65	-16.5	-0.7	-16.1	-0.91	-19.2	-1.08	-21.6	-1.18	-22.5
BR1	-1.42	-41.2	-0.86	-24.4	-0.43	-12.0	-0.09	-2.3	0.25	6.2	0.39	9.2	0.25	5.5	0.23	5.0	0.27	5.8
BR2	-0.93	-36.5	-0.86	-30.3	-0.81	-27.1	-0.67	-20.7	-0.4	-11.6	-0.07	-1.9	0.09	2.3	0.09	2.3	0.11	2.7
BR3	-1.23	-40.6	-1.23	-37.7	-1.3	-37.8	-1.32	-36.5	-1.23	-32.5	-0.93	-23.5	-0.61	-15.0	-0.55	-13.3	-0.43	-10.1
SCH1	-0.15	-6.3	-0.04	-1.6	0.01	0.4	0.03	1.1	0.15	5.0	0.54	15.8	0.47	12.5	0.53	13.6	0.46	11.1
SCH2	-0.04	-1.1	-0.11	-2.8	-0.1	-2.5	-0.02	-0.5	-0.05	-1.2	-0.06	-1.3	-0.07	-1.5	-0.08	-1.7	-0.13	-2.7
SR	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2
StbR	-0.16	-4.2	0.09	2.1	-0.04	-0.9	0.03	0.6	-0.07	-1.2	-0.19	-3.1	-0.19	-2.9	-0.25	-3.8	-0.22	-3.2

Table A-2 Delta (Project – Existing) D.O. Percentiles for Critical Cells: Plan 6a, 5 ft deepening, No injections

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	0.01	0.3	0	0.0	0	0.0	-0.02	-0.5	-0.04	-0.9	-0.04	-0.9	-0.07	-1.5	-0.1	-2.1	-0.09	-1.9
FR2	-0.14	-3.8	0.2	5.3	0.38	9.9	0.44	10.9	0.39	9.2	0.38	8.6	0.3	6.5	0.41	8.7	0.23	4.5
FR3	0.12	3.4	0.07	1.9	0.06	1.6	0.04	1.0	-0.01	-0.2	-0.07	-1.6	-0.2	-4.2	0.02	0.4	-0.13	-2.3
FR4	0.11	3.1	0.1	2.8	0.08	2.2	0	0.0	-0.04	-1.0	-0.2	-4.5	-0.36	-7.3	-0.29	-5.5	0.03	0.5
FR5	0.11	3.0	0.04	1.1	-0.01	-0.3	-0.03	-0.7	-0.13	-3.0	-0.51	-10.4	-0.59	-10.9	-0.56	-9.9	-0.5	-8.7
FR6	0.03	0.8	0.07	1.9	0	0.0	-0.05	-1.2	-0.07	-1.6	-0.4	-8.4	-0.71	-12.7	-0.62	-10.7	-0.57	-9.6
FR7	0.23	5.5	0.28	6.6	0.32	7.4	0.28	6.1	0.42	8.3	-0.05	-0.8	0.05	0.8	0.19	3.0	0.63	9.7
FR8	-0.27	-5.8	-0.26	-5.4	-0.38	-7.5	-0.54	-9.8	-0.27	-4.4	-0.06	-0.9	-0.11	-1.6	-0.12	-1.8	-0.23	-3.2
FR9	0.03	0.6	0.29	5.8	0.15	2.8	0.25	4.4	0.1	1.6	0.09	1.4	0.17	2.5	0.18	2.6	0.17	2.4
FR10	0.38	8.8	0.26	5.4	0.28	5.7	0.23	4.3	-0.02	-0.3	-0.11	-1.7	-0.08	-1.2	-0.16	-2.3	-0.06	-0.8
FR11	-1.46	-35.0	-1.99	-42.3	-2.21	-44.8	-2.5	-47.7	-2.89	-51.0	-3.25	-52.9	-3.47	-53.4	-3.53	-53.2	-3.95	-55.4
MR1	-0.21	-4.8	-0.19	-4.2	-0.19	-4.1	-0.23	-4.7	-0.22	-4.3	-0.42	-7.5	-0.42	-7.1	-0.34	-5.7	-0.23	-3.7
MR2	0.19	4.7	0.21	5.1	0.16	3.7	0.09	1.9	-0.09	-1.8	-0.29	-5.2	-0.25	-4.3	-0.22	-3.7	-0.25	-4.1
MR3	0.49	13.2	0.47	12.1	0.44	11.0	0.45	10.7	0.42	9.3	0.12	2.4	-0.3	-5.3	-0.33	-5.6	-0.36	-5.8
MR4	0.47	12.1	0.42	10.4	0.47	11.4	0.38	8.7	0.45	9.8	0.41	8.4	0.53	10.5	0.51	9.8	0.58	10.7
MR5	0.71	47.7	0.74	36.3	0.71	29.5	0.81	26.6	0.39	7.8	-0.04	-0.6	-0.04	-0.6	-0.11	-1.6	-0.08	-1.1
MR6	0.53	25.1	0.16	6.4	-0.35	-11.6	-0.81	-23.1	-2.8	-49.9	-3.34	-52.5	-3.54	-52.1	-3.67	-52.0	-3.83	-52.3
LBR1	0.49	13.7	0.47	10.8	0.37	7.8	0.36	7.0	0.37	6.8	0.46	8.2	0.35	5.9	0.39	6.3	0.23	3.6
LBR2	0.79	21.4	0.71	18.4	0.72	18.1	0.76	18.3	0.75	17.1	0.78	17.0	0.79	16.6	0.8	16.4	0.55	10.5
LBR3	-0.35	-12.1	-0.61	-18.6	-0.65	-18.7	-0.64	-17.4	-0.63	-15.9	-0.71	-16.4	-0.91	-19.2	-1.1	-22.0	-1.22	-23.3
BR1	-1.53	-44.3	-1.01	-28.7	-0.54	-15.0	-0.11	-2.8	0.22	5.5	0.37	8.7	0.26	5.7	0.24	5.2	0.29	6.2
BR2	-0.96	-37.6	-1.04	-36.6	-1.01	-33.8	-0.88	-27.2	-0.68	-19.8	-0.64	-17.3	-0.52	-13.5	-0.52	-13.2	-0.47	-11.7
BR3	-1.31	-43.2	-1.31	-40.2	-1.39	-40.4	-1.4	-38.7	-1.31	-34.7	-1.03	-26.1	-0.68	-16.7	-0.62	-14.9	-0.51	-12.0
SCH1	-0.09	-3.8	-0.1	-3.9	0	0.0	0.08	2.8	0.04	1.3	-0.13	-3.8	-0.13	-3.4	-0.11	-2.8	-0.23	-5.6
SCH2	-0.06	-1.6	-0.11	-2.8	-0.09	-2.2	-0.05	-1.2	-0.05	-1.2	-0.04	-0.9	-0.05	-1.1	-0.07	-1.5	-0.06	-1.2
SR	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2
StbR	-0.09	-2.3	0.08	1.9	0.02	0.4	0.07	1.4	-0.02	-0.4	-0.15	-2.4	-0.17	-2.6	-0.19	-2.9	-0.18	-2.6

Table A-3 Delta (Project – Existing) D.O. Percentiles for Critical Cells: Plan 6a, 4 ft deepening, No injections

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	-0.02	-0.5	-0.03	-0.7	-0.01	-0.2	-0.05	-1.1	-0.03	-0.7	-0.04	-0.9	-0.06	-1.3	-0.06	-1.3
FR2	-0.16	-4.4	0.19	5.1	0.37	9.6	0.43	10.7	0.4	9.5	0.4	9.1	0.31	6.7	0.42	9.0	0.24	4.7
FR3	0.1	2.9	0.05	1.4	0.04	1.1	0.06	1.6	0	0.0	-0.06	-1.4	-0.13	-2.7	0.09	1.8	-0.08	-1.4
FR4	0.09	2.6	0.08	2.2	0.08	2.2	0.01	0.3	-0.01	-0.2	-0.17	-3.9	-0.31	-6.2	-0.19	-3.6	0.1	1.8
FR5	0.1	2.8	0.01	0.3	-0.07	-1.8	-0.06	-1.5	-0.17	-3.9	-0.59	-12.1	-0.6	-11.1	-0.6	-10.7	-0.57	-9.9
FR6	0.05	1.4	0.07	1.9	0.01	0.3	-0.04	-1.0	-0.05	-1.2	-0.38	-7.9	-0.57	-10.2	-0.44	-7.6	-0.43	-7.3
FR7	0.51	12.2	0.58	13.6	0.7	16.2	0.73	15.8	0.82	16.3	0.31	5.2	0.27	4.3	0.4	6.3	0.63	9.7
FR8	-0.22	-4.7	-0.22	-4.6	-0.31	-6.1	-0.48	-8.7	-0.18	-2.9	-0.04	-0.6	-0.07	-1.0	-0.09	-1.3	-0.22	-3.1
FR9	-0.28	-5.7	-0.35	-7.0	-0.47	-8.8	-0.6	-10.5	-0.4	-6.4	-0.22	-3.3	-0.19	-2.8	-0.27	-3.8	-0.18	-2.5
FR10	0.38	8.8	0.26	5.4	0.27	5.5	0.24	4.5	-0.01	-0.2	-0.12	-1.9	-0.08	-1.2	-0.15	-2.1	-0.07	-1.0
FR11	-1.46	-35.0	-1.99	-42.3	-2.21	-44.8	-2.5	-47.7	-2.89	-51.0	-3.25	-52.9	-3.47	-53.4	-3.53	-53.2	-3.95	-55.4
MR1	-0.17	-3.9	-0.16	-3.5	-0.14	-3.0	-0.2	-4.1	-0.19	-3.7	-0.37	-6.6	-0.32	-5.4	-0.27	-4.5	-0.12	-1.9
MR2	0.21	5.2	0.23	5.5	0.16	3.7	0.1	2.2	-0.06	-1.2	-0.26	-4.7	-0.22	-3.8	-0.18	-3.1	-0.2	-3.3
MR3	0.52	14.1	0.41	10.5	0.43	10.8	0.47	11.2	0.39	8.6	0.06	1.2	-0.37	-6.5	-0.47	-7.9	-0.48	-7.8
MR4	0.47	12.1	0.42	10.4	0.47	11.4	0.39	8.9	0.45	9.8	0.45	9.2	0.51	10.1	0.51	9.8	0.57	10.5
MR5	0.71	47.7	0.74	36.3	0.71	29.5	0.81	26.6	0.38	7.6	-0.03	-0.5	-0.04	-0.6	-0.11	-1.6	-0.07	-1.0
MR6	0.53	25.1	0.16	6.4	-0.35	-11.6	-0.81	-23.1	-2.8	-49.9	-3.34	-52.5	-3.54	-52.1	-3.67	-52.0	-3.83	-52.3
LBR1	0.46	12.9	0.46	10.6	0.38	8.0	0.36	7.0	0.37	6.8	0.46	8.2	0.35	5.9	0.39	6.3	0.21	3.2
LBR2	0	0.0	0.7	18.1	0.71	17.9	0.77	18.5	0.75	17.1	0.78	17.0	0.78	16.4	0.8	16.4	0.54	10.3
LBR3	-0.3	-10.4	-0.6	-18.3	-0.63	-18.2	-0.62	-16.8	-0.62	-15.7	-0.7	-16.1	-0.92	-19.5	-1.1	-22.0	-1.2	-22.9
BR1	-1.63	-47.2	-1.18	-33.5	-0.61	-17.0	-0.16	-4.1	0.21	5.2	0.38	9.0	0.26	5.7	0.24	5.2	0.29	6.2
BR2	-1.14	-44.7	-1.05	-37.0	-1	-33.4	-0.82	-25.3	-0.51	-14.8	-0.15	-4.1	0.02	0.5	0.06	1.5	0.13	3.2
BR3	-1.41	-46.5	-1.41	-43.3	-1.45	-42.2	-1.46	-40.3	-1.37	-36.2	-1.13	-28.6	-0.74	-18.1	-0.66	-15.9	-0.59	-13.9
SCH1	-0.11	-4.6	-0.1	-3.9	0.02	0.7	0.07	2.5	0.04	1.3	-0.13	-3.8	-0.16	-4.2	-0.09	-2.3	-0.14	-3.4
SCH2	-0.04	-1.1	-0.05	-1.3	-0.06	-1.5	-0.05	-1.2	-0.06	-1.4	-0.07	-1.6	-0.06	-1.3	-0.06	-1.3	-0.05	-1.0
SR	-0.01	-0.2	0	0.0	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2
StbR	-0.02	-0.5	0.1	2.4	0.07	1.5	0.11	2.2	-0.02	-0.4	-0.09	-1.5	-0.13	-2.0	-0.15	-2.3	-0.19	-2.8

Table A-4 Delta (Project – Existing) D.O. Percentiles for Critical Cells: Plan 6a, 3 ft deepening, No injections

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	0.01	0.3	-0.01	-0.3	-0.02	-0.5	-0.02	-0.5	-0.04	-0.9	-0.02	-0.4	-0.02	-0.4	-0.06	-1.3	-0.03	-0.6
FR2	-0.15	-4.1	0.19	5.1	0.38	9.9	0.43	10.7	0.4	9.5	0.41	9.3	0.31	6.7	0.43	9.2	0.23	4.5
FR3	0.1	2.9	0.05	1.4	0.05	1.4	0.08	2.1	0.03	0.7	0.01	0.2	-0.1	-2.1	0.13	2.6	-0.05	-0.9
FR4	0.1	2.9	0.08	2.2	0.07	1.9	0.05	1.3	0.01	0.2	-0.11	-2.5	-0.2	-4.0	-0.08	-1.5	0.11	2.0
FR5	0.1	2.8	0.03	0.8	-0.03	-0.8	-0.02	-0.5	-0.11	-2.6	-0.51	-10.4	-0.41	-7.6	-0.36	-6.4	-0.31	-5.4
FR6	0.07	1.9	0.08	2.1	0.02	0.5	0	0.0	-0.02	-0.5	-0.31	-6.5	-0.39	-7.0	-0.29	-5.0	-0.28	-4.7
FR7	-0.11	-2.6	-0.07	-1.6	-0.1	-2.3	-0.2	-4.3	-0.37	-7.4	-0.6	-10.0	-0.21	-3.4	-0.15	-2.4	-0.1	-1.5
FR8	-0.19	-4.1	-0.22	-4.6	-0.34	-6.7	-0.48	-8.7	-0.25	-4.1	-0.18	-2.8	-0.21	-3.1	-0.19	-2.8	-0.25	-3.5
FR9	-0.23	-4.7	-0.3	-6.0	-0.41	-7.7	-0.49	-8.6	-0.31	-4.9	-0.17	-2.6	-0.17	-2.5	-0.26	-3.7	-0.18	-2.5
FR10	0.38	8.8	0.26	5.4	0.27	5.5	0.23	4.3	-0.01	-0.2	-0.12	-1.9	-0.08	-1.2	-0.16	-2.3	-0.07	-1.0
FR11	-1.46	-35.0	-1.99	-42.3	-2.21	-44.8	-2.5	-47.7	-2.89	-51.0	-3.25	-52.9	-3.47	-53.4	-3.53	-53.2	-3.95	-55.4
MR1	-0.13	-2.9	-0.13	-2.9	-0.09	-1.9	-0.15	-3.1	-0.14	-2.7	-0.3	-5.4	-0.21	-3.6	-0.18	-3.0	-0.08	-1.3
MR2	0.21	5.2	0.24	5.8	0.18	4.2	0.11	2.4	-0.05	-1.0	-0.2	-3.6	-0.17	-2.9	-0.1	-1.7	-0.13	-2.2
MR3	0.52	14.1	0.5	12.9	0.47	11.8	0.49	11.7	0.43	9.5	0.15	3.0	-0.22	-3.9	-0.25	-4.2	-0.3	-4.8
MR4	0.5	12.9	0.43	10.7	0.48	11.7	0.39	8.9	0.44	9.5	0.41	8.4	0.51	10.1	0.5	9.7	0.56	10.4
MR5	0.72	48.3	0.76	37.3	0.7	29.0	0.79	25.9	0.38	7.6	-0.04	-0.6	-0.05	-0.8	-0.11	-1.6	-0.07	-1.0
MR6	0.53	25.1	0.16	6.4	-0.35	-11.6	-0.81	-23.1	-2.8	-49.9	-3.34	-52.5	-3.54	-52.1	-3.67	-52.0	-3.83	-52.3
LBR1	0.44	12.3	0.47	10.8	0.39	8.2	0.35	6.8	0.35	6.4	0.45	8.0	0.34	5.7	0.37	6.0	0.2	3.1
LBR2	0.79	21.4	0.73	18.9	0.73	18.4	0.76	18.3	0.75	17.1	0.79	17.2	0.79	16.6	0.82	16.8	1.22	23.2
LBR3	-0.3	-10.4	-0.58	-17.7	-0.61	-17.6	-0.61	-16.6	-0.6	-15.2	-0.7	-16.1	-0.91	-19.2	-1.09	-21.8	-1.2	-22.9
BR1	-1.76	-51.0	-1.32	-37.5	-0.77	-21.4	-0.21	-5.4	0.23	5.7	0.37	8.7	0.27	5.9	0.25	5.4	0.31	6.6
BR2	-1.26	-49.4	-1.31	-46.1	-1.25	-41.8	-1.02	-31.5	-0.79	-23.0	-0.74	-20.0	-0.64	-16.7	-0.63	-16.0	-0.57	-14.1
BR3	-1.55	-51.2	-1.51	-46.3	-1.57	-45.6	-1.54	-42.5	-1.44	-38.1	-1.21	-30.6	-0.8	-19.6	-0.74	-17.8	-0.61	-14.4
SCH1	-0.17	-7.1	0	0.0	0	0.0	0.04	1.4	0.2	6.6	0.62	18.2	0.56	14.9	0.56	14.4	0.47	11.4
SCH2	0	0.0	-0.06	-1.5	-0.03	-0.7	-0.04	-1.0	-0.04	-0.9	-0.04	-0.9	-0.05	-1.1	-0.04	-0.9	-0.04	-0.8
SR	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	0	0.0	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2
StbR	0.11	2.9	0.14	3.3	0.12	2.6	0.13	2.6	-0.01	-0.2	-0.07	-1.1	-0.11	-1.7	-0.11	-1.7	-0.12	-1.8

Table A-5 Delta (Project – Existing) D.O. Percentiles for Critical Cells: Plan 6b, 2 ft deepening, No injections

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	-0.02	-0.5	-0.03	-0.8	-0.05	-1.2	-0.03	-0.7	-0.04	-0.9	0	0.0	-0.02	-0.4	-0.03	-0.6	-0.01	-0.2
FR2	-0.25	-6.8	0.12	3.2	0.28	7.3	0.41	10.2	0.38	9.0	0.41	9.3	0.35	7.6	0.45	9.6	0.26	5.1
FR3	0.09	2.6	0.02	0.6	0.05	1.4	0.07	1.8	0.03	0.7	0.03	0.7	0.07	1.5	0.18	3.6	0	0.0
FR4	0.07	2.0	0.06	1.7	0.06	1.7	0.03	0.8	0.03	0.7	-0.06	-1.4	-0.13	-2.6	-0.09	-1.7	0.03	0.5
FR5	0.08	2.2	0	0.0	-0.09	-2.3	-0.05	-1.2	-0.15	-3.5	-0.5	-10.2	-0.35	-6.5	-0.28	-5.0	-0.23	-4.0
FR6	0.06	1.6	0.08	2.1	0.02	0.5	0	0.0	0	0.0	-0.25	-5.2	-0.25	-4.5	-0.18	-3.1	-0.19	-3.2
FR7	0.38	9.1	0.4	9.4	0.47	10.9	0.45	9.8	0.58	11.5	0.13	2.2	0.12	1.9	0.17	2.7	0.54	8.3
FR8	-0.14	-3.0	-0.17	-3.6	-0.28	-5.5	-0.4	-7.3	-0.16	-2.6	-0.12	-1.9	-0.18	-2.7	-0.17	-2.5	-0.22	-3.1
FR9	0.28	5.7	0.61	12.1	0.47	8.8	0.44	7.7	0.18	2.9	0.15	2.3	0.21	3.1	0.16	2.3	0.16	2.2
FR10	0.3	7.0	0.23	4.8	0.19	3.8	0.16	3.0	-0.05	-0.8	-0.17	-2.6	-0.1	-1.5	-0.24	-3.4	-0.09	-1.2
FR11	-1.46	-35.0	-1.99	-42.3	-2.21	-44.8	-2.5	-47.7	-2.89	-51.0	-3.25	-52.9	-3.47	-53.4	-3.53	-53.2	-3.95	-55.4
MR1	-0.1	-2.3	-0.1	-2.2	-0.05	-1.1	-0.13	-2.7	-0.13	-2.5	-0.27	-4.8	-0.15	-2.5	-0.09	-1.5	-0.04	-0.6
MR2	0.16	4.0	0.17	4.1	0.07	1.6	0.02	0.4	-0.13	-2.6	-0.21	-3.8	-0.11	-1.9	-0.09	-1.5	-0.09	-1.5
MR3	0.41	11.1	0.32	8.2	0.34	8.5	0.32	7.6	0.28	6.2	0.01	0.2	-0.43	-7.5	-0.45	-7.6	-0.47	-7.6
MR4	-0.05	-1.3	0.65	16.1	0.79	19.2	0.82	18.7	0.86	18.7	0.88	18.0	1	19.8	1.07	20.7	1.31	24.2
MR5	-0.09	-6.0	-0.48	-23.5	-0.59	-24.5	-0.5	-16.4	0.04	0.8	-0.12	-1.9	-0.12	-1.8	-0.17	-2.5	-0.13	-1.8
MR6	3.32	157.3	3.37	135.3	3.16	105.0	3.03	86.3	1.19	21.2	0.79	12.4	0.58	8.5	0.41	5.8	0.25	3.4
LBR1	-0.39	-10.9	-0.14	-3.2	0.08	1.7	0.13	2.5	0.07	1.3	0.16	2.8	0.11	1.8	0.13	2.1	0.05	0.8
LBR2	0.14	3.8	0.26	6.7	0.24	6.0	0.25	6.0	0.25	5.7	0.27	5.9	0.25	5.2	0.3	6.1	0.43	8.2
LBR3	-1.13	-39.1	-1.32	-40.2	-1.4	-40.3	-1.29	-35.1	-1.21	-30.6	-1.25	-28.8	-1.43	-30.2	-1.56	-31.3	-1.71	-32.6
BR1	-2.32	-67.2	-1.76	-50.0	-1.04	-29.0	-0.37	-9.5	0.17	4.2	0.36	8.5	0.27	5.9	0.26	5.6	0.32	6.8
BR2	-1.93	-75.7	-1.95	-68.7	-1.83	-61.2	-1.41	-43.5	-1.06	-30.8	-1.02	-27.6	-0.87	-22.7	-0.82	-20.9	-0.75	-18.6
BR3	-2.22	-73.3	-2.19	-67.2	-2.21	-64.2	-2.14	-59.1	-2.03	-53.7	-1.57	-39.7	-1.08	-26.5	-0.97	-23.4	-0.87	-20.5
SCH1	-0.06	-2.5	-0.06	-2.3	0	0.0	0.02	0.7	0.04	1.3	-0.11	-3.2	-0.11	-2.9	-0.07	-1.8	-0.14	-3.4
SCH2	0	0.0	-0.04	-1.0	-0.04	-1.0	-0.04	-1.0	-0.04	-0.9	-0.04	-0.9	-0.04	-0.9	-0.04	-0.9	-0.01	-0.2
SR	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	0	0.0	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2
StbR	0.23	6.0	0.26	6.2	0.17	3.7	0.18	3.6	0.02	0.4	-0.06	-1.0	-0.07	-1.1	-0.07	-1.1	-0.06	-0.9

Table A-6 Delta (Project – Existing) D.O. Percentiles for Zones' Averages: Plan 6a, 6 ft deepening, No injections

Zone Name	Project - Baseline Difference (mg/l)									Project - Baseline Relative Difference (%)								
	1%	5%	10%	25%	50%	75%	90%	95%	99%	1%	5%	10%	25%	50%	75%	90%	95%	99%
FR1	-0.05	-0.07	-0.07	-0.04	-0.07	-0.09	-0.13	-0.11	-0.13	-1.2	-1.6	-1.7	-0.9	-1.5	-1.9	-2.6	-2.3	-2.5
FR2	0.03	-0.02	-0.04	-0.03	-0.07	-0.09	-0.14	-0.14	-0.14	0.7	-0.5	-1.0	-0.7	-1.6	-1.9	-2.8	-2.9	-2.8
FR3	-0.08	-0.07	-0.06	-0.08	-0.10	-0.16	-0.26	-0.39	-0.52	-2.0	-1.6	-1.4	-1.8	-2.1	-3.3	-5.3	-7.6	-9.9
FR4	-0.11	-0.10	-0.12	-0.12	-0.20	-0.37	-0.56	-0.71	-0.77	-2.6	-2.4	-2.9	-2.8	-4.4	-7.6	-10.7	-12.6	-13.1
FR5	-0.11	-0.15	-0.15	-0.19	-0.30	-0.52	-0.75	-0.71	-0.63	-2.7	-3.5	-3.5	-4.2	-6.3	-10.0	-13.2	-12.0	-10.4
FR6	-0.15	-0.19	-0.27	-0.32	-0.52	-0.74	-0.82	-0.57	-0.48	-3.6	-4.4	-6.0	-6.9	-10.3	-13.2	-13.6	-9.4	-7.8
FR7	-0.28	-0.36	-0.42	-0.53	-0.69	-0.45	-0.38	-0.37	-0.38	-6.0	-7.4	-8.4	-10.0	-11.5	-7.1	-5.8	-5.5	-5.5
FR8	-0.40	-0.54	-0.54	-0.60	-0.49	-0.29	-0.26	-0.35	-0.33	-7.8	-10.0	-9.8	-10.2	-7.7	-4.3	-3.8	-4.9	-4.6
FR9	-0.56	-0.50	-0.50	-0.37	-0.23	-0.19	-0.23	-0.19	-0.16	-9.7	-8.3	-8.1	-5.8	-3.5	-2.7	-3.1	-2.6	-2.2
FR10	-0.21	-0.09	-0.10	-0.12	-0.10	-0.08	-0.07	-0.07	-0.08	-3.6	-1.6	-1.6	-1.8	-1.5	-1.2	-0.9	-1.0	-1.0
FR11	-0.42	-0.40	-0.41	-0.44	-0.47	-0.46	-0.52	-0.51	-0.48	-7.3	-6.8	-6.9	-7.0	-7.1	-6.7	-7.1	-7.1	-6.5
MR1	-0.27	-0.28	-0.28	-0.30	-0.33	-0.45	-0.40	-0.39	-0.34	-5.6	-5.8	-5.6	-5.7	-6.0	-7.6	-6.7	-6.3	-5.5
MR2	-0.02	-0.04	-0.09	-0.15	-0.24	-0.40	-0.40	-0.39	-0.27	-0.4	-0.8	-1.7	-2.8	-4.3	-6.8	-6.5	-6.4	-4.3
MR3	0.24	0.16	0.14	0.12	0.05	-0.14	-0.31	-0.31	-0.36	5.3	3.4	3.0	2.4	1.0	-2.5	-5.1	-5.0	-5.7
MR4	0.13	0.06	0.13	0.18	0.16	0.17	0.21	0.29	0.30	2.6	1.2	2.5	3.2	2.8	2.9	3.5	4.7	4.8
MR5	0.04	0.14	0.15	0.14	0.03	-0.05	-0.07	-0.15	-0.07	1.1	3.1	3.2	2.8	0.6	-0.7	-1.0	-2.2	-0.9
MR6	-0.16	-0.25	-0.34	-0.44	-0.89	-1.16	-1.41	-1.48	-1.64	-3.8	-5.6	-7.1	-8.6	-15.1	-17.9	-20.2	-20.8	-22.3
LBR1	0.14	0.16	0.22	0.21	0.25	0.30	0.35	0.41	0.41	3.0	3.3	4.2	4.0	4.5	5.3	5.9	6.9	6.8
LBR2	0.33	0.29	0.28	0.35	0.36	0.37	0.46	0.45	0.43	7.5	6.4	6.1	7.2	7.0	7.0	8.6	8.3	7.8
LBR3	-0.28	-0.18	-0.14	-0.13	-0.09	0.01	0.10	0.14	0.23	-6.7	-4.4	-3.3	-2.9	-2.0	0.3	2.1	2.8	4.6
BR1	-0.86	-0.46	-0.28	-0.07	0.12	0.12	0.11	0.08	0.09	-23.1	-12.0	-7.0	-1.7	2.7	2.7	2.4	1.7	1.9
BR2	-1.08	-1.04	-1.01	-0.94	-0.63	-0.13	-0.05	-0.18	-0.12	-29.9	-28.3	-27.0	-24.5	-15.7	-3.0	-1.1	-4.0	-2.6
BR3	-1.07	-1.02	-1.00	-0.94	-0.94	-0.86	-0.72	-0.62	-0.63	-28.1	-26.8	-26.1	-24.0	-23.2	-20.5	-16.8	-14.3	-14.2
SCh1	-0.22	-0.20	-0.19	-0.14	-0.14	-0.18	-0.21	-0.21	-0.21	-5.2	-4.7	-4.5	-3.3	-3.2	-4.1	-4.5	-4.4	-4.3
SCh2	-0.17	-0.13	-0.16	-0.13	-0.13	-0.17	-0.19	-0.17	-0.23	-3.9	-3.0	-3.5	-2.9	-2.7	-3.4	-3.8	-3.4	-4.5
SR	-0.15	-0.15	-0.15	-0.16	-0.15	-0.13	-0.18	-0.17	-0.18	-2.5	-2.6	-2.4	-2.4	-2.1	-1.9	-2.4	-2.3	-2.3
StbR	-0.21	-0.14	-0.18	-0.22	-0.22	-0.25	-0.28	-0.35	-0.43	-3.9	-2.6	-3.3	-3.9	-3.6	-4.0	-4.3	-5.3	-6.4

Table A-7 Delta (Project – Existing) D.O. Percentiles for Zones' Averages: Plan 6a, 5 ft deepening, No injections

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	-0.06	-0.09	-0.07	-0.05	-0.08	-0.10	-0.12	-0.10	-0.12	-1.4	-2.0	-1.6	-1.2	-1.7	-2.0	-2.5	-2.1	-2.5
FR2	0.02	-0.03	-0.04	-0.03	-0.08	-0.08	-0.12	-0.14	-0.14	0.5	-0.7	-0.9	-0.7	-1.7	-1.6	-2.5	-2.8	-2.8
FR3	-0.08	-0.07	-0.06	-0.09	-0.10	-0.15	-0.23	-0.36	-0.49	-2.1	-1.8	-1.6	-2.1	-2.2	-3.3	-4.7	-7.1	-9.3
FR4	-0.11	-0.10	-0.12	-0.12	-0.20	-0.35	-0.50	-0.63	-0.63	-2.8	-2.5	-2.9	-2.8	-4.4	-7.2	-9.5	-11.2	-10.7
FR5	-0.11	-0.15	-0.15	-0.18	-0.28	-0.48	-0.64	-0.57	-0.50	-2.6	-3.5	-3.3	-4.0	-6.0	-9.3	-11.3	-9.7	-8.3
FR6	-0.14	-0.19	-0.27	-0.30	-0.49	-0.66	-0.67	-0.46	-0.37	-3.4	-4.3	-5.9	-6.5	-9.6	-11.9	-11.2	-7.5	-5.9
FR7	-0.26	-0.33	-0.38	-0.48	-0.61	-0.37	-0.33	-0.34	-0.38	-5.6	-6.8	-7.7	-9.1	-10.2	-5.9	-5.1	-5.1	-5.5
FR8	-0.36	-0.49	-0.51	-0.56	-0.38	-0.25	-0.24	-0.32	-0.25	-7.0	-9.1	-9.2	-9.5	-6.0	-3.8	-3.5	-4.5	-3.4
FR9	-0.49	-0.42	-0.42	-0.31	-0.20	-0.17	-0.20	-0.16	-0.13	-8.5	-7.0	-6.9	-4.8	-3.0	-2.5	-2.8	-2.1	-1.7
FR10	-0.22	-0.09	-0.10	-0.12	-0.10	-0.08	-0.05	-0.06	-0.07	-3.6	-1.6	-1.6	-1.8	-1.5	-1.2	-0.7	-0.8	-1.0
FR11	-0.42	-0.40	-0.41	-0.45	-0.47	-0.46	-0.52	-0.51	-0.48	-7.3	-6.8	-6.8	-7.0	-7.1	-6.7	-7.1	-7.1	-6.5
MR1	-0.26	-0.26	-0.26	-0.27	-0.30	-0.41	-0.36	-0.31	-0.35	-5.3	-5.4	-5.2	-5.2	-5.3	-7.0	-5.9	-5.1	-5.5
MR2	0.00	-0.03	-0.08	-0.12	-0.22	-0.35	-0.33	-0.32	-0.25	0.0	-0.6	-1.6	-2.3	-3.9	-5.9	-5.5	-5.2	-4.1
MR3	0.23	0.16	0.17	0.14	0.06	-0.14	-0.29	-0.29	-0.35	5.1	3.4	3.5	2.8	1.2	-2.3	-4.7	-4.7	-5.5
MR4	0.14	0.05	0.13	0.17	0.15	0.17	0.21	0.29	0.30	2.7	1.0	2.5	3.1	2.7	2.9	3.5	4.7	4.9
MR5	0.05	0.13	0.15	0.15	0.03	-0.05	-0.07	-0.15	-0.07	1.2	2.9	3.1	2.9	0.6	-0.7	-1.0	-2.1	-0.9
MR6	-0.15	-0.24	-0.34	-0.45	-0.90	-1.16	-1.40	-1.49	-1.64	-3.6	-5.4	-7.2	-8.8	-15.1	-17.9	-20.2	-20.8	-22.3
LBR1	0.14	0.17	0.22	0.21	0.24	0.29	0.35	0.41	0.40	2.8	3.4	4.4	4.0	4.4	5.1	6.0	6.9	6.7
LBR2	0.33	0.30	0.29	0.34	0.35	0.38	0.45	0.43	0.45	7.4	6.5	6.3	7.0	6.8	7.2	8.5	8.0	8.2
LBR3	-0.26	-0.17	-0.13	-0.12	-0.09	0.02	0.11	0.13	0.23	-6.2	-4.0	-2.9	-2.7	-2.0	0.5	2.1	2.5	4.5
BR1	-0.93	-0.52	-0.33	-0.11	0.09	0.12	0.11	0.09	0.11	-24.9	-13.7	-8.3	-2.7	2.1	2.7	2.4	2.0	2.2
BR2	-1.15	-1.09	-1.06	-1.01	-0.69	-0.17	-0.08	-0.18	-0.15	-31.8	-29.7	-28.3	-26.2	-17.3	-4.0	-1.7	-4.0	-3.2
BR3	-1.13	-1.07	-1.04	-0.97	-0.95	-0.87	-0.71	-0.61	-0.62	-29.7	-28.0	-27.1	-24.8	-23.5	-20.8	-16.6	-14.0	-14.0
SCh1	-0.22	-0.20	-0.19	-0.14	-0.15	-0.18	-0.20	-0.18	-0.17	-5.2	-4.8	-4.5	-3.4	-3.3	-3.9	-4.2	-3.9	-3.6
SCh2	-0.17	-0.12	-0.15	-0.13	-0.13	-0.16	-0.19	-0.16	-0.20	-3.9	-2.8	-3.3	-2.8	-2.7	-3.3	-3.7	-3.2	-3.8
SR	-0.15	-0.15	-0.15	-0.16	-0.15	-0.13	-0.18	-0.17	-0.18	-2.5	-2.6	-2.4	-2.4	-2.1	-1.9	-2.4	-2.3	-2.3
StbR	-0.17	-0.11	-0.17	-0.20	-0.19	-0.22	-0.24	-0.31	-0.35	-3.2	-2.1	-3.1	-3.4	-3.1	-3.5	-3.8	-4.7	-5.1

Table A-8 Delta (Project – Existing) D.O. Percentiles for Zones' Averages: Plan 6a, 4 ft deepening, No injections

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	-0.06	-0.08	-0.09	-0.06	-0.06	-0.09	-0.12	-0.12	-0.15	-1.5	-1.9	-1.9	-1.2	-1.3	-1.9	-2.5	-2.4	-2.9
FR2	0.02	-0.03	-0.05	-0.02	-0.07	-0.06	-0.10	-0.11	-0.12	0.4	-0.7	-1.2	-0.5	-1.4	-1.3	-2.1	-2.2	-2.4
FR3	-0.12	-0.07	-0.06	-0.07	-0.09	-0.14	-0.18	-0.30	-0.43	-2.9	-1.8	-1.5	-1.6	-2.0	-3.0	-3.8	-5.9	-8.1
FR4	-0.12	-0.11	-0.13	-0.12	-0.18	-0.32	-0.44	-0.52	-0.51	-3.0	-2.8	-3.0	-2.6	-4.0	-6.6	-8.3	-9.2	-8.7
FR5	-0.12	-0.15	-0.14	-0.17	-0.26	-0.43	-0.56	-0.45	-0.41	-2.8	-3.5	-3.2	-3.7	-5.6	-8.3	-9.9	-7.5	-6.8
FR6	-0.13	-0.17	-0.25	-0.28	-0.45	-0.59	-0.55	-0.35	-0.29	-3.2	-4.0	-5.4	-6.0	-8.8	-10.5	-9.0	-5.7	-4.7
FR7	-0.23	-0.28	-0.34	-0.44	-0.49	-0.29	-0.28	-0.31	-0.33	-5.1	-5.9	-6.9	-8.2	-8.2	-4.6	-4.3	-4.6	-4.8
FR8	-0.34	-0.43	-0.46	-0.51	-0.30	-0.22	-0.20	-0.29	-0.27	-6.6	-8.0	-8.3	-8.6	-4.8	-3.3	-2.9	-4.1	-3.8
FR9	-0.42	-0.35	-0.34	-0.27	-0.15	-0.14	-0.18	-0.12	-0.11	-7.2	-5.8	-5.6	-4.3	-2.3	-2.1	-2.4	-1.6	-1.5
FR10	-0.22	-0.10	-0.10	-0.12	-0.10	-0.08	-0.05	-0.05	-0.07	-3.7	-1.6	-1.6	-1.8	-1.5	-1.2	-0.7	-0.7	-0.9
FR11	-0.42	-0.40	-0.41	-0.45	-0.47	-0.46	-0.52	-0.51	-0.48	-7.3	-6.8	-6.9	-7.0	-7.1	-6.7	-7.2	-7.0	-6.5
MR1	-0.23	-0.23	-0.24	-0.24	-0.27	-0.37	-0.31	-0.28	-0.29	-4.9	-4.7	-4.8	-4.7	-4.8	-6.2	-5.1	-4.6	-4.6
MR2	0.01	0.00	-0.06	-0.09	-0.17	-0.31	-0.29	-0.30	-0.24	0.2	0.0	-1.3	-1.7	-3.1	-5.2	-4.7	-4.8	-3.9
MR3	0.25	0.17	0.17	0.14	0.08	-0.12	-0.27	-0.29	-0.33	5.4	3.7	3.5	2.7	1.5	-2.1	-4.4	-4.7	-5.3
MR4	0.14	0.05	0.12	0.17	0.16	0.17	0.22	0.28	0.29	2.8	1.0	2.3	3.1	2.8	2.9	3.6	4.6	4.7
MR5	0.05	0.12	0.15	0.14	0.04	-0.05	-0.08	-0.15	-0.07	1.2	2.7	3.3	2.8	0.6	-0.8	-1.1	-2.1	-0.9
MR6	-0.14	-0.24	-0.34	-0.43	-0.90	-1.16	-1.40	-1.49	-1.64	-3.4	-5.3	-7.2	-8.4	-15.1	-17.9	-20.2	-20.8	-22.3
LBR1	0.13	0.17	0.22	0.21	0.24	0.30	0.36	0.41	0.40	2.7	3.3	4.3	4.0	4.4	5.2	6.2	6.9	6.6
LBR2	0.33	0.29	0.29	0.34	0.36	0.37	0.46	0.44	0.47	7.4	6.4	6.2	7.1	7.0	7.1	8.6	8.2	8.5
LBR3	-0.24	-0.16	-0.12	-0.12	-0.09	0.02	0.11	0.13	0.24	-5.9	-3.9	-2.8	-2.6	-1.9	0.5	2.1	2.6	4.7
BR1	-0.99	-0.59	-0.38	-0.13	0.09	0.13	0.13	0.10	0.11	-26.4	-15.6	-9.5	-3.1	2.1	3.0	2.7	2.1	2.4
BR2	-1.23	-1.16	-1.10	-1.06	-0.76	-0.19	-0.10	-0.23	-0.16	-34.0	-31.4	-29.4	-27.6	-19.0	-4.5	-2.2	-4.9	-3.4
BR3	-1.15	-1.11	-1.06	-0.98	-0.95	-0.87	-0.70	-0.60	-0.60	-30.3	-29.1	-27.6	-25.1	-23.4	-20.8	-16.2	-13.8	-13.5
SCh1	-0.20	-0.18	-0.17	-0.13	-0.13	-0.17	-0.19	-0.21	-0.20	-4.9	-4.3	-4.0	-3.1	-3.1	-3.8	-4.2	-4.5	-4.2
SCh2	-0.17	-0.13	-0.15	-0.13	-0.11	-0.14	-0.16	-0.14	-0.18	-4.0	-3.0	-3.3	-2.8	-2.3	-2.9	-3.2	-2.8	-3.5
SR	-0.15	-0.15	-0.15	-0.16	-0.15	-0.13	-0.18	-0.17	-0.18	-2.5	-2.6	-2.4	-2.4	-2.1	-1.9	-2.4	-2.3	-2.3
StbR	-0.13	-0.08	-0.14	-0.16	-0.15	-0.17	-0.21	-0.28	-0.31	-2.4	-1.5	-2.6	-2.8	-2.5	-2.8	-3.2	-4.2	-4.6

Table A-9 Delta (Project – Existing) D.O. Percentiles for Zones' Averages: Plan 6a, 3 ft deepening, No injections

Zone Name	Project - Baseline Difference (mg/l)									Project - Baseline Relative Difference (%)								
	1%	5%	10%	25%	50%	75%	90%	95%	99%	1%	5%	10%	25%	50%	75%	90%	95%	99%
FR1	-0.05	-0.08	-0.07	-0.05	-0.06	-0.08	-0.11	-0.11	-0.14	-1.2	-1.7	-1.5	-1.0	-1.3	-1.7	-2.2	-2.3	-2.7
FR2	0.02	-0.02	-0.03	-0.01	-0.06	-0.05	-0.08	-0.09	-0.09	0.5	-0.5	-0.8	-0.3	-1.3	-1.0	-1.7	-1.8	-1.8
FR3	-0.11	-0.07	-0.06	-0.05	-0.07	-0.12	-0.13	-0.23	-0.32	-2.7	-1.8	-1.4	-1.1	-1.5	-2.5	-2.6	-4.6	-6.0
FR4	-0.12	-0.11	-0.11	-0.09	-0.16	-0.28	-0.34	-0.36	-0.37	-3.0	-2.7	-2.6	-2.1	-3.5	-5.8	-6.5	-6.5	-6.3
FR5	-0.10	-0.14	-0.13	-0.14	-0.23	-0.36	-0.44	-0.31	-0.30	-2.5	-3.2	-3.0	-3.1	-4.9	-6.9	-7.7	-5.2	-5.0
FR6	-0.13	-0.16	-0.21	-0.24	-0.39	-0.48	-0.38	-0.24	-0.20	-3.1	-3.6	-4.7	-5.2	-7.7	-8.5	-6.3	-4.0	-3.2
FR7	-0.20	-0.26	-0.30	-0.37	-0.39	-0.21	-0.23	-0.25	-0.28	-4.3	-5.3	-5.9	-6.9	-6.5	-3.3	-3.4	-3.8	-4.1
FR8	-0.30	-0.36	-0.38	-0.42	-0.23	-0.18	-0.17	-0.28	-0.19	-5.9	-6.6	-6.9	-7.1	-3.6	-2.8	-2.5	-3.9	-2.6
FR9	-0.34	-0.28	-0.26	-0.20	-0.12	-0.12	-0.13	-0.09	-0.09	-5.8	-4.6	-4.3	-3.2	-1.9	-1.7	-1.7	-1.3	-1.2
FR10	-0.22	-0.09	-0.10	-0.11	-0.10	-0.08	-0.05	-0.05	-0.07	-3.6	-1.6	-1.6	-1.8	-1.5	-1.2	-0.7	-0.7	-0.9
FR11	-0.42	-0.40	-0.41	-0.44	-0.47	-0.46	-0.52	-0.52	-0.48	-7.3	-6.8	-6.9	-7.0	-7.1	-6.7	-7.2	-7.1	-6.5
MR1	-0.21	-0.20	-0.22	-0.19	-0.22	-0.28	-0.24	-0.22	-0.25	-4.4	-4.0	-4.4	-3.6	-4.0	-4.8	-4.0	-3.7	-3.9
MR2	0.05	0.04	-0.04	-0.05	-0.13	-0.26	-0.23	-0.24	-0.23	1.1	0.8	-0.8	-1.0	-2.3	-4.4	-3.9	-3.9	-3.7
MR3	0.26	0.19	0.19	0.15	0.08	-0.09	-0.26	-0.28	-0.31	5.6	4.0	3.9	2.9	1.5	-1.6	-4.3	-4.5	-4.9
MR4	0.13	0.06	0.12	0.16	0.16	0.17	0.21	0.28	0.29	2.6	1.2	2.2	3.0	2.8	2.8	3.4	4.6	4.6
MR5	0.05	0.11	0.15	0.13	0.04	-0.05	-0.08	-0.15	-0.07	1.2	2.5	3.1	2.6	0.6	-0.8	-1.2	-2.1	-0.9
MR6	-0.13	-0.23	-0.34	-0.45	-0.90	-1.16	-1.40	-1.49	-1.64	-3.1	-5.1	-7.2	-8.8	-15.2	-17.9	-20.1	-20.8	-22.3
LBR1	0.13	0.17	0.22	0.21	0.24	0.28	0.34	0.41	0.41	2.6	3.4	4.3	4.0	4.3	4.9	5.9	6.8	6.8
LBR2	0.33	0.30	0.29	0.34	0.34	0.38	0.46	0.43	0.44	7.5	6.5	6.2	7.0	6.8	7.3	8.7	8.0	8.0
LBR3	-0.23	-0.15	-0.11	-0.11	-0.08	0.02	0.10	0.13	0.24	-5.5	-3.6	-2.5	-2.5	-1.8	0.5	2.1	2.6	4.9
BR1	-1.04	-0.64	-0.42	-0.14	0.08	0.13	0.13	0.11	0.13	-27.8	-16.9	-10.7	-3.5	1.9	2.9	2.8	2.3	2.6
BR2	-1.31	-1.21	-1.17	-1.10	-0.82	-0.23	-0.12	-0.24	-0.16	-36.2	-32.9	-31.3	-28.8	-20.4	-5.5	-2.7	-5.2	-3.3
BR3	-1.19	-1.14	-1.10	-1.00	-0.96	-0.87	-0.69	-0.60	-0.59	-31.4	-29.8	-28.6	-25.6	-23.8	-20.7	-16.0	-13.7	-13.3
SCh1	-0.21	-0.19	-0.17	-0.13	-0.14	-0.18	-0.19	-0.20	-0.19	-5.0	-4.5	-3.9	-3.1	-3.2	-3.9	-4.2	-4.2	-3.9
SCh2	-0.16	-0.12	-0.15	-0.12	-0.10	-0.14	-0.15	-0.13	-0.18	-3.6	-2.8	-3.2	-2.5	-2.1	-2.8	-3.1	-2.6	-3.4
SR	-0.15	-0.15	-0.15	-0.16	-0.15	-0.13	-0.18	-0.17	-0.18	-2.5	-2.6	-2.4	-2.4	-2.1	-1.9	-2.4	-2.3	-2.3
StbR	-0.09	-0.05	-0.11	-0.12	-0.11	-0.13	-0.15	-0.24	-0.25	-1.8	-0.9	-2.0	-2.2	-1.9	-2.0	-2.4	-3.6	-3.7

Table A-10 Delta (Project – Existing) D.O. Percentiles for Zones' Averages: Plan 6b, 2 ft deepening, No injections

Zone Name	Project - Baseline Difference (mg/l)									Project - Baseline Relative Difference (%)								
	1%	5%	10%	25%	50%	75%	90%	95%	99%	1%	5%	10%	25%	50%	75%	90%	95%	99%
FR1	-0.07	-0.09	-0.09	-0.08	-0.06	-0.08	-0.11	-0.10	-0.13	-1.6	-2.1	-1.9	-1.8	-1.4	-1.6	-2.2	-2.1	-2.5
FR2	0.00	-0.04	-0.06	-0.04	-0.06	-0.04	-0.07	-0.07	-0.08	0.1	-0.9	-1.3	-0.8	-1.2	-0.9	-1.5	-1.5	-1.5
FR3	-0.13	-0.08	-0.07	-0.05	-0.08	-0.11	-0.10	-0.20	-0.23	-3.1	-2.1	-1.6	-1.2	-1.7	-2.3	-2.0	-3.9	-4.4
FR4	-0.13	-0.12	-0.12	-0.11	-0.16	-0.25	-0.27	-0.26	-0.26	-3.1	-2.9	-2.8	-2.5	-3.5	-5.2	-5.1	-4.6	-4.4
FR5	-0.11	-0.15	-0.14	-0.14	-0.21	-0.30	-0.32	-0.21	-0.21	-2.6	-3.4	-3.2	-3.1	-4.5	-5.8	-5.6	-3.6	-3.4
FR6	-0.12	-0.16	-0.20	-0.23	-0.35	-0.39	-0.26	-0.18	-0.14	-2.9	-3.6	-4.4	-4.8	-7.0	-6.9	-4.3	-2.9	-2.2
FR7	-0.16	-0.21	-0.26	-0.30	-0.28	-0.15	-0.19	-0.23	-0.27	-3.4	-4.4	-5.3	-5.7	-4.6	-2.3	-2.8	-3.4	-3.9
FR8	-0.22	-0.31	-0.31	-0.33	-0.16	-0.14	-0.15	-0.21	-0.16	-4.3	-5.7	-5.6	-5.7	-2.5	-2.1	-2.2	-2.9	-2.2
FR9	-0.26	-0.19	-0.17	-0.14	-0.09	-0.09	-0.09	-0.08	-0.06	-4.5	-3.1	-2.8	-2.2	-1.3	-1.3	-1.2	-1.1	-0.8
FR10	-0.22	-0.10	-0.12	-0.12	-0.10	-0.10	-0.06	-0.05	-0.06	-3.7	-1.6	-2.0	-1.8	-1.5	-1.4	-0.8	-0.7	-0.8
FR11	-0.44	-0.42	-0.43	-0.46	-0.48	-0.47	-0.53	-0.53	-0.50	-7.7	-7.1	-7.2	-7.2	-7.3	-6.9	-7.3	-7.2	-6.7
MR1	-0.18	-0.17	-0.19	-0.17	-0.24	-0.25	-0.21	-0.19	-0.22	-3.7	-3.5	-3.8	-3.3	-4.3	-4.3	-3.5	-3.1	-3.5
MR2	0.00	0.01	-0.08	-0.11	-0.14	-0.26	-0.22	-0.21	-0.19	0.0	0.2	-1.6	-2.1	-2.5	-4.5	-3.7	-3.4	-3.1
MR3	0.13	0.09	0.09	0.02	-0.01	-0.18	-0.29	-0.31	-0.34	2.9	2.0	1.8	0.3	-0.2	-3.2	-4.7	-5.0	-5.3
MR4	-0.03	-0.10	-0.04	-0.01	-0.04	-0.03	0.00	0.07	0.09	-0.5	-1.9	-0.7	-0.3	-0.7	-0.4	0.0	1.2	1.5
MR5	-0.73	-0.69	-0.58	-0.52	-0.10	-0.10	-0.15	-0.18	-0.10	-17.3	-15.4	-12.5	-10.4	-1.7	-1.6	-2.2	-2.6	-1.4
MR6	1.62	1.49	1.42	1.31	0.66	0.38	0.12	0.01	-0.18	39.0	33.1	29.9	25.8	11.2	5.8	1.7	0.1	-2.4
LBR1	-0.09	-0.06	-0.04	-0.02	-0.02	0.01	0.08	0.08	0.07	-1.9	-1.1	-0.7	-0.4	-0.3	0.1	1.4	1.3	1.2
LBR2	0.08	0.05	0.05	0.07	0.05	0.08	0.13	0.15	0.12	1.7	1.1	1.1	1.4	1.1	1.5	2.5	2.7	2.2
LBR3	-0.85	-0.78	-0.70	-0.62	-0.56	-0.39	-0.26	-0.21	-0.16	-20.4	-18.4	-16.3	-13.9	-11.9	-8.0	-5.3	-4.3	-3.1
BR1	-1.44	-0.92	-0.58	-0.26	0.07	0.13	0.13	0.12	0.14	-38.6	-24.0	-14.8	-6.4	1.5	2.9	2.9	2.6	2.8
BR2	-1.98	-1.84	-1.76	-1.58	-1.07	-0.34	-0.21	-0.29	-0.20	-54.8	-49.9	-47.2	-41.2	-26.6	-8.1	-4.7	-6.4	-4.3
BR3	-1.79	-1.73	-1.69	-1.64	-1.63	-1.59	-1.35	-1.28	-1.19	-47.4	-45.5	-44.1	-42.1	-40.1	-37.9	-31.4	-29.4	-26.9
SCh1	-0.17	-0.18	-0.17	-0.15	-0.15	-0.18	-0.19	-0.20	-0.19	-4.2	-4.2	-3.9	-3.4	-3.4	-4.0	-4.1	-4.3	-4.1
SCh2	-0.16	-0.12	-0.13	-0.13	-0.11	-0.13	-0.15	-0.13	-0.16	-3.5	-2.7	-2.9	-2.8	-2.2	-2.7	-3.1	-2.6	-3.1
SR	-0.15	-0.15	-0.15	-0.16	-0.15	-0.13	-0.18	-0.17	-0.18	-2.5	-2.6	-2.4	-2.5	-2.2	-1.9	-2.4	-2.3	-2.3
StbR	-0.05	-0.03	-0.06	-0.08	-0.08	-0.09	-0.13	-0.17	-0.20	-0.9	-0.5	-1.1	-1.4	-1.4	-1.4	-1.9	-2.6	-3.0

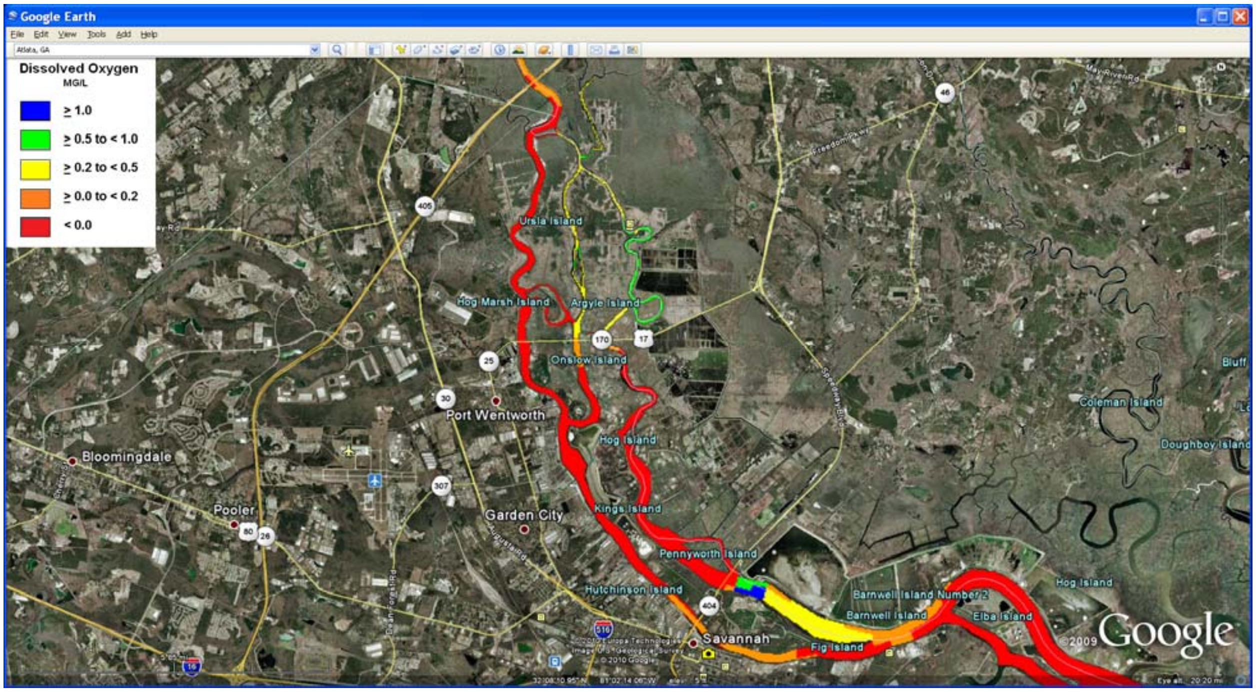

Figure A-1 Delta Bottom D.O. (50th percentile): Deepening and mitigation plan 6a-6ft

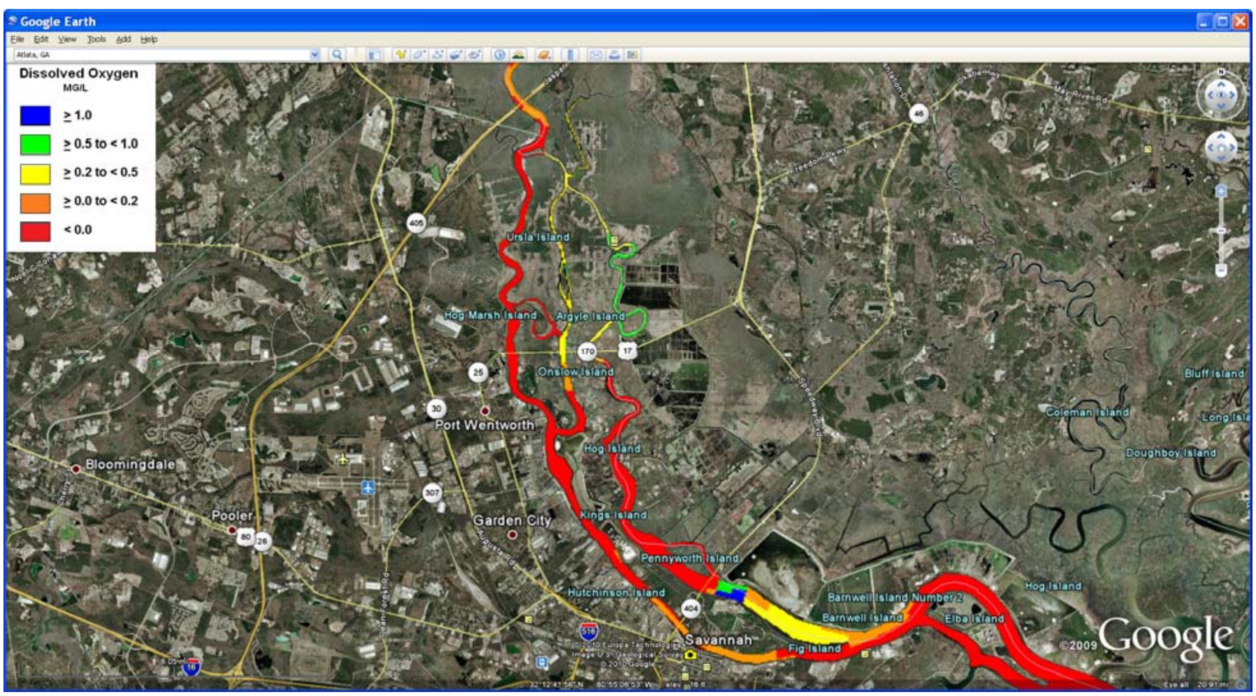

Figure A-2 Delta Bottom D.O. (50th percentile): Deepening and mitigation plan 6a-5ft

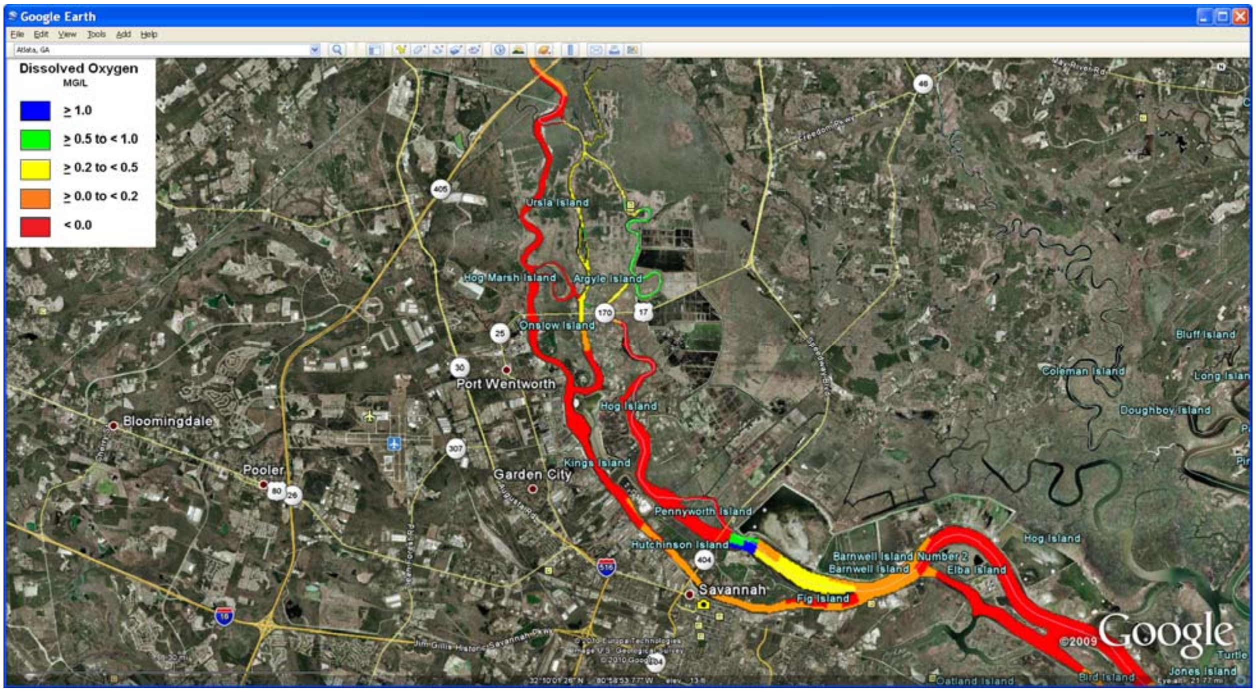

Figure A-3 Delta Bottom D.O. (50[th] percentile): Deepening and mitigation plan 6a-4ft

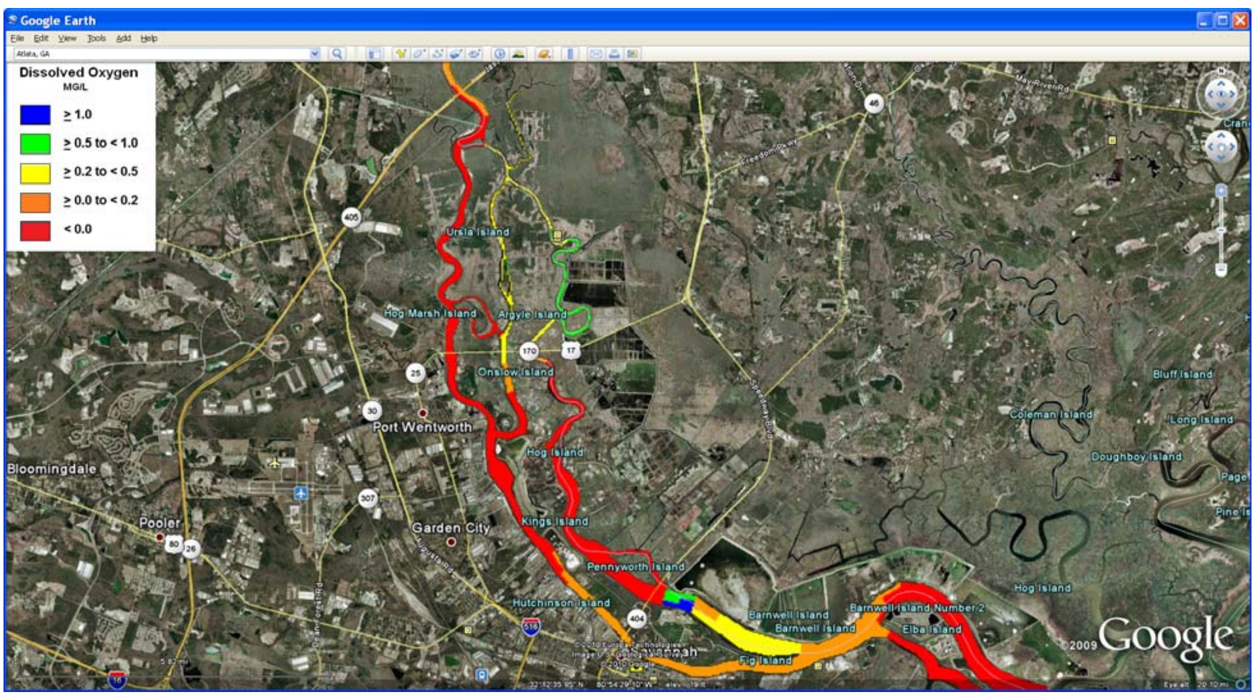

Figure A-4 Delta Bottom D.O. (50[th] percentile): Deepening and mitigation plan 6a-3ft

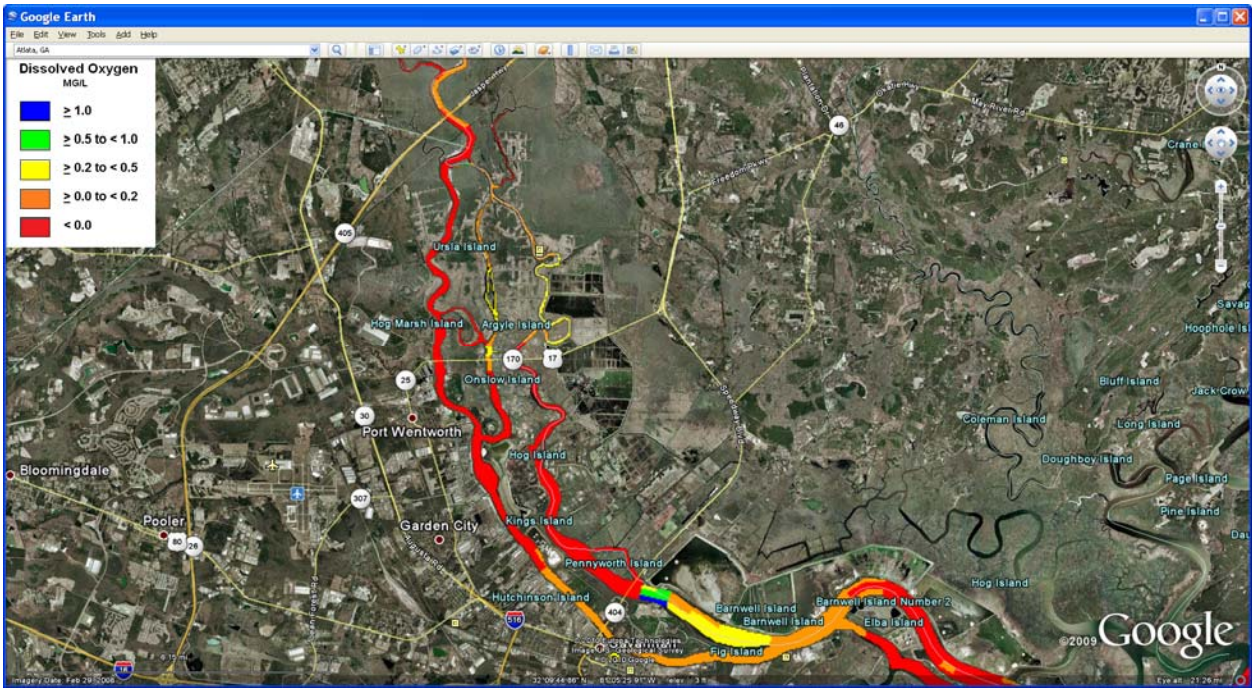

Figure A-5 Delta Bottom D.O. (50th percentile): Deepening and mitigation plan 6b-2ft

APPENDIX B

DISSOLVED OXYGEN REGIME OF SAVANNAH ESTUARY: AUGUST 1997 (AVERAGE FLOW), ALTERNATIVE DEEPENING WITH MITIGATION PLANS 6A AND 6B, D.O. DISCHARGE WITH MITIGATION PURPOSES

TABLES AND FIGURES

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Table B-1 Delta (Project – Existing) D.O. Percentiles for Critical Cells: Plan 6a, 6 ft deepening, and mitigation D.O. injections

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	0.07	1.8	0.06	1.5	0.05	1.2	0.06	1.4	0.03	0.7	0.04	0.9	0.01	0.2	-0.02	-0.4	0	0.0
FR2	0.18	4.9	0.17	4.5	0.15	3.9	0.18	4.5	0.17	4.0	0.14	3.2	0.12	2.6	0.13	2.8	-0.22	-4.3
FR3	0.26	7.4	0.23	6.4	0.27	7.4	0.3	7.8	0.29	7.2	0.43	10.0	0.28	5.9	0.54	10.7	0.35	6.3
FR4	0.28	8.0	0.28	7.9	0.38	10.5	0.29	7.4	0.34	8.4	0.43	9.8	0.2	4.0	0.3	5.6	0.48	8.7
FR5	0.53	14.6	0.57	15.2	0.54	13.9	0.52	12.7	0.56	13.0	0.33	6.7	0.14	2.6	0.09	1.6	0.19	3.3
FR6	0.58	15.7	0.67	17.8	0.72	18.5	0.63	15.3	0.73	17.1	0.5	10.5	0.06	1.1	0.08	1.4	0.1	1.7
FR7	0.51	12.2	0.55	12.9	0.6	13.9	0.47	10.2	0.29	5.8	-0.26	-4.3	-0.04	-0.6	0.19	3.0	0.25	3.9
FR8	0.27	5.8	0.24	5.0	0.08	1.6	-0.11	-2.0	-0.13	-2.1	-0.01	-0.2	0.03	0.4	0.04	0.6	-0.08	-1.1
FR9	0.66	13.5	0.87	17.3	0.74	13.9	0.66	11.5	0.41	6.5	0.38	5.8	0.47	6.9	0.56	8.0	0.69	9.6
FR10	1.83	42.5	1.55	32.4	1.49	30.1	1.46	27.4	1.11	18.8	0.84	13.1	1.04	15.6	0.77	11.0	0.69	9.6
FR11	-1.46	-35.0	-1.99	-42.3	-2.21	-44.8	-2.5	-47.7	-2.89	-51.0	-3.25	-52.9	-3.47	-53.4	-3.53	-53.2	-3.95	-55.4
MR1	0.37	8.4	0.4	8.8	0.42	9.1	0.32	6.5	0.26	5.0	0.08	1.4	0	0.0	0.03	0.5	-0.04	-0.6
MR2	0.66	16.4	0.78	18.8	0.71	16.4	0.58	12.6	0.34	6.7	0.11	2.0	0.08	1.4	0.08	1.4	0.19	3.2
MR3	0.98	26.5	0.92	23.7	0.92	23.0	0.94	22.4	0.89	19.7	0.55	10.8	0.12	2.1	0.02	0.3	-0.01	-0.2
MR4	0.95	24.4	0.91	22.6	0.92	22.3	0.91	20.7	0.97	21.0	1.08	22.1	1.21	23.9	1.27	24.5	1.3	24.0
MR5	1.52	102.0	1.55	76.0	1.56	64.7	1.57	51.5	1.46	29.4	0.92	14.8	1	15.2	0.85	12.3	0.75	10.5
MR6	0.53	25.1	0.16	6.4	-0.35	-11.6	-0.81	-23.1	-2.8	-49.9	-3.34	-52.5	-3.54	-52.1	-3.67	-52.0	-3.83	-52.3
LBR1	1.24	34.7	1.07	24.6	1.1	23.2	1.06	20.7	1.02	18.8	1.2	21.3	1.13	18.9	1.12	18.2	1.17	18.1
LBR2	1.25	33.9	1.42	36.8	1.45	36.5	1.45	34.9	1.43	32.6	1.47	32.0	1.49	31.2	1.52	31.1	1.31	24.9
LBR3	0.25	8.7	-0.05	-1.5	-0.11	-3.2	-0.12	-3.3	-0.08	-2.0	-0.14	-3.2	-0.34	-7.2	-0.48	-9.6	-0.58	-11.1
BR1	0.29	8.4	0.36	10.2	0.34	9.5	0.2	5.1	0.37	9.2	0.37	8.7	0.24	5.3	0.22	4.8	0.27	5.8
BR2	0.21	8.2	0.25	8.8	0.27	9.0	0.3	9.3	0.47	13.7	0.49	13.2	0.55	14.3	0.5	12.7	0.54	13.4
BR3	-0.06	-2.0	-0.17	-5.2	-0.26	-7.6	-0.31	-8.6	-0.08	-2.1	0.33	8.4	0.4	9.8	0.46	11.1	0.47	11.1
SCH1	-0.04	-1.7	0.08	3.1	0.11	4.1	0.13	4.6	0.23	7.6	0.6	17.6	0.51	13.5	0.56	14.4	0.48	11.6
SCH2	0.1	2.7	0.04	1.0	0.05	1.2	0.13	3.1	0.09	2.1	0.09	2.0	0.07	1.5	0.07	1.5	0.02	0.4
SR	1.45	30.9	1.51	31.9	1.48	29.8	1.52	28.6	1.44	25.6	1.37	22.9	1.69	27.7	1.75	28.4	1.78	28.6
StbR	0.2	5.2	0.42	10.0	0.31	6.8	0.39	7.7	0.27	4.7	0.15	2.4	0.13	2.0	0.07	1.1	0.12	1.8

Table B-2 Delta (Project – Existing) D.O. Percentiles for Critical Cells: Plan 6a, 5 ft deepening, and mitigation D.O. injections

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	0.05	1.3	0.06	1.5	0.05	1.2	0.07	1.7	0.03	0.7	0.02	0.4	0	0.0	-0.02	-0.4	-0.03	-0.6
FR2	0.16	4.4	0.15	4.0	0.14	3.6	0.16	4.0	0.15	3.6	0.14	3.2	0.1	2.2	0.11	2.3	-0.22	-4.3
FR3	0.23	6.6	0.19	5.3	0.23	6.3	0.24	6.2	0.21	5.2	0.24	5.6	0.19	4.0	0.5	9.9	0.3	5.4
FR4	0.23	6.6	0.24	6.7	0.29	8.0	0.21	5.4	0.23	5.7	0.22	5.0	0.03	0.6	0.16	3.0	0.45	8.2
FR5	0.49	13.5	0.58	15.5	0.58	14.9	0.54	13.2	0.64	14.8	0.44	9.0	0.19	3.5	0.26	4.6	0.32	5.5
FR6	0.46	12.5	0.45	12.0	0.41	10.5	0.38	9.2	0.37	8.7	0.21	4.4	-0.22	-3.9	-0.15	-2.6	-0.05	-0.8
FR7	0.6	14.4	0.65	15.3	0.7	16.2	0.69	15.0	0.82	16.3	0.35	5.9	0.4	6.4	0.57	9.0	1.07	16.5
FR8	0.1	2.1	0.11	2.3	0.04	0.8	-0.12	-2.2	0.11	1.8	0.3	4.7	0.27	4.0	0.26	3.8	0.17	2.4
FR9	0.4	8.2	0.66	13.1	0.56	10.5	0.65	11.4	0.49	7.8	0.52	7.9	0.62	9.1	0.66	9.4	0.67	9.3
FR10	1.86	43.2	1.59	33.3	1.57	31.7	1.53	28.8	1.17	19.8	0.91	14.2	1.1	16.5	0.84	12.0	0.75	10.4
FR11	-1.46	-35.0	-1.99	-42.3	-2.21	-44.8	-2.5	-47.7	-2.89	-51.0	-3.25	-52.9	-3.47	-53.4	-3.53	-53.2	-3.95	-55.4
MR1	0.18	4.1	0.17	3.8	0.2	4.3	0.2	4.1	0.21	4.1	0.02	0.4	0.01	0.2	0.07	1.2	0.17	2.7
MR2	0.73	18.1	0.76	18.3	0.65	15.0	0.54	11.7	0.32	6.3	0.08	1.4	0.13	2.2	0.15	2.5	0.19	3.2
MR3	1.06	28.6	1	25.7	0.97	24.3	1	23.9	0.95	21.0	0.63	12.4	0.18	3.2	0.1	1.7	0.03	0.5
MR4	1.05	27.0	1	24.8	1.02	24.8	1.01	23.0	1.09	23.6	1.23	25.2	1.35	26.7	1.43	27.6	1.45	26.8
MR5	1.67	112.1	1.74	85.3	1.67	69.3	1.72	56.4	1.63	32.8	1.15	18.5	1.24	18.9	1.06	15.4	1.01	14.2
MR6	0.53	25.1	0.16	6.4	-0.35	-11.6	-0.81	-23.1	-2.8	-49.9	-3.34	-52.5	-3.54	-52.1	-3.67	-52.0	-3.83	-52.3
LBR1	1.39	38.9	1.29	29.7	1.28	26.9	1.2	23.4	1.17	21.5	1.35	23.9	1.3	21.8	1.29	20.9	1.34	20.7
LBR2	1.62	43.9	1.59	41.2	1.59	40.1	1.57	37.7	1.57	35.8	1.6	34.8	1.66	34.8	1.67	34.2	1.48	28.1
LBR3	0.35	12.1	0.07	2.1	0.03	0.9	0	0.0	0.07	1.8	-0.03	-0.7	-0.22	-4.7	-0.37	-7.4	-0.47	-9.0
BR1	0.21	6.1	0.28	8.0	0.28	7.8	0.13	3.3	0.31	7.7	0.33	7.8	0.19	4.2	0.17	3.7	0.23	4.9
BR2	0.31	12.2	0.21	7.4	0.2	6.7	0.23	7.1	0.41	11.9	0.42	11.4	0.48	12.5	0.46	11.7	0.5	12.4
BR3	0	0.0	-0.12	-3.7	-0.25	-7.3	-0.25	-6.9	-0.09	-2.4	0.28	7.1	0.35	8.6	0.4	9.6	0.42	9.9
SCH1	0.02	0.8	0	0.0	0.1	3.7	0.16	5.7	0.14	4.7	-0.04	-1.2	-0.07	-1.9	-0.05	-1.3	-0.19	-4.6
SCH2	0.08	2.1	0.02	0.5	0.04	1.0	0.08	1.9	0.07	1.6	0.09	2.0	0.07	1.5	0.06	1.3	0.07	1.5
SR	1.45	30.9	1.51	31.9	1.49	30.0	1.53	28.8	1.45	25.8	1.37	22.9	1.7	27.8	1.75	28.4	1.79	28.7
StbR	0.33	8.6	0.5	11.8	0.44	9.6	0.45	8.9	0.35	6.2	0.23	3.7	0.19	2.9	0.18	2.7	0.2	2.9

Table B-3 Delta (Project – Existing) D.O. Percentiles for Critical Cells: Plan 6a, 4 ft deepening, and mitigation D.O. injections

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	0.04	1.0	0.02	0.5	0	0.0	0.04	0.9	0.01	0.2	0.03	0.7	0.04	0.9	0	0.0	0.04	0.8
FR2	0.14	3.8	0.14	3.7	0.13	3.4	0.16	4.0	0.14	3.3	0.14	3.2	0.1	2.2	0.13	2.8	-0.21	-4.1
FR3	0.19	5.4	0.17	4.7	0.21	5.8	0.22	5.7	0.19	4.7	0.22	5.1	0.18	3.8	0.48	9.5	0.28	5.0
FR4	0.2	5.7	0.22	6.2	0.26	7.2	0.19	4.8	0.19	4.7	0.14	3.2	0.05	1.0	0.18	3.4	0.45	8.2
FR5	0.44	12.2	0.54	14.4	0.52	13.4	0.49	12.0	0.58	13.5	0.4	8.2	0.19	3.5	0.27	4.8	0.34	5.9
FR6	0.38	10.3	0.36	9.6	0.34	8.7	0.3	7.3	0.27	6.3	0.08	1.7	-0.18	-3.2	-0.05	-0.9	-0.02	-0.3
FR7	0.82	19.7	0.87	20.5	1.03	23.8	1.05	22.8	1.16	23.1	0.64	10.7	0.6	9.6	0.75	11.8	0.98	15.1
FR8	0.08	1.7	0.1	2.1	0.01	0.2	-0.14	-2.5	0.17	2.8	0.3	4.7	0.29	4.3	0.29	4.2	0.15	2.1
FR9	0.01	0.2	-0.03	-0.6	-0.15	-2.8	-0.25	-4.4	-0.1	-1.6	0.12	1.8	0.15	2.2	0.09	1.3	0.15	2.1
FR10	1.85	42.9	1.57	32.8	1.52	30.7	1.49	28.0	1.13	19.1	0.88	13.7	1.06	15.9	0.81	11.6	0.73	10.1
FR11	-1.46	-35.0	-1.99	-42.3	-2.21	-44.8	-2.5	-47.7	-2.89	-51.0	-3.25	-52.9	-3.47	-53.4	-3.53	-53.2	-3.95	-55.4
MR1	0.13	2.9	0.15	3.3	0.18	3.9	0.16	3.3	0.19	3.7	0	0.0	0.05	0.8	0.09	1.5	0.21	3.4
MR2	0.67	16.6	0.73	17.6	0.62	14.3	0.51	11.0	0.31	6.1	0.07	1.3	0.14	2.4	0.15	2.5	0.2	3.3
MR3	1.03	27.8	0.96	24.7	0.93	23.3	0.97	23.2	0.92	20.4	0.6	11.8	0.13	2.3	0.1	1.7	0.01	0.2
MR4	1.02	26.2	0.96	23.8	0.99	24.0	0.97	22.1	1.04	22.6	1.16	23.7	1.29	25.5	1.3	25.1	1.34	24.8
MR5	1.6	107.4	1.65	80.9	1.61	66.8	1.63	53.4	1.55	31.2	1.03	16.5	1.12	17.0	0.94	13.6	0.87	12.2
MR6	0.53	25.1	0.16	6.4	-0.35	-11.6	-0.81	-23.1	-2.8	-49.9	-3.34	-52.5	-3.54	-52.1	-3.67	-52.0	-3.83	-52.3
LBR1	1.28	35.9	1.26	29.0	1.18	24.8	1.11	21.6	1.09	20.1	1.27	22.5	1.21	20.3	1.2	19.5	1.23	19.0
LBR2	0.57	15.4	1.5	38.9	1.51	38.0	1.5	36.1	1.5	34.2	1.52	33.0	1.55	32.5	1.57	32.2	1.39	26.4
LBR3	0.32	11.1	0.01	0.3	-0.02	-0.6	-0.06	-1.6	-0.01	-0.3	-0.1	-2.3	-0.28	-5.9	-0.46	-9.2	-0.5	-9.5
BR1	0.16	4.6	0.2	5.7	0.21	5.8	0.06	1.5	0.28	6.9	0.31	7.3	0.16	3.5	0.14	3.0	0.2	4.3
BR2	0.15	5.9	0.12	4.2	0.13	4.3	0.14	4.3	0.35	10.2	0.39	10.5	0.44	11.5	0.43	10.9	0.46	11.4
BR3	-0.06	-2.0	-0.2	-6.1	-0.32	-9.3	-0.32	-8.8	-0.17	-4.5	0.23	5.8	0.3	7.4	0.36	8.7	0.36	8.5
SCH1	-0.05	-2.1	0.07	2.7	0.1	3.7	0.12	4.2	0.23	7.6	0.66	19.4	0.57	15.1	0.59	15.2	0.48	11.6
SCH2	0.07	1.9	-0.02	-0.5	0.04	1.0	0.09	2.2	0.07	1.6	0.09	2.0	0.08	1.7	0.09	1.9	0.07	1.5
SR	1.45	30.9	1.51	31.9	1.48	29.8	1.52	28.6	1.44	25.6	1.37	22.9	1.7	27.8	1.75	28.4	1.78	28.6
StbR	0.35	9.1	0.44	10.4	0.42	9.2	0.45	8.9	0.3	5.3	0.24	3.9	0.18	2.8	0.18	2.7	0.15	2.2

Table B-4 Delta (Project – Existing) D.O. Percentiles for Critical Cells: Plan 6a, 3 ft deepening, and mitigation D.O. injections

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	0.05	1.3	0.03	0.8	0.01	0.2	0.03	0.7	0.01	0.2	0.05	1.1	0.06	1.3	0.03	0.6	0.06	1.3
FR2	0.15	4.1	0.15	4.0	0.12	3.1	0.17	4.2	0.16	3.8	0.13	3.0	0.14	3.0	0.17	3.6	-0.19	-3.7
FR3	0.19	5.4	0.16	4.5	0.17	4.7	0.22	5.7	0.2	4.9	0.21	4.9	0.21	4.4	0.48	9.5	0.27	4.8
FR4	0.2	5.7	0.19	5.3	0.21	5.8	0.2	5.1	0.19	4.7	0.14	3.2	0.13	2.6	0.2	3.8	0.43	7.8
FR5	0.31	8.6	0.27	7.2	0.22	5.7	0.24	5.9	0.16	3.7	-0.13	-2.7	0.01	0.2	0.05	0.9	0.15	2.6
FR6	0.27	7.3	0.28	7.4	0.23	5.9	0.23	5.6	0.22	5.2	-0.01	-0.2	-0.05	-0.9	0.05	0.9	0.07	1.2
FR7	0.6	14.4	0.62	14.6	0.69	15.9	0.67	14.5	0.81	16.1	0.4	6.7	0.42	6.7	0.53	8.3	1.04	16.0
FR8	0.08	1.7	0.11	2.3	0.03	0.6	-0.08	-1.5	0.22	3.6	0.35	5.4	0.32	4.8	0.3	4.4	0.24	3.4
FR9	0.02	0.4	-0.03	-0.6	-0.1	-1.9	-0.15	-2.6	0.06	1.0	0.28	4.2	0.25	3.6	0.22	3.1	0.37	5.1
FR10	1.84	42.7	1.57	32.8	1.52	30.7	1.48	27.8	1.14	19.3	0.88	13.7	1.06	15.9	0.81	11.6	0.72	10.0
FR11	-1.46	-35.0	-1.99	-42.3	-2.21	-44.8	-2.5	-47.7	-2.89	-51.0	-3.25	-52.9	-3.47	-53.4	-3.53	-53.2	-3.95	-55.4
MR1	0.11	2.5	0.11	2.4	0.17	3.7	0.15	3.1	0.2	3.9	0.02	0.4	0.1	1.7	0.16	2.7	0.27	4.3
MR2	0.7	17.4	0.71	17.1	0.65	15.0	0.58	12.6	0.41	8.1	0.2	3.6	0.19	3.3	0.25	4.2	0.19	3.2
MR3	1.02	27.6	0.98	25.2	0.95	23.8	0.96	22.9	0.95	21.0	0.62	12.2	0.17	3.0	0.12	2.0	0.03	0.5
MR4	1.01	26.0	0.96	23.8	1	24.3	0.96	21.9	1.04	22.6	1.14	23.3	1.26	24.9	1.31	25.3	1.33	24.6
MR5	1.6	107.4	1.68	82.4	1.6	66.4	1.63	53.4	1.56	31.4	1.03	16.5	1.12	17.0	0.94	13.6	0.87	12.2
MR6	0.53	25.1	0.16	6.4	-0.35	-11.6	-0.81	-23.1	-2.8	-49.9	-3.34	-52.5	-3.54	-52.1	-3.67	-52.0	-3.83	-52.3
LBR1	1.26	35.3	1.27	29.2	1.2	25.3	1.1	21.4	1.09	20.1	1.27	22.5	1.21	20.3	1.2	19.5	1.23	19.0
LBR2	1.6	43.4	1.5	38.9	1.53	38.5	1.5	36.1	1.49	33.9	1.53	33.3	1.58	33.1	1.64	33.6	2.14	40.7
LBR3	0.33	11.4	0.02	0.6	0	0.0	-0.04	-1.1	0.02	0.5	-0.06	-1.4	-0.28	-5.9	-0.42	-8.4	-0.52	-9.9
BR1	0.12	3.5	0.19	5.4	0.19	5.3	0.04	1.0	0.24	6.0	0.29	6.8	0.15	3.3	0.13	2.8	0.19	4.1
BR2	0.18	7.1	0.07	2.5	0.09	3.0	0.12	3.7	0.31	9.0	0.36	9.7	0.41	10.7	0.39	9.9	0.44	10.9
BR3	-0.06	-2.0	-0.17	-5.2	-0.28	-8.1	-0.32	-8.8	-0.22	-5.8	0.04	1.0	0.12	2.9	0.16	3.9	0.23	5.4
SCH1	-0.09	-3.8	0.07	2.7	0.06	2.2	0.1	3.5	0.25	8.3	0.66	19.4	0.59	15.6	0.58	14.9	0.49	11.8
SCH2	0.1	2.7	0.04	1.0	0.08	2.0	0.07	1.7	0.07	1.6	0.07	1.6	0.04	0.9	0.05	1.1	0.06	1.2
SR	1.45	30.9	1.51	31.9	1.49	30.0	1.53	28.8	1.44	25.6	1.37	22.9	1.7	27.8	1.75	28.4	1.78	28.6
StbR	0.45	11.7	0.48	11.4	0.46	10.1	0.47	9.3	0.31	5.4	0.27	4.4	0.21	3.2	0.22	3.3	0.23	3.4

Table B-5 Delta (Project – Existing) D.O. Percentiles for Critical Cells: Plan 6b, 2 ft deepening, and mitigation D.O. injections

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	0.03	0.8	0.02	0.5	0	0.0	0.05	1.2	0.03	0.7	0.08	1.8	0.09	1.9	0.08	1.7	0.11	2.3
FR2	0.14	3.8	0.14	3.7	0.13	3.4	0.19	4.7	0.17	4.0	0.17	3.9	0.23	5.0	0.22	4.7	-0.08	-1.6
FR3	0.2	5.7	0.15	4.2	0.17	4.7	0.22	5.7	0.22	5.4	0.28	6.5	0.38	7.9	0.53	10.5	0.35	6.3
FR4	0.2	5.7	0.19	5.3	0.22	6.1	0.2	5.1	0.23	5.7	0.23	5.2	0.2	4.0	0.26	4.9	0.38	6.9
FR5	0.29	8.0	0.25	6.7	0.29	7.5	0.27	6.6	0.24	5.6	-0.03	-0.6	0.21	3.9	0.29	5.2	0.28	4.8
FR6	0.26	7.0	0.29	7.7	0.25	6.4	0.26	6.3	0.27	6.3	0.08	1.7	0.11	2.0	0.17	2.9	0.16	2.7
FR7	0.65	15.6	0.68	16.0	0.76	17.6	0.76	16.5	0.91	18.1	0.47	7.9	0.46	7.3	0.52	8.2	0.87	13.4
FR8	0.12	2.6	0.11	2.3	0	0.0	-0.07	-1.3	0.17	2.8	0.22	3.4	0.17	2.5	0.16	2.3	0.11	1.5
FR9	0.61	12.5	0.92	18.3	0.81	15.2	0.8	14.0	0.56	8.9	0.53	8.0	0.63	9.2	0.59	8.4	0.64	8.9
FR10	1.85	42.9	1.59	33.3	1.52	30.7	1.51	28.4	1.15	19.5	0.89	13.8	1.08	16.2	0.82	11.7	0.72	10.0
FR11	-1.46	-35.0	-1.99	-42.3	-2.21	-44.8	-2.5	-47.7	-2.89	-51.0	-3.25	-52.9	-3.47	-53.4	-3.53	-53.2	-3.95	-55.4
MR1	0.15	3.4	0.16	3.5	0.21	4.5	0.19	3.9	0.21	4.1	0.09	1.6	0.2	3.4	0.24	4.0	0.31	5.0
MR2	0.66	16.4	0.67	16.1	0.6	13.9	0.53	11.5	0.36	7.1	0.17	3.1	0.27	4.7	0.28	4.7	0.32	5.3
MR3	0.94	25.4	0.88	22.6	0.86	21.5	0.86	20.5	0.85	18.8	0.55	10.8	0.2	3.5	0.17	2.9	0.08	1.3
MR4	0.87	22.4	1.4	34.7	1.48	35.9	1.51	34.4	1.58	34.3	1.72	35.2	1.89	37.4	2.01	38.8	2.3	42.5
MR5	0.86	57.7	0.51	25.0	0.41	17.0	0.47	15.4	1.38	27.8	1.04	16.7	1.12	17.0	0.97	14.1	0.86	12.1
MR6	3.7	175.4	3.69	148.2	3.38	112.3	3.13	89.2	1.27	22.6	0.74	11.6	0.56	8.2	0.41	5.8	0.33	4.5
LBR1	0.53	14.8	0.71	16.3	0.95	20.0	0.9	17.5	0.86	15.8	1.04	18.4	1.05	17.6	1.05	17.0	1.23	19.0
LBR2	0.75	20.3	0.96	24.9	0.95	23.9	0.96	23.1	0.93	21.2	0.97	21.1	1	21.0	1.05	21.5	1.31	24.9
LBR3	-0.28	-9.7	-0.54	-16.5	-0.67	-19.3	-0.66	-17.9	-0.66	-16.7	-0.67	-15.4	-0.82	-17.3	-0.95	-19.0	-1.09	-20.8
BR1	0.31	9.0	0.47	13.4	0.59	16.4	0.41	10.5	0.48	11.9	0.46	10.8	0.31	6.8	0.33	7.1	0.45	9.6
BR2	0.44	17.3	0.42	14.8	0.57	19.1	0.62	19.1	0.76	22.1	0.71	19.2	0.73	19.0	0.73	18.6	0.86	21.3
BR3	-0.44	-14.5	-0.57	-17.5	-0.66	-19.2	-0.67	-18.5	-0.25	-6.6	1.15	29.1	1.49	36.5	1.61	38.8	1.82	42.8
SCH1	0.04	1.7	0.02	0.8	0.08	3.0	0.1	3.5	0.11	3.7	-0.04	-1.2	-0.07	-1.9	-0.01	-0.3	-0.09	-2.2
SCH2	0.11	2.9	0.08	2.0	0.09	2.2	0.08	1.9	0.07	1.6	0.09	2.0	0.08	1.7	0.07	1.5	0.09	1.9
SR	1.45	30.9	1.51	31.9	1.48	29.8	1.52	28.6	1.44	25.6	1.37	22.9	1.7	27.8	1.75	28.4	1.78	28.6
StbR	0.54	14.1	0.59	14.0	0.5	10.9	0.52	10.3	0.37	6.5	0.29	4.7	0.26	4.0	0.26	3.9	0.3	4.4

Table B-6 Delta (Project – Existing) D.O. Percentiles for Zones' Averages: Plan 6a, 6 ft deepening, and mitigation D.O. injections

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	0.10	0.08	0.08	0.12	0.09	0.07	0.04	0.04	0.00	2.3	1.8	1.7	2.6	1.9	1.4	0.9	0.8	0.1
FR2	0.24	0.20	0.17	0.22	0.17	0.19	0.17	0.17	0.18	5.7	4.9	3.9	5.0	3.8	4.1	3.4	3.5	3.6
FR3	0.21	0.24	0.25	0.28	0.26	0.22	0.21	0.15	0.09	5.2	5.9	6.0	6.4	5.8	4.6	4.2	2.9	1.7
FR4	0.31	0.37	0.40	0.40	0.46	0.46	0.35	0.23	0.20	7.6	8.8	9.6	9.1	10.2	9.4	6.6	4.2	3.5
FR5	0.42	0.45	0.50	0.46	0.50	0.32	0.13	0.06	0.12	10.2	10.6	11.6	10.2	10.6	6.2	2.4	1.0	2.0
FR6	0.54	0.53	0.48	0.42	0.29	0.05	-0.06	0.03	0.08	12.9	12.3	10.6	8.9	5.8	0.8	-1.1	0.5	1.3
FR7	0.37	0.31	0.26	0.19	-0.05	0.03	0.05	0.01	-0.03	8.0	6.5	5.3	3.5	-0.8	0.5	0.8	0.1	-0.5
FR8	0.25	0.10	0.14	0.02	0.01	0.11	0.13	0.03	0.12	4.8	1.9	2.6	0.4	0.2	1.7	1.9	0.5	1.7
FR9	-0.02	0.03	0.00	0.05	0.14	0.18	0.16	0.23	0.27	-0.4	0.4	0.0	0.8	2.1	2.5	2.2	3.1	3.6
FR10	0.44	0.43	0.38	0.41	0.41	0.40	0.47	0.51	0.59	7.5	7.1	6.1	6.4	6.1	5.7	6.5	7.0	8.0
FR11	0.48	0.43	0.42	0.39	0.35	0.32	0.40	0.42	0.46	8.3	7.4	7.0	6.1	5.3	4.6	5.5	5.8	6.2
MR1	0.38	0.41	0.36	0.35	0.28	0.18	0.15	0.15	0.11	8.0	8.4	7.2	6.8	5.1	3.0	2.4	2.4	1.7
MR2	0.57	0.57	0.50	0.45	0.37	0.22	0.17	0.15	0.18	12.3	11.9	10.1	8.6	6.7	3.7	2.9	2.4	2.9
MR3	0.85	0.78	0.75	0.73	0.65	0.45	0.32	0.31	0.34	18.6	16.5	15.5	14.3	11.9	7.7	5.2	4.9	5.3
MR4	0.75	0.74	0.75	0.79	0.77	0.81	0.91	1.02	1.01	15.1	14.4	14.4	14.6	13.7	13.8	14.9	16.6	16.2
MR5	1.01	1.06	1.06	1.02	0.87	0.68	0.72	0.65	0.63	24.0	23.6	22.7	20.2	15.1	10.5	10.5	9.2	8.7
MR6	0.08	-0.02	-0.12	-0.22	-0.70	-0.94	-1.25	-1.28	-1.36	1.8	-0.4	-2.5	-4.3	-11.9	-14.5	-18.0	-17.9	-18.5
LBR1	0.91	0.87	0.91	0.91	0.93	0.97	1.11	1.12	1.13	19.0	17.4	18.0	17.2	16.8	17.0	18.9	18.7	18.6
LBR2	1.05	1.01	1.01	1.06	1.05	1.09	1.22	1.22	1.22	23.6	22.1	21.7	21.9	20.7	20.9	23.1	22.6	22.2
LBR3	0.43	0.55	0.58	0.60	0.64	0.77	0.88	0.94	1.07	10.4	12.9	13.5	13.5	13.5	15.8	17.9	18.7	21.2
BR1	0.38	0.48	0.42	0.49	0.51	0.48	0.46	0.42	0.42	10.1	12.5	10.7	11.8	11.7	10.7	9.7	8.9	8.6
BR2	0.37	0.38	0.39	0.39	0.41	0.55	0.59	0.43	0.41	10.2	10.4	10.3	10.2	10.1	13.2	13.5	9.4	8.7
BR3	0.07	0.15	0.17	0.19	0.16	0.16	0.21	0.29	0.29	1.9	4.0	4.4	4.8	3.8	3.9	4.8	6.7	6.7
SCh1	0.09	0.11	0.11	0.14	0.14	0.07	0.05	0.06	0.04	2.2	2.6	2.5	3.2	3.1	1.5	1.1	1.2	0.9
SCh2	0.15	0.17	0.14	0.16	0.18	0.14	0.13	0.11	0.08	3.4	3.8	3.2	3.4	3.7	2.8	2.5	2.3	1.6
SR	0.96	0.98	0.92	0.93	0.90	0.85	1.12	1.10	1.15	16.3	16.5	14.9	14.2	13.2	12.0	15.0	14.6	15.1
StbR	0.26	0.34	0.31	0.27	0.25	0.19	0.15	0.09	0.07	4.9	6.4	5.6	4.7	4.1	3.0	2.4	1.3	1.1

Table B-7 Delta (Project – Existing) D.O. Percentiles for Zones' Averages: Plan 6a, 5 ft deepening, and mitigation D.O. injections

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	0.08	0.07	0.06	0.09	0.07	0.05	0.03	0.02	0.00	1.9	1.5	1.4	2.0	1.5	1.2	0.6	0.5	0.1
FR2	0.22	0.19	0.16	0.19	0.15	0.18	0.14	0.14	0.14	5.3	4.4	3.7	4.3	3.4	3.8	2.9	2.8	2.8
FR3	0.18	0.21	0.20	0.23	0.22	0.17	0.16	0.08	0.01	4.4	5.2	4.8	5.3	4.9	3.6	3.3	1.5	0.2
FR4	0.23	0.26	0.31	0.29	0.29	0.24	0.12	0.06	0.03	5.7	6.2	7.3	6.6	6.4	4.9	2.3	1.1	0.6
FR5	0.29	0.30	0.33	0.30	0.30	0.12	-0.04	-0.02	0.01	7.0	7.0	7.6	6.7	6.3	2.4	-0.8	-0.3	0.2
FR6	0.29	0.28	0.26	0.22	0.11	-0.05	-0.11	0.06	0.12	6.9	6.6	5.6	4.6	2.3	-1.0	-1.8	1.0	1.9
FR7	0.20	0.14	0.12	0.04	-0.07	0.09	0.12	0.09	0.04	4.2	2.8	2.4	0.7	-1.2	1.4	1.8	1.3	0.6
FR8	0.14	0.01	0.04	-0.01	0.07	0.18	0.20	0.12	0.23	2.6	0.2	0.8	-0.3	1.1	2.8	3.0	1.7	3.2
FR9	-0.01	0.05	0.05	0.13	0.22	0.26	0.23	0.32	0.37	-0.2	0.9	0.8	2.0	3.3	3.8	3.2	4.3	5.0
FR10	0.54	0.52	0.49	0.51	0.50	0.50	0.57	0.63	0.72	9.2	8.6	7.9	7.9	7.5	7.3	7.9	8.6	9.8
FR11	0.63	0.58	0.56	0.55	0.50	0.46	0.56	0.60	0.64	11.1	10.0	9.4	8.6	7.6	6.6	7.7	8.3	8.7
MR1	0.22	0.27	0.28	0.29	0.28	0.20	0.20	0.19	0.18	4.7	5.6	5.5	5.6	5.1	3.3	3.3	3.1	2.8
MR2	0.53	0.56	0.49	0.48	0.40	0.28	0.24	0.21	0.24	11.4	11.6	10.0	9.2	7.3	4.8	3.9	3.4	3.8
MR3	0.89	0.86	0.82	0.82	0.73	0.52	0.40	0.39	0.45	19.5	18.2	16.9	16.0	13.4	8.9	6.5	6.3	7.1
MR4	0.86	0.86	0.86	0.88	0.88	0.92	1.01	1.13	1.16	17.4	16.7	16.4	16.4	15.5	15.7	16.7	18.5	18.6
MR5	1.13	1.18	1.18	1.12	1.01	0.80	0.86	0.80	0.80	26.9	26.3	25.3	22.3	17.5	12.4	12.7	11.3	11.1
MR6	0.11	0.01	-0.10	-0.21	-0.68	-0.91	-1.22	-1.25	-1.31	2.6	0.2	-2.1	-4.2	-11.6	-14.1	-17.5	-17.5	-17.8
LBR1	1.02	1.01	1.03	1.03	1.04	1.08	1.22	1.25	1.26	21.5	20.1	20.3	19.4	18.9	18.9	20.8	20.9	20.7
LBR2	1.16	1.13	1.14	1.16	1.16	1.20	1.34	1.33	1.38	26.2	24.7	24.5	24.1	23.0	23.0	25.3	24.7	25.2
LBR3	0.56	0.66	0.69	0.71	0.74	0.88	0.99	1.05	1.17	13.4	15.7	16.2	15.8	15.8	18.2	20.1	21.0	23.2
BR1	0.33	0.42	0.37	0.43	0.46	0.45	0.43	0.39	0.38	8.8	11.1	9.2	10.4	10.6	10.0	9.1	8.3	7.7
BR2	0.35	0.36	0.38	0.36	0.36	0.49	0.53	0.38	0.36	9.7	9.8	10.1	9.4	9.1	11.8	12.2	8.3	7.7
BR3	0.11	0.18	0.19	0.23	0.19	0.20	0.29	0.38	0.39	2.9	4.8	5.0	5.8	4.7	4.7	6.8	8.8	8.8
SCh1	0.07	0.09	0.09	0.12	0.11	0.07	0.06	0.06	0.05	1.6	2.2	2.0	2.8	2.5	1.5	1.3	1.3	1.2
SCh2	0.14	0.15	0.13	0.14	0.15	0.12	0.11	0.11	0.10	3.2	3.4	2.9	2.9	3.2	2.4	2.1	2.1	1.9
SR	1.17	1.20	1.12	1.12	1.10	1.05	1.37	1.36	1.41	19.9	20.1	18.2	17.2	16.3	14.8	18.4	18.0	18.5
StbR	0.36	0.39	0.35	0.31	0.29	0.25	0.21	0.16	0.18	6.9	7.4	6.4	5.4	4.8	4.0	3.3	2.4	2.6

Table B-8 Delta (Project – Existing) D.O. Percentiles for Zones' Averages: Plan 6a, 4 ft deepening, and mitigation D.O. injections

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	0.07	0.06	0.05	0.09	0.07	0.04	0.04	0.02	-0.02	1.6	1.4	1.1	2.1	1.6	0.9	0.7	0.4	-0.4
FR2	0.20	0.17	0.14	0.18	0.15	0.18	0.14	0.14	0.13	4.9	4.1	3.3	4.1	3.2	3.7	2.8	2.8	2.7
FR3	0.15	0.18	0.18	0.23	0.20	0.16	0.16	0.10	0.04	3.7	4.4	4.4	5.2	4.5	3.5	3.2	1.9	0.7
FR4	0.21	0.22	0.27	0.27	0.26	0.21	0.09	0.03	0.03	5.0	5.4	6.3	6.1	5.7	4.2	1.7	0.5	0.6
FR5	0.24	0.25	0.28	0.26	0.24	0.09	-0.04	0.04	0.05	5.7	5.9	6.5	5.7	5.1	1.8	-0.6	0.6	0.8
FR6	0.23	0.23	0.21	0.19	0.09	-0.05	-0.06	0.09	0.13	5.5	5.3	4.6	3.9	1.7	-0.9	-1.1	1.4	2.1
FR7	0.15	0.10	0.09	0.02	-0.05	0.11	0.13	0.08	0.05	3.3	2.1	1.9	0.4	-0.8	1.7	2.0	1.2	0.8
FR8	0.11	0.01	0.03	-0.02	0.09	0.19	0.18	0.15	0.17	2.2	0.1	0.5	-0.4	1.4	2.9	2.6	2.1	2.3
FR9	0.01	0.06	0.07	0.14	0.22	0.23	0.23	0.31	0.34	0.1	1.1	1.2	2.2	3.3	3.4	3.3	4.2	4.6
FR10	0.49	0.48	0.44	0.46	0.45	0.45	0.54	0.57	0.66	8.4	8.0	7.1	7.2	6.8	6.5	7.4	7.8	8.9
FR11	0.55	0.51	0.49	0.47	0.43	0.39	0.47	0.51	0.55	9.7	8.7	8.3	7.4	6.5	5.7	6.5	7.0	7.4
MR1	0.18	0.23	0.24	0.27	0.27	0.19	0.17	0.18	0.18	3.8	4.8	4.8	5.1	4.8	3.2	2.8	2.9	2.8
MR2	0.50	0.53	0.48	0.45	0.39	0.27	0.20	0.19	0.22	10.7	11.0	9.6	8.6	7.2	4.6	3.4	3.1	3.5
MR3	0.86	0.83	0.78	0.77	0.68	0.49	0.37	0.35	0.39	18.9	17.6	16.2	15.1	12.5	8.4	6.0	5.6	6.2
MR4	0.80	0.80	0.80	0.83	0.82	0.87	0.96	1.08	1.08	16.1	15.5	15.3	15.4	14.5	14.8	15.8	17.6	17.3
MR5	1.07	1.12	1.13	1.06	0.93	0.74	0.79	0.73	0.72	25.6	24.9	24.1	21.0	16.1	11.4	11.6	10.3	9.9
MR6	0.10	0.00	-0.11	-0.22	-0.69	-0.92	-1.24	-1.26	-1.34	2.5	0.0	-2.4	-4.2	-11.7	-14.2	-17.8	-17.7	-18.2
LBR1	0.95	0.93	0.97	0.96	0.98	1.03	1.16	1.18	1.19	20.0	18.6	19.0	18.1	17.8	18.0	19.8	19.8	19.7
LBR2	1.11	1.07	1.07	1.11	1.10	1.14	1.28	1.28	1.35	24.9	23.4	23.1	23.1	21.9	21.8	24.2	23.8	24.6
LBR3	0.51	0.62	0.65	0.67	0.69	0.83	0.94	1.00	1.12	12.4	14.7	15.2	14.8	14.7	17.0	19.1	19.9	22.3
BR1	0.27	0.37	0.32	0.38	0.43	0.42	0.40	0.37	0.38	7.2	9.6	8.0	9.2	10.0	9.3	8.5	7.8	7.8
BR2	0.28	0.30	0.32	0.30	0.31	0.45	0.49	0.34	0.33	7.7	8.2	8.5	7.9	7.8	10.7	11.3	7.4	7.0
BR3	0.06	0.13	0.15	0.18	0.15	0.16	0.26	0.34	0.35	1.5	3.3	3.8	4.6	3.7	3.8	5.9	7.8	7.9
SCh1	0.09	0.12	0.09	0.12	0.11	0.06	0.04	0.04	0.03	2.1	2.8	2.2	2.8	2.5	1.3	0.9	0.8	0.6
SCh2	0.11	0.14	0.11	0.12	0.15	0.12	0.10	0.11	0.09	2.5	3.1	2.5	2.6	3.1	2.5	2.0	2.2	1.7
SR	1.06	1.09	1.02	1.03	1.00	0.95	1.24	1.23	1.28	18.1	18.3	16.6	15.7	14.8	13.4	16.7	16.3	16.8
StbR	0.36	0.37	0.31	0.29	0.28	0.24	0.20	0.15	0.14	7.0	6.9	5.7	5.1	4.6	3.8	3.1	2.3	2.1

Table B-9 Delta (Project – Existing) D.O. Percentiles for Zones' Averages: Plan 6a, 3 ft deepening, and mitigation D.O. injections

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	0.08	0.06	0.07	0.09	0.07	0.05	0.03	0.02	-0.02	1.7	1.4	1.5	2.0	1.5	1.0	0.7	0.3	-0.5
FR2	0.19	0.17	0.14	0.19	0.15	0.18	0.14	0.15	0.14	4.7	4.1	3.3	4.2	3.2	3.9	2.9	3.1	2.9
FR3	0.14	0.18	0.18	0.23	0.20	0.17	0.18	0.15	0.10	3.4	4.3	4.3	5.2	4.5	3.6	3.7	2.9	1.9
FR4	0.19	0.21	0.22	0.24	0.22	0.19	0.11	0.09	0.09	4.6	5.0	5.3	5.5	4.9	3.9	2.1	1.6	1.5
FR5	0.21	0.20	0.24	0.23	0.19	0.10	0.00	0.11	0.11	5.0	4.7	5.6	5.1	4.1	2.0	0.0	1.8	1.8
FR6	0.17	0.18	0.17	0.15	0.08	0.00	0.03	0.16	0.19	4.0	4.1	3.8	3.2	1.5	0.0	0.5	2.6	3.0
FR7	0.13	0.08	0.08	0.03	0.02	0.17	0.15	0.15	0.09	2.8	1.7	1.6	0.6	0.4	2.6	2.2	2.2	1.3
FR8	0.11	0.03	0.05	0.01	0.14	0.21	0.20	0.13	0.25	2.1	0.5	1.0	0.2	2.3	3.2	2.9	1.8	3.5
FR9	0.05	0.12	0.13	0.18	0.24	0.25	0.27	0.32	0.37	0.9	1.9	2.2	2.8	3.7	3.7	3.8	4.4	4.9
FR10	0.49	0.47	0.44	0.46	0.45	0.45	0.53	0.57	0.65	8.4	7.8	7.1	7.2	6.8	6.5	7.3	7.7	8.8
FR11	0.55	0.51	0.50	0.47	0.43	0.39	0.47	0.51	0.55	9.7	8.7	8.3	7.4	6.5	5.6	6.5	7.0	7.4
MR1	0.16	0.22	0.23	0.27	0.29	0.23	0.20	0.22	0.18	3.3	4.4	4.5	5.2	5.2	3.8	3.4	3.6	2.9
MR2	0.50	0.57	0.50	0.48	0.42	0.30	0.24	0.21	0.26	10.7	11.9	10.1	9.2	7.6	5.1	4.0	3.4	4.1
MR3	0.88	0.85	0.80	0.79	0.69	0.50	0.38	0.36	0.38	19.3	17.9	16.5	15.4	12.8	8.6	6.2	5.8	6.0
MR4	0.80	0.79	0.80	0.82	0.81	0.87	0.95	1.06	1.07	16.2	15.3	15.2	15.1	14.4	14.8	15.6	17.3	17.2
MR5	1.08	1.11	1.13	1.06	0.93	0.74	0.79	0.73	0.72	25.6	24.8	24.1	21.1	16.1	11.5	11.6	10.2	9.9
MR6	0.11	0.01	-0.11	-0.22	-0.70	-0.92	-1.24	-1.26	-1.33	2.8	0.2	-2.3	-4.4	-11.7	-14.2	-17.8	-17.7	-18.1
LBR1	0.95	0.93	0.97	0.97	0.97	1.02	1.16	1.18	1.20	19.9	18.6	19.1	18.2	17.7	17.9	19.7	19.8	19.7
LBR2	1.11	1.07	1.07	1.11	1.10	1.15	1.28	1.27	1.30	24.9	23.4	23.0	22.9	21.8	22.1	24.1	23.6	23.6
LBR3	0.52	0.63	0.66	0.67	0.70	0.82	0.94	1.00	1.13	12.6	14.9	15.4	15.0	14.8	17.0	19.0	20.1	22.4
BR1	0.25	0.34	0.28	0.35	0.41	0.42	0.39	0.37	0.37	6.6	8.9	7.1	8.6	9.5	9.2	8.4	7.7	7.6
BR2	0.25	0.27	0.29	0.28	0.28	0.42	0.47	0.32	0.31	6.8	7.3	7.7	7.3	7.0	9.9	10.7	7.0	6.6
BR3	0.02	0.11	0.13	0.16	0.15	0.15	0.26	0.35	0.35	0.6	2.9	3.3	4.2	3.6	3.7	6.0	8.1	8.0
SCh1	0.05	0.08	0.08	0.11	0.10	0.05	0.02	0.02	0.02	1.2	2.0	1.9	2.5	2.2	1.1	0.5	0.5	0.5
SCh2	0.11	0.13	0.12	0.13	0.15	0.12	0.11	0.10	0.09	2.5	3.0	2.6	2.8	3.2	2.4	2.2	2.0	1.8
SR	1.06	1.09	1.02	1.03	1.00	0.95	1.24	1.23	1.28	18.1	18.3	16.6	15.7	14.8	13.4	16.7	16.3	16.8
StbR	0.38	0.38	0.34	0.30	0.31	0.29	0.23	0.21	0.20	7.2	7.2	6.2	5.2	5.1	4.6	3.6	3.1	2.9

Table B-10 Delta (Project – Existing) D.O. Percentiles for Zones' Averages: Plan 6b, 2 ft deepening, and mitigation D.O. injections

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	0.07	0.06	0.05	0.07	0.08	0.07	0.05	0.03	-0.01	1.7	1.3	1.2	1.6	1.7	1.4	1.0	0.5	-0.2
FR2	0.21	0.18	0.15	0.20	0.17	0.20	0.18	0.21	0.22	5.0	4.2	3.6	4.4	3.7	4.3	3.7	4.3	4.4
FR3	0.15	0.18	0.19	0.24	0.23	0.21	0.24	0.25	0.24	3.7	4.3	4.5	5.5	5.2	4.4	5.0	4.9	4.5
FR4	0.20	0.22	0.24	0.26	0.26	0.25	0.23	0.23	0.20	4.8	5.3	5.8	6.0	5.7	5.2	4.3	4.1	3.5
FR5	0.23	0.23	0.26	0.26	0.23	0.19	0.14	0.21	0.21	5.4	5.5	5.9	5.7	4.9	3.6	2.4	3.5	3.5
FR6	0.21	0.20	0.21	0.20	0.15	0.10	0.17	0.23	0.25	4.9	4.7	4.6	4.3	2.9	1.7	2.8	3.7	4.0
FR7	0.18	0.14	0.14	0.11	0.13	0.22	0.20	0.17	0.14	4.0	3.0	2.7	2.0	2.1	3.6	3.0	2.5	2.0
FR8	0.19	0.09	0.14	0.11	0.23	0.25	0.24	0.19	0.27	3.7	1.7	2.5	1.9	3.7	3.8	3.5	2.7	3.7
FR9	0.14	0.19	0.25	0.25	0.30	0.30	0.31	0.34	0.38	2.4	3.3	4.0	3.9	4.5	4.3	4.3	4.6	5.1
FR10	0.50	0.48	0.45	0.48	0.46	0.46	0.54	0.58	0.67	8.4	8.0	7.2	7.4	6.9	6.7	7.5	7.8	9.0
FR11	0.55	0.51	0.49	0.47	0.43	0.39	0.47	0.52	0.55	9.6	8.7	8.2	7.4	6.4	5.7	6.5	7.1	7.4
MR1	0.21	0.27	0.27	0.32	0.29	0.26	0.25	0.25	0.22	4.4	5.6	5.3	6.0	5.2	4.4	4.1	4.1	3.5
MR2	0.56	0.56	0.47	0.45	0.42	0.28	0.24	0.22	0.26	12.1	11.7	9.5	8.7	7.6	4.8	3.9	3.6	4.2
MR3	0.81	0.73	0.74	0.70	0.63	0.45	0.31	0.30	0.25	17.7	15.5	15.3	13.7	11.5	7.6	5.0	4.8	3.9
MR4	0.72	0.65	0.69	0.69	0.68	0.71	0.79	0.87	0.94	14.5	12.5	13.1	12.7	12.1	12.1	12.9	14.3	15.0
MR5	0.54	0.56	0.60	0.64	0.79	0.72	0.77	0.73	0.70	12.9	12.6	12.9	12.8	13.6	11.1	11.3	10.2	9.6
MR6	2.00	1.85	1.69	1.54	0.90	0.51	0.27	0.20	0.07	48.1	41.1	35.6	30.3	15.3	7.8	3.9	2.9	0.9
LBR1	0.75	0.74	0.75	0.75	0.73	0.73	0.88	0.87	0.86	15.6	14.8	14.8	14.2	13.3	12.8	15.0	14.6	14.2
LBR2	0.85	0.81	0.82	0.82	0.80	0.83	0.94	0.98	0.96	19.1	17.8	17.7	17.1	15.8	15.9	17.7	18.1	17.6
LBR3	-0.09	0.01	0.07	0.13	0.24	0.42	0.55	0.60	0.72	-2.1	0.2	1.5	2.8	5.0	8.6	11.1	12.0	14.3
BR1	0.60	0.63	0.57	0.52	0.49	0.50	0.46	0.44	0.43	16.2	16.6	14.4	12.5	11.5	11.0	9.9	9.3	8.9
BR2	0.68	0.72	0.74	0.76	0.74	0.76	0.71	0.56	0.53	18.9	19.5	19.8	19.9	18.4	18.1	16.2	12.2	11.3
BR3	-0.11	-0.05	-0.02	0.10	0.08	0.10	0.13	0.17	0.21	-2.9	-1.3	-0.5	2.4	2.1	2.3	2.9	4.0	4.6
SCh1	0.09	0.10	0.09	0.11	0.10	0.05	0.04	0.04	0.04	2.2	2.5	2.3	2.6	2.3	1.2	0.9	0.9	0.8
SCh2	0.13	0.15	0.13	0.14	0.16	0.13	0.12	0.12	0.11	2.9	3.3	2.8	2.9	3.4	2.7	2.5	2.4	2.2
SR	1.06	1.09	1.02	1.03	1.00	0.95	1.25	1.23	1.28	18.1	18.3	16.6	15.7	14.8	13.4	16.7	16.3	16.8
StbR	0.40	0.41	0.38	0.34	0.34	0.31	0.28	0.24	0.23	7.7	7.8	6.9	6.0	5.5	4.9	4.4	3.6	3.4

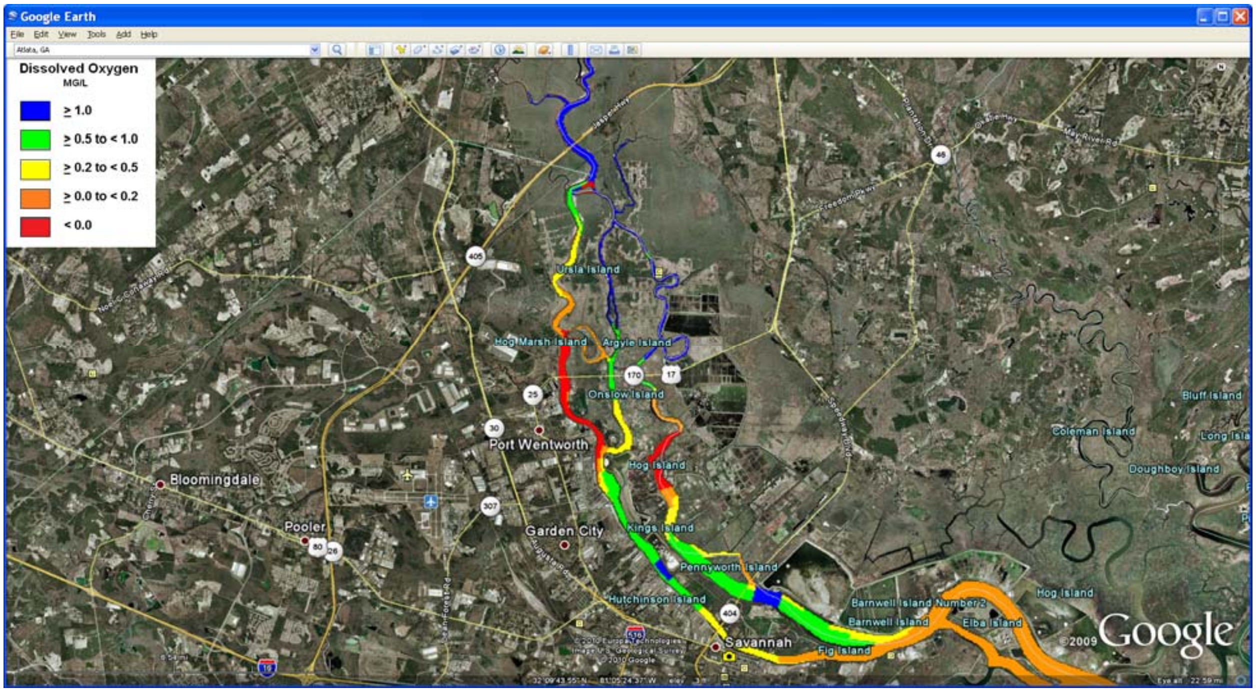

Figure B-1 Delta D.O. (50th percentile): Mitigation plan 6a-6ft and D.O. discharge

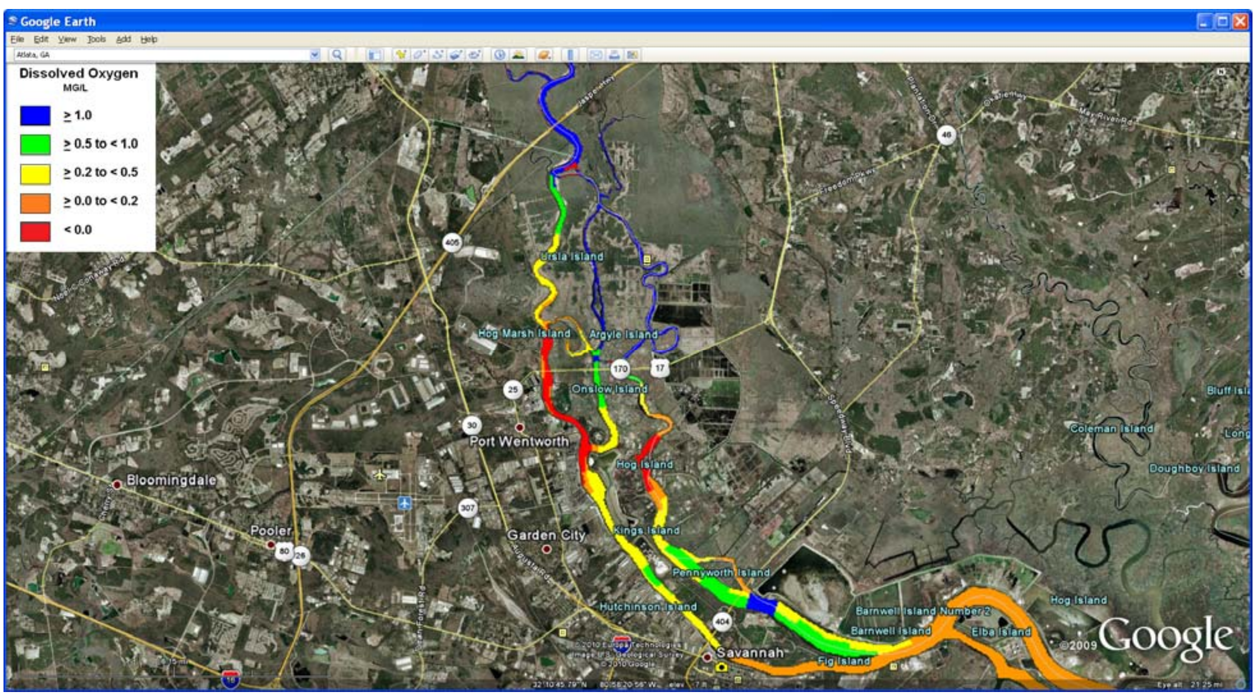

Figure B-2 Delta D.O. (50th percentile): Mitigation plan 6a-5ft and D.O. discharge

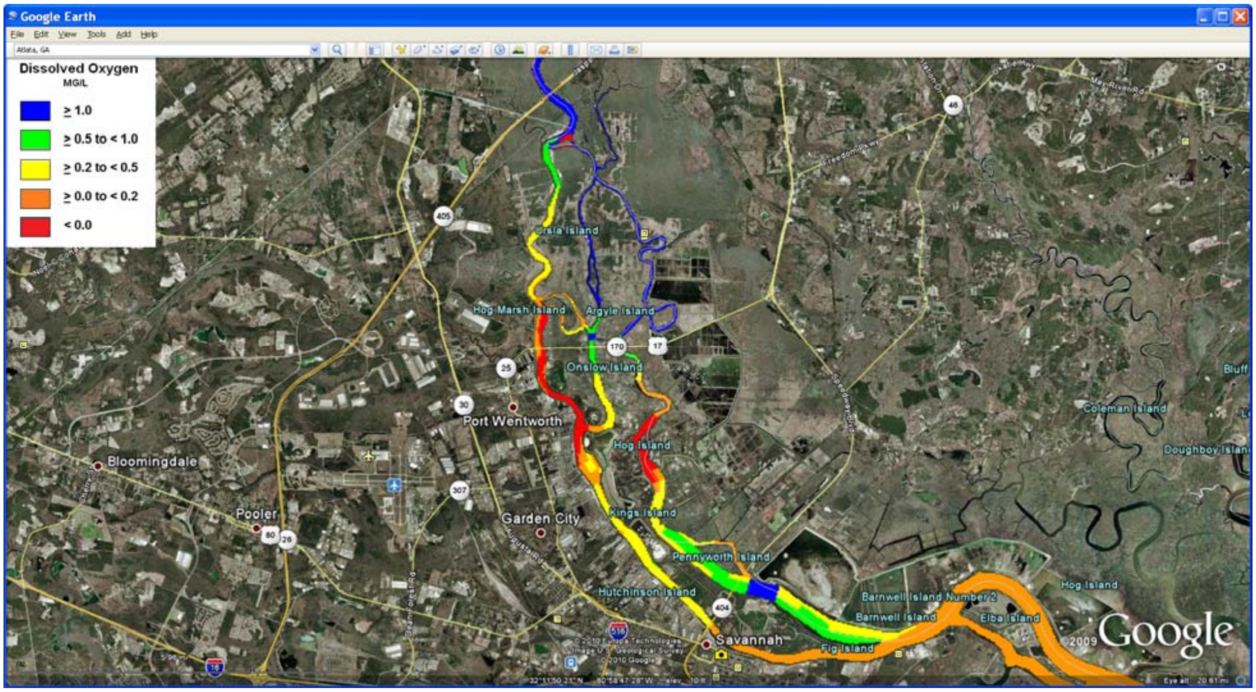

Figure B-3 Delta D.O. (50th percentile): Mitigation plan 6a-4ft and D.O. discharge

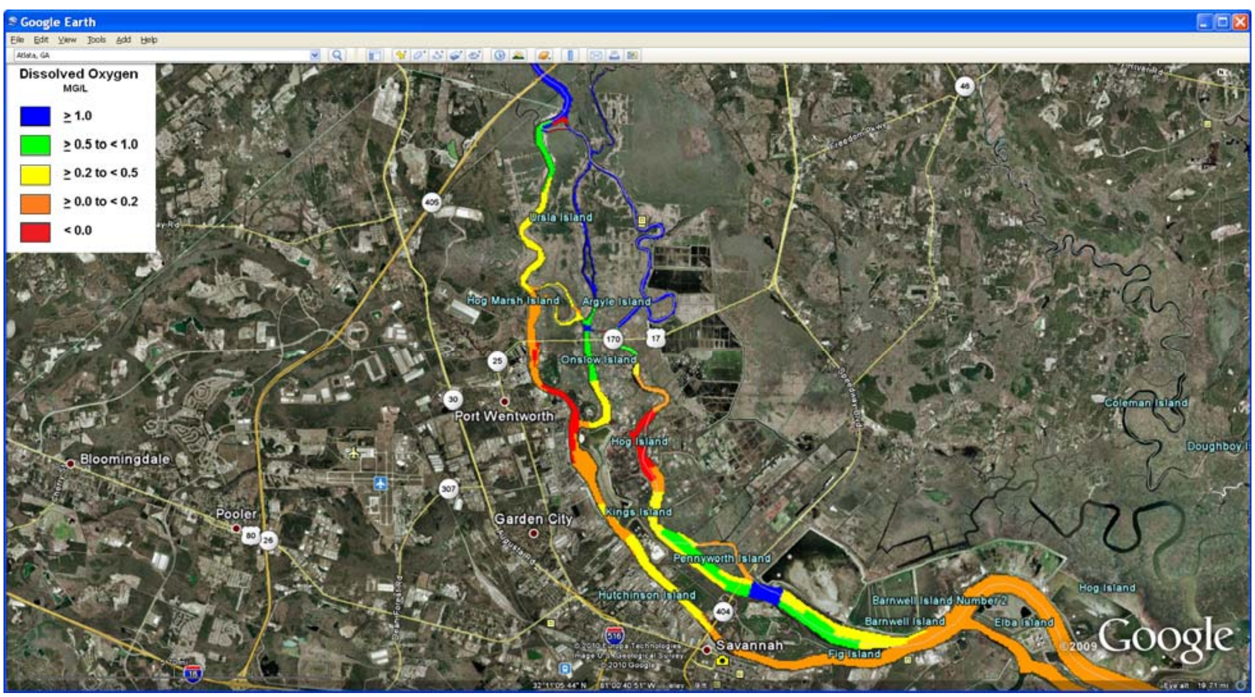

Figure B-4 Delta D.O. (50th percentile): Mitigation plan 6a-3ft and D.O. discharge

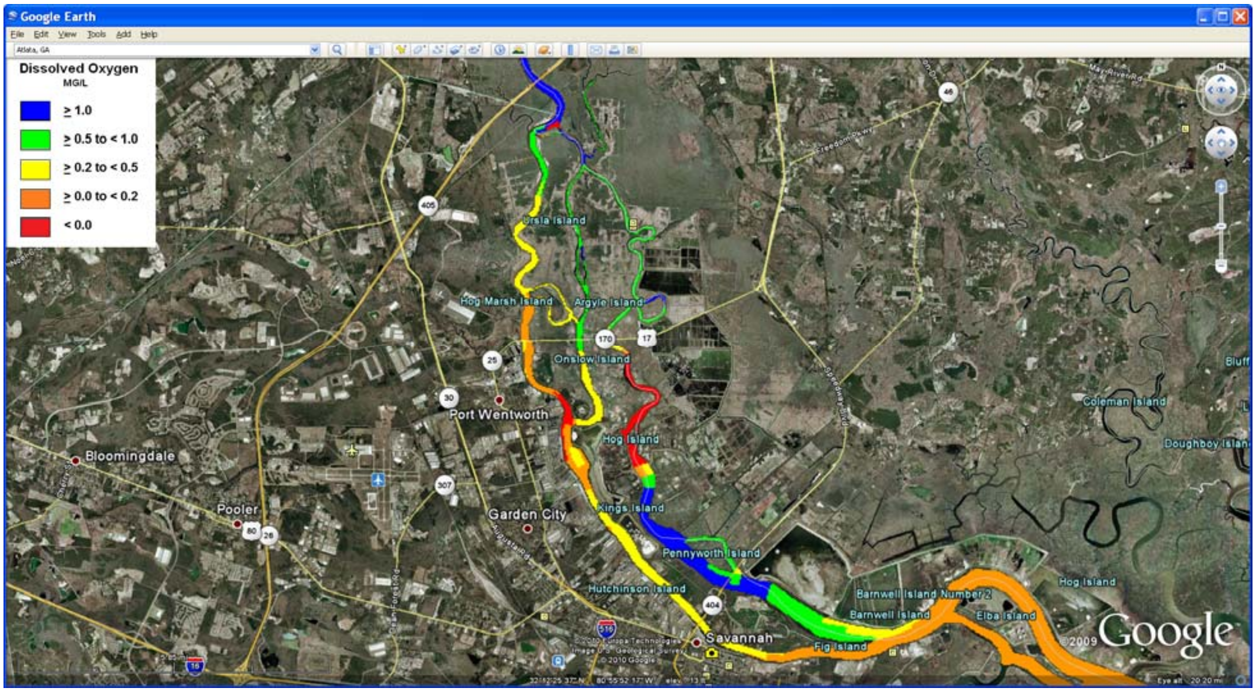

Figure B-5 Delta D.O. (50th percentile): Mitigation plan 6b-2ft and D.O. discharge

APPENDIX C

DISSOLVED OXYGEN MITIGATION RESULTS FOR OXYGEN IMPROVEMENT SYSTEMS LOCATED NEAR INTERNATIONAL PAPER AND GEORGIA PACIFIC

TABLES

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Table C-1 Mitigation success for facilities located near IP and GP: 1BL criteria, 5th percentile

	DEPTH ALTERNATIVE				
Vertical Layer	**44-foot**	**45-foot**	**46-foot**	**47-foot**	**48-foot**
Surface	98.9	99.8	99.8	99.8	99.8
Mid-Depth	93.3	98.4	98	98.1	98.2
Bottom	97.2	97.1	97.5	97.3	97
Water Column	97.6	99.9	99.9	99.9	99.9

Table C-2 Mitigation success for facilities located near IP and GP: 1BL criteria, 10th percentile

	DEPTH ALTERNATIVE				
Vertical Layer	**44-foot**	**45-foot**	**46-foot**	**47-foot**	**48-foot**
Surface	99.5	99.7	99.7	99.7	99.7
Mid-Depth	93.5	98.5	97.9	98	98.1
Bottom	97.4	98.1	97.3	97.3	98.6
Water Column	97.5	99.9	99.9	99.9	99.9

Table C-3 Mitigation success for facilities located near IP and GP: 1BL criteria, 25th percentile

	DEPTH ALTERNATIVE				
Vertical Layer	**44-foot**	**45-foot**	**46-foot**	**47-foot**	**48-foot**
Surface	99.9	99.8	99.9	99.9	99.9
Mid-Depth	94.5	98.7	98.4	98.3	98.5
Bottom	97	98.5	97.3	98.1	98.4
Water Column	97.7	99.9	99.9	99.9	99.9

Table C-4 Mitigation success for facilities located near IP and GP: 1BL criteria, 50th percentile

	DEPTH ALTERNATIVE				
Vertical Layer	**44-foot**	**45-foot**	**46-foot**	**47-foot**	**48-foot**
Surface	99.7	99.7	99.6	99.6	99.6
Mid-Depth	95.3	98.4	97.2	97.8	98
Bottom	97.8	98.8	97.4	97.3	97
Water Column	98.2	99.9	99.9	99.9	99.9

Table C-5 Mitigation success for facilities located near IP and GP: 3BL criteria, 5th percentile

	DEPTH ALTERNATIVE				
Vertical Layer	44-foot	45-foot	46-foot	47-foot	48-foot
Surface	99.3	98	98	98.4	99.2
Mid-Depth	94	94.5	94.5	96.2	95.1
Bottom	96.9	93.9	92.3	95.1	96.4
Water Column	98	99.9	99.8	99.8	99.7

Table C-6 Mitigation success for facilities located near IP and GP: 3BL criteria, 10th percentile

	DEPTH ALTERNATIVE				
Vertical Layer	44-foot	45-foot	46-foot	47-foot	48-foot
Surface	99.5	98.1	98.3	98.6	99.1
Mid-Depth	94.3	94.9	94.7	95.9	95.4
Bottom	96.6	95.2	95	95.1	95.9
Water Column	98	99.9	99.8	99.8	99.9

Table C-7 Mitigation success for facilities located near IP and GP: 3BL criteria, 25th percentile

	DEPTH ALTERNATIVE				
Vertical Layer	44-foot	45-foot	46-foot	47-foot	48-foot
Surface	99.8	98.6	98.9	99	99.9
Mid-Depth	94.9	95.9	95.9	96.6	96.5
Bottom	95.8	94.7	94.3	94.3	94.7
Water Column	98.4	99.7	99.6	99.5	99.9

Table C-8 Mitigation success for facilities located near IP and GP: 3BL criteria, 50th percentile

	DEPTH ALTERNATIVE				
Vertical Layer	44-foot	45-foot	46-foot	47-foot	48-foot
Surface	99.7	99.2	98.9	99.1	99.6
Mid-Depth	96.2	95.7	94.4	95	95.7
Bottom	96.9	94.4	93.1	94	93.5
Water Column	98.8	99.3	98.8	98.9	98.9

APPENDIX D

SAVANNAH ENHANCED MODEL (SHEP) POSTPROCESSOR

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The post-processor for Savannah enhanced hydrodynamic and water quality model (WAMS) is a stand-alone program that can read EFDC and WASP output files (BMD files) and generate required outputs in specific formats for impact analysis. The GUI of the current version of the postprocessor is presented on Figure D-1.

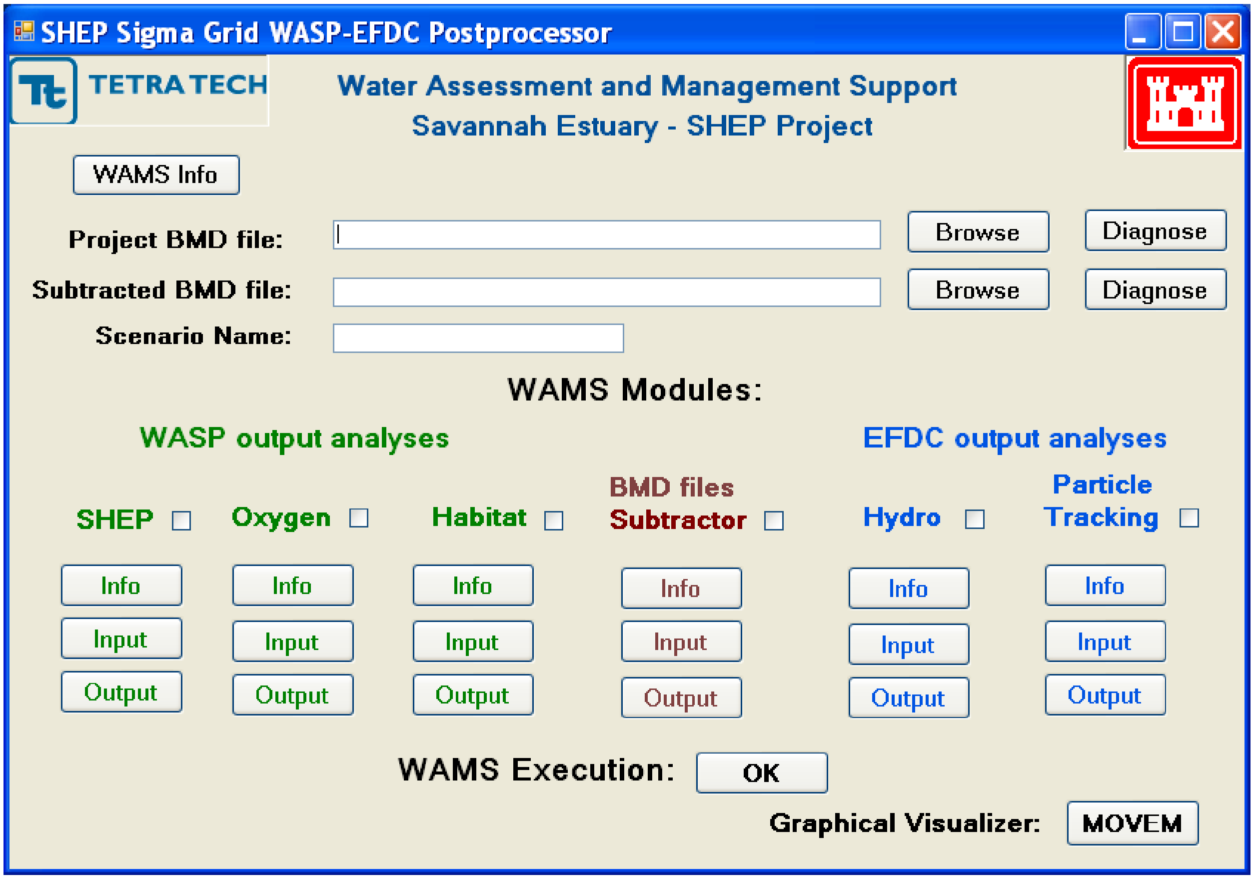

Figure D1 WASP-EFDC postprocessor for models developed for SHEP project

The module "Oxygenation" was developed for identification of parameters of dissolved oxygen improvement system and evaluation of effectiveness of SHEP mitigation measures.

The modified postprocessor outputs information for the following harbor's spatial objects:

- Critical Cell – the cell with lowest D.O. concentrations during specified simulation period
- Critical Segment – an assemblage of cross section cells located at the critical cell's j-coordinate
- Zone – an assemblage of cells that is limited by specified horizontal and vertical boundaries

The basic criteria for assessing the success of D.O. mitigation is the condition of meeting existing (pre-project) or higher values of D.O. concentrations for 97% of the estuarine waters at least. WAMS provides estimates of such waters volume for all user's selected zones.

The postprocessor outputs the results of hydrodynamic and water quality simulations as a set of following files with tables:

1. File name: <Oxygen\Tables\><Scenario name><Mitigation success.CSV>. The tables contain the percentage of volume that meets 97% requirement for all cells of selected zones, all zones and the whole estuary for 1st, 5th, 10th, 25th, 50th, 75th, 95th, and 99th percentiles of D.O. concentrations.

2. File name: <Oxygen\Tables\><Scenario name><_CriticCell_DO_%.CSV>. The table contains D.O. percentiles distribution for a cell with lowest D.O. concentrations inside each zone. The information allows purposefully focusing the mitigation measures on most critical parts of the zones.

3. File name: <Oxygen\Tables\><Scenario name><_CriticCell_Sal_%.CSV>. The table contains salinity percentiles distribution for each zone's critical cell. It helps to identify salinity impact on formation of lowest D.O. concentrations inside each zone.

4. File name: <Oxygen\Tables\><Scenario name><_C_DO_Viol.CSV>. The table contains percentage of simulation records with D.O. standards' violations for each cell of the computational grid during the simulation period:

$$A_i^k = \frac{100}{N_t}\sum_{t=1}^{N_t}\delta_{it}^k, \qquad ,$$

$$\delta_{it}^k = 1, \quad if\ C_{it} \geq S^k;\ \delta_{it}^k = 0, \quad if\ C_{it} \prec S^k$$

where A_i^k is a number of violations of the *k*-th D.O. standard S^k for *i*-th cell; C_{it} is the D.O. concentration in *i*-th cell for *t*-th record; N_t is the number of time records in BMD WASP output file

5. File name: <Oxygen\Tables\><Scenario name><_C_DO_Viol_Analys.CSV>. The table contains numbers of cells that correspond to deciles of the cumulative distribution function of numbers of violation of D.O. standards

$$G_j^k = \sum_{i=1}^{N_c} Z_{ij}^k, \quad j = 1,...,10$$

$$if\ (j-1)*10 \prec A_i^k \leq j*10 \quad Z_{ij}^k = 1, \quad otherwise\ Z_{ij}^k = 0,$$

where G_j^k is the number of cells with *k*-th standard violation within a range of *j* and *j-1* deciles; N_c is the number of cells in the computational grid.

6. File name: <Oxygen\Tables\><Scenario name><_C_Viol_WC_Volume.CSV>. The table contains percentage of water volumes with violations of D.O. standards through the water column of each specified zone

$$B_m^k = \frac{\sum_{t=1}^{N_t}\sum_{n=1}^{N_v}\sum_{i=1}^{N_m} V_{tin}\delta_{tin}^k}{\sum_{t=1}^{N_t}\sum_{n=1}^{N_v}\sum_{i=1}^{N_m} V_{tin}} \cdot 100\% \qquad ,$$

$$\delta_{tin}^k = 1, \quad if\ C_{tin} \geq S^k;\ \delta_{tin}^k = 0, \quad if\ C_{tin} \prec S^k$$

where N_v is the maximum number of vertical layers; N_m is the number of horizontal cells in a zone *m*; V_{tin} is the volume of a cell with coordinates (*i, n*) at time *t*.

7. File name: <Oxygen\Tables\><Scenario name><_C_Viol_WL_Volume.CSV>. The table contains percentage of water volume with violations of D.O. standards for each specified zone and selected vertical layers

$$B_m^k = \frac{\sum_{t=1}^{N_t}\sum_{n=N_b}^{N_e}\sum_{i=1}^{N_m} V_{tin}\delta_{tin}^k}{\sum_{t=1}^{N_t}\sum_{n=N_b}^{N_e}\sum_{i=1}^{N_m} V_{tin}} \cdot 100 ,$$

$$\delta_{tin}^k = 1, \quad if\ C_{tin} \geq S^k;\ \delta_{tin}^k = 0, \quad if\ C_{tin} \prec S^k$$

where N_b and N_e are the beginning and ending of vertical n-coordinates for zone m; V_{tijn} is the volume of a cell with coordinates (i, j, n) at time t.

8. File name:< Oxygen\Tables\><Scenario name><_CriticSeg_DO_A_TS.CSV>. The table contains time series of 1-, 7-, and 30-day average D.O. for each critical segment's water column, and it's top and bottom halves

9. File name: <Oxygen\Tables\><Scenario name><_CriticSeg_Sal_A_TS.CSV>. The table contains time series of 1-, 7-, and 30-day average salinity for each critical segment's water column, and it's top and bottom halves

10. File name: <Oxygen\Tables\><Scenario name><_Z_DO_%. CSV>. The table contains volume-weighted D.O. percentiles distributions for each zone and specified vertical layers

11. File name: <Oxygen\Tables\><Scenario name><_Z_Sal_%.CSV>. The table contains volume-weighted salinity percentiles distributions for each zone and specified vertical layers

12. File name: <Oxygen\Tables\><Scenario name><_Z_DO_Viol.CSV>. The table contains percentages (F_m) of occurrences of D.O. standards violations by each zone's volume-weighted D.O.

$$R_{tm} = \frac{\sum_{i=1}^{N_m}\sum_{n=N_b}^{Ne} V_{tin} C_{tin}}{\sum_{i=1}^{N_m}\sum_{n=N_b}^{Ne} V_{tin}} ,$$

$$F_m = \frac{100\%}{N_t} \cdot \sum_{t=1}^{N_t} \delta_{tm}^k ,$$

$$\delta_{tm}^k = 1, \quad if\ R_{tm} \geq S^k;\ \delta_{tm}^k = 0, \quad if\ R_{tm} \prec S^k ,$$

where R_{tm} is the volume-weighted D.O. concentration for zone m and time record t.

13. File name: <Oxygen\Tables\><Scenario name><_Z_DO_Mass.CSV>. The table contains D.O. deficit in reference to the current D.O. minimum standard St.4: average deficit over simulation period – D_m, as well as maximum instant D.O. deficit and time of this event for each specified zone

$$D_m = \frac{1}{N_t}\sum_{t=1}^{N_t}\sum_{n=N_b}^{N_e}\sum_{i=1}^{N_m}(S^k - C_{tin})$$

The tables (items 10 – 13) contain information about each selected zone volume-weighted D.O. and salinity concentrations' averages and their correspondence to D.O. standards. The information allows estimating the contribution of each zone into the general pattern of D.O. regime of the estuary.

APPENDIX E

ECO2 QUOTATION ON SPEECE CONE ON MARCH 17, 2010

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Eco2 quotation included below.

ECO2

3/17/2010
Savannah Harbor, Oxygen Injection
ECO2 SuperOxygenation
Preliminary design & budget estimate
Steven Davie, Submitted by Eco Oxygen Technologies
Oxygen supply by on site oxygen generation PSA

Design Operating Conditions		**units**			
Oxygen Supply		lbs / day		5,000	
Electrical Unit Cost		$ / kwhr		$0.06	
Annual Usage		days		180	
ECO2 System Design and Capital Cost		**units**	**quantity**	**rate**	**cost**
ECO2 cone with PLC oxygen flow control	12	ft. Dia.	1	$748,474	$748,474
Oxygen dissolution	4,000	lbs / day	1	4,000	
Side Stream Flow	12,600	gpm	1	12,600	
Sub total					$748,474
Outsourced/3rd party Capital Cost		**units**	**quantity**	**rate**	**cost**
Installation (including side stream pump)			1	$250,000	$250,000
Oxygen Generator (PSA)	5,000	lbs / day	1	$170,000	$170,000
Sub total					$420,000
Annual Operating Cost		**units**	**quantity**	**rate**	**cost**
Electrical draw - Oxygen Generator	1,815	kwhr / day	1	$0.06	$19,600
Electrical draw - Side Stream Pump	75	hp	1	$0.06	$14,500
O&M - Oxygen Generator & Side Stream Pump				20%	$6,800
License fee - ECO2 process technology	4,000	lbs / day	1	$0.01	$7,200
Sub total					$48,100
Total Capital Cost Estimate including Onsite Oxygen Generation					**$1,168,474**
Total Annual Operating Cost Estimate (180 days)					**$48,100**

Notes:
The cost estimate for installation, side stream pump and oxygen generation equipment need to be validated.
Cost estimates valid for 30 days and do not include taxes or shipping
Cost estimates subject to verification of design data
Purchase subject to Terms & Conditions of Purchase Agreement and Process Technology License Agreement

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