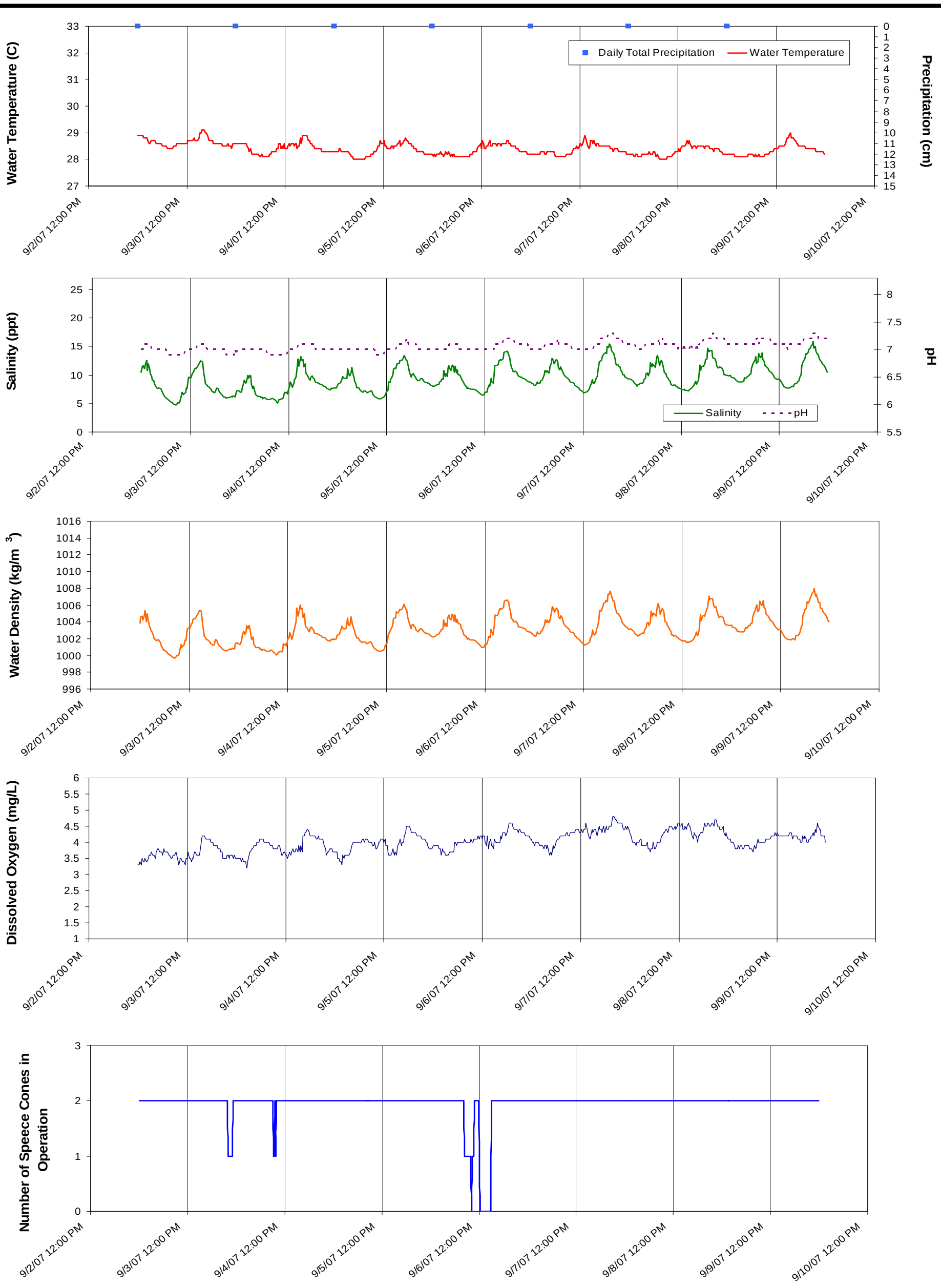


Prepared by: MKB 11/19/07

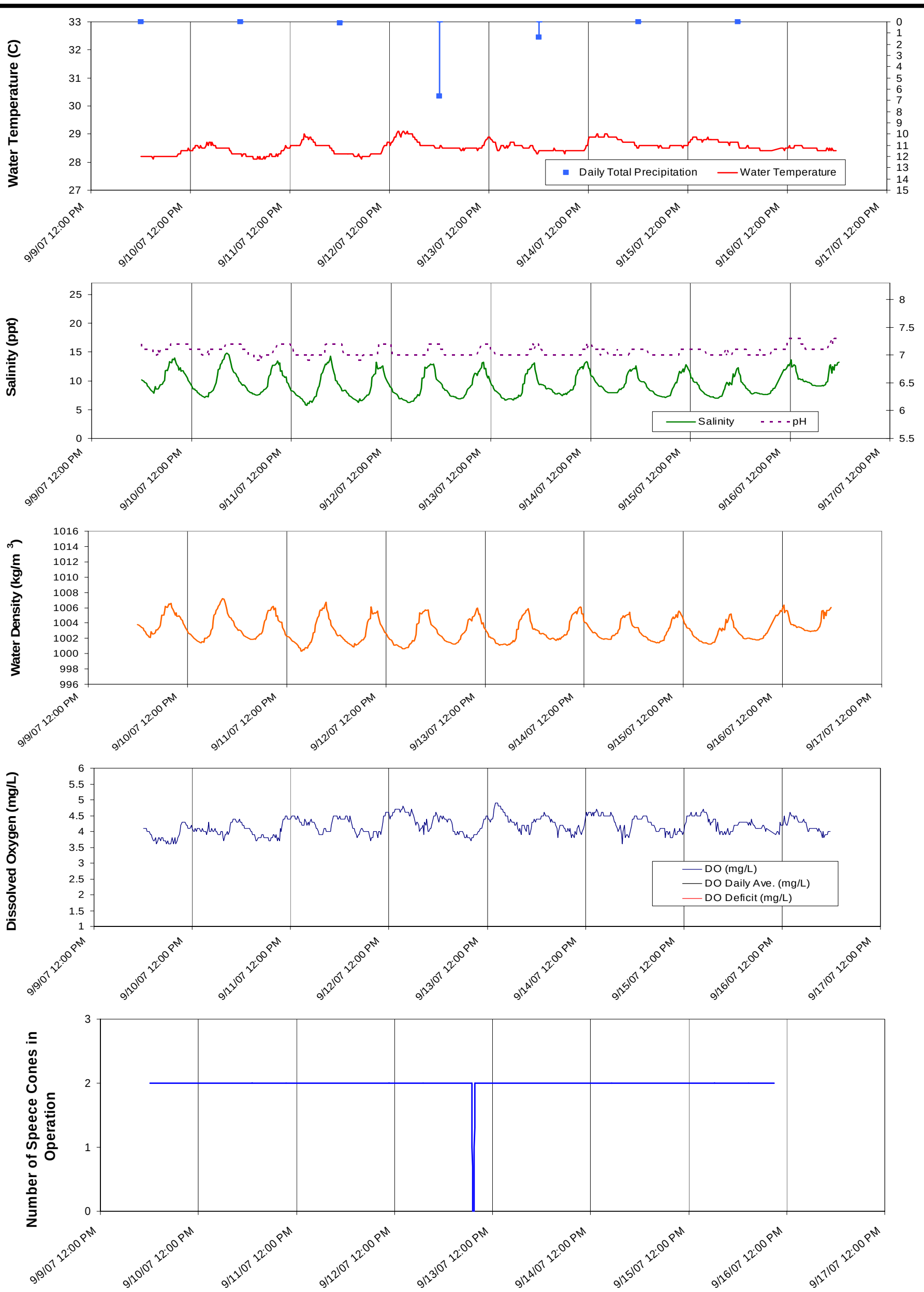
Checked by: VUO 11/19/07

SAVANNAH HARBOR
REOXYGENATION DEMONSTRATION PROJECT
GEORGIA PORTS AUTHORITY
SAVANNAH, GEORGIA

MACTEC

USGS Gage Station at USACE Dock
Sep 3 – 9, 2007

Project Number: 6110070004 Figure 4-8.1



Prepared by: MKB 11/19/07

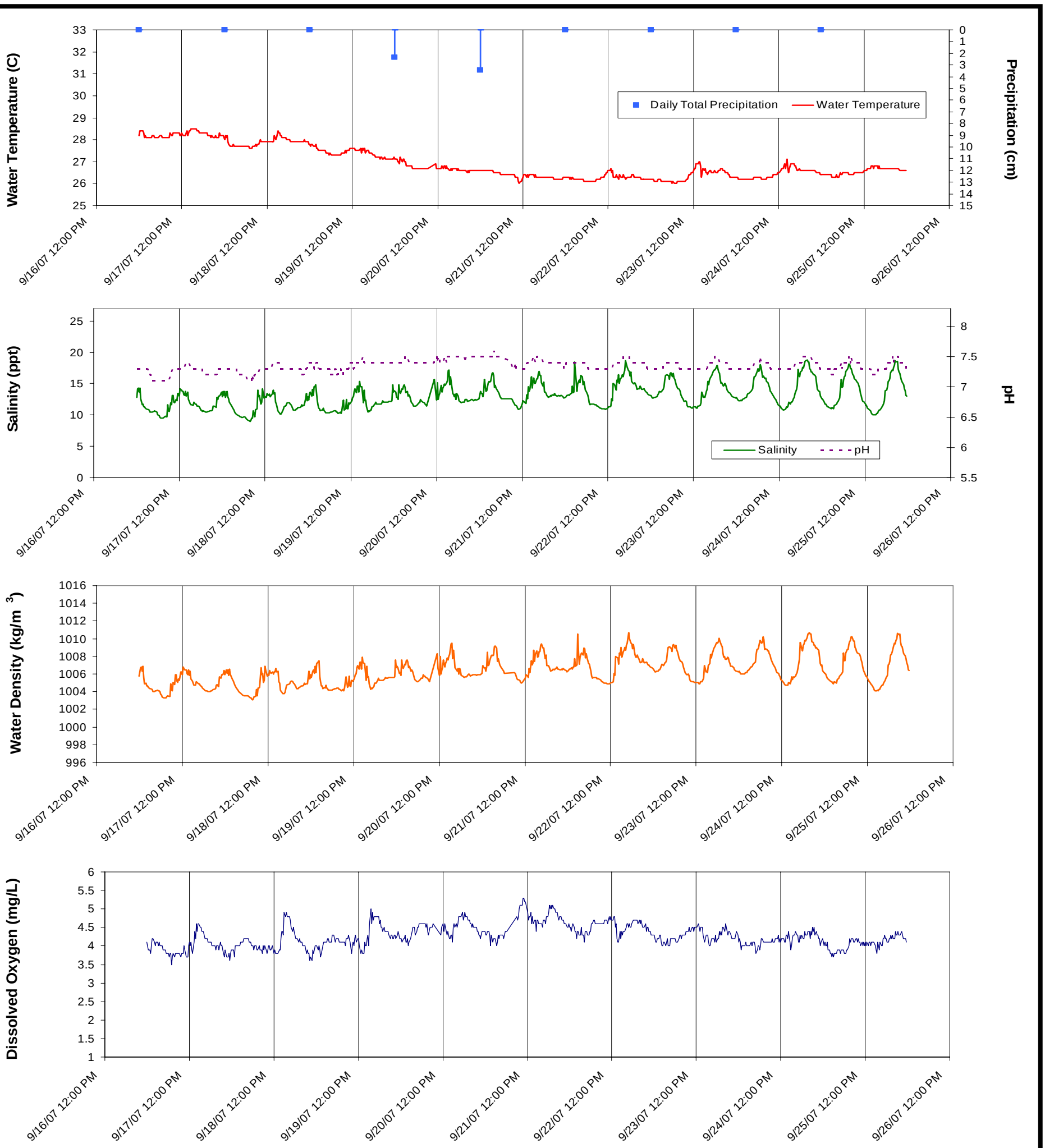
Checked by: VUO 11/19/07

SAVANNAH HARBOR
REOXYGENATION DEMONSTRATION PROJECT
GEORGIA PORTS AUTHORITY
SAVANNAH, GEORGIA

MACTEC

USGS Gage Station at USACE Dock
Sep 10 – 16, 2007

Project Number: 6110070004 Figure 4-8.1



Prepared by: MKB 11/19/07

Checked by: VUO 11/19/07

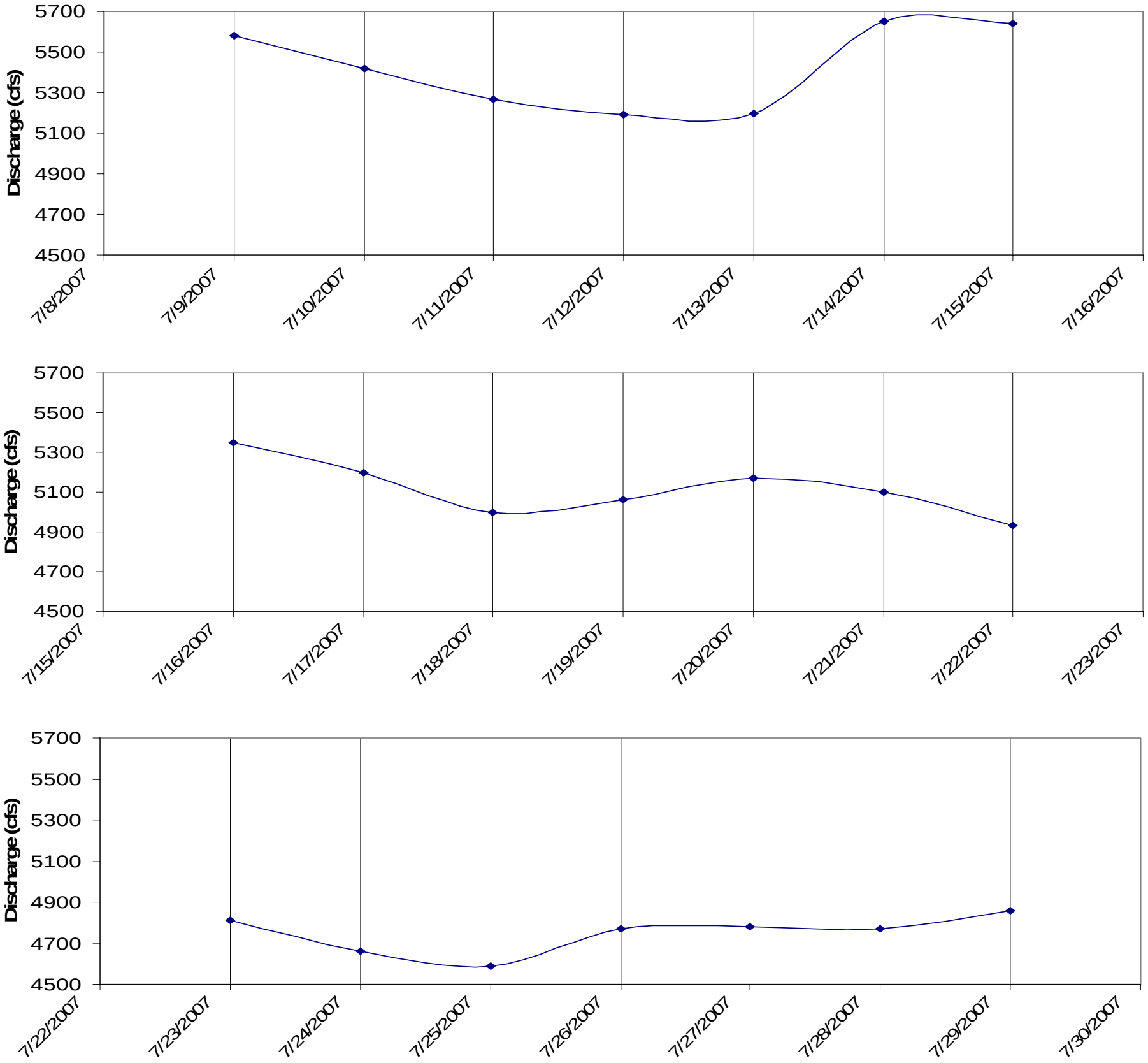
SAVANNAH HARBOR
REOXYGENATION DEMONSTRATION PROJECT
GEORGIA PORTS AUTHORITY
SAVANNAH, GEORGIA

MACTEC

USGS Gage Station at USACE Dock
Sep 17 – 25, 2007

Project Number: 6110070004

Figure 4-8.1



Prepared by: MKB 11/19/07

Checked by: VUO 11/19/07

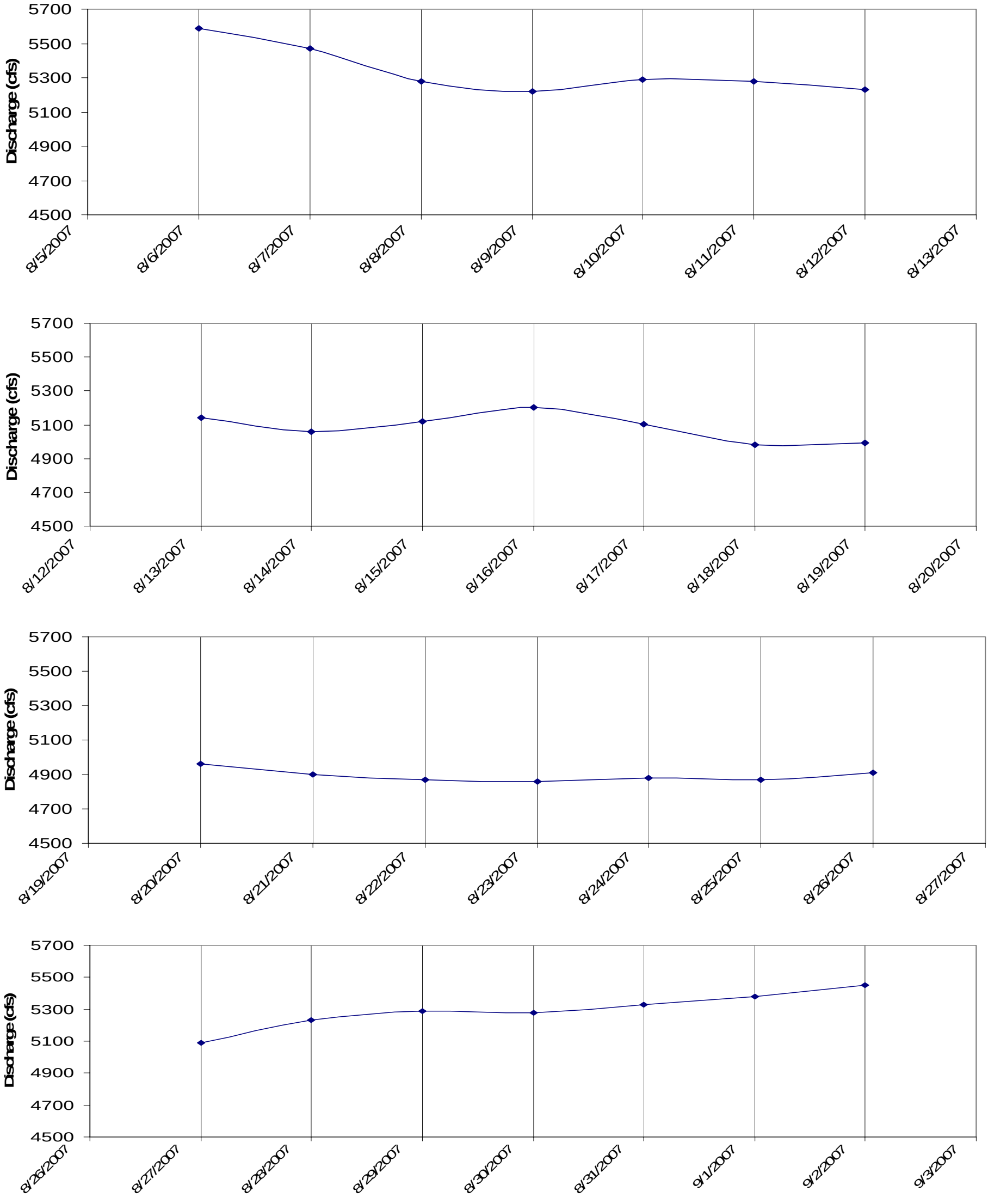
SAVANNAH HARBOR
REOXYGENATION DEMONSTRATION PROJECT
GEORGIA PORTS AUTHORITY
SAVANNAH, GEORGIA

MACTEC

USGS Savannah River Clyo Gage
Daily Water Discharge
July 9 – August 5, 2007

Project Number: 6110070004

Figure 4-8.2



Prepared by: MKB 11/19/07

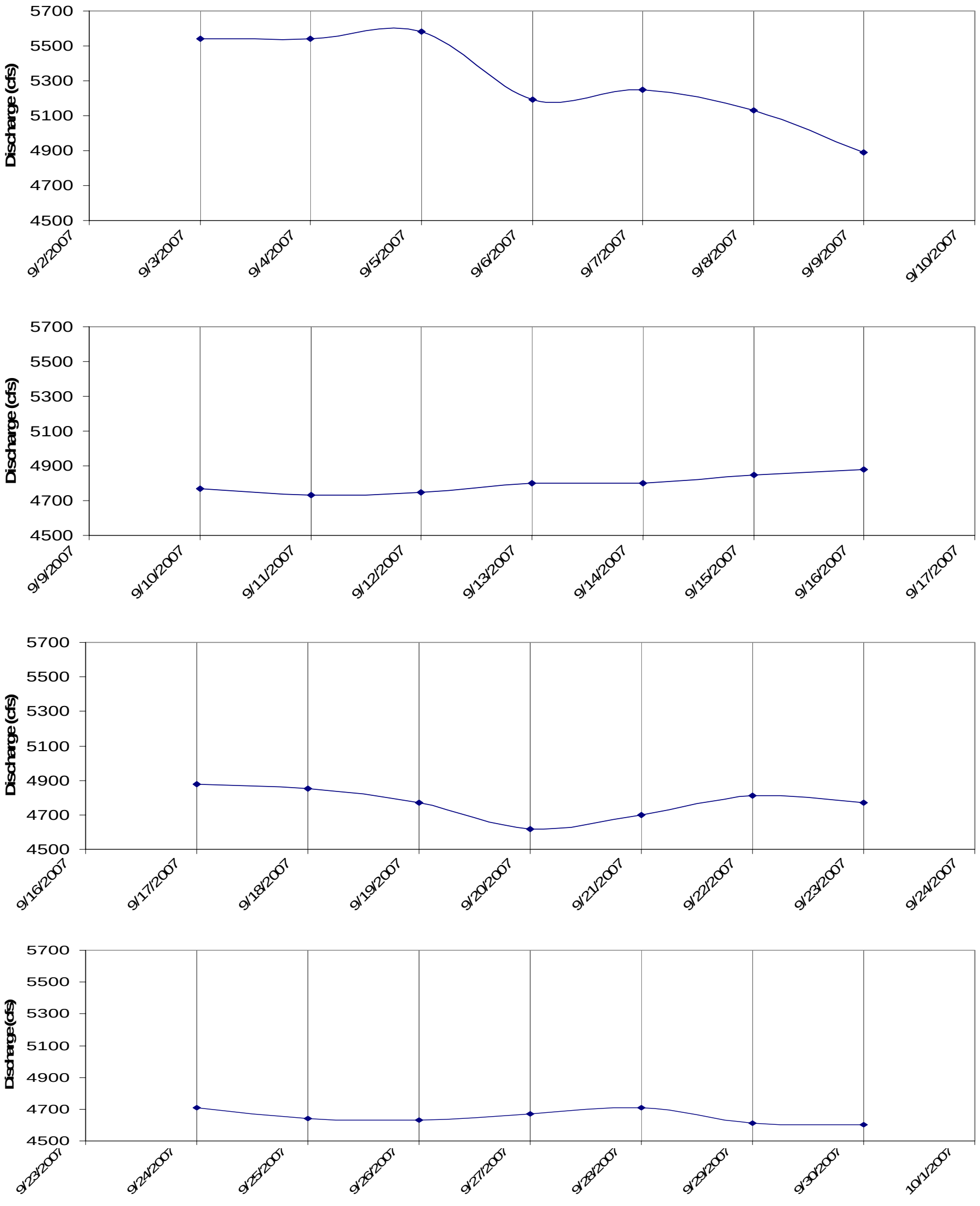
Checked by: VUO 11/19/07

SAVANNAH HARBOR
REOXYGENATION DEMONSTRATION PROJECT
GEORGIA PORTS AUTHORITY
SAVANNAH, GEORGIA

MACTEC

USGS Savannah River Clyo Gage
Daily Water Discharge
August 6 – September 2, 2007

Project Number: 6110070004 Figure 4-8.2



Prepared by: MKB 11/19/07

Checked by: VUO 11/19/07

SAVANNAH HARBOR
REOXYGENATION DEMONSTRATION PROJECT
GEORGIA PORTS AUTHORITY
SAVANNAH, GEORGIA

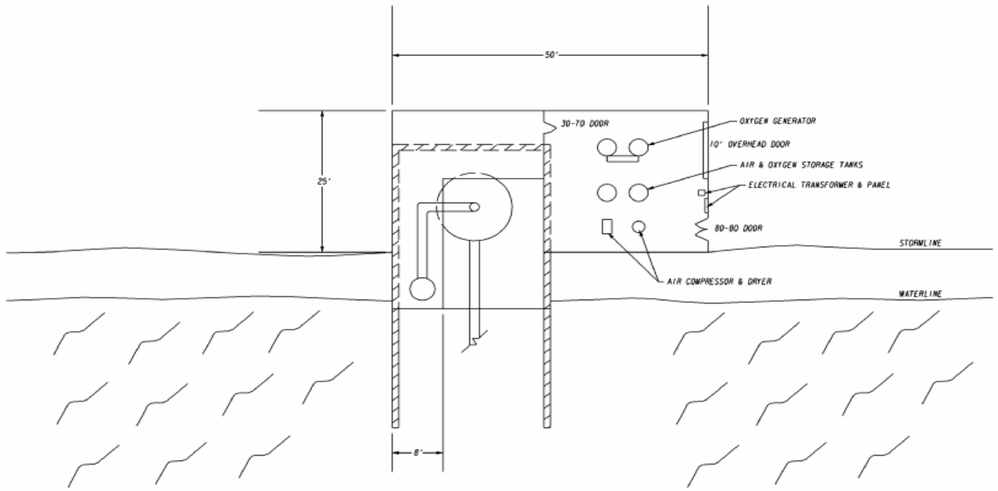
MACTEC

USGS Savannah River Clyo Gage
Daily Water Discharge
September 3 – September 30, 2007

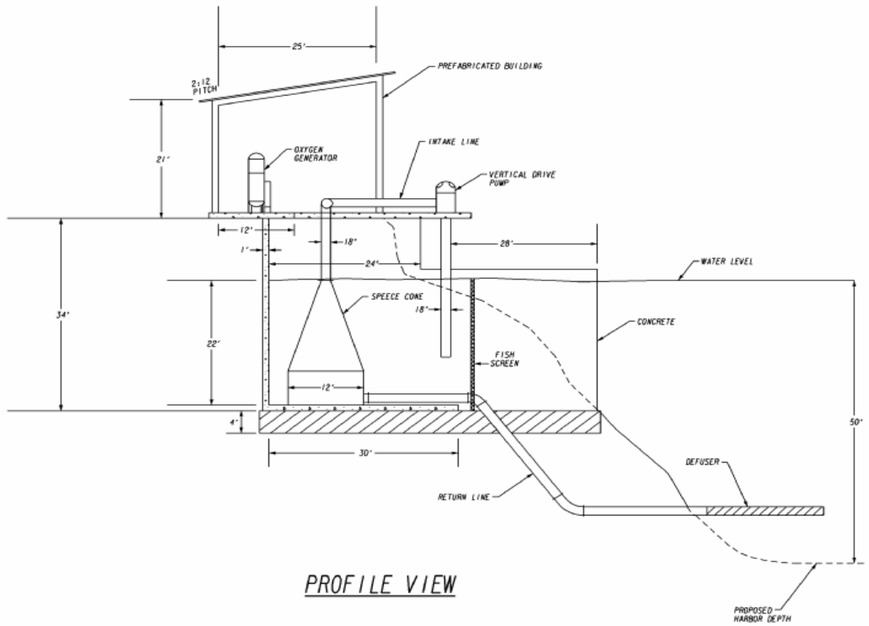
Project Number: 6110070004

Figure 4-8.2

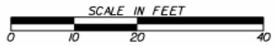
WELL OPTION



PLAN VIEW



PROFILE VIEW



Prepared by: JMH 11/19/07

Checked by: DGU 11/19/07

SAVANNAH HARBOR
REOXYGENATION DEMONSTRATION PROJECT
GEORGIA PORTS AUTHORITY
SAVANNAH, GEORGIA

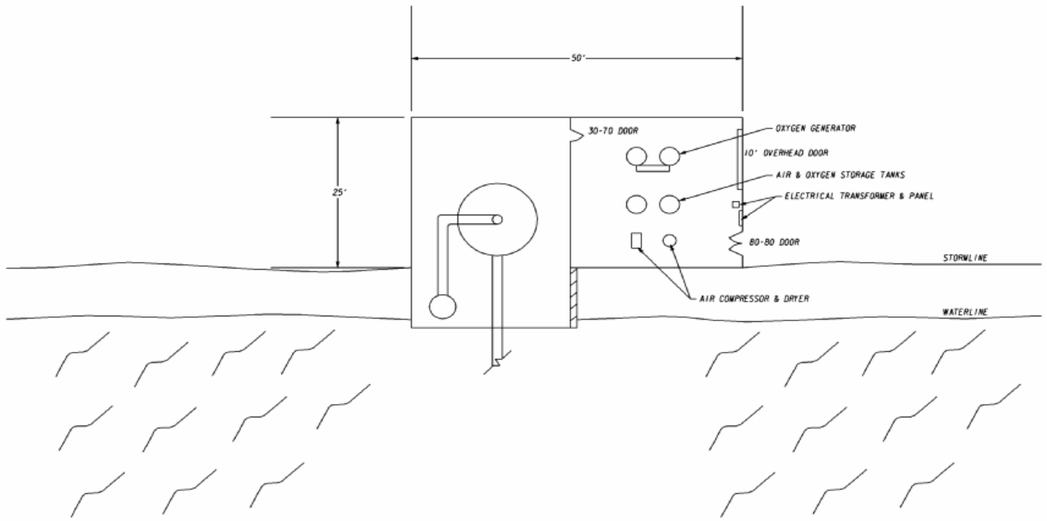
MACTEC

Permanent ReOx Installation Well Option

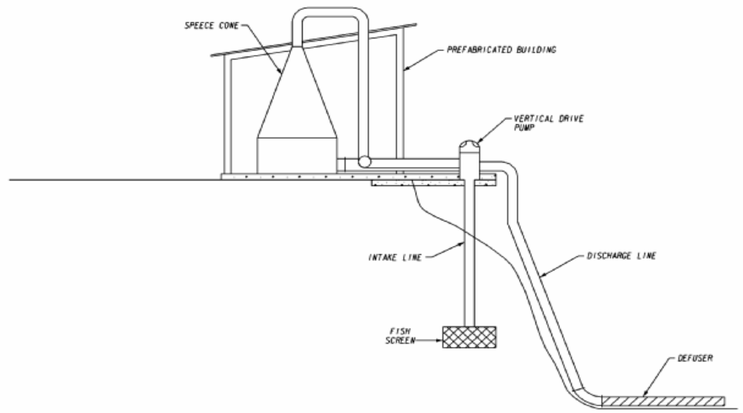
Project Number: 6110070004

Figure: 5-1

ABOVE GROUND OPTION



PLAN VIEW



PROFILE VIEW

Prepared by: JMH 11/19/07

Checked by: DGU 11/19/07

SAVANNAH HARBOR
REOXYGENATION DEMONSTRATION PROJECT
GEORGIA PORTS AUTHORITY
SAVANNAH, GEORGIA

MACTEC

Permanent ReOx Installation Above Ground Option

Project Number: 6110070004

Figure: 5-2

Table 5-2
Annual Operations and Maintenance ROM Cost Estimate

Projected Yearly Costs per Cone		
	Oxygen Generator	**Liquid Oxygen**
Maintenance		
Motors	$1,320	$1,320
Pump	$1,320	$1,320
Oxygen Generator	$1,320	$0
Compressor	$1,320	$0
Screen	$3,119	$3,119
Building	$1,361	$1,361
Subtotal	$8,442	$5,801
Operation		
Pump	$5,500	$5,500
Lighting	$1,500	$1,500
Oxygen Generator	$3,500	$0
Liquid Oxygen	$0	$92,120
Subtotal	$10,500	$99,120
25% Contengency	$4,735	$26,230
Total Estimated Yearly Expense	**$23,677**	**$131,151**

Notes:

1. Cost are based on RS Means Costwork 2007 where possible and inteded to provide a rough order of magnitude (ROM) annual operations cost estimate
2. Maintenance costs based on national averages for state employees. Costs also assume standard maintenance for a three (3) month period during operations.
3. Screen costs reflect cost of diver and crew to clean and service fish screen. Also includes 2 additional dives for service during operation and are based on national average wage rates
4. Electrical costs are representative of normal operations using current pricing structure
5. Liquid oxygen based on 15,000 pounds per day and include the use of temporary tank and evaporater provided by oxygen supplier.

APPENDIX A

GEODATABASE
(Electronic Only)

APPENDIX A

Appendix A contains the project database located on the attached DVD in Microsoft Access format. In addition to the database file, selected tables have been prepared as referenced in the text.

APPENDIX B

SAVANNAH HARBOR REOXYGENATION WATER QUALITY MONITORING PLAN

SAVANNAH HARBOR REOXYGENATION WATER QUALITY MONITORING PLAN

Prepared for:

GEORGIA PORTS AUTHORITY

Prepared by:

MACTEC ENGINEERING AND CONSULTING, INC.
3200 Town Point Drive NW, Suite 100
Kennesaw, Georgia 30144

June 11, 2007

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The water quality monitoring plan developed for the Savannah Reoxygenation Demonstration Project is described in this report. The Georgia Ports Authority (GPA) is to deepen the navigation channel of the Savannah Harbor to accommodate the passage of larger deep-draft ships. However, deepening the harbor has the effect of reducing the reaeration capacity of the river and thereby reducing dissolved oxygen (DO) concentrations in the deepened channel.

MACTEC Engineering and Consulting Inc. was contracted by the Georgia Ports Authority to carry out a DO mitigation demonstration project. The ReOxygenation (ReOx) project will inject DO into the harbor to mitigate the incremental DO deficit resulting from the proposed deepening.

Under this demonstration project water quality monitoring plan, the frequency and methods for instream monitoring of DO and other water quality parameters (pH, specific conductivity, temperature, salinity, and depth) have been developed.

Water quality monitoring will be conducted at three stationary points in the river (at GPA Berth 20, at the barge location, and the US Army Corps of Engineers (USACE) Dock). Water quality monitoring sondes will be deployed at 1 meter below the surface, near mid depth, and 1 meter from the bottom at each location. Redundant sondes will also be deployed as a data check and to minimize potential data loss during the project. Personnel will be deployed regularly (at a minimum 4 times per week) to replace sondes.

In addition to the stationary locations, DO and water quality measurements will be taken in the river at various depths along horizontal and vertical transects. There will be five horizontal transects (at Berth 20, upstream of the Talmadge Bridge, at the barge location, at the convention center, and at the USACE Dock). Sampling will be performed centered on high or low slack tides (tides will vary during the project). The vertical transect will be along the center of the navigation channel and will include 13 locations extending from Berth 20 to the USACE Dock.

1 INTRODUCTION

This water quality monitoring plan for the Savannah Harbor ReOxygenation Demonstration Project (ReOx project), describes the methods that will be used to monitor dissolved oxygen (DO) and other water quality parameters (pH, specific conductivity, temperature, salinity, and water depth) for the demonstration. This effort is being conducted to aid GPA in assessing the oxygen addition mitigation alternative for the proposed Savannah Harbor deepening project. The deepening project will increase the depth of the harbor, allowing passage to the port of larger deep-draft container ships. Deepening of the harbor will result in reduced reaeration capacity for the river. The ReOx project mitigates for this lost reaeration capacity, and may ultimately lead to permanent ReOx system installations along the deepened harbor channel.

This water quality monitoring plan describes specific responsibilities, equipment requirements, operating procedures; and data quality objectives for water quality monitoring during the ReOx demonstration project.

2 SURFACE WATER MONITORING

2.1 Water Quality Monitoring Program

Water quality monitoring is to be conducted at select locations within the Savannah Harbor ReOx project area (Figure 1), to assess instream conditions before, during, and one week after the reoxygenation project demonstration period. The parameters to be monitored in the field include dissolved oxygen (DO), pH, conductivity, temperature, salinity, and water depth.

The pH, conductivity, and DO instrumentation will be calibrated prior to sondes deployment for the continuous monitoring, and twice-daily (at a minimum) for the weekly monitoring events. Continuous monitor sondes calibration will be checked (at least once a week), and calibration for weekly events will occur before use and at the end of the day. Instrument calibration and maintenance will be conducted in accordance with the manufacturer's instructions and the procedures specified in this monitoring plan. Additional calibration checks may be performed as site conditions dictate. All calibration data will be recorded and filed with the project field records.

2.1.1 Continuous Monitoring Schedule and Events

Three weeks prior to start up of the ReOx system, during the demonstration period, and continuing for one week after the shutdown of the ReOx system, in situ water quality monitoring will be conducted using YSI 6920 multi-parameter recording sondes. Fourteen (14) continuous monitoring sondes will be deployed to monitor water quality in the field. The sondes will continuously record water quality data at shallow, mid-, and deep river channel depths at the following temporary locations: upstream from the ReOx system; at the ReOx barge location; and downstream from the ReOx system (Figure 2). Duplicate sondes will be deployed at each location and depth to reduce the potential for data gaps resulting from instrument problems. Two additional monitoring stations will be setup at the ReOx system discharge, to measure the concentrations of DO injected into the river.

2.1.2 Continuous Monitoring Procedures

Water quality data will be automatically recorded at quarter-hour intervals for the locations shown in Figure 2. Field personnel will be deployed two (2) or more times per week to download

data from the sondes, verify the sondes are working properly, and provide maintenance. The sondes will be changed out and recalibrated on average twice every week. The reference standards for field instrument calibration are described in Appendix A of this plan. If there is evidence of fouling on the sondes or significant drift in the data, then the sondes will be changed out more often. To allow for uninterrupted data monitoring, scheduling for the change out and recalibration of the sondes will be such that a continuous monitoring sonde and its associated duplicate should not be changed at the same time during a particular station visit.

The YSI 6920 sondes must be calibrated and certified by the manufacturer or authorized representative prior to initial field deployment. Additional calibration of the sondes will be in accordance with the manufacturer's specification and the guidelines that are outlined for instrument calibration in this monitoring plan.

2.1.3 Supplemental Weekly Monitoring Schedule and Events

Each week, field personnel will collect supplemental water quality data "snapshots" using the river grid system defined in the EPA/USACE Savannah Harbor Water Quality Model (Tetra-Tech, 2005) that falls within the ReOx demonstration project area. Dissolved oxygen, pH, water depth, conductivity and salinity profiles will be taken to allow for spatial evaluation of water quality between the fixed continuous monitoring locations. This will also allow data to be collected at the bottom of the navigation channel where DO is typically lowest.

Hand held YSI 6290 multi-parameter sondes will be used to monitor water quality parameters. Five (5) select river transect locations (Figure 3) will be sampled on a weekly basis, beginning three (3) weeks before the ReOx system is turned on and continuing until one week after the ReOx system is shut down. A total of fourteen (14) points will be sampled within each transect cross section as follows:

Table 1

Supplemental Weekly Monitoring Schedule at Transect Locations Savannah Harbor ReOxygenation Water Quality Monitoring Plan

Location Within Transect	Sampling Depth (ft)
Left and Right Overbank –outside of navigation channel	3 ft below surface3 ft above bottom
Left and Right –within navigation channel	3 ft below surface depth mid-depth 3 ft above bottom
Center of navigation channel	3 ft below surface 1/3 of total depth 2/3 of total depth 3 ft above bottom

ft- feet

Prepared By: VUO 05/27/07
Checked By: MET 05/28/07

In addition, thirteen (13) longitudinal (Figure 4) sampling locations will be monitored weekly using the hand held YSI 6920 sondes. These mid-channel DO measurements will be taken at four (4) select depths: 3 ft below water surface; 1/3 of total depth; 2/3 of total depth; and 3 ft above bottom.

These weekly monitoring events will be timed to coincide with local slack tide conditions (low or height).

2.1.4 Weekly Monitoring Sampling Procedures

For the weekly water quality parameters monitoring, the standards for field instruments calibration, are explained in Appendix A of this document. A minimum of ten percent (10%) of field duplicate samples should be collected at the sampling locations to meet the measure of precision necessary to maintain and follow the quality control protocols for this water quality monitoring. Discrete quality assurance (QA) DO samples will be collected using Kemmerer or Van Dorn type water samplers (Figure 5). Samples will be fixed in the field and returned to the field laboratory for DO analysis.

3 DATA QUALITY OBJECTIVES

The data quality objective for the ReOx project is to arrive at a level of sufficient and credible data that supports a reasonable level of certainty that the monitoring results are correct. The quality controls for the ReOx project are limited to assessing the precision, representativeness, comparability, and accuracy of the monitored parameter values.

3.1 PRECISION

Precision is a measure of how reproducible the data collected are between duplicate samples. It determines the consistency of repeated samples that are tested. Precision measurements are obtained by the field team taking independent duplicate measurements for parameters recorded.

To evaluate the precision of field measurements for the ReOx project, duplicate measurements will be taken at the same time and place for the continuous monitoring points and ten percent (10%) of the weekly monitoring points. The relative percent difference between duplicate measurements will show how precise the data are for the parameters sampled.

3.2 ACCURACY

This is a measure of confidence that the data collected in the field reflect the true value of a given parameter. In this field monitoring, accuracy is primarily a function of proper instrument calibration. Over time, some instruments tend to drift away from their initial calibration. Different types of instruments are affected by drift to different degrees.

In order to check that the sondes are not drifting too far from calibration, periodic accuracy checks will be performed by checking and recalibrating the sondes at the frequencies specified in section two (2) of this plan, and observing the instrument reading of known reference standards. The ranges of expected values for DO, pH, conductivity, temperature, salinity, and water depths are shown in Table 2.

3.3 REPRESENTATIVENESS

Sampling sites and procedures used in this study have been designed so that the resulting data are representative of the conditions within the local study area. Systematic sampling has been designed in such a way that samples will be taken at different depths at five locations across the

river channel for five transects along the reach of the study area (Figure 3). These transects correspond to river grid boundaries that were used in previous Savannah River Modeling study (Tetra-Tech, 2005). In addition, thirteen (13) longitudinal sampling locations (Figure 4) have been selected for mid-channel DO measurements.

3.4 COMPLETENESS

The completeness of data quality controls relies on how many samples need to be taken to be able to use the information collected. Percent completeness is the number of planned measurements judged valid divided by the total number of measurements taken multiplied by 100. For example, should the field team take the required parameters at each of the five transects for the weekly monitoring stations plus at least 10% duplicate sample at each station the completeness factor will have been met.

3.5 COMPARABILITY

The data to be gathered by the field team extends over a planned period of about 13 weeks. The ReOx demonstration data will be compared with historic continuous monitoring data from the Savannah River Modeling study (Tetra-Tech, 2005). The ReOx demonstration project data will also be compared with concurrent monitoring data expected to be available from a recently installed USGS continuous monitoring station located at the U.S. Army Corps of Engineers dock (the downstream limit of the ReOx project area).

4 DATA MANAGEMENT AND QUALITY CONTROL

Field sampling personnel will be responsible for monitoring all the parameters at the required sampling frequency and locations specified in this plan. The following section provides a list of equipment that will be needed to conduct the field work outlined in this monitoring plan.

4.1 DATA LOGS AND FIELD NOTES

Monitoring data recorded on the YSI 6920 series logger from the continuous monitoring sites will be downloaded to field laptop computers at every sampling location visit. Scheduled monitoring data will also be downloaded to the field computer at the end of each day of sampling. Other data collected by other field equipments (e.g. GPS, Geo Collector, etc.) will be downloaded to the field computer regularly. All data downloaded to the field laptop computers will be backed up to other digital media (DVDs, memory sticks, etc.) at the end of every field sampling.

Field notes will be taken for all sampling sites and recorded in a bound field notebook. It is important that all observations be recorded while at the sampling site to reduce confusion of conditions or unusual events at different sites. Information recorded includes: identification of the monitoring site; date and time of sampling; identity of the sampler(s); results of field analyses; description of the weather, including percent cloud cover and air temperature; description of the site appearance; and any unusual conditions observed. The sampling team will also record information on precipitation that occurred in the days preceding each sampling event, which will be obtained from the nearest rain gage.

4.2 DATA ANALYSIS

A spreadsheet will be used to compile the data in the computer. The data will be analyzed by the project leader, and others. The results of the data will be compiled in the final project report.

Throughout the course of the ReOx demonstration data collection, data will be routinely screened for trends and suspect data. Screening will include calculation of the DO deficit and percent of DO saturation as ongoing data quality and consistency indicators.

5 EQUIPMENTS

The YSI 6920 global change sondes will be utilized during the measurement of all field parameters.

5.1 EQUIPMENT NEEDS

The equipments needed to monitor water quality for Savannah Harbor Study according to this plan are listed below:

- YSI 6920 Sondes
- Field Cable
- Laptop Computer
- 6095B MS-8/DB-9 Adapter
- Appropriate calibration standards
- GPS
- Life Jackets
- Bluecharts
- Thermometer
- 500-mL glass container
- Deionizer (maximum conductivity of 1 µS/cm)
- Cleaning equipment
- Hobby knife or scalpel
- Fine screw driver
- Extra AA-size alkaline batteries
- Field notebooks
- Beaker, 2,000 mL, glass or Teflon™
- Bottles for biological oxygen demand (BOD) analysis, glass stoppered, 300 mL
- Stirrer, magnetic
- Stirring bars, Teflon™ coated
- Cylinder, graduated, 250 mL
- Flask, Erlenmeyer, 250 mL
- Buret, 25-mL capacity with 0.05-mL graduations and Teflon™ stopcock
- Buret, support stand
- Buret, clamp, double
- Alkaline iodide-azide reagent
- Manganous sulfate reagent
- Sulfamic acid granules
- Sodium thiosulfate, 0.025 *N* titrant
- Starch indicator solution
- Clippers, for opening reagent pillows
- Appropriate safety gloves, glasses, and apron
- Waste disposal container
- White background sheet
- Bottle, squeeze dispenser, for deionized water
- Kemmerer or Van Dorn type sampler

5.2 FIELD INSTRUMENTS SPECIFICATION

The specification for the YSI 6920 Instrument is listed in the Table 2 below:

Table 2

Field Instruments Specification
Savannah Harbor ReOxygenation
Water Quality Monitoring Plan

PARAMETER	INSTRUMENT	RANGE	ACCURACY
Dissolved Oxygen	YSI 6920	0 to 50 mg/L	± 0.2 mg/L
pH	YSI 6920	0 to 14 units	± 0.2
Conductivity	YSI 6920	0 to 100 mS/cm	± 0.5 of reading + 0.001mS/cm
Temperature	YSI 6920	-5 to +50°C	± 0.15°C
Salinity	YSI 6920	0 to 70 ppt	± 0.01 of reading or 0.1 ppt, whichever is greater
Water Depths	YSI 6920	0 to 200 ft	± 0.4 ft

mg/L – milligrams per liter
mS/cm – millisiemens per centimeter
°C – degrees Celsius
ppt – part per thousand
ft - feet

5.3 ROUTINE MAINTENANCE

All equipment that will be used in the field to obtain water quality measurements will be maintained. At the beginning and end of each sampling day, equipment must be inspected for damage, or faulty parts and any problems reported to the project leader. The project leader will be responsible for all equipment, its repair status, and the ordering of parts. An equipment inventory will be maintained. Table 3 will serve as the field equipment maintenance record sheet.

Table 3

Field Equipment Maintenance Record Sheet
Savannah Harbor ReOxygenation
Water Quality Monitoring Plan

Date	Equipment	Problem or what repair is needed	What was done or ordered?	Date and price