EXHIBIT C

Savannah Harbor Checklist
for reporting the recommended elements of a "5R Approach"

Waterbody/Watershed Identification

Organization [a]	Georgia Environmental Protection Division
Point of Contact [b]	Jeff Larson, Assistant Branch Chief, Watershed Protection Branch, 404 675-1664, Jeff.Larson@dnr.state.ga.us
Project Title [c]	Point Source Dissolved Oxygen Impaired Water in the Savannah River Basin, Georgia and South Carolina
Waterbody(s)	Savannah Harbor (SR 25 (old US Hwy 17) to Elba Island Cut) identified as "R030601090318" on Georgia's "2012" Section 303(d) list of impaired waters.
Watershed(s)	Savannah River (HUC12: 03061090307)
No. Waterbody / Pollutant Combinations	One (1) – Savannah Harbor listed as impaired for Dissolved Oxygen
No. Watersheds Improved [d]	One (1) –Savannah River (HUC12: 03061090307)

Description of Baseline Conditions

Watershed(s) [e]	Outlet Savannah River "HUC12: 03061090307"		
Impairments [f]	HUC12: 03061090307	Waterbody ID: R030601090318	Impairment Cause: Dissolved Oxygen
Baseline Data	The current DO criteria for the Savannah Harbor are "a daily average of 5.0 mg/L and no less than 4.0 mg/L at all times. If it is determined that the "natural condition" in the waterbody is less than the values stated above, then the criteria will revert to the "natural condition" and the water quality standard will allow for a 0.1 mg/L deficit from the "natural" dissolved oxygen value. Up to a 10% deficit will be allowed if it is demonstrated that resident aquatic species shall not be adversely affected." Hydrodynamic and water quality models developed for the Savannah River and Harbor illustrate that 1999 was both a critical year and a year that represented the 1955 to 2008 period of record. Based on these analyses, 1999 was selected as the representative critical condition year for modeling. These models show that portions of the Harbor "naturally" have a DO concentration below the 5.0 mg/L daily average. These models also show that if NPDES permittees (in the River and Harbor area) were to discharge effluent at their permitted limits then they would cause more than a 0.1 mg/L deficit from the natural condition. Selected natural condition model run results are found in Figures 10 & 11 and results of permitted dischargers on the DO deficit are found in Figure 12 of "*Subcategory 5R Documentation for Point Source Dissolved Oxygen Impaired Water in the Savannah River Basin, Georgia and South Carolina.*" (hereinafter referred to as the Savannah Harbor 5R Plan).		
Map [g]	See Figure 1 Savannah Harbor Location Map of the Savannah Harbor 5R Plan.		

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Evidence of Watershed Approach

Area of Effort [h]	"The Savannah River Basin is located on the border of eastern Georgia and western South Carolina and has a drainage area of 10,577 square miles. The Savannah River serves as the boundary between Georgia and South Carolina, and the Harbor is shared by both states. The portions of the Savannah River Basin included in this plan are the middle and lower watersheds encompassing the area from Thurmond Dam to the Atlantic Ocean. Land uses within these watersheds are mostly forestlands, wetlands, and agriculture." (Section 1 of the Savannah Harbor 5R Plan)
Key Stakeholders Involved and Their Roles [i]	The Savannah River/Harbor Discharge Group (Discharge Group) is composed of representatives of the majority of the dischargers in the Area of Effort. The Discharge Group was facilitated by Malcolm Pirnie/ARCADIS. The Discharge Group initiated a facilitated process to derive equitable allocations among the 24 wastewater dischargers to achieve the DO water quality criterion provision that allows a 0.1 mg/L DO deficit from "natural" DO conditions. This allocation process made use of the Savannah River and Harbor DO Calculator Version 4.0 that can be used to calculate the effect of various combinations of the 24 wastewater effluent dischargers on the DO levels in the Savannah River and Harbor (Section 4.3 of Savannah Harbor 5R Plan). A list of the 24 dischargers is provided in Table 10 of the Savannah Harbor 5R Plan. Additional information pertaining to the technical basis for determining the load reductions for each wastewater discharger is discussed in Appendix B of the Savannah Harbor 5R Plan. The Memorandum of Understanding between the dischargers to the Savannah River and Harbor is included in Appendix C of the Savannah Harbor 5R Plan. This memorandum contains a list of load reductions on which the Discharge Group has reached consensus. This load reduction represents approximately 98% of the needed reduction. NPDES permits will be reissued with enforceable conditions to attain compliance with water quality standards.
Watershed Plan & Other Supporting Documentation [j]	The Georgia Environmental Protection Department (EPD), the South Carolina Department of Health and Environmental Control (DHEC), the Environmental Protection Agency (EPA) and the Discharge Group collaborated to develop the Savannah Harbor 5R Plan, which includes the documentation to support EPD's decision to place the impaired water under subcategory 5R on the Clean Water Act Section 303(d) list. It is EPD's intent to move the Savannah River (from SR 25 (old US Hwy 17) to Elba Island Cut) from Category 5R to Category 4b once the permits in Table 10 contain limits sufficient to implement the applicable water quality standards. Once these permit limits are met, EPD's intent is to remove DO as a cause of impairment and to move the move the water from Category 4b to Category 1 (assuming all other water quality standards are being achieved) (Page ii of the Savannah Harbor 5R Plan). The Plan documents the applicable water quality criteria for DO (Section 2); identifies the sources of oxygen demanding pollutants (Section 4); describes the models used to determine the "natural" DO of the Harbor and the impact of dischargers (permitted and unpermitted) on the DO concentrations (Sections 3 – 5); describes the Savannah River and Harbor DO Calculator Version 4.0 that is being used to allocate necessary wasteload reductions among 24 NPDES discharges (Section 4.3); contains a plan and schedule to reissue NPDES permits that meet water quality criteria (Section 6), and a plan to monitor compliance with the DO criteria (Section 6.1).

Point Sources	A list of the existing dischargers is included in Table 10 of the Savannah Harbor 5R Plan. The existing NPDES permits should be reissued within 3 years of finalizing this document to include conditions that will result in attainment of water quality standards. New applications will be requested from each permitted facility within sixty days of finalization of this document. Submittal deadlines will be scheduled based on differing application and applicant requirements. The schedules will be provided to EPA as soon as possible (Section 6). Permitted storm water dischargers (Municipal Separate Storm Sewer System [MS4]) discharges have been found not to contribute oxygen demanding pollutants at levels above background loading conditions, and therefore are not considered to be NPDES point sources from which reductions must be obtained under the 5R process (Section 4.4 & 5.3).
Nonpoint Sources	"The vast majority of the nonpoint source loadings of oxygen-demanding substances are from natural background sources including detritus transported in the stream, detritus from marsh areas flowing directly into the Harbor, and tidally-transported detritus from the ocean. These natural background nonpoint source loads are not controllable and therefore additional nonpoint source reduction to improve water quality is not an option" (Section 4.4 of the Savannah Harbor 5R Plan). "Therefore, the non-NPDES regulated sources are aggregated with the natural background loads in this analysis. If, at a later date, a significant upstream non-NPDES regulated source is identified, this analysis will be revised to account for this source" (Section 5.4 of the Savannah Harbor 5R Plan).
Restoration Work[(k)]	When NPDES permits are reissued, they will contain enforceable conditions to attain compliance with water quality standards. The State NPDES programs may, in accordance with the requirements of 40 CFR 122.47, include compliance schedules in permits to enable the wastewater facilities to attain the entire necessary load reductions in the most timely and effective means. The compliance schedules for meeting reductions will be of differing lengths based on unique conditions for each permittee. Permits should be reissued within 3 years of finalizing this document. New applications will be requested from each permitted facility within sixty days of finalization of this document. Submittal deadlines will vary based on differing application requirements (Section 6 of the Savannah Harbor 5R Document). Water quality trading may be used as a method for achieving compliance with the DO criteria. Any water quality trading will have to be approved by the States and EPA and will have to be reflected in the dischargers' NPDES permits (Section 7.1 of the Savannah Harbor 5R Plan). Permitted storm water dischargers (e.g. Municipal Separate Storm Sewer System [MS4]) have been found not to contribute oxygen demanding pollutants above background loading conditions, so reductions from these sources are not required.(Section 4.4 & 5.3 of the Savannah Harbor 5R Plan). "The majority of the non-NPDES loadings are from natural background sources. These sources are a very minor contributor of oxygen consuming wastes under critical low flow conditions because of the absence of storm water runoff. Therefore, the non-NPDES regulated sources are aggregated with the natural background loads in this analysis. If, at a later date, a significant upstream non-NPDES regulated source is identified, this analysis will be revised to account for this source." (Section 4.4 and 5.4 of the Savannah Harbor 5R Plan).

Critical Milestones/Monitoring

Anticipated Critical Milestone(s):	A list of the 24 NPDES permits whose discharges impact DO concentrations in the Savannah Harbor is provided in Table 10 of the Savannah Harbor 5R Plan. These permits should be reissued within 3 years of finalizing this document and they will contain enforceable conditions to attain compliance with water quality standards. New applications will be requested from each permitted facility within sixty days of finalization of this document. Submittal deadlines will vary based on differing application requirements. The State NPDES programs may, in accordance with the requirements of 40 CFR 122.47, include compliance schedules in permits to enable the wastewater facilities to attain the entire necessary load reductions in the most timely and effective means (Section 6 of the Savannah Harbor 5R Plan). These compliance schedules will be of differing lengths based on unique conditions for each permittee.
Monitoring Component	The DO criteria for the Savannah Harbor are in part based upon the "natural DO" of the water and a 0.1 deficit from this natural concentration. The "natural DO" concentration has been established through modeling. The models cannot be used to determine what the "natural DO" should be at any given spot at any particular time. Therefore it will not be possible to measure compliance with the criteria simply by taking instream DO measurements. Compliance with the effluent limitations contained in the reissued NPDES permits should have the corresponding effect of returning the impaired waterbody to compliance with the applicable DO water quality standard. As long as the NPDES BOD5 and ammonia permit limits meet the numeric DO target as calculated by the Savannah River and Harbor DO Calculator Version 4.0, the DO water quality standard will be met. As such, effluent data required in each facility's operating permit will be reviewed, at a minimum, every 2-years consistent with the Section 303(d) listing cycle to evaluate whether water quality standards are being achieved. If effluent data indicate compliance with their applicable effluent limits, then the waterbody may be moved from category 5R to the appropriate attainment category on the State of Georgia's Integrated Report. If effluent data do not indicate compliance with their applicable effluent limits, additional pollution controls or compliance measures may be explored and implemented. (Section 6.1 of the Savannah Harbor 5R Plan)

Key Dates

Critical Milestone Dates	The 24 Permits listed in Table 10 of the Savannah Harbor 5R Plan should be reissued within 3 years of finalizing this document. New applications will be requested from each permitted facility within sixty days of finalization of this document. Submittal deadlines will vary based on differing application requirements. The State NPDES programs may, in accordance with the requirements of 40 CFR 122.47, include compliance schedules in permits to enable the wastewater facilities to attain the entire necessary load reductions in the most timely and effective means (Section 6 of the Savannah Harbor 5R Plan). These schedules will be of differing lengths based on unique conditions for each permittee. In addition, effluent monitoring data required in each facility's operating permit will be reviewed, at a minimum, every 2-years consistent with the Section 303(d) listing cycle to evaluate whether water quality standards are being achieved. (Section 6.1 of the Savannah Harbor 5R Plan.)

Estimated Completion Date for the Restoration Activities	The NPDES permits should be reissued within 3 years of finalizing this document. "The State NPDES programs may, in accordance with the requirements of 40 CFR 122.47, include compliance schedules in permits to enable the wastewater facilities to attain the entire necessary load reductions in the most timely and effective means" (Section 6 of the Savannah Harbor 5R Plan). It is not possible to provide a more definitive estimate for when the water will be restored at this time as this will depend in large part on what type of treatment upgrades are needed for the permittees to meet load reductions.
Estimated Delisting Date	It is EPD's intent to delist the Savannah Harbor (from Category 5R to Category 4b) once the permits in Table 10 contain limits sufficient to meet the applicable water quality criteria. Once all permit limits have been met, it is EPD's intent to move the water from Category 4b to Category 1 (provided all other water quality criteria are being met) (Page ii of the Savannah Harbor 5R Plan).

Financial Commitments

Estimated Implementation Cost	The vast majority of nonpoint sources loading is considered to be from natural background sources that are not controllable; therefore, additional nonpoint source reduction is not necessary. (Section 4.4 of the Savannah Harbor 5R Plan). The 24 dischargers in Table 10 will be issued NPDES permits that meet water quality standards (Section 6 of the Savannah Harbor 5R Plan). The cost to these permittees to meet their permit is not known at this time, but compliance is mandatory.
Funding Sources	The NPDES permitting authorities have committed to reissuing the NPDES permits within 3 years of finalizing this document to reflect the entire load reduction necessary to attain compliance with water quality standards. (Section 6 of the Savannah Harbor 5R Plan)

(a) – (k) Elements corresponding to elements a-k required for the "Reporting Watershed Improvement" (SP-12) Templates. These elements may supply information needed to report improvements which have occurred within the watershed under Measure SP-12; additionally, a section showing evidence of the improvements would be required. See "Guidance on Reporting Watershed Improvement under Measure SP-12" for more complete descriptions of the information requested for SP-12 credit.

Subcategory 5R Documentation for Point Source Dissolved Oxygen Impaired Water in the Savannah River Basin, Georgia and South Carolina

Savannah Harbor (SR 25 (old US Hwy 17) to Elba Island Cut)
Waterbody Identification: R030601090318
HUC12: 03061090307

Organization: Georgia Environmental Protection Division in Cooperation with South Carolina Department of Health and Environmental Control

Point of Contact: Jeff Larson, GA EPD and Jeff DeBessonet, SC DHEC

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Subcategory 5R Documentation for Point Source Dissolved Oxygen Impaired Water in the Savannah River Basin

Executive Summary

This plan documents the total pollutant loading of oxygen-demanding substances (5-day biochemical oxygen demand [BOD_5] and ammonia) that can assimilate and still achieve the applicable water quality standards for the Savannah River Basin from Fort Pulaski (River Mile 0) to the Seaboard Coastline Railway Bridge (River Mile 27.4). The Savannah Harbor is located at the mouth of the Savannah River where it discharges to the Atlantic Ocean. The Savannah River, including the Harbor, serves as the boundary between Georgia and South Carolina.

This plan is based on Georgia's dissolved oxygen (DO) water quality criterion that was established for the Savannah Harbor in March 2010 and South Carolina's DO water quality criterion established for the Savannah Harbor. This plan evaluates the sources of oxygen-demanding substances that may cause or contribute to the non-attainment of the applicable DO water quality standards. The Savannah River and Harbor DO Calculator Version 4.0 (June 2010) was developed as an efficient method to evaluate oxygen-demanding reduction strategies that will most practicably allow the DO water quality standard to be met. The Savannah River/ Harbor Discharger Group applied the Savannah River and Harbor DO Calculator Version 4.0 to develop a wasteload reduction implementation strategy that will most practicably allow the DO water quality criterion to be met. The Savannah River/Harbor Discharger Group's process for deriving equitable wasteload allocations for the 24 continuous NPDES dischargers is discussed in the Appendix B.

The Georgia Environmental Protection Division (EPD), the South Carolina Department of Health and Environmental Control (DHEC), the Environmental Protection Agency (EPA) and a Technical Modeling Advisory Group collaborated to develop the documentation contained in this plan, which supports the EPD's decision to place the impaired waters under subcategory 5R on the State's Section 303(d) list. The supporting documentation contained in this plan includes (1) the watershed and waterbody identification, (2) description of applicable water quality standards, (3) source assessment for oxygen demanding pollutants, (4) description of the hydrodynamic and water quality models used to develop the Savannah River and Harbor DO Calculator Version 4.0 for determining the effects of the 24 continuous NPDES dischargers on the DO levels in the Savannah Harbor, (5) schedule for reissuing the existing 24 NPDES permits to include enforceable conditions that will achieve water quality standards, and (6) an effluent monitoring plan to track the effectiveness of the revised effluent limits. The appendices include the Savannah River/Harbor Discharger Group's technical basis for the wasteload allocations as well as the memorandum of understanding signed by the Savannah River/Harbor Discharger Group. .

It is understood that the November 2006 EPA Savannah Harbor Total Maximum Daily Load (TMDL), which was based on the previous Georgia DO Standard will be withdrawn

upon EPA's approval of EPD's decision to list the impaired water contained in this plan under subcategory 5R on the Clean Water Act Section 303(d) list. It is EPD's intent to move the Savannah River (from SR 25 (old US Hwy 17) to Elba Island Cut) from Category 5R to Category 4b once the permits in Table 10 contain limits sufficient to implement the applicable water quality standards. Once these permit limits are met, EPD's intent is to remove DO as a cause of impairment and to move the water from Category 4b to Category 1 (assuming all other water quality standards are being achieved).

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1. Savannah Harbor Description

The Savannah River Basin is located on the border of eastern Georgia and western South Carolina and has a drainage area of 10,577 square miles. The Savannah River serves as the boundary between Georgia and South Carolina, and the Harbor is shared by both states. The portions of the Savannah River Basin included in this Plan are the middle and lower watersheds encompassing the area from Thurmond Dam to the Atlantic Ocean. Land uses within these watersheds are mostly forestlands, wetlands, and agriculture.

The area of concern is the Savannah Harbor from SR 25 (old US Hwy 17) to Elba Island Cut. This segment is identified as segment R030601090318 (HUC12: 03061090307), which was listed on the State of Georgia's Section 303(d) list as impaired for dissolved oxygen (DO) beginning with the 2002 list. This segment has a designated use of Coastal Fishing. EPA established a Total Maximum Daily Load (TMDL) for this segment in 2006 based on its failure to meet the previous DO water quality standard associated with the State of Georgia's Coastal Fishing designated use and data collected in the summers of 1997 and 1999. Since that time, EPA approved the State of Georgia's revised DO water quality standard for the Coastal Fishing designated use. The revised Georgia DO water quality standard for the Savannah Harbor and the South Carolina DO water quality standard for the Savannah Harbor are in Section 2; however, the portion of the Savannah Harbor that is currently 303(d) listed as impaired for dissolved oxygen is limited to Georgia state waters. Because the impairment is limited to Georgia waters, the information contained in this plan is based on Georgia's revised DO water quality criterion in Georgia *Rules and Regulations for Water Quality Control*, Chapter 391-3-6-.03 that was approved by EPA in March 2010.

The hydrodynamic and water quality models that were used to analyze the oxygen-demanding pollutant loadings extend upstream on the Savannah River to River Mile 61.0 near Clyo, Georgia, at United States Geologic Survey (USGS) station 02198500. The downstream end of the models extends approximately 25 miles offshore from Oyster Island to cover the navigational channel of Savannah Harbor. The models cover the Savannah River, the Front River, the Middle River, the Little Back River, the Back River, the South Channel, and the offshore portions in the Atlantic Ocean. Figure 1 is a map that shows the overall location of the study area.

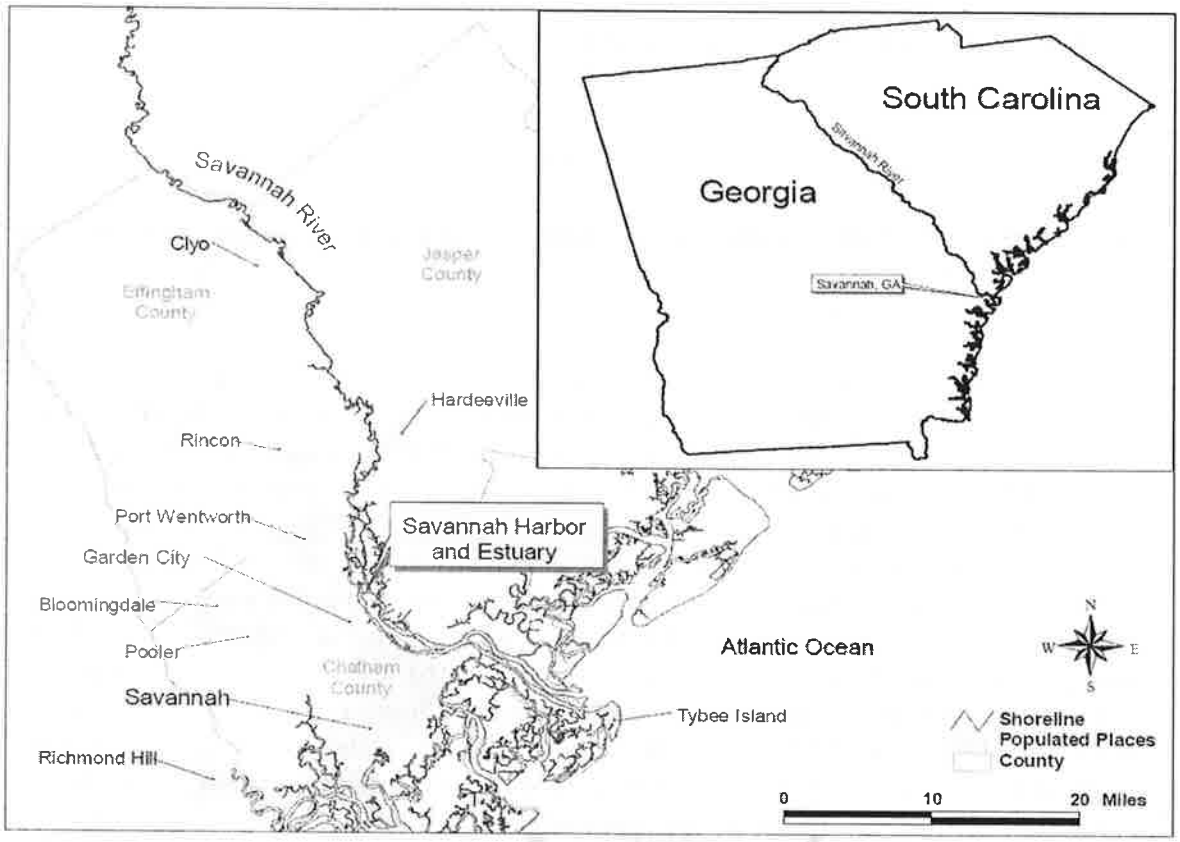

Figure 1 Savannah Harbor Location Map

Water quality studies that were conducted over the past twenty years were used to characterize the DO regime of the harbor, determine the principle causes of impairment, and provide sufficient data and information to develop complex hydrodynamic and water quality models. The data used in the calibration and confirmation of the hydrodynamic and water quality models were collected by the Georgia Ports Authority (GPA), the United States Geological Survey (USGS), the Georgia Environmental Protection Division (EPD), the U.S. Army Corps of Engineers (USACE), and the United State Environmental Protection Agency (EPA). Additional details on the water quality and hydrodynamic modeling can be found in *Development of the Hydrodynamic and Water Quality Model for the Savannah Harbor Expansion Project, January 2006* (Tetra Tech 2006) and in the draft EPA and Tetra Tech Z-Grid Modeling Report (EPA 2010).

2. Numeric Target

2.1. Georgia DO Standard for Savannah Harbor

The water use classification for the Savannah Harbor is Coastal Fishing. The criterion violated is DO. The criteria for DO for this use classification as stated in Georgia *Rules and Regulations for Water Quality Control*, Chapter 391-3-6-.03, Water Use Classifications and Water Quality Standards are:

"Dissolved Oxygen (D.O.): A daily average of 5.0 mg/L and no less than 4.0 mg/L at all times. If it is determined that the "natural condition" in the waterbody is less than the values stated above, then the criteria will revert to the "natural condition" and the water quality standard will allow for a 0.1 mg/L deficit from the "natural" dissolved oxygen value. Up to a 10% deficit will be allowed if it is demonstrated that resident aquatic species shall not be adversely affected."

2.2. South Carolina DO Standard for Savannah Harbor

The South Carolina DO criteria states that "Certain natural conditions may cause a depression of dissolved oxygen in surface waters while existing and classified uses are still maintained. The Department shall allow a dissolved oxygen depression in these naturally low dissolved oxygen waterbodies as prescribed below pursuant to the Act, Section 48-1-83, et seq., 1976 Code of Laws:

a. For purposes of section D of this regulation, the term "naturally low dissolved oxygen waterbody" is a waterbody that, between and including the months of March and October, has naturally low dissolved oxygen levels at some time and for which limits during those months shall be set based on a critical condition analysis. The term does not include the months of November through February unless low dissolved oxygen levels are known to exist during those months in the waterbody. For a naturally low dissolved oxygen waterbody, the quality of the surface waters shall not be cumulatively lowered more than 0.1 mg/l for dissolved oxygen from point sources and other activities; or

b. Where natural conditions alone create dissolved oxygen concentrations less than 110 percent of the applicable water quality standard established for that waterbody, the minimum acceptable concentration is 90 percent of the natural condition. Under these circumstances, an anthropogenic dissolved oxygen depression greater than 0.1 mg/l shall not be allowed unless it is demonstrated that resident aquatic species shall not be adversely affected pursuant to Section 48-1-83. The Department may modify permit conditions to require appropriate instream biological monitoring.

c. The dissolved oxygen concentrations shall not be cumulatively lowered more than the deficit described above utilizing a daily average unless it can be demonstrated that resident aquatic species shall not be adversely affected by an alternate averaging period."

3. Modeling Approach

EPA Region 4 used the Savannah Harbor Z-Grid Models to calculate the effects of the dischargers on the DO regime in the Savannah Harbor (Tetra Tech 2008; EPA 2010). The Z-Grid models build on the original harbor model developed for EPA Region 4 during the development of the TMDL in 2004-2005 and the enhanced model for the United States Army Corps of Engineers (USACE) finalized on January 30, 2006 (2004, 2006 Tetra Tech).

The hydrodynamic model used is the Environmental Fluid Dynamics Code (EFDC) developed and maintained by Tetra Tech (Hamrick 1992). The water quality model used is the Water Quality Analysis Simulation Program (WASP) maintained by EPA.

The setup, calibration, and confirmation of the original EFDC and WASP Savannah Harbor models are well documented in the Tetra Tech January 30, 2006, modeling report. (2006 Tetra Tech) After two years of intense efforts by several modelers and many agency meetings, final acceptance letters approving the use of these models were received from the EPA Region 4, Georgia EPD, South Carolina Department of Health and Environmental Control (DHEC), National Marine Fisheries, and the United States Fish and Wildlife Service (USF&W) in March 2006. Other reviewers of the enhanced models included the Harbor Committee (MACTEC as their consultant), the USACE Engineer Research and Development Center (ERDC), and the USGS.

3.1. Z-Grid

During 2007, EPA Region 4 determined a need to convert the sigma grid of the enhanced models to a Z-Grid. The need was based on model run times and an issue of having layers "squeezed" or "compressed" in the shallow Middle, Back, and Little Back Rivers. This phenomenon created unrealistic DO concentrations in the surface and bottom layers.

The Z-Grid allows a different number of vertical layers throughout the model domain. The original sigma grid was six vertical layers and was converted to a Z-Grid with five vertical layers in the navigation channel and one vertical layer in the Middle, Back, Little Back, and Upper Savannah Rivers. The Z-Grid allowed for the invert of the river bottom elevation to be modified with one vertical layer going upstream from the I-95 Bridge to the Clyo USGS gage on the Savannah River. The longitudinal slope was evenly distributed from the headwater cell to above the I-95 Bridge by adjusting bottom elevations. The water surface elevation at the headwater boundary cell was raised to better match the gage height reported at the Clyo USGS gage. In addition to the Z-Grid conversion, the watershed tributary flows and marsh areas were revised.

The Z-Grid contains 608 horizontal cells and 1,778 total cells when including the vertical cells. Figure 2 shows the Harbor portion of the Z-Grid.

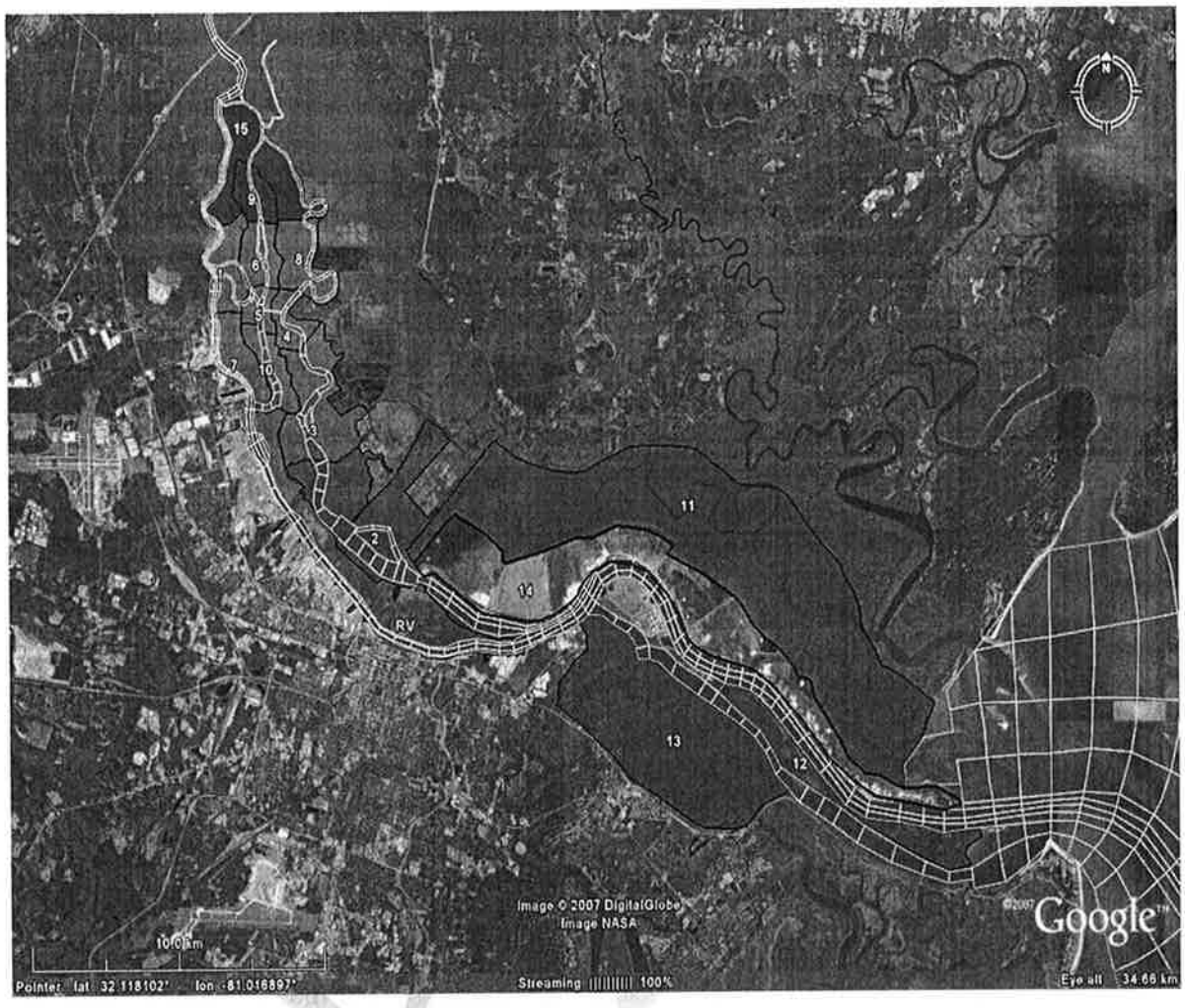

Figure 2 Z-Grid Harbor Cells and Existing Marsh Areas

3.2. Updated Marsh Approach

The marsh areas were revised from the sigma grid model (Tetra Tech 2006) to include the areas downstream of Fort Jackson. One area upstream near the I-95 Bridge was added as well. Table 1 reflects the new marsh loadings. The color of each marsh indicates where it was included in the WASP model as a freshwater (blue), brackish (orange) or saltwater (red) marsh.

Table 1 **Existing Marsh Loads**

Marsh	Actual Area (acres)	Actual Depth (meters)	BODU Export Rate (kg/day/acre)	BODU (kg/day)	BODU (lb/day)
Q1	742	0.12	6	4,454	9,820
Q2	3,467	0.25	12	41,606	91,726
Q3	1,682	0.18	6	10,089	22,243
Q4	421	0.21	6	2,527	5,570
Q5	310	0.20	6	1,862	4,104
Q6	570	0.16	6	3,423	7,546
Q7	731	0.29	6	4,384	9,665
Q8	845	0.14	6	5,070	11,177
Q9	485	0.21	3	1,456	3,210
Q10	602	0.22	6	3,613	7,966
Q11	12,676	0.15	12	152,114	335,353
Q12	1,548	0.15	12	18,580	40,963
Q13	5,819	0.15	12	69,822	153,931
Q14	6,049	0.15		5,155	11,364 *
Q15	1,633	0.15	3	4,898	10,798
			TOTALS =	**329,053**	**725,436**

* Q14 is Dredge Disposal Area Managed by the Corps, the load was calculated based on BOD_5 and weir flows as a peak load.

To address seasonality of the marsh loads, a reference paper was used that measured dissolved inorganic carbon (DIC) in tidal freshwater marshes in Virginia and the adjacent estuary. The paper is titled "Transport of Dissolved Inorganic Carbon from a Tidal Freshwater Marsh to the York River Estuary" by Scott C. Neubauer and Iris C. Anderson from the Virginia Institute of Marine Science, School of Marine Science, College of William and Mary.

The percentages in the Table below were derived from the referenced study and are applied to the loads listed in Table 1 (for existing) to develop the monthly WASP loads for Ultimate Carbonaceous Biochemical Oxygen Demand (CBODu) from the marsh areas.

Table 2 **Seasonal Distribution of Marsh Loads**

Month	Percent of Total Load
January	20
February	20
March	40
April	40
May	60
June	80
July	100

Month	Percent of Total Load
August	100
September	80
October	60
November	40
December	40

3.3. Updated Hydrodynamics

The original flow, velocity, elevation and temperature predictions were calculated using the EFDC hydrodynamic model and calibrated to the extensive 1997 and 1999 data set (2006 Tetra Tech). The EFDC model inputs were updated to reflect more recent information. This information includes new flow and velocity data collected by USGS gages in the harbor, long-term DO data measured at the USACE Dock, updates to the boundary conditions, connection to EPD's river model, and updates to water quality kinetics. Figure 3 shows the original sampling locations for the 1999 study, some of which were also used for the 2008 data collection.

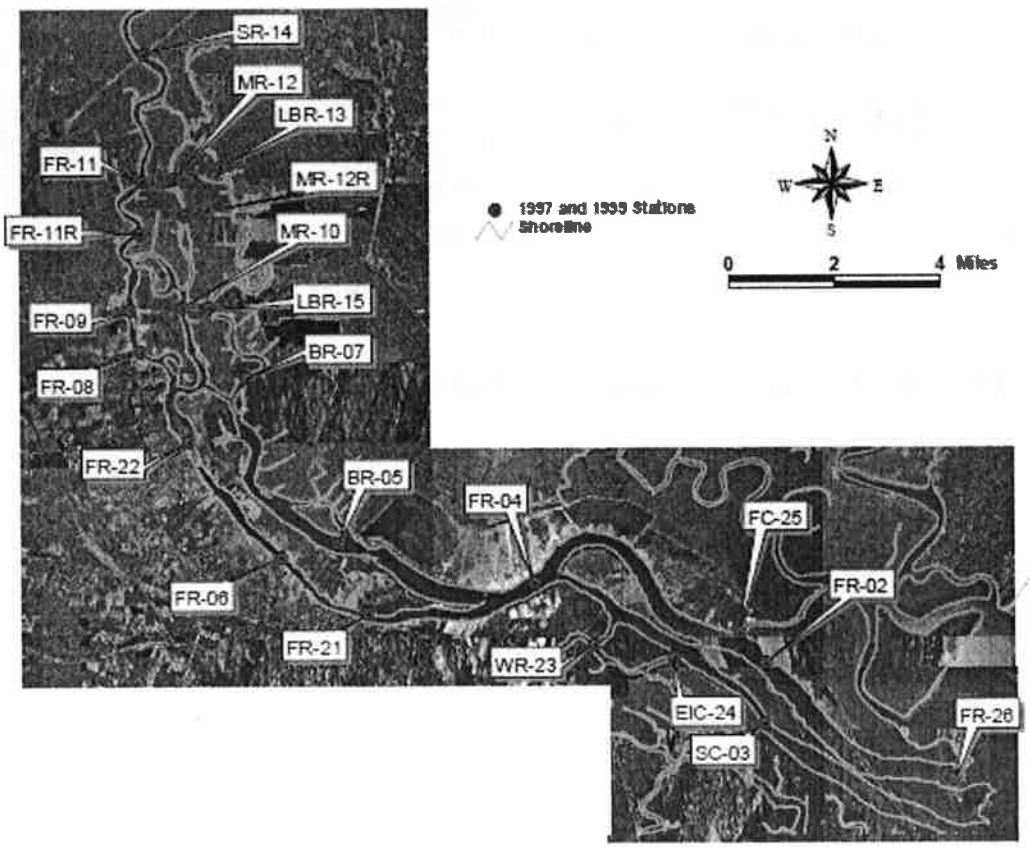

Figure 3 1999 Sampling Locations

3.3.1. Middle and Back Rivers Updated Hydrodynamics

The USGS collected detailed (15 minute) water surface elevation, velocity, and flow data during the fall and winter of 2008 – 2009 at the Middle and Back Rivers near the Houlihan Bridge crossings at Stations MR-10 and LBR-15, respectively. These data were used to improve the hydrodynamic predictive ability of the model in the Middle and Back Rivers. The updates focused on improving the width and depths of the river channels in the models and changing the marsh storage areas to better reflect the movement of water through the channels so the model would better reflect the measured flows, velocities, and elevations (2010 EPA Region 4). Figure 4 and Figure 5 illustrate an example of the models predictive capabilities for gage height and flows for Little Back River at Houlihan Bridge. The performance of the model is considered very good.

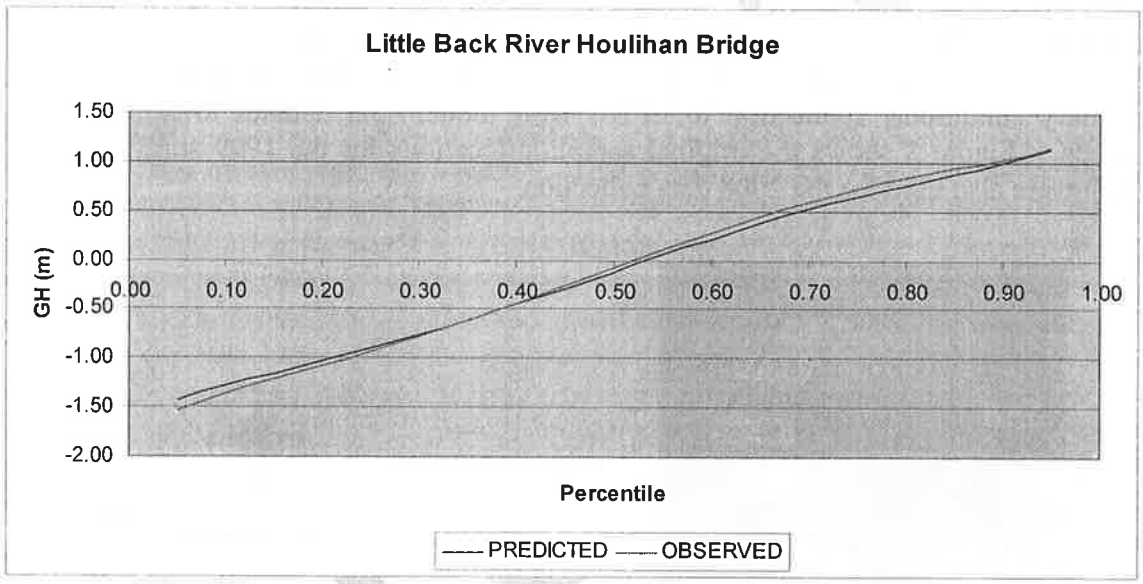

Figure 4 Percentile Comparison of Predicted and Measured Gage Heights

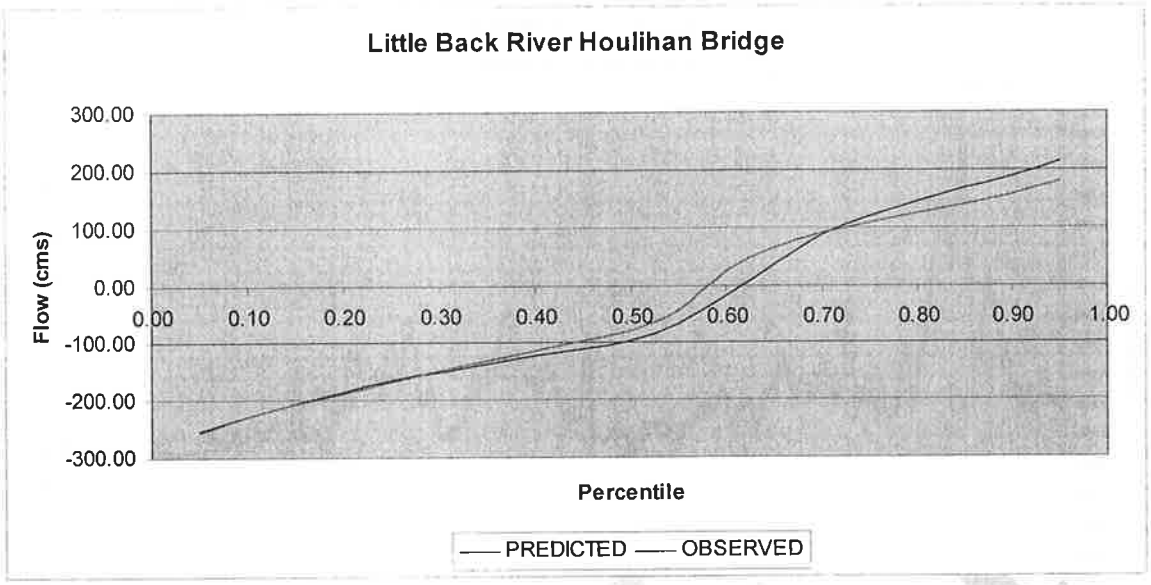

Figure 5 Percentile Comparison of Predicted and Measured Flows

3.3.2. Upstream Boundary Conditions at Clyo

Georgia EPD has developed a hydrodynamic and water quality model (GaEPD RIV1 Model) for the Savannah River from Augusta Lock and Dam to Clyo. This model was used to transport the oxygen demanding substances from the upper watershed to the Harbor Model. The River Model provided the flow, DO, Temperature, CBOD (fast and slow), and ammonia boundary conditions for the calibrated and TMDL Harbor Models. (2010 EPA Region 4)

The 2006 EFDC model used USGS gage flow data and monthly measured temperatures at Clyo for the upstream boundary. Since 2006, EPD has updated and recalibrated the Savannah River (Augusta Lock and Dam to Clyo) RIV1 Model. The hourly flow and temperature outputs at Clyo, from RIV1 were used as the headwater conditions for the Harbor hydrodynamic model. This provides a seamless connection between the Savannah River RIV1 Model and the Savannah Harbor Model. Figure 6 and Figure 7 illustrate the comparison of RIV1 flows and temperatures to observed data.

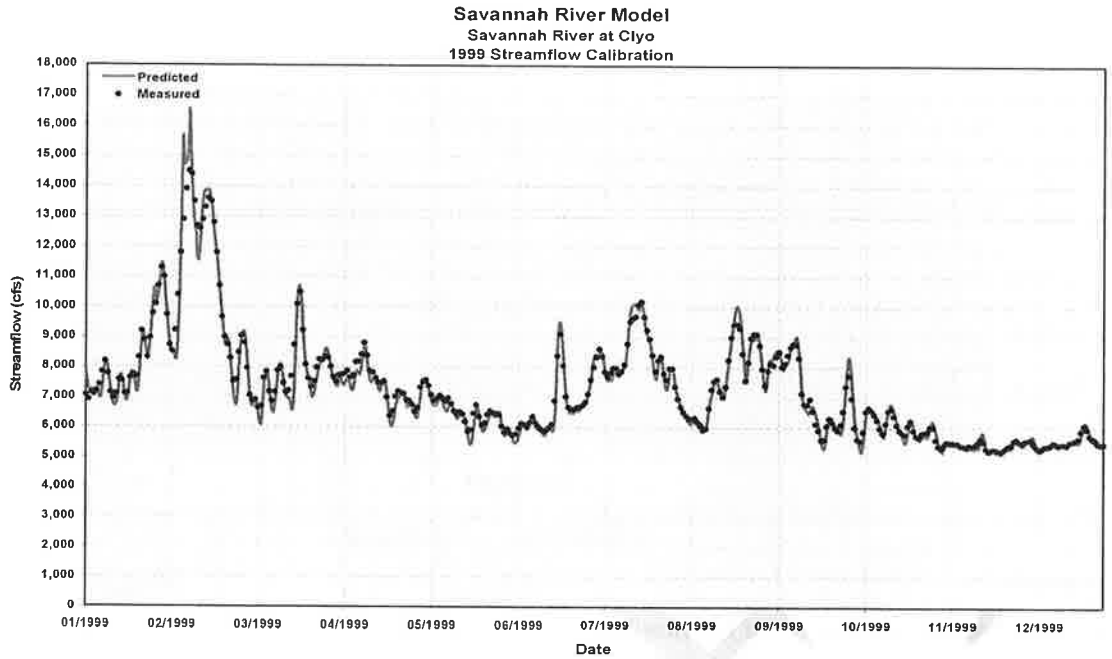

Figure 6 1999 Stream Calibration Flow at Clyo

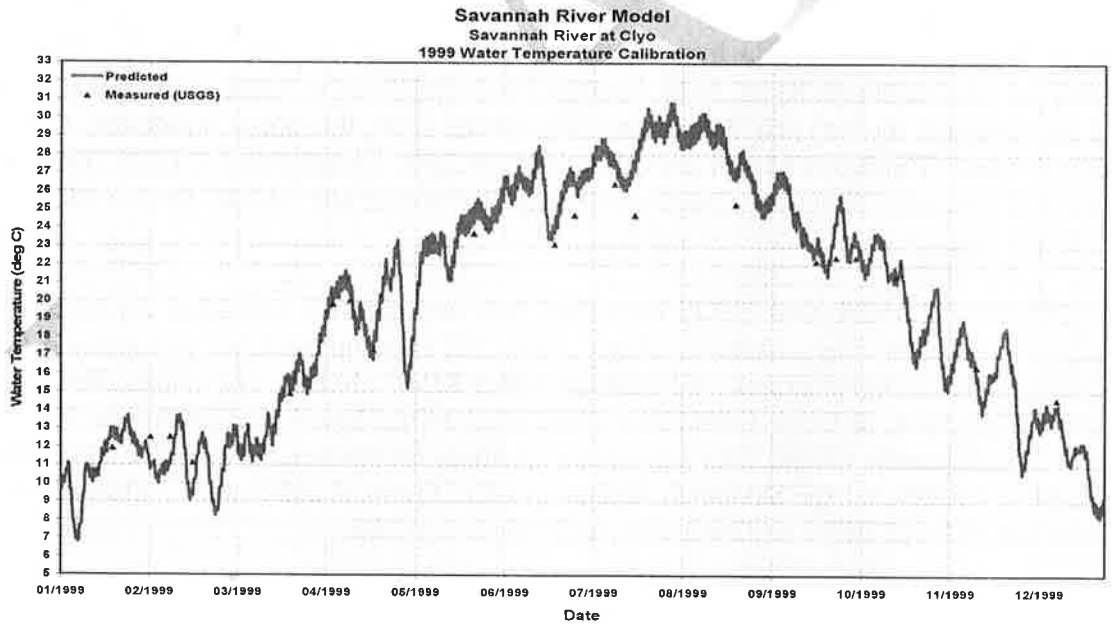

Figure 7 1999 Stream Temperature Calibration at Clyo

3.4. Updated Water Quality Rates and Kinetics

The main changes to the water quality portion of the 2006 Savannah Harbor Model (2006 Tetra Tech) were an update of the reaeration approach and a fine tuning of the CBOD

decay rates. The main modeling parameters impacting the DO balance of the Harbor are the reaeration rate, the Sediment Oxygend Demand (SOD) rate and the oxygen demanding substances (BOD and ammonia) decay rates. Table 3 provides a summary of the rates used in the Harbor Model.

Table 3 WASP Kinetic Rates

WASP Kinetic Parameters	Value
Reaeration Rate @ 20 °C (per day)	O'Connor-Dobbins Formulation
Sediment Oxygen Demand (g/m2/day) @20 °C	0.7 to 2.4
BOD (1) Decay Rate Constant @20 °C (per day)	0.06
BOD (2) Decay Rate Constant @20 °C (per day)	0.04
BOD (3) Decay Rate Constant @20 °C (per day)	0.02
Ammonia, nitrate, phosphorus rates @20 °C (per day)	0.015

3.4.1. Reaeration Rate and Sediment Oxygen Demand

The Savannah Harbor water quality model was updated to employ the O'Connor-Dobbins Reaeration formulation that uses velocity and total depth (a WASP7 update) of the river to determine the reaeration rates for the Savannah Harbor System.

Sediment Oxygen Demand rates were revised and ranged from 0.7 to 2.4 $g/m^2/day$ at @20 °C:

- 0.7 $g/m^2/day$ for Ocean, Middle and Back Rivers
- 1.6 $g/m^2/day$ for Upper Savannah River Clyo to Hwy 17 bridge
- 2.0 $g/m^2/day$ for main Harbor area
- 2.4 $g/m^2/day$ for Sediment basin and Turning Basins.

3.4.2. Pollutant Decay Rates

The WASP 7 model has the option of using up to three CBODu components, i.e, the BOD loads to the model can be divided into three varying CBODu components. Based on analyses of the River's long term BODs and the wastewater dischargers effluent long term BODs, it was determined that CBODu decay rates of 0.02, 0.04, and 0.06 per day best reflected the BOD decay activity going on in the Harbor System. Each BOD load to the system was partitioned into one of these compartments based on their specific long term BOD characteristics.

- Marsh BOD loads were put in the 0.04/day compartment
- River fast decaying BOD loads were put in the 0.06/ day compartment
- River slow decaying BOD loads were put in the 0.02/ day compartment
- Ocean BOD concentrations/loads half were put in 0.06 and the rest were put in the 0.02/ day compartments

- Dischargers BOD loads were put in to their appropriate compartment based on their specific long term data discussed in more detail in Section 4.

Note the original 2006 modeling had a CBODu decay rate compartment of 0.12/day to reflect the decay of secondary treated wastewater in the Harbor. Now most of the wastewater is more highly treated and the 0.12/day decay rate is no longer appropriate.

3.5. Modeling Technical Review Group

Interactive discussions between state and federal agency staff and dischargers regarding the Savannah Harbor DO issue have been ongoing for more than a decade. Formation of a group of technical experts from the Savannah Harbor Committee, Central Savannah River Area TMDL Group, and agencies was established to provide ongoing input on model development for the river and harbor portions of the system. The Savannah Harbor Committee and the Central Savannah River Area TMDL Group combined in 2011 to form a single group: Savannah River/Harbor Discharger Group. The participants in the modeling subgroup were nominated by USEPA, Georgia EPD, South Carolina DHEC, and Savannah River/Harbor Discharger Group for their expertise in modeling and for their specific knowledge of the Savannah River and Harbor ecosystem (2009 SHMTRG). The modeling subgroup reviewed and refined modeling tools that were used to develop the load reductions and effluent limits contained in this plan to achieve the Georgia DO water quality standard that was approved by EPA in 2010.

4. Source Assessment for Oxygen Demanding Pollutants

A required element of the documentation needed to support listing an impaired water in subcategory 5R on a state's Clean Water Act Section 303(d) list is the examination of the potential sources of the pollutant of concern in the watershed, including facilities regulated by the NPDES program, non-point sources, other sources of pollution, and background levels of the pollutant in the affected waterbody. The following section discusses the source assessment for oxygen demanding substances in the Savannah River and Harbor.

4.1. NPDES Permits

The NPDES permitted discharges to the Savannah watershed can be separated in to three groups:

- Direct Discharges to the Harbor
- Direct Discharges to Savannah River below Thurmond Dam to Clyo
- Watershed Discharges to tributaries feeding the Savannah River

4.1.1. Harbor NPDES Dischargers

Table 4 NPDES Permitted Dischargers BOD_5 and Ammonia Loads to Harbor lists the relevant NPDES dischargers to the Harbor along with their permit number and permitted BOD_5 and ammonia loadings. Figure 8 shows the location of discharges to the Harbor.

Table 4 NPDES Permitted Dischargers BOD_5 and Ammonia Loads to Harbor

Facility Name	Receiving Water	Flow (MGD)	Monthly Average CBOD5 (mg/L)	Monthly Average Ammonia-N (mg/L)	Monthly Average CBOD5 (lb/day)	Monthly Average Ammonia-N (lb/day)
BASF	Harbor	1.2*	--	87.9*	--	880
Garden City WPCP	Harbor	2.0	30.0	17.4	500	290
Georgia Pacific - Savannah River Mill	Harbor	18.0	72.3*	2.0*	10,850	300
Hardeeville	Harbor	4.0	7.6	5.5	253.0	183
International Paper Company - Savannah Mill	Harbor	27.3	109.8*	2.0*	25,000	455
PCS Nitrogen Fertilizer Sav	Harbor	4.0*	--	30.0*	--	1,000
Savannah - President Street WPCP	Harbor	27.0	18.5	12.6	4166	2,837
Savannah - Travis Field WPCP	Harbor	2.0	20.0	12.0	334	200
Savannah - Wilshire WPCP	Harbor	4.5	30.0	17.4	1,126	653
US Army - Hunter Airfield	Harbor	1.3	20.0	17.4	217	189
Weyerhaeuser Company - Port Wentworth	Harbor	13.0	61.8*	2.0*	6,700	216

Note: Some parameters in Table 4 were calculated from the permit limits. For example where no monthly average CBOD5 or ammonia mass limit was defined in a permit, the load was calculated using the average flow and concentration permit limit. Similarly, where no CBOD5 or ammonia concentration limit is defined in a permit, the concentration was calculated using the average flow and mass permit limit. These calculated values are noted with a (*).

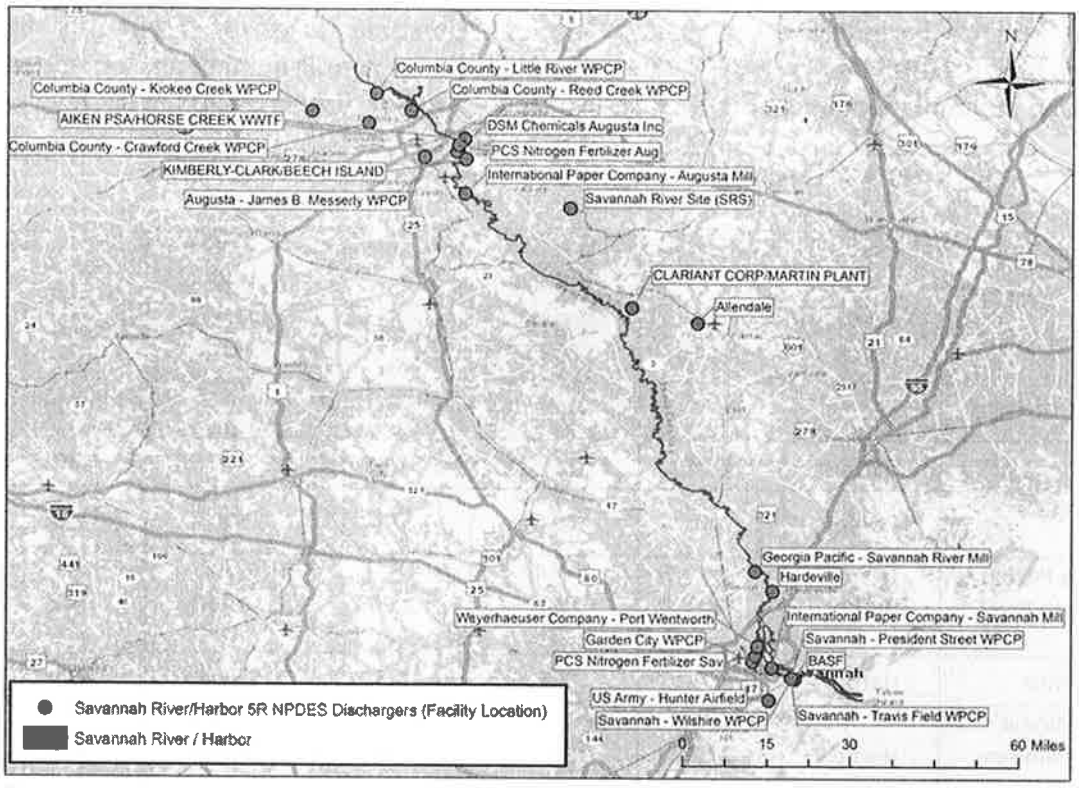

Figure 8 NPDES Permit Discharge Location

Long-term BOD analyses were completed (2000 and 2004 MACTEC; 2006 Tetra Tech; 2010 EPA Region 4) on the dischargers' wastewater to develop the appropriate f ratios and the CBODu category to put the BOD_5 loads into the model. Table 5 provides the CBODu and ultimate Nitrogenous BOD (NBOD) loads to the Savannah Harbor Model.

Table 5 Harbor Dischargers Permitted CBODu and NBODu Loads

Facility Name	Receiving Water	Permit Number	CBODu (lbs/day)	NBODu (lbs/day)
BASF	Harbor	GA0048330	--	4,022
Garden City WPCP	Harbor	GA0031038	2,760	1,326
Georgia Pacific - Savannah River Mill	Harbor	GA0046973	59,892	1371
Hardeville	Harbor	SC0034584	1,396	836
International Paper Company - Savannah Mill	Harbor	GA0001988	146,300	2,079

PCS Nitrogen Fertilizer	Harbor	GA0002356	--	4,570
Savannah - President Street WPCP	Harbor	GA0025348	22,991	12,965
Savannah - Travis Field WPCP	Harbor	GA0020427	1,843	914
Savannah - Wilshire WPCP	Harbor	GA0020443	6,216	2,984
US Army - Hunter Airfield	Harbor	GA0027588	1,197	864
Weyerhaeuser Company - Port Wentworth	Harbor	GA0002798	54,334	987
TOTAL	Harbor		296,929	32,918

4.1.2. River NPDES Dischargers

Table 6 lists the NPDES dischargers along with their permit number and permitted BOD_5 and ammonia loadings to Savannah River upstream from Clyo. Figure 8 shows the River discharger locations.

Table 6 NPDES Permitted Dischargers BOD_5 and Ammonia Loads to River

Facility Name	Receiving Water	Flow (MGD)	Monthly Average CBOD5 (mg/L)	Monthly Average Ammonia-N (mg/L)	Monthly Average CBOD5 (lb/day)	Monthly Average Ammonia-N (lb/day)
Aiken PSA/Horse Creek WWTF	River	26.0	33.0	11.0	7,156	2,385
Allendale	River	4.0	25.0	20.0	834	667
Augusta - James B. Messerly WPCP	River	46.1	10.0	1.5	3,843	576
Clariant Corp/Martin Plant	River	1.63*	45.0*	109.6*	612	1,490
Columbia County - Crawford Creek WPCP	River	1.5	12.0	1.22	150	15
Columbia County - Little River WPCP	River	6.0	7.5	4.3	375	215
Columbia County - Reed Creek WPCP	River	4.6	10.0	2.0	383	76
Columbia County - Kiokee Creek	River	0.30	20.0	7.0	50	17

Facility Name	Receiving Water	Flow (MGD)	Monthly Average CBOD5 (mg/L)	Monthly Average Ammonia-N (mg/L)	Monthly Average CBOD5 (lb/day)	Monthly Average Ammonia-N (lb/day)
WPCP						
DSM Chemicals Augusta Inc	River	3.01	29.0*	--	727	--
International Paper Company - Augusta Mill	River	42.0	85.6*	3.0	30,000	683
Kimberly-Clark/Beech Island	River	11.0	43.9*	--	4,031	--
PCS Nitrogen Fertilizer Aug	River	1.4	30.0	99.5*	350	1,162
Savannah River Site (SRS)	Watershed	2.6*	20.0*	2.0*	435	43

Note: Some parameters in Table 6 were calculated from the permit limits. For example where no monthly average CBOD5 or ammonia mass limit was defined in a permit, the load was calculated using the average flow and concentration permit limit. Similarly, where no CBOD5 or ammonia concentration limit is defined in a permit, the concentration was calculated using the average flow and mass permit limit. These calculated values are noted with a (*).

Table 7 provides the ultimate CBOD and NBOD loads to the River Model.

Table 7 River Dischargers Permitted CBODu and NBODu Loads

Facility Name	Receiving Water	Permit Number	CBODu (lbs/day)	NBODu (lbs/day)
Aiken PSA/Horse Creek WWTF	River	SC0024457	25,889	10,899
Allendale	River	SC0039918	3,019	3,048
Augusta - James B. Messerly WPCP	River	GA0037621	13,903	2,632
Clariant Corp/Martin Plant	River	SC0042803	2,214	6,809
Columbia County-Combined	River	GA0038342 GA0031992 GA0047775 GA0031984	3,470	1,484
DSM Chemicals Augusta Inc	River	GA0002160	2,632	--
International Paper Company - Augusta Mill	River	GA0002801	108,600	3,121

Facility Name	Receiving Water	Permit Number	CBODu (lbs/day)	NBODu (lbs/day)
Kimberly-Clark/Beech Island	River	SC0000582	14,592	--
PCS Nitrogen Fertilizer	River	GA0002071	1,267	5,310
Savannah River Site (SRS) Discharges	River	SC0000175	1,574	197
TOTAL	River		175,893	33,500

4.1.3. Watershed NPDES Dischargers to Tributaries

The watershed discharges to the Savannah River tributaries at their existing loadings have an insignificant impact on the DO levels in the Harbor and are not included as a factor in this analysis. However, the BOD_5 and ammonia loadings from future discharges or expansions of existing dischargers over their 1999 loadings should be examined and if significant included in the River Model and Savannah River and Harbor DO Calculator Version 4.0. Current or future tributary discharger loadings, including municipal and industrial stormwater, are allowable if it is demonstrated through modeling that their loads are at background conditions by the time they reach the river.

4.1.4. Total Ultimate Oxygen Demand for NPDES Dischargers

The summary of the Ultimate Oxygen Demand (UOD) loads from NPDES Dischargers to the Savannah Harbor and River System is listed in Table 8..

Table 8 Summary of the Permitted UOD Loads for the Harbor and the River

Receiving Water	CBODu (lbs/day)	NBODu (lbs/day)	UOD (lbs/day)
Harbor	296,929	32,918	329,847
River	177,160	33,500	209,393
TOTAL	474,089	66,418	540,507

4.2. Time-variable loading approach for NPDES Discharger Inputs

A traditional water quality analysis and load allocation approach uses steady state models with 7Q10 streamflows, average tides, and constant WTF discharger loads incorporated into monthly permit limits. The Savannah Harbor variable discharge approach uses a dynamic three dimensional model with actual flows, tides, meteorological data, and variable (daily) WTF discharger loads. These variable loads, through the Savannah River and Harbor DO Calculator Version 4.0, are incorporated into the analysis and are developed into appropriate NPDES monthly permit limits. The variable loading approach considers assimilative capacity of the flows above the 7Q10 and provides protection for flows below the 7Q10.

The variable discharger load time-series are based on historical wastewater effluent data for each facility and then simulated using monthly permit load and Coefficient of Variation (CV). For the smaller dischargers, a constant load based on the monthly permitted load and CV were used. For the five largest dischargers, three years of daily time-series loading were used, with each year time-series representing a high, medium, and low loading year. These three loading years were based on and are representative of fifty years of simulated discharge loadings. HydroQual's (HQI) 2010 report provides the details for each of the wastewater dischargers (2010 HQI). Figure 9 illustrates the relationship between the monthly permitted load and the actual discharge daily time-series for BOD_5. Appendix A is the flow analysis of the Savannah River and concluded that 1999 represents both a critical year and a year that represents the 1955 to 2008 period of record.

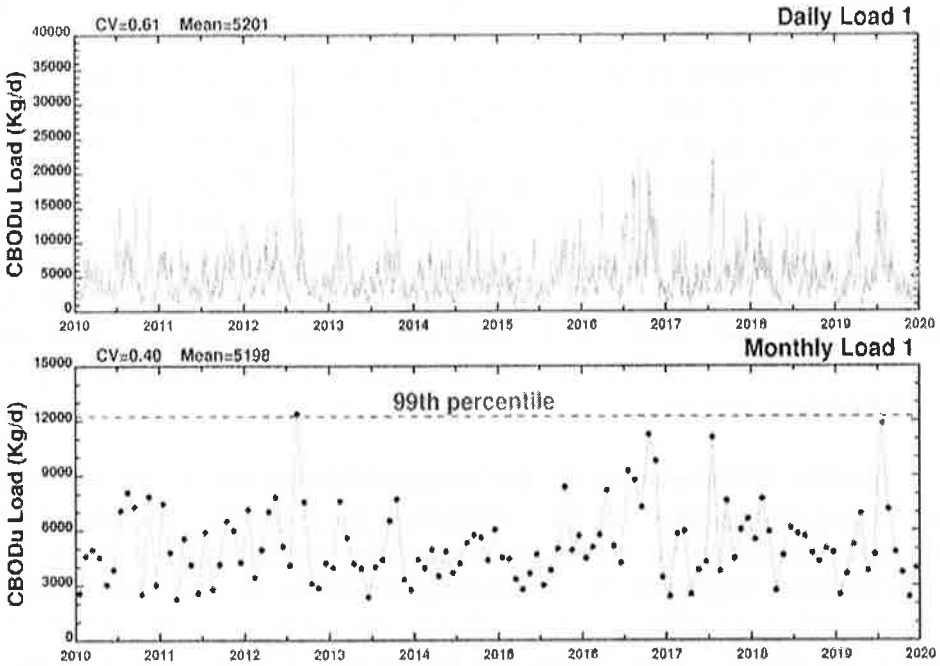

Figure 9 Monthly Permit CBODu Load and the 99 Percentile

The use of variable discharge loads in permits is not a "new" idea. The Westvaco P&P Mill in Virgina has a variable discharge NPDES permit. Also EPA's *Technical Support Document for Water Quality-Based Toxics* Control (1991 EPA) provides methodology and examples of incorporating variable load calculations in permits using the 99th percentile and an appropriate CV Additional details of this approach are laid out in the *Development of Time Variable TMDL Calculator and Supporting Analyses* . (2010 HQI).

4.3. Savannah River and Harbor DO Calculator Version 4.0

The Savannah River and Harbor DO Calculator Version 4.0 (June 2010) was developed as an efficient method to calculate the effect of various combinations of the 24 wastewater effluent dischargers on the DO levels in the Savannah River and Harbor (2010 HQI). For purposes of this 5R process, the Savannah River and Harbor DO Calculator Version 4.0 (June 2010) will serve as the basis for criteria compliance assessment and for implementation of the 5R process, including wasteload allocations as outlined in Appendix B. The target governing the discharge of wastewater BOD_5 and ammonia to the Savannah River and Harbor is that the maximum decrease in DO during March through October should be 0.1 mg/L or less. With 24 wastewater dischargers, there are many combinations of wastewater effluent BOD_5 and ammonia that could meet this delta DO constraint of 0.1 mg/L. Given the run time of an annual water quality model simulation, it is impractical to evaluate a sufficient number of wastewater BOD_5 and ammonia loading combinations to adequately satisfy all the requests for loading

options by the wastewater dischargers. However, because the magnitude of a wastewater facility's BOD_5 and ammonia discharge is directly proportional to its calculated effect on the River's DO levels, the results of stored model simulations for each discharger at a specific BOD_5 and ammonia input can be used to quickly calculate the change in river DO associated with different BOD_5 and ammonia loads. Thus, the modeled DO level at a specific wastewater discharge is applied to determine the effect a specific wastewater load has on the DO levels in the River. For example, if a wastewater discharge decreases the DO levels in the Savannah River by 0.4 mg/L at an effluent of 10,000 lb/day of BOD_5, then to reduce their impact to the DO levels in the River by half or 0.2 mg/L, their effluent would need to also be reduced by half, or 5,000 lb/day of BOD_5. The sum of each wastewater facility's calculated decreases in river DO based on their respective BOD_5 and ammonia loads produces the total decrease in DO for the Savannah River. Therefore, many loading combinations can be evaluated without performing additional lengthy model runs.

Two unique features of the analysis for the Savannah Harbor are: 1) the allowance for an exceedance of the maximum 0.1 mg/L decrease in Harbor DO from natural conditions and 2) the representation of the significant wastewater loads as time variable rather than using the traditional approach of calculating the decrease in river DO when all dischargers are at their monthly permitted BOD_5 limit, a highly improbable occurrence. The calculation of the allowable Harbor DO decrease of 0.1 mg/L implies that a variety of years representing different Savannah River flow conditions in conjunction with many combinations of time variable loads from each discharger should be evaluated to be confident that the calculated DO deficit represents long term conditions rather than one specific river flow condition or one specific time variable loading pattern for each discharger. However, the effort and number of model runs to develop this long term condition evaluation would be impractical. As a consequence of extensive modeling analyses, it was determined that performing the river delta DO compliance analysis with the river hydrodynamics for the year 1999, plus point source time variable BOD_5 loads representing high, medium, and low loading conditions approximated very closely the delta DO derived from the modeling analysis using many combinations of Savannah River hydrology and time variable BOD_5 loads. This approximation of using one representative model year, 1999, and three time variable loading patterns for each major discharger in conjunction with the concept of using stored model results in the Savannah River and Harbor DO Calculator Version 4.0 to compute the decrease in river DO for different effluent BOD_5 and ammonia loads for each discharger allows a very cost-effective and efficient way of evaluating the DO compliance success of many combinations of loading patterns for the 24 wastewater dischargers to the Savannah Harbor and River System.

Further simplification in applying the Savannah River and Harbor DO Calculator Version 4.0 was to represent the smaller wastewater dischargers with constant maximum monthly permit BOD_5 and ammonia loads rather than three years of daily time variable loads. However, a factor was developed from modeling analyses that is applied to the inputted constant monthly permit load such that the DO decrease computed from the time variable representation of these small loads is approximately the same as is computed with

constant monthly BOD_5 and ammonia loads. This factor depends on the variability of the daily effluent for BOD_5 and ammonia and the number of discharges and is expressed as the CV for each individual discharger. For these dischargers' BOD_5 loads, it is estimated that this factor is between 0.6 and 0.7.

4.4. Background Sources and Nonpoint Sources

The vast majority of the nonpoint source loadings of oxygen-demanding substances are from natural background sources including detritus transported in the stream, detritus from marsh areas flowing directly into the Harbor, and tidally-transported detritus from the ocean. These natural background nonpoint source loads are not controllable and therefore additional nonpoint source reduction to improve water quality is not an option.

In developing the 5R documentation, EPA evaluated oxygen-demanding loads from industrial and municipal stormwater sources discharging pursuant to an NPDES permit into, or upstream of, the Harbor. These loads were shown to have no measurable impact on the dissolved oxygen levels in the critical areas of concern in the Harbor. During critical periods, permitted stormwater loads were considered to be equivalent to, and part of, the natural background. EPA expects that stormwater pollution prevention plans will continue to provide for use of best management practices to ensure that such stormwater loadings do not increase above natural background levels. As long as stormwater loads continue to be less than, or equivalent to, natural background loads, the 5R process does not necessitate reductions to existing industrial and municipal stormwater sources discharging pursuant to an individual or general NPDES stormwater permit (e.g., MS4, industrial and construction general permits). Tributaries discussed in 4.1.3 are also included in the background conditions.

As a matter of practice, EPA has established, acknowledged and approved TMDL allocations for dischargers not subject to reduction expectations where their discharge meets a performance standard of natural background concentrations. For purposes of this 5R process, any new or existing discharger that can demonstrate that its loading is within natural background shall be considered a background source. For purposes of this 5R process, background includes those dischargers whose impact on the delta DO deficit is of such an inconsequential nature that such discharges may be deemed part of the background load.

5. Load Allocation Development

This plan documents the total pollutant loading of oxygen-demanding substances (5-day biochemical oxygen demand [BOD_5] and ammonia) that can be assimilated and still achieve the applicable water quality standard. This analysis includes determining the allowable loadings for facilities and sources regulated by the NPDES program, as well as from all other sources including natural background, and a margin of safety (MOS), to account for uncertainty in the analysis.

The allowable loadings are expressed in terms of Ultimate Total Oxygen Demand (TODu), where:

$$TODu = CBODu + NBODu$$

CBODu = BOD_5 multiplied times a f-ratio associated with the appropriate CBODu decay rate(s).
NBODu = ammonia multiplied by 4.57 conversion factor

This analysis provides for the calculation of the appropriate BOD_5 and ammonia effluent limits thru the use of the Savannah River and Harbor DO Calculator Version 4.0.

Because of the distribution of the NPDES dischargers and associated loads throughout the Savannah Harbor and River system and the potential for numerous allocation strategies, the Savannah River/Harbor Discharger Group applied the Savannah River and Harbor DO Calculator Version 4.0 to develop a TODu and associated NPDES BOD_5, ammonia, and DO limits that comply with both the Georgia and South Carolina DO Standards.

If new data becomes available that effects decay rates used in the River or Harbor Model or that affects other modeling assumptions, this information will be reviewed by the Modeling Technical Review Group. If it is determined that it will affect the Harbor loads, then the models and TMDL Calculator will be updated.

5.1. Critical Conditions

For an estuarine analysis, critical conditions are more complex than the critical conditions typically considered for a river system (e.g., summer temperatures and 7Q10 flow). Tidal dynamics play an important role in the DO levels of the Savannah Harbor. The streams flows, tides, and metrological data from calendar year 1999 were determined to best represent the critical conditions and were used to develop the models, and to construct the Savannah River and Harbor DO Calculator Version 4.0. Critical conditions were established to include an event that would occur once in ten years on the average or less often. In May 2000 and May 2003 letters, Georgia and South Carolina set the critical conditions for Savannah Harbor as:

- Upstream boundary determined by the States' Savannah River Model;
- Harbor model kinetic rates and parameters as determined by the Savannah Harbor Model calibration;
- 1999 harbor channel bathymetric physical conditions;
- A critical flow including a seven-day ten-year low-flow (7Q10), taking into account the low-flow release from Thurmond Dam;
- Meteorological and tidal conditions based on 1999 data.

Therefore, critical conditions applied to the Savannah Harbor DO analysis are based on model runs for March thru October 1999, incorporating the existing harbor physical

conditions and the upstream low flow, as well as actual 1999 tidal regimes, temperature, and other meteorological conditions measured during these periods.

Additional analyses of the critical conditions were completed through the Technical Model Group Review. SCDHEC conducted a flow analysis of the Savannah River and concluded that the period of record from 1955 through 2008 was an appropriate time frame for evaluating appropriate critical conditions. In addition, HQI conducted a fifty year DO analysis and showed that 1999 was the year that best represented the past 50 years (2010 HQI).

Based on the critical conditions defined here, associated wasteload allocations only apply during the critical months. NPDES permits may provide for different limits during the non-critical season.

5.2. Numeric Target

For several months during the March thru October period, the natural background DO for the Harbor is below the daily average standard of 5 mg/L. This time frame is defined by SCDHEC regulations as the critical period. Therefore, the target DO is a daily average DO deficit of 0.1 mg/L. The Savannah Harbor system was divided into 27 zones as shown in Table 9.

Table 9 Zone Descriptions and Extents

Zone	Zone Name	Ga and/or SC Waters
FR-01	Main Channel RM 0 to RM 2	Ga/SC
FR-03	Main Channel RM 2 to RM 4	Ga/SC
FR-05	Main Channel RM 4 to RM 6	Ga/SC
FR-07	Main Channel RM 6 to RM 8	Ga/SC
FR-09	Main Channel RM 8 to RM 10	Ga/SC
FR-11	Main Channel RM 10 to RM12	Ga/SC
FR-13	Main Channel RM 12 to RM 14	Ga
FR-15	Main Channel RM 14 to RM 16	Ga
FR-17	Main Channel RM 16 to RM 18	Ga
FR-19	Main Channel RM 18 to RM 20	Ga
FR-21	Main Channel RM 20 to RM 22	Ga
FR-23	Main Channel RM 22 to RM 24	Ga
FR-25	Main Channel RM 24 to RM 26	Ga
FR-27	Main Channel RM 26 to RM 28	Ga/SC
FR-29	Main Channel RM 28 to RM 30	Ga/SC
FR-35	Main Channel RM 30 to RM 40	Ga/SC
FR-45	Main Channel RM 40 to RM 50	Ga/SC
FR-55	Main Channel RM 50 to RM 60	Ga/SC
MR-01	Lower Middle River	Ga
MR-02	Upper Middle River	Ga
BR-01	Back River	Ga/SC

Zone	Zone Name	Ga and/or SC Waters
LBR-02	Lower Little Back River	Ga/SC
LBR-03	Upper Little Back River	Ga/SC
SC	South Channel	Ga
Ocean1	Ocean Channel Mouth to 10 miles	Ga/SC
Ocean2	Ocean Channel 10 to 20 miles	Ga/SC
SedBas	Sediment Basin - connecting Back River to Main Channel	Ga/SC

The models produced daily average DO time series for each zone. The 1999 Baseline Model, the Harbor and River models with no point source BOD or ammonia loadings, was run and a daily average DO per zone was computed. Figure 10 illustrates the daily average DO time series for Zone FR-13, one of the lowest DO areas of the Harbor. Figure 11 illustrates the natural daily average DO August 30, 1999, for each of the 27 zones.

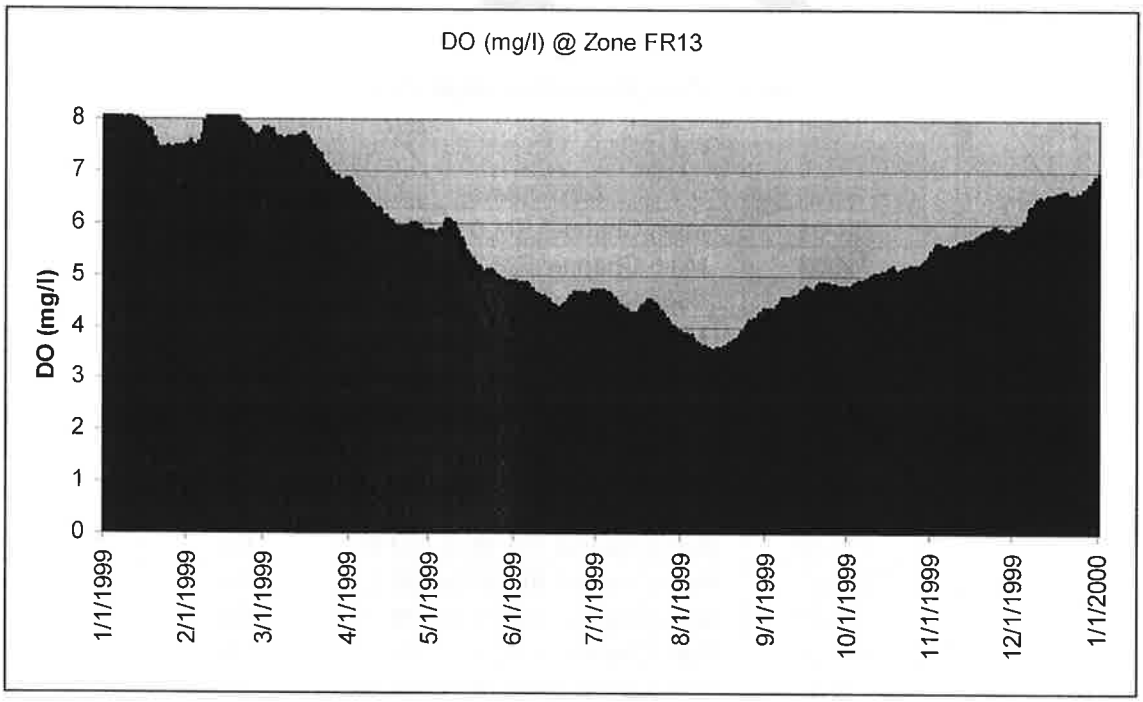

Figure 10 1999 Time Series Daily Average DO for Zone FR-13

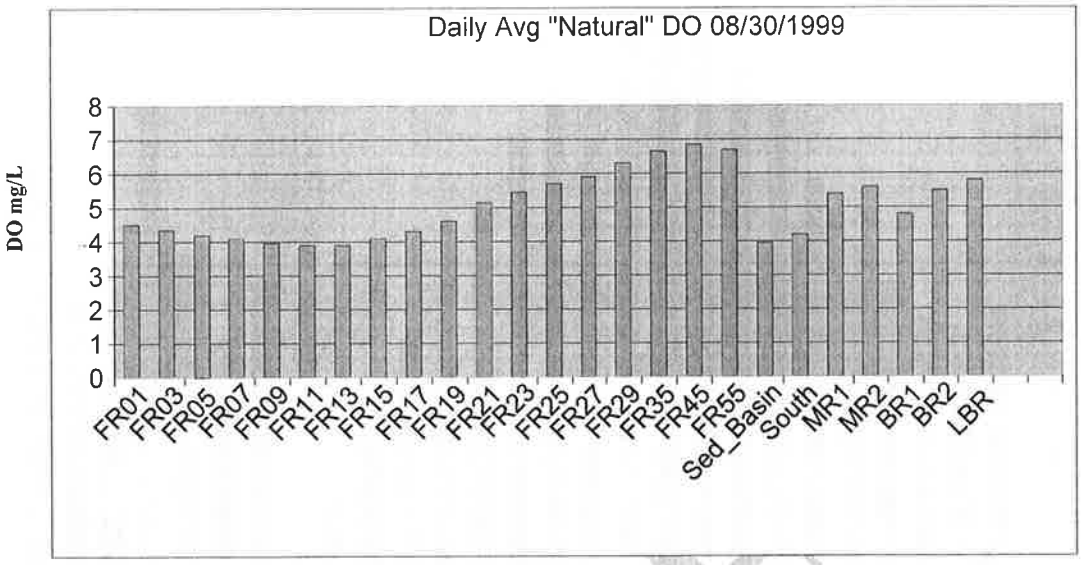

Figure 11 Daily Average DO by Zones

Scenario Model runs were simulated using various point source discharge BOD and ammonia loads. The numeric target of 0.1 mg/L DO deficit was calculated by taking the 90th percentile of the daily DO differences by subtracting the Scenario Model outputs from the Baseline Model outputs for each zone, for the time period from March through October. Figure 12 illustrates the calculated DO deficits for a permit limit scenario for each of the zones.

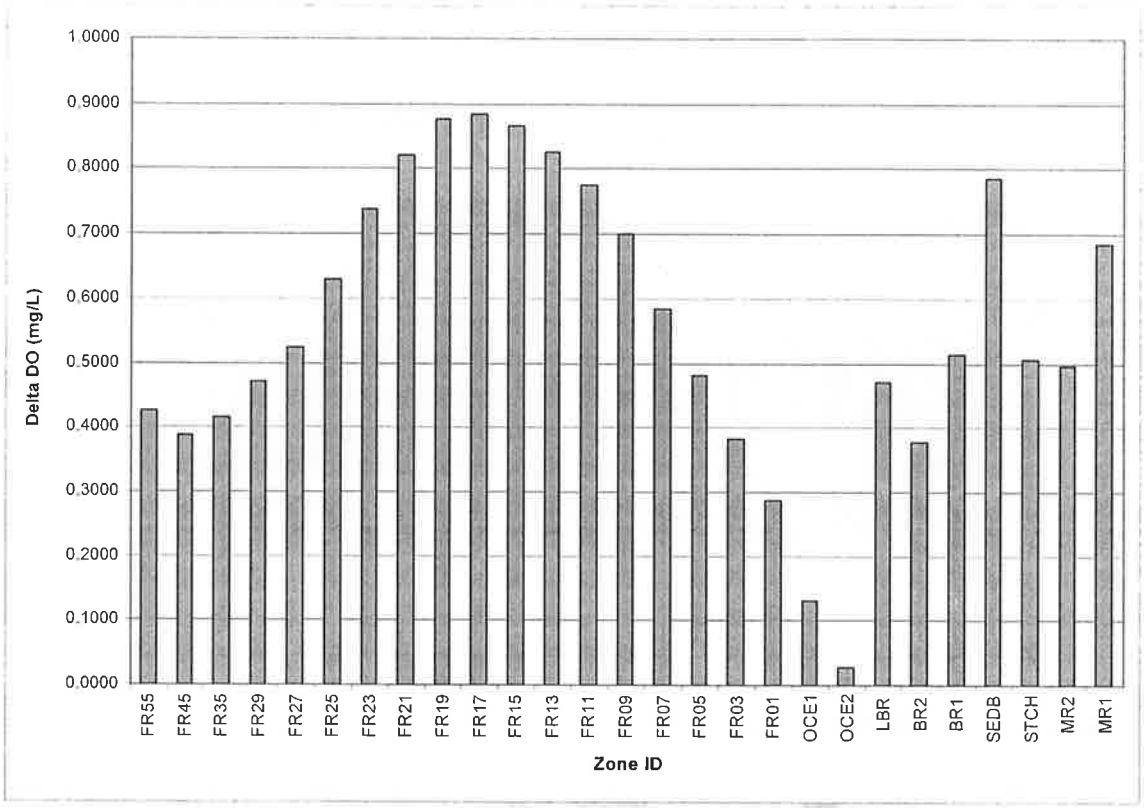

Figure 12 DO Deficits by Zone due to Point Sources at Permitted Loads

5.3. NPDES Regulated Point Sources

This analysis determines the portion of the receiving water's loading capacity that is allocated to NPDES regulated point sources. This 5R process establishes the allocations for continuous non-storm water dischargers using the Savannah River and Harbor DO Calculator Version 4.0.

The background sources described in Section 4.4, while including point sources subject to NPDES permit requirements, have been found not to contribute oxygen demanding pollutants at levels above background loading conditions, and therefore are not considered to be NPDES point sources from which reductions must be obtained under the 5R process.

5.4. Non-NPDES Regulated Sources

The majority of the non-NPDES loadings are from natural background sources. These sources are minor contributors of oxygen consuming wastes under critical low flow conditions because of the absence of storm water runoff. Therefore, the non-NPDES regulated sources are aggregated with the natural background loads in this analysis. If, at a later date, a significant upstream non-NPDES regulated source is identified, this analysis will be revised to account for this source.

The natural background loadings to the harbor are as follows:

- Upstream loads from natural riverine TODu = 85,000 lbs/day
- Marsh loadings = 145,000 lbs/day
- Ocean boundary conditions for CBODu = 5 mg/L and ammonia = 0.07 mg/L, which cause Savannah Harbor's natural DO levels to decrease due to the tidal flux for CBODu and ammonia into the Harbor system .

5.5. Margin of Safety

A margin of safety (MOS) accounts for the uncertainty in the relationship between the pollutant loads and the quality of the receiving waterbody. For Savannah Harbor, the amount of uncertainty is considered to be low. This system has been the subject of extensive study, including extensive data collection, and model development by various state and federal agencies. The Savannah Harbor MOS is implicitly provided by the abundance of data, the calibrated and verified three dimensional model, and conservative critical condition assumptions used in this analysis.

5.6. Seasonal Variation

Seasonal variation is incorporated in this analysis by evaluating multiple years of data. For the hydrodynamic and water quality models, the years 1997 through 2008 were evaluated.

Based on the critical conditions defined here, associated wasteload allocations only apply during the critical months. This analysis recognizes that permit loads can be larger in the winter months when the DO criteria of a daily average of 5.0 mg/L not less than 4.0 mg/L applies. Thus, the River and Harbor Models can also be used to develop seasonal wasteload allocations and NPDES permit limits. NPDES permits may provide for different limits during the non-critical season.

6. Calculating Load Reductions and Effluent Limits for Continuous NPDES Permits

The major dischargers to the Savannah River from Augusta, Georgia, through the Harbor initiated a facilitated process to derive equitable allocations among the 24 wastewater dischargers to achieve the DO water quality criterion provision that allows a 0.1 mg/L DO deficit from "natural" DO conditions. The Savannah River /Harbor Discharge Group was facilitated by Malcolm Pirnie/ARCADIS.

The Savannah River/Harbor Discharger Group used the Savannah River and Harbor DO Calculator Version 4.0 to evaluate various scenarios and develop a load reduction implementation strategy that will most practicably allow the numeric DO water quality criterion to be met. As long as the selected NPDES BOD_5 and ammonia permit limits meet the numeric DO target as calculated by the Savannah River and Harbor DO Calculator Version 4.0, the DO water quality standard will be met.

If new data becomes available that effects decay rates used in the River or Harbor Model or that affects other modeling assumptions, this information will be reviewed by the Modeling Technical Review Group. If it is determined that it will affect the Harbor loads, then the models and TMDL Calculator will be updated.

When NPDES permits are reissued they will contain enforceable conditions to attain compliance with water quality standards. The State NPDES programs may, in accordance with the requirements of 40 CFR 122.47, include compliance schedules in permits to enable the wastewater facilities to attain the entire necessary load reductions in the most timely and effective means. The existing NPDES permits in Table 10 should be reissued within 3 years of finalizing this document to include conditions that will result in attainment of water quality standards. New applications will be requested from each permitted facility within sixty days of finalization of this document. Submittal deadlines will be scheduled based on differing application and applicant requirements. The schedules will be provided to EPA as soon as possible. Additional information pertaining to the technical basis for determining the load reductions for each wastewater discharger is discussed in Appendix B. The Memorandum of Understanding between the dischargers to the Savannah River and Harbor is included in Appendix C, which reflects the consensus of the signatory dischargers for achieving 98% of the necessary DO deficit reduction.

Table 10 NPDES Permits

Facility Name	State	Type
BASF	GA	Ind
Garden City WPCP	GA	Mun
Georgia Pacific -Savannah River Mill	GA	Ind
Hardeeville	SC	Mun
International Paper Company -Savannah Mill	GA	Ind
PCS Nitrogen Fertilizer Savannah	GA	Ind
Savannah -President Street WPCP	GA	Mun
Savannah -Travis Field WPCP	GA	Mun
Savannah -Wilshire WPCP	GA	Mun
US Army -Hunter Airfield	GA	Mun
Weyerhaeuser Company -Port Wentworth	GA	Ind
Aiken PSA/Horse Creek WWTF	SC	Mun
Allendale	SC	Mun
Augusta -James B. Messerly WPCP	GA	Mun
Clariant Corp/Martin Plant	SC	Ind
Columbia County -Crawford Creek WPCP	GA	Mun

Facility Name	State	Type
Columbia County -Little River WPCP	GA	Mun
Columbia County -Reed Creek WPCP	GA	Mun
Columbia County -Kiokee Creek WPCP	GA	Mun
DSM Chemicals Augusta Inc	GA	Ind
International Paper Company -Augusta Mill	GA	Ind
Kimberly-Clark/Beech Island	SC	Ind
PCS Nitrogen Fertilizer Aug	GA	Ind
Savannah River Site (SRS) Discharges	SC	Ind

6.1. Monitoring Plan to Track Effectiveness of Revised Effluent Limits

Compliance with the effluent limitations contained in the reissued NPDES permits should have the corresponding effect of returning the impaired waterbody to compliance with the applicable DO water quality standard. As long as the NPDES BOD_5 and ammonia permit limits meet the numeric DO target as calculated by the Savannah River and Harbor DO Calculator Version 4.0, the DO water quality standard will be met. As such, effluent data required in each facility's operating permit will be reviewed, at a minimum, every 2-years consistent with the Section 303(d) listing cycle to evaluate whether water quality standards are being achieved. If effluent data indicate compliance with their applicable effluent limits, then the waterbody may be moved from category 5R to the appropriate attainment category on the State of Georgia's Integrated Report. If effluent data do not indicate compliance with their applicable effluent limits, additional pollution controls or compliance measures may be explored and implemented.

6.2. Tributary Dischargers

The Savannah River and Harbor models implicitly account for the existing loads from the tributary wastewater dischargers as part of the background pollutant load to the Savannah River and Harbor. Expansion of existing facilities and new facilities discharging to tributaries must demonstrate that their discharge does not increase the tributary's background UOD loading to the mainstem of the Savannah River.

6.3. Future Dischargers

If the River and Harbor conditions change due to future activities such as the proposed Savannah Harbor deepening project with the required mitigation plan or one or more existing dischargers is further reduced or eliminated and forfeits their allocation for this reduced or eliminated discharge, the water quality model and/or Savannah River and

Harbor DO Calculator Version 4.0 may be rerun to determine the allowable assimilative capacity available for future discharge expansions or allowance of new dischargers.

7. Trading and Implementation Considerations

7.1. EPA Trading Policy

Water quality trading (also called effluent trading) is an innovative way for water quality agencies and community stakeholders to develop cost-effective solutions to address water quality problems in their watersheds. EPA supports the concept of water quality trading in watersheds with multiple sources of pollutants, and specifically endorses the use of trading to implement the 5R process. Appropriate trading of pollutant allocations and/or DO deficits between or among sources, or through oxygen injection into the Harbor, is allowed under the 5R process as long as the total loading does not cause an exceedance of the DO deficit allocated to the regulated point sources. The Savannah River and Harbor DO Calculator Version 4.0 will allow the States' to evaluate and determine UOD (CBOD5 and ammonia) load and oxygen injection trading to ensure that water quality standards will be met. Any water quality trading will have to be approved by the States and EPA and will have to be reflected in the dischargers' NPDES permits.

EPA issued a Water Quality Trading Policy ("policy") on January 13, 2003 to provide guidance to states and tribes on how trading can occur under the Clean Water Act and its implementing regulations. The policy discusses Clean Water Act requirements that are relevant to water quality trading including: requirements to obtain permits, anti-backsliding provisions, and development of water quality standards including antidegradation policy, National Pollutant Discharge Elimination System permit regulations, TMDLs and water quality management plans (http://www.epa.gov/owow/watershed/trading/tradingpolicy.html) EPA has also developed a Water Quality Trading Toolkit that provides additional details about trading and how it works. The toolkit can be found at: (http://water.epa.gov/type/watersheds/trading/WQTToolkit.cfm).

7.2. Implementation Considerations

EPA also endorses the full range of administrative and regulatory tools available to the States to provide flexibility in implementing the 5R process, including the tools described in EPA's letter to the States dated August 27, 2007.

EPA recognizes that the Clean Water Act does not limit compliance schedules to the five-year permit term where a longer period is justified under Section 502(17) of the Act and 40 CFR §§ 122.2 and 122.47.

With respect to implementation of the Savannah Harbor 5R process in particular, EPA and the States recognizes that the required process alterations and improvements will vary, and in some cases, the States may need to allow long-term compliance schedules consistent with the regulatory requirements noted above. Although some compliance schedules may exceed five-years, the schedules will have to include interim dates as required by 40 CFR 122.47(a)(3). While Federal Regulations require that interim dates not exceed one year, Georgia regulations require that interim dates not exceed nine months.

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REFERENCES

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Savannah River and Harbor DO Calculator Version 4.0, sav_tmdl_calculator_v4.0.xls, (June 2010)

Draft Savannah Harbor Water Quality Model, January 2010. Prepared by EPA Region 4. (2010 EPA Region 4)

Wastewater Characterization Study, Lower Savannah River, Final Report, May 2000. Report prepared for the Savannah Harbor Committee. (MACTEC formerly LAWGIBB Group)

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8. Appendix A: Savannah Harbor DO Model Critical Conditions for Savannah River Flow

The effect of NPDES oxygen demand loads on dissolved oxygen (DO) in Savannah Harbor depends on upstream flow in the Savannah River. High river flow dilutes wastewater and helps flush the estuary, which reduces impact from effluent loading. The reverse is true during low flow conditions. The model endpoint delta DO is highly sensitive to river flow, so selection of the river design condition was an important consideration in the TMDL analysis. A dynamic upstream flow condition was chosen over the traditional steady 7Q10 approach to take full advantage of available data and modeling. In the dynamic approach, the model is run using an actual flow period that represents the range and distribution of hydrologic conditions.

The USGS gage at Clyo (02198500) is the upstream boundary in the Harbor Model. Daily mean stream discharge is continuously reported from 1929 forward. The Model Technical Review Group (MTRG) evaluated the Clyo data and considered three questions: 1) what historical period from the flow record best represents existing and future conditions? 2) which year, or combination of years, from the modeled period 1997 forward best represents the historical period? and 3) what to do if future conditions change due to Drought Plan modification or reauthorization of the Corps lakes?

Historical period. The period before completion of Thurmond Dam in 1954 does not represent current or foreseeable future conditions and was excluded. The record from 1955 forward shows a change in the flow data during the 1980s, when low flows appear to decrease. Conversations with Corps staff indicated project operation might have changed during the 1980s from maintaining downstream navigation flows to maintaining summer lake levels, which could have reduced downstream flows. Savannah River flows were compared to flows on Brier Creek (02198000), an unregulated tributary. Brier Creek showed a similar pattern of reduced low flows (Figure). Based on the comparison to the natural stream, the MTRG concluded that basin hydrology was a significant factor in addition to any possible effects from the dam. In order to capture the full range of hydrologic variation as well as any operational changes, the historical period from 1955 forward was evaluated.

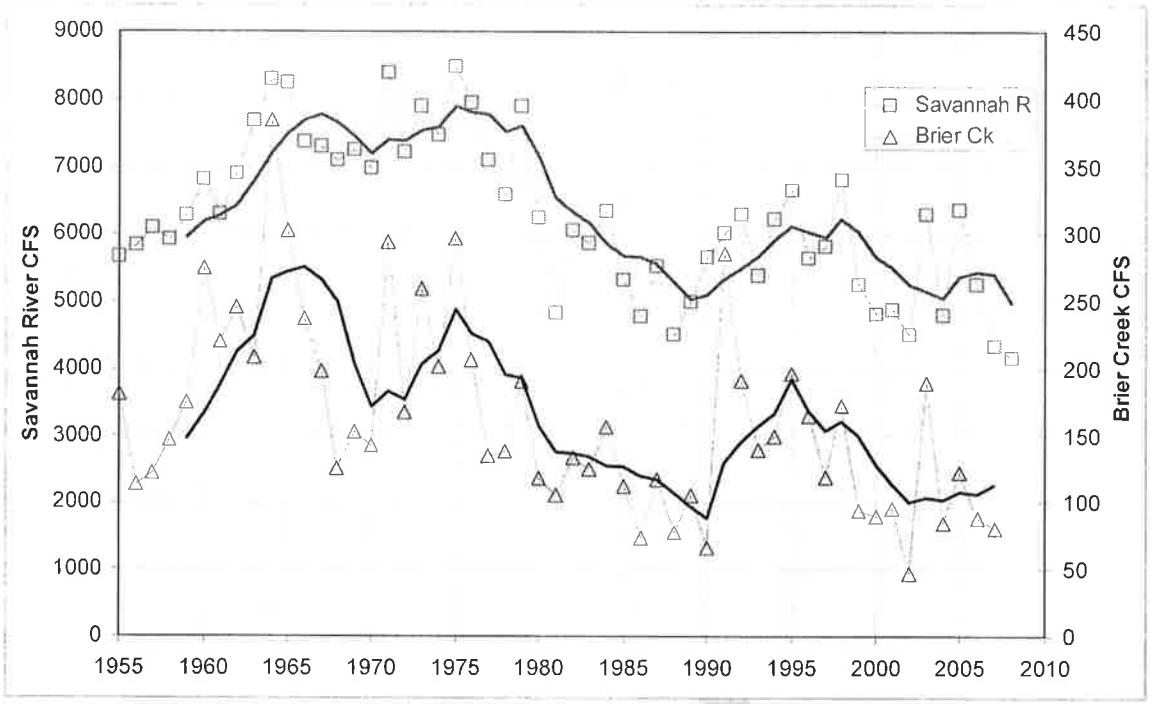

Figure 13 Savannah River and Brier Creek Flow Comparison

Representative year. It is not practical to simulate the entire period from 1955 forward in the DO model. Sufficient model input data are available only for recent years, and the model runtime is a significant constraint. A representative year was selected from the modeled period in order to represent the variability in the historical record and to maximize the number of simulations that could be completed in a reasonable timeframe.

HydroQual completed a 50 year empirical modeling analysis (2010 HQI) and illustrated that 1999 was both a critical year and a year that represented the 1955 to 2008 period of record. Based on these analyses, the MTRG selected 1999 as the representative critical condition year for TMDL modeling.

Future conditions. In response to the recent drought, state and federal agencies, and other stakeholders with an interest in Savannah basin water management issues are considering a range of alternatives including modification of the Savannah Drought Plan, which balances lake levels and downstream flows during drought conditions, and changes to the Federal Authorization of the Corps lakes, which determines authorized lake uses. This analysis is based on historical river flow conditions, which could change in the future depending on the outcome of these discussions. Proposed changes to these management plans would require National Environmental Policy Act (NEPA) review, and it is expected that issues arising from changes to the river flow regime would be addressed during the NEPA process.

9. Appendix B: Technical Basis of Wasteload Allocation Proposal (Savannah River/Harbor Discharge Group)

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Imagine the result

Savannah River/Harbor Discharger Group

Technical Basis of Wasteload Allocation Proposal

Savannah Harbor TMDL

August 4, 2011

10. Appendix C: Memorandum of Understanding Between Dischargers to the Savannah River and Harbor

MEMORANDUM OF UNDERSTANDING
BETWEEN
DISCHARGERS TO THE SAVANNAH RIVER AND HARBOR

I. PURPOSE

In 2010, the U.S. Environmental Protection Agency (EPA) published a draft revised total maximum daily load (TMDL) to address dissolved oxygen impairments of the Savannah Harbor. The TMDL will require major reductions in the permitted loads of oxygen-demanding substances to the Savannah River and Harbor. EPA and the states of Georgia and South Carolina have allowed the affected dischargers to develop a mutually agreeable set of individual wasteload allocations (WLAs), to be incorporated into the final TMDL. EPA also developed a TMDL Calculator to be used to evaluate potential allocation scenarios.

This memorandum of understanding (MOU) reflects the consensus of the signatory dischargers to a specific set of WLAs for the first component of the TMDL implementation. The consensus was achieved through a facilitated process that sought compromise between various equity concepts.

This MOU does not represent the agreement of any discharger to an individual WLA independent of the larger agreement of the signatories. In addition, this MOU is dependent upon the technical and regulatory assumptions set forth in section III below. By entering into this MOU, the signatory dischargers do not waive any rights that they may have to contest the TMDL or its underlying technical basis.

II. WASTELOAD ALLOCATIONS

The specific set of WLAs set forth in Table 1 reflects the consensus of the signatory dischargers. The technical basis of the WLA is provided in the attached document entitled *Technical Basis of Wasteload Allocation Proposal*, which is hereby incorporated by reference. The distribution of individual WLAs was derived using the TMDL Calculator version 4.0 which predicts that the distribution will achieve approximately 98% of the reductions necessary to achieve the TMDL.

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