ENVIRONMENTAL IMPACT STATEMENT
APPENDIX L: Cumulative Impacts Analysis

SAVANNAH HARBOR EXPANSION PROJECT

Chatham County, Georgia and Jasper County, South Carolina

January 2012

US Army Corps of Engineers
Savannah District
South Atlantic Division

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Cumulative Impacts Analysis

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SAVANNAH HARBOR EXPANSION PROJECT

CUMULATIVE IMPACTS ANALYSIS

1. Background

The assessment of cumulative impacts in NEPA documents is required by CEQ regulations (CEQ, 1987). According to the CEFQ, a cumulative effect "is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time."

An assessment of cumulative effects helps one identify the significance of an impact. The assessment sets the stage for determining the importance of the incremental effect produced by a proposed action. When considering significance, one should examine whether the action is related to other actions with individually insignificant, but cumulatively significant impacts. The CEQ regulations state that "significance exists if it is reasonable to anticipate a cumulatively significant impact on the environment." The CEQ produced a handbook titled "Considering Cumulative Effects under the National Environmental Policy Act" to guide agencies in the preparation of cumulative impact analysis.

2. Three Steps of Cumulative Impacts Analysis

As described in the CEQ handbook, the cumulative impact analysis process involves three basic processes:

1. Scoping for cumulative effects
2. Describing the affected environment
3. Determining the environmental consequences

3. Scoping For Cumulative Impacts

An analysis of cumulative effects should include past, present, and future actions and encompass all Federal, non-Federal, and private actions. The analysis should focus on each affected resource, ecosystem, and human community, with the study effort focusing on truly meaningful impacts. As directed by the CEQ handbook, the scoping for potential cumulative effects should include:

1. Identifying the significant potential cumulative effects and defining assessment goals.
2. Establishing the geographic scope of the analysis
3. Establishing the time frame for the analysis

4. Identifying other actions affecting the resources, ecosystems and human communities of concern.

4. Describing the Affected Environment

In describing the affected environment, the CEQ handbook suggests using natural boundaries and focusing on each affected resource, ecosystem, and human community. Consequently this part of the cumulative analysis should include:

1. Characterizing the resources, ecosystems, and human communities identified during scoping in terms of their response to change and capacity to withstand stress
2. Characterizing the stresses affecting these resources, ecosystems, and human communities and their relation to regulatory thresholds
3. Defining a baseline condition for the resources, ecosystems and human communities.

5. Determining the Environmental Consequences of Cumulative Impacts

This portion of the cumulative effects analysis addresses additive, countervailing, synergistic effects, looking beyond the life of the action, and addressing the sustainability of resources, ecosystems, and human communities. Consequently, this part of the cumulative analysis should include:

1. Identifying the important cause-and effect relationship relationships between human activities and resources, ecosystems, and human communities
2. Determining the magnitude and significance of cumulative impacts
3. Modifying or adding alternatives to avoid, minimize, or mitigate significant cumulative impacts,
4. Monitoring to determine the cumulative effects of the selected alternative and adapting management measures as required.

6. Scoping for Cumulative Impacts

Scoping for the cumulative impacts associated with the Savannah Harbor Expansion Project (SHEP) was aided by numerous information sources. During the course of the study, various environmental studies were conducted on the harbor and its various resources and ecosystems. These studies included water quality and sediment characterization studies, salinity and dissolved oxygen modeling, fishery studies and other study efforts directed at various resources. Table 1 shows some of the studies conducted in support of the SHEP.

Table 1. Summary of SHEP Modeling Studies

Report	Title	Author	Date
Water Quality Mitigation	*Oxygen Injection Design Report Savannah Harbor Expansion Project*	Tetra Tech, Inc.	October 2010
Model Calibration (EFDC & WASP)	*Development of the Hydrodynamic and Water Quality Models for the Savannah Harbor Expansion Project*	Tetra Tech, Inc.	January 2006
Fishery Impacts	*Habitat Impacts of the Savannah Harbor Expansion Project*	Tetra Tech, Inc.	October 2006
Chloride Model Development (Superseded)	*Savannah Harbor Expansion Project – Chloride Data Analysis and Model Development*	Tetra Tech, Inc.	November 2006
Water Quality Impacts	*Water Quality Impacts of the Savannah Harbor Expansion Project*	Tetra Tech, Inc.	February 2007
Marsh Modeling Report	*Simulations of Water Levels and Salinity in the Rivers and Tidal Marshes in the Vicinity of the Savannah National Wildlife Refuge, Coastal South Carolina and Georgia*	US Geological Survey	June 2006
Chloride Impacts	*Chloride Impact Evaluation Impacts of Harbor Deepening Only*	USACE Savannah District SAS-EN	February 2007
Hurricane Surge Impacts	*Hurricane Surge Modeling*	USACE Savannah District SAS-EN	September 2005
Chloride Impacts (Superseded)	*Savannah Harbor Expansion Project Evaluation of Chloride Impacts with Proposed Mitigation Plan*	USACE Savannah District SAS-EN	December 2007
Fishery Impacts (SNS Impacts Superseded)	*Savannah Harbor Expansion Project Evaluation of Fishery Habitat Impacts with Proposed Mitigation Plan*	USACE Savannah District SAS-EN	January 2010
Hurricane Surge Impacts	*Savannah Harbor Expansion Project Evaluation of Hurricane Surge Impacts with Proposed Mitigation Plan*	USACE Savannah District SAS-EN	December 2007
Wetland Impacts	*Savannah Harbor Expansion Project Evaluation of Marsh/Wetland Impacts with Proposed Mitigation Plan*	USACE Savannah District SAS-EN	November 2007

Report	**Title**	**Author**	**Date**
Water Quality Impacts	*Savannah Harbor Expansion Project Evaluation of Water Quality Impacts with Proposed Mitigation Plan*	USACE Savannah District SAS-EN	September 2009
Wetland Impacts	*Savannah Harbor Expansion Project Mitigation Evaluation for Marsh/Wetland Impacts*	USACE Savannah District SAS-EN	November 2007
Wetland Impacts (Sensitivity Analysis)	*Savannah Harbor Expansion Project Sensitivity Analysis of Proposed Navigation Meeting Areas*	USACE Savannah District SAS-EN	September 2009
Wetland Impacts (Sensitivity Analysis Obsolete)	*Savannah Harbor Expansion Project Sensitivity Analysis of Proposed Sill on Middle River*	USACE Savannah District SAS-EN	September 2009
Wetland Impacts	*Wetland/Marsh Impact Evaluation*	USACE Savannah District SAS-EN	February 2007
Wetland Impacts (Obsolete)	*Savannah Harbor Deepening Project ATM Marsh Succession Model Marsh/Wetland Impact Evaluation*	USACE Mobile District SAM	May 2007
Wetland Impacts (Obsolete)	*Savannah Harbor Deepening Project USGS/USFWS Marsh Succession Model Marsh/Wetland Impact Evaluation*	USACE Mobile District SAM	June 2007
Fishery Impacts	*Savannah Harbor Expansion Project Evaluation of Adult SNS (Summer) Habitat Impacts with Proposed Mitigation Plan*	USACE Savannah District SAS	March 2011
Fishery Impacts	*Savannah Harbor Expansion Project Evaluation of Adult SNS (Winter) Habitat Impacts with Proposed Mitigation Plan*	USACE Savannah District SAS	March 2011
Fishery Impacts	*Savannah Harbor Expansion Project Evaluation of Juvenile SNS (Winter) Habitat Impacts with Proposed Mitigation*	USACE Savannah District SAS	March 2011
Chloride Model Development	*Chloride Modeling Savannah Harbor Expansion Project*	Tetra Tech, Inc. & Advanced Data Mining Services, LLC	December 2010
Chloride Impacts	*Assessment of Chloride Impact from Savannah Harbor Deepening*	Arthur Freedman Associates, Inc.	April 2011

In addition to scientific data generated from the various studies, the District received input from technical experts from Federal and State resource agencies. Scoping for cumulative impact assessment also benefited from input from the Stakeholder Evaluation Group (SEG), which included others interested in the future of the resources in Savannah Harbor. The cumulative impact analysis was also aided by information contained in the Draft Fish and Wildlife Coordination Act Section 2(b) Report submitted by the US Fish and Wildlife Service's Office of Ecological Services field office in Charleston, SC. This report (November 2008) included input from the National Marine Fisheries Service, the South Carolina Department of Natural Resources, and the Georgia Department of Natural Resources.

7. Identification of Critical Resources or Issues

As discussed above, the CEQ handbook directs that cumulative effect analysis should "Focus on truly meaningful effects". The Savannah Harbor Expansion Project could affect the human environment through several potential avenues. A broad list of potential avenues and items for consideration was developed as a result of the scoping process.

The Cooperating Agencies reviewed that list of items and agreed that the following were the major resources or issues of concern for this project:

- Wetlands
- Fisheries
- Dissolved Oxygen
- Groundwater
- Endangered Species
- Tybee and Nearshore Area

The remainder of this cumulative impact analysis will focus on each of the major resources or issues of concern identified above. For each resource or issue, the analysis will use the following format:

Issue
Geographic scope
Historical basis (baseline condition)
Past actions / stresses
Present condition
Present actions / stresses
Capacity to withstand stress
Future actions / stresses
Incremental impact
Alternatives to avoid, minimize, or mitigate cumulative effects

8. Wetlands

Issue

Wetland concerns addressed in this cumulative impact analysis were divided into three categories. The first concern centers around the Savannah National Wildlife Refuge (SNWR) operated by the US Fish and Wildlife Service. The SNWR withdraws freshwater from Little Back River to assist in the management of diked impoundments for migratory waterfowl. Withdrawal of water with salinity concentrations greater than 0.5 ppt is considered detrimental to their freshwater waterfowl management operations.

The second major wetland concern is the remaining tidal freshwater marsh in the Savannah Harbor estuary. Federal and State natural resource agencies consider tidal freshwater marsh to be of particularly high value because of the plant and animal diversity that it supports. In addition, tidal freshwater marsh is much rarer on a national basis than brackish marsh or saltmarsh.

The third major wetland concern addressed in this cumulative impact analysis is the salt and brackish marsh in the estuary. Industrial development and harbor maintenance (construction of dredged material disposal areas) have impacted much of this resource over time.

A. Savannah National Wildlife Refuge Freshwater Waterfowl Management Operations (Impounded Marshes)

Geographic Scope

The geographic scope of this analysis is the SNWR. The primary purpose of the SNWR is to provide habitat for wintering waterfowl and other migratory birds.

The Refuge lies adjacent to and upstream of Savannah Harbor in Chatham and Effingham Counties, Georgia and Jasper County, South Carolina. The downstream end of the refuge on the Savannah River is located around River Mile 17. The SNWR extends upriver to about River Mile 41, about 14 miles above the I-95 crossing. The SNWR consists of 29,175 acres of palustrine forested wetlands, palustrine and estuarine emergent wetlands, palustrine scrub-shrub wetlands, riverine wetlands, diked waterfowl impoundments (managed wetlands), and uplands. The SNWR obtains freshwater for its diked waterfowl impoundments through freshwater control works that were constructed as part of the Sediment Basin Project in Savannah Harbor. The SNWR obtains its freshwater primarily through the Diversion Canal Intake (water control structure No.1) located on Lucknow Canal just off Little Back River. The water is used to fill the diked waterfowl impoundments (about 5,700 acres) in the fall to provide food and habitat for migratory birds. Figure 1 shows that portion of the SNWR in the immediate study area.

The private lands located east of the SNWR generally known as the Fife and Clydesdale Plantations contain diked impoundments which are primarily used for waterfowl management. The SNWR supplies freshwater through the freshwater control system to these two plantations because the freshwater control system was constructed to supply a dependable source of freshwater for both the SNWR and these adjacent landowners.

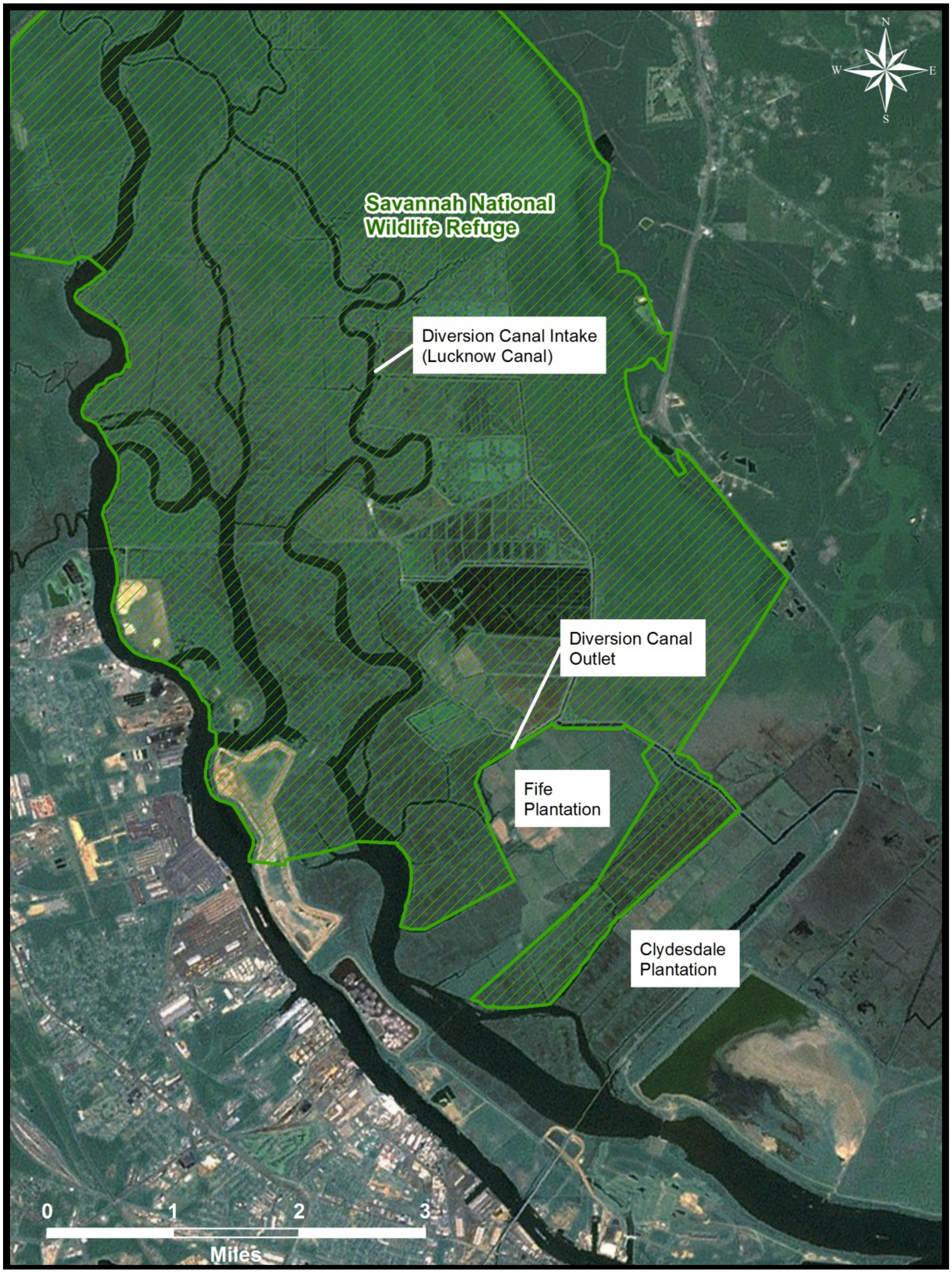

Figure 1. SNWR- SHEP study area.

Historic Basis

On April 6, 1927, Executive Order 4626 established the Savannah River Bird Refuge and set aside 2,352 acres as a preserve and breeding ground for native birds. Executive Order No. 5748 (November 12, 1931) added 207 acres to the Refuge and renamed the area the Savannah River Wildlife Refuge. Executive Order 7391 (June 17, 1936) added 6,527 acres to the Refuge. Presidential Proclamation 2416 (July 30, 1940) renamed it the Savannah National Wildlife Refuge. Much of the Refuge consisted of old rice fields, and the old rice levees form the basis for the current impoundment dikes.

The three Executive Orders cited above provided the initial 9,086 acres of the SNWR. The remaining 20,089 acres comprising the SNWR were purchased using various funds (Duck Stamp Funds, Land and Water Conservation Funds, etc.) with the last purchase being the Solomon tract (887 acres) in 1999.

When the SNWR was established in 1927, the Savannah Harbor Navigation Project was authorized to be maintained to 26 feet MLW, compared to its current authorized depth of 42 feet MLW. In addition, maintenance dredging in Savannah Harbor in 1927 did not include the current practice of allowable overdepth dredging. This practice permits dredging to occur an extra 2-6 feet deeper in critical shoaling areas in the channel to reduce dredging frequency.

Past Actions/Stresses

Since the SNWR began operations in 1927, there have been four harbor deepening projects. In addition, the Sediment Control Works Project was constructed and placed into operation. The Savannah Harbor navigation channel was deepened to 30 feet MLW in 1937 and to 34 MLW in 1958. The navigation channel was then deepened to 38 feet MLW in 1975 and to 42 feet MLW in 1994. All of these deepening projects allowed saltwater to migrate farther upstream. Information supplied in the Fish and Wildlife Coordination Act Section 2(b) Report indicates that the freshwater interface has moved from near the City of Savannah (Mile 14 of Savannah Harbor) in 1940 (30 foot channel) to near the upstream limit of the project (Mile 21.3) just below the Georgia Highway 25 (Houlihan) Bridge (42 foot channel). Figure 2 taken from the November 2008 US Fish and Wildlife Service Draft Fish and Wildlife Coordination Act Report, shows the historical change in the location of the freshwater interface from 1875 to the present.

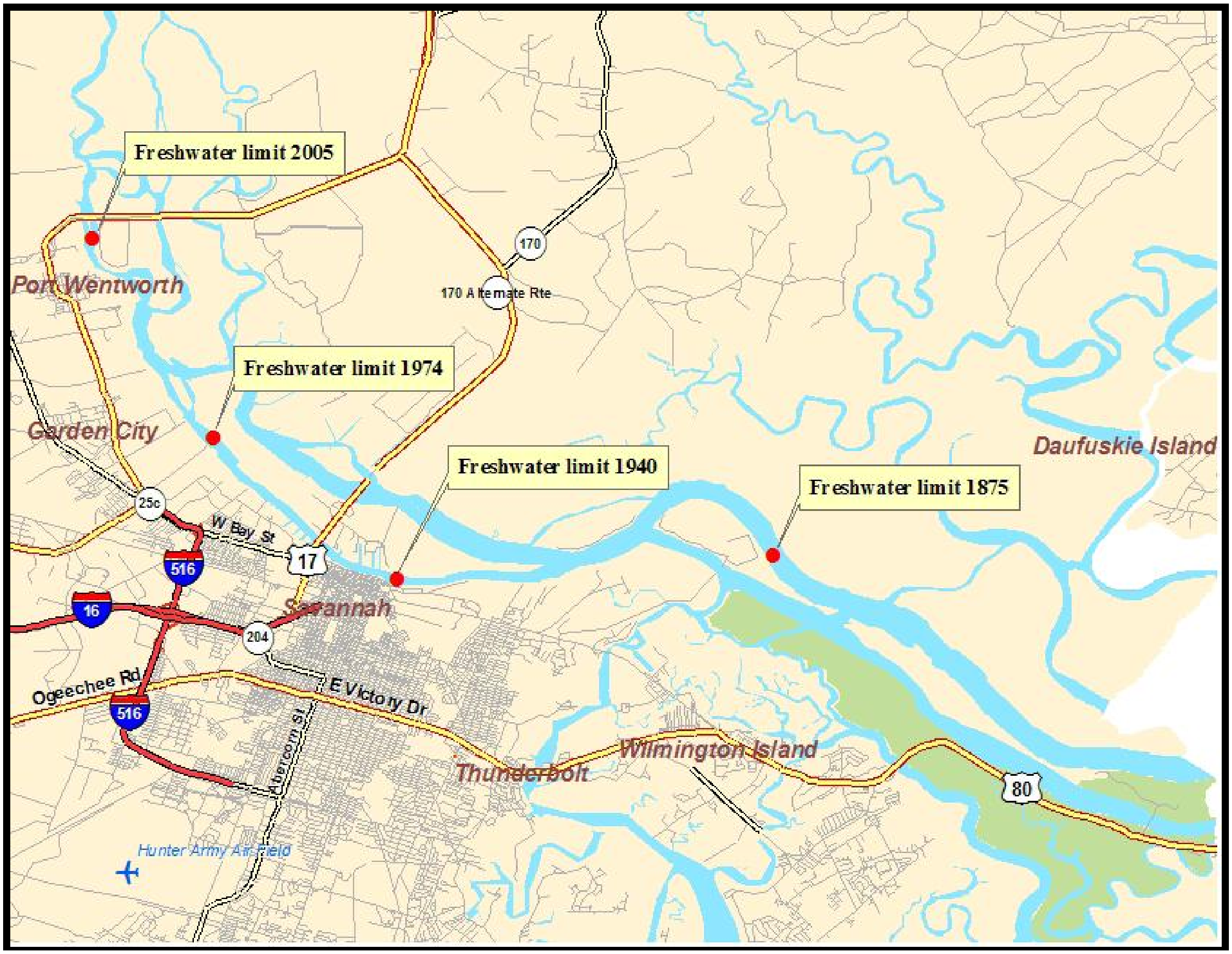

Figure 2. Historical freshwater interface Savannah Harbor.

In addition to the harbor deepening projects described above, the Sediment Control Works Project became operational in 1977 just after completion of the 38 foot channel. The project consisted of a Tide Gate Structure across Back River and a Sediment Basin downstream of the Tidegate. The project also included a drainage canal (New Cut) across Argyle Island which was designed to increase velocities in the navigation channel and thus reduce shoaling. This project was designed to concentrate sedimentation outside the navigation channel in a location (Sediment Basin) close to dredged material disposal areas (CDFs 12A and 12B).

During the design phases of the Sediment Control Works Project and the 38-foot channel in the early 1970s, it became apparent that these projects would have significant impacts on salinity levels in the vicinity of the SNWR. The tide gates would close forcing water through New Cut to Front River. This increased salinity levels in Back River. A Freshwater Control Works Project was, therefore, designed to mitigate for anticipated salinity increases in the vicinity of the SNWR. This system is still used to supply freshwater to the SNWR and the adjacent private landowners. This Freshwater Control System included various channel improvements in McCoys Cut, Middle River and Little Back River, a main water supply structure just off Little Back River, water control structures and supply canals in the Refuge, and a supply canal to the adjacent landowners.

At the request of the USFWS, one component of the system (cutting off a bend in Little Back River), was not constructed. System maintenance problems caused by higher than anticipated salinity levels in Little Back River caused issues for the SNWR.   Personnel at the SNWR complained that they were unable to withdraw freshwater (0.5 or less ppt salinity) during periods of low flows and high tides. Periods of low flows in the Savannah River normally occur during the fall months when the SNWR starts filling their impoundments. The US Fish and Wildlife Service subsequently retrofitted water control structures that rusted and failed after completion of the project.

In addition to problems with the Freshwater Control System, the US Fish and Wildlife Service complained about the impacts of high salinity levels in Little Back River on freshwater marsh and striped bass habitat. As a result, the Tidegate Structure was taken out of operation in March 1991 and New Cut was closed in March 1992 to reduce salinity levels in the vicinity of the SNWR. Taking the Tidegate Structure out of operation and closing New Cut also helped to mitigate any further increases in upstream salinity levels from construction of the 42-foot channel, which was completed in 1994.

Present Condition

The SNWR manages about 5,700 acres of diked impoundments for waterfowl. These impoundments include about 3,000 acres of freshwater pools which include both draw-down pools and permanently flooded pools. The draw-down pools are drained annually between March 15 and May 15 and manipulated to promote growth of emergent waterfowl food plants. These pools are then re-flooded in the fall of each year. The permanent pools remain flooded all year to promote growth of submerged aquatic plants and to provide wood duck brood rearing and alligator habitat. These pools are drained, dried, burned and mowed when undesirable vegetation becomes a problem or productivity of desirable plants decreases.

Currently, salinity levels in Little Back River during average and high flow river conditions are acceptable for the Refuge to withdraw adequate freshwater for their waterfowl management operations. During extreme low flow periods, Refuge staff must still time the flooding of their freshwater pools around the lunar cycle because of high salinity levels. Although conditions at the diversion canal intake permitted fresh water to be withdrawn on most occasions, the physical condition of the system became a problem. The system fell into disrepair characterized by water control structures that either failed or were in the process of failing. Two main structures supply freshwater to the Refuge. The south water control structure was completely out of service as all four of the 48-inch openings failed. Three of the eight pipes in the north water control structure also failed. Thirteen of the interior water control structures which are used to supply water to the individual management units also showed signs of rust and deterioration.

The US Fish and Wildlife Service considers availability of freshwater (salinity less than 0.5 ppt) necessary to maintain maximum use of the SNWR's managed wetlands. Freshwater coastal impoundments produce a greater variety of marsh plants, many of which are desirable duck food, than brackish impoundments. The Service also manages several impoundments to provide high quality feeding habitats for many species of wading birds, including the endangered wood stork. Freshwater impoundments are also managed to provide nesting and feeding habitat for shorebirds, and feeding habitat for neo-tropical migrants.

Present Actions/Stresses

Based on information supplied by the US Fish and Wildlife Service, the Freshwater Control System was in dire need of repair. The November 2008 Fish and Wildlife Coordination Act Report characterized the system as "susceptible to imminent failure". According to the report, loss of the ability to control water levels within the impoundments would subject the Refuge to the ebb and flow of the tides which would result in severe damage to Refuge roads, dikes, and internal water control structures. The Service would also lose the ability to supply fresh water to the adjacent Fife and Clydesdale Plantations.

Savannah District completed a Letter Report in October 2009 that recommended the Corps rehabilitate the water control structures in the Freshwater Control System back to their original condition. The Corps' South Atlantic Division office approved that report on October 16, 2009. Repairs to the Freshwater Control System commenced in 2010 and the repairs on Federal lands were completed in 2011.

Capacity to Withstand Stress

The USFWS must have access to freshwater to properly manage their diked impoundments for migratory waterfowl. There are two potential stresses that could impact their ability to draw freshwater from Little Back River. First, the physical integrity of the Freshwater Control System must be maintained.   This was accomplished with completion of the repairs to rehabilitate the system by the Corps in December 2011. Second, any action that would increase upstream salinity levels in Savannah Harbor could affect the USFWS' ability to withdraw freshwater from their intake off Little Back River.

Future Actions/Stresses

Future actions/stresses that could affect the SNWR include construction of the SHEP, construction of a proposed Jasper County Marine Terminal, and sea level rise. The SHEP evaluated various alternative harbor deepening plans which would deepen Savannah Harbor from its authorized depth of 42 feet mean low water to 44, 45, 46, 47, or 48 feet MLW. All of the deepening alternatives would increase salinity levels at the diversion canal entrance (Structure No. 1) without mitigation.

If constructed, a proposed Jasper County Marine Terminal (container) would be located in Jasper County, South Carolina on what is now CDFs 14A and 14B. Although no detailed studies have been conducted relative to this proposed facility, impacts on upstream salinity levels at the

Refuge would probably be minor. If the SHEP is constructed and that channel is determined to be sufficient for the needs of a Jasper County container terminal, no further channel improvements (other than an access channel) would be required to operate that terminal. If the SHEP is not constructed, development of a Jasper County container terminal would require deepening and extension of the entrance channel and deepening of the interior channel to its facility. While the SHEP would involve channel deepening upstream to River Mile 18.8, the proposed Jasper Project would only require a deepened channel to about River Mile 6. Deepening of the harbor to River Mile 6 would not result in a major change in the present location of the saltwater/freshwater interface, and thus the project would not cause a major increase in salinity levels at the SNWR.

Sea level rise could cause a major increase in salinity levels in Little Back River at the SNWR. According to NOAA, the historic sea level rise is 3.05 mm/year. At the request of the resource agencies, the SHEP model studies evaluated a 25-cm and 50-cm rise in sea level over the life of the project (50 years). Looking at a worse case scenario (50-cm rise in sea level over a 50-year period with the existing 42-foot project), model results indicate that salinity levels (10% exceedance) at the SNWR during periods of average flows would be about 0.45 ppt which would increase to 1.52 ppt during low flow periods.

Incremental Impact

The incremental effects of past harbor deepening projects and the resultant increases in upstream salinity levels are readily apparent. The SNWR began operations in 1927 when the authorized navigation channel was 26 feet MLW. In 1940 with an authorized navigation project depth of 30 feet, the freshwater interface moved upstream but remained downstream of the SNWR and was still below the US 17 Bridge. Completion of the 34-foot navigation project resulted in the freshwater interface moving past the US 17 Bridge to GPA's Garden City Terminal. Model predictions for the Sediment Control Project (Tide Gate Structure and Sediment Basin) and deepening the harbor to 38 feet MLW indicated that these projects would cause increased salinity levels in the vicinity off the SNWR. The impacts of the construction of the 38-foot channel on upstream salinity levels were exacerbated by construction and operation of the Sediment Control Works which pushed higher salinity water up Back River into Little Back and Middle Rivers into the SNWR. Consequently, a Freshwater Control System was included in the Sediment Control Works project to mitigate for increased salinities. Salinity levels were higher with the Tidegate operating than anticipated. Consequently the structure was taken out of operation in 1991 and New Cut was closed in 1992 to reduce the upstream movement of higher salinity water into Little Back River.

Today, the freshwater interface is located near the upstream limit of the project just downstream of the Georgia Highway 25 Bridge and upstream of the upper limit of the Savannah Harbor Navigation Project (Mile 21.5). Salinity levels at the SNWR intake are generally within acceptable limits (0.5 ppt or less) because the Tidegate is no longer in operation. Deepening the harbor to 44, 45, 46, 47, or 48 feet MLW would increase salinity levels in the vicinity of the SNWR, thus mitigation would be required to insure that the refuge has access to freshwater.

Alternatives to Avoid, Minimize, or Mitigate Cumulative effects

Increases in upstream salinity levels that would result from deepening the harbor to 44, 45, 46, or 47, or 48 feet were predicted using the Environmental Fluid Dynamics Computer Code (EFDC) model. The EFDC model comprises an advanced three-dimensional surface water modeling system for hydrodynamic and reactive transport simulations of rivers, lakes, reservoirs, wetland systems, estuaries and the coastal ocean.

Based on the modeling results, salinity levels at the SNWR intake would remain within acceptable limits (0.5 ppt or less) during average flows for all alternative depths with no mitigation. The model predicts that salinity levels at the intake would range from 0.1-0.3 ppt for the 44, 45, and 46 foot channels and 0.2-0.4 ppt for the 47 and 48 foot channel without mitigation measures during average flow periods.

However, the model indicates that fresh water would not be available at the SNWR intake during periods of low flow for all alternative channel depths without some form of mitigation. Model predictions indicate that salinity levels at the intake during low flow periods would average 0.7-0.9 ppt for the 44, 45 and 46 foot channels and 0.9-1.1 ppt for the 47 and 48 foot channel without mitigation.

To reduce increases in upstream salinity levels caused by the alternative channel deepening plans, model investigations evaluated various flow and channel modifications. These flow and channel modifications would decrease upstream salinity levels by reducing the flow of higher salinity water into Little Back River and Middle Rivers and increasing the flow of fresh water from the Savannah River into these streams.

For the 44-foot channel, a diversion structure would be constructed at McCoys Cut (the western arm would be closed) to divert more freshwater into Little River and Middle River, and Rifle Cut would be closed to prevent higher salinity water from entering Little Back River. The Tidegate would also be removed and a sill and submerged berm constructed across the mouth of the Sediment Basin to reduce water from Front River with higher salinity levels from entering Back River. This plan was designated Plan 6B (Figure 3).

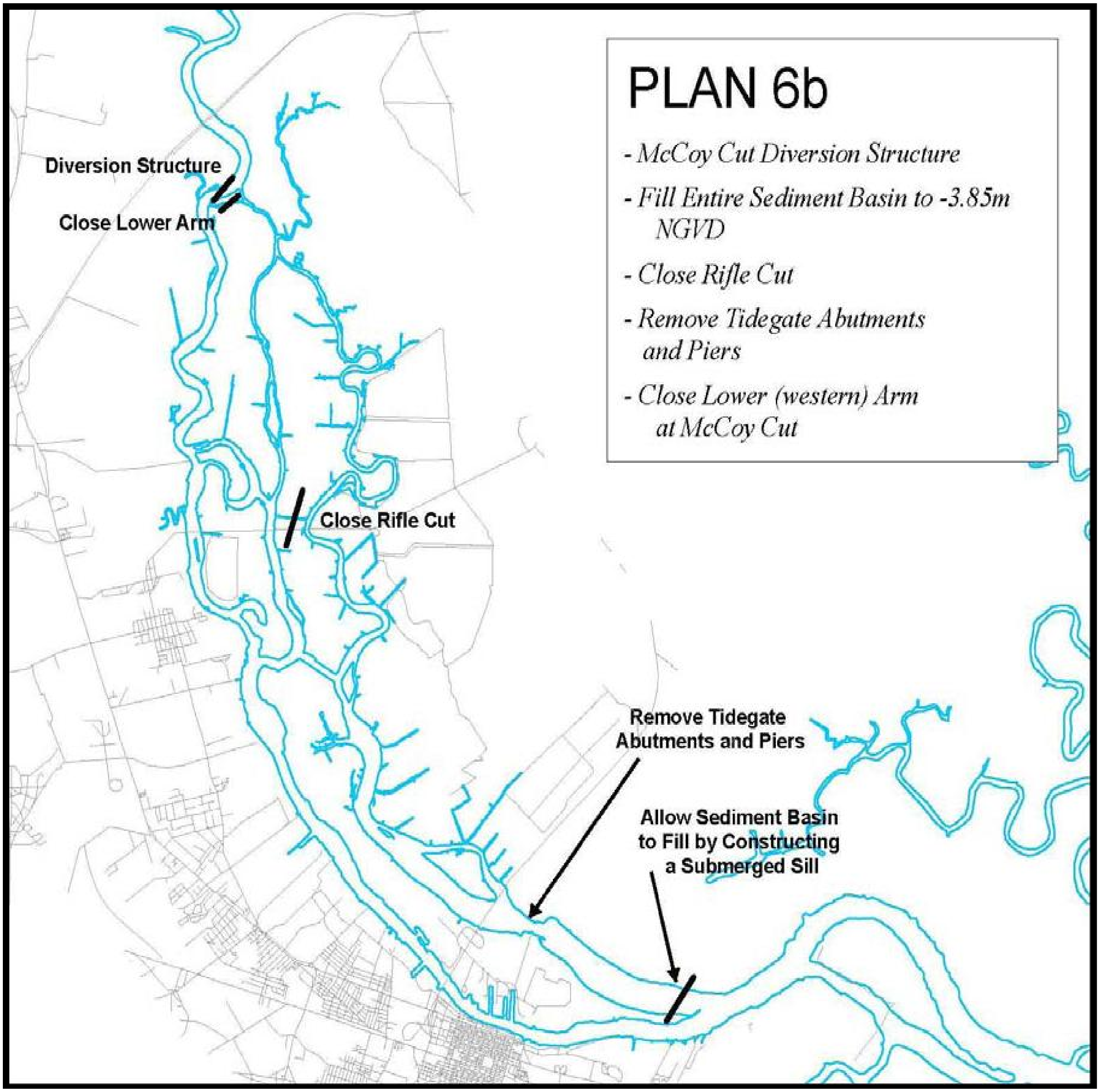

Figure 3. Proposed mitigation flow re-routing Plan 6B.

With mitigation Plan 6B implemented, model predictions indicate that salinity levels at the intake would range from 0.04 ppt during average flow periods to 0.33 ppt during low flow periods which would provide a dependable source of freshwater to the SNWR with the 44-foot project in place.

The proposed mitigation plan (Plan 6A) for the 45, 46, 47, and 48-foot depth alternatives would involve the same features plus the addition of limited channel deepening in McCoys Cut, Little

Back River and Middle River to increase flows of fresh water from the Savannah River into these streams. Figure 4 shows the flow rerouting components of Mitigation Plan 6A.

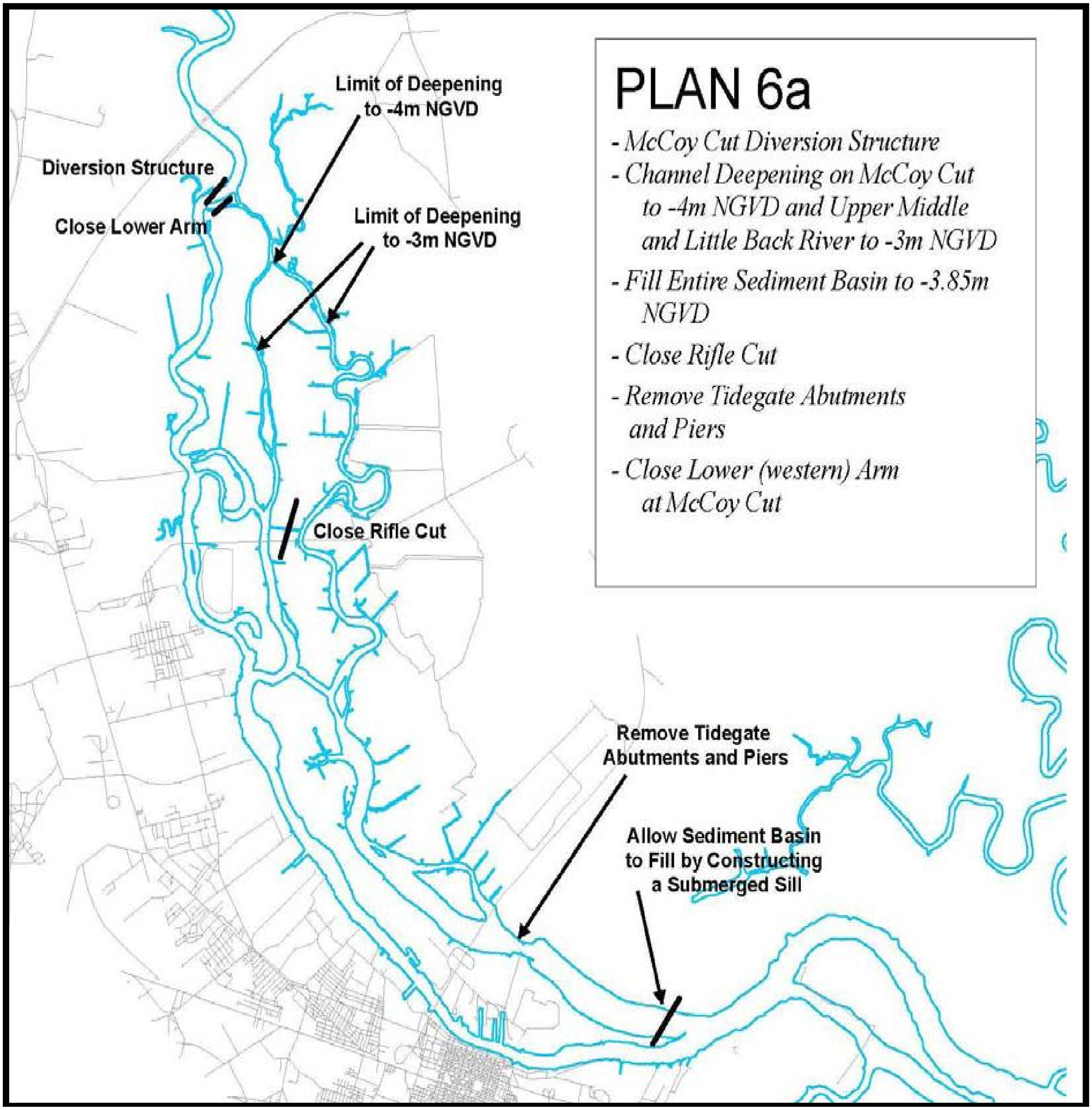

Figure 4. Proposed mitigation flow re-routing Plan 6A.

Model predictions indicate that salinity levels at the intake during periods of average flow would be 0.04 ppt, 0.04 ppt, 0.05ppt and 0.05 ppt for the 45, 46, 47 and 48 foot channels, respectively with mitigation Plan 6A implemented. During periods of low flows, salinity levels at the intake are predicted to be 0.36 ppt, 0.42 ppt, 0.49 ppt and 0.55 ppt for the 45, 46, 47 and 48 foot channel, respectively, with mitigation Plan 6A implemented. Consequently, model predictions indicate that implementation of Mitigation Plan 6A would provide a dependable source of freshwater at the SNWR intake for the 45, 46, and 47 foot projects during low flows.

As discussed above, a predicted rise in sea level may cause a substantial increase in upstream salinity levels in the Savannah estuary. Looking at a high-sea-level-rise scenario (50 cm rise in sea level over a 50-yer period with the existing 42-foot channel), modeling indicates that salinity at the SNWR intake during average flow periods would increase from about 0.02 ppt to 0.11 ppt (50^{th} percentile exceedance).

A rise in sea level with any of the proposed channel deepening alternatives in place would also result in an increase in upstream salinity levels but to a lesser extent because of the mitigation benefits provided by either Plan 6B or 6A. Table 2 shows predicted salinity values at the USFWS intake on Lucknow Canal with both a 25-cm and 50-cm rise in sea level for the existing 42-foot channel and the 44, 45, 46, 47 and 48-foot depth alternatives. The efficiency of Mitigation Plans 6A and 6B in reducing salinity levels at the SNWR intake is apparent from the salinity values shown in Table 2.

Table 2. Predicted Salinity Values in Lucknow Canal

	Existing **No Deepening No Mitigation**	**44 ft Depth & Mitigation Plan 6B**	**45 ft Depth & Mitigation Plan 6A**	**46 ft Depth & Mitigation Plan 6A**	**47 ft Depth & Mitigation Plan 6A**	**48 ft Depth & Mitigation Plan 6A**
Basic Evaluation	0.02/0.14	0.00/0.04	0.00/0.04	0.00/0.04	0.00 / 0.05	0.00/0.05
Sensitivity Analysis #1 (Low Flow)	0.15/0.57	0.05/0.33	0.05/0.036	0.06/0.42	0.08 / 0.49	0.09/0.55
Sensitivity Analysis #2A (25cm Sea Level Rise)	0.05/0.26	0.01/0.08	0.01/0.08	0.01/0.10	0.01 / 0.11	0.01/0.12
Sensitivity Analysis #2B (50cm Sea Level Rise)	0.11/0.45	0.03/0.17	0.03/0.17	0.02/0.19	0.025 / 0.22	0.03/0.24

NOTE: Values reported in 50/10 percent exceedance level (ppt)

B. Tidal Freshwater Marshes

Geographic Scope

The geographic scope of the cumulative impact assessment of tidal freshwater marsh impacts is the Savannah Harbor estuary. More specifically it is the remaining tidal freshwater marsh located in the estuary which occurs from the Interstate Highway 95 crossing of the Savannah River (River Mile 27.5) to near the Georgia Highway 25 bridge (Mile 21.5) Much of the remaining tidal freshwater marsh in the Savannah Harbor estuary is located within the SNWR.   Brackish marshes are located downstream of this, to near the International Paper lagoon (River Mile 17). The brackish marshes overlap some of the area covered by the intertidal freshwater marshes, depending on the rainfall that occurred the previous few years. Salt marshes are generally found downstream of River Mile 17.

Historic Basis

The following section includes information from a variety of sources, including Tetra Tech/ US EPA, USFWS, Georgia DNR-EPD, and the Corps. The wetland acreages reported by each organization vary depending on boundary conditions and methods of analysis.

Savannah is a historic city that was settled as a port in 1733. Changes in the landscape that have altered the surrounding wetlands can be traced back to that time. Native American inhabitants did not drastically alter the wetland communities, as did the European settlers.

In the early 1700's, bottomland hardwoods covered most of the freshwater wetlands. Those forests existed downstream to approximately the junction of Back River and the main Savannah River (See Figure 2). That location is based on two factors. The first is the continued discovery of old bald cypress stumps in present saltmarsh, which indicates those areas had previously supported freshwater forest species. Secondly, that location is the downstream extent of successful rice culture, indicating that when those lands were initially cleared the river salinity was consistently below 0.5 ppt (the commonly accepted threshold between fresh and saltwater). Brackish marshes probably extended close to the river mouth, where saltmarsh then occurred. Based on this understanding of the historic wetlands, freshwater wetlands (Cyprus swamps) were the dominant vegetation in the area, while saltmarsh occupied a much narrower range along the coast than is presently observed.

Past Actions / Stresses

The largest single action that adversely affected tidal freshwater wetlands in the estuary was the modification of those wetlands for rice production. In 1752, the prohibition of slavery was lifted in the Savannah colony, resulting in a flourishing production of rice. Slaves cleared expansive wetlands, constructed dikes needed to manage the water in fields, and dug ditches needed to move fresh water to the fields and drain from those fields. These activities became widespread in the estuary, and rice quickly became the most significant crop in Georgia. Following the abolition of slavery in 1863, the profitability of the low country method of rice production declined significantly and rice gradually faded from the local economy.

Exactly how much of the historic freshwater wetlands in Savannah Harbor were bottomland hardwoods versus tidal freshwater marsh is difficult to determine. However, based on historic records, it appears that most of the tidal lowlands in Savannah Harbor were cypress swamps.

After the decline of rice production, some rice fields were reclaimed by nature, some were filled for development, while others remain intact and are managed for wildlife. Hutchinson Island located across from the City of Savannah riverfront was used extensively for rice production. Over time, these fields were filled with dredged sediment to provide areas for both development and upland agricultural pursuits. The managed wetlands in the SNWR were diked and impounded mostly for rice culture in the 18^{th} and 19^{th} centuries, and are now used for fresh water waterfowl management.

Figure 5 shows a model representation of what are believed to be the marshes as they occurred in 1854. This figure (Savannah Harbor Z-Grid Modeling Report, Tetra Tech, Inc. July 2008) was produced during the 2010 development of a revised EPA Draft Total Maximum Daily Load (TMDL) for dissolved oxygen in Savannah Harbor. The BLUE color shows the location of the freshwater marsh, the ORANGE color shows the brackish marsh, and the RED shows the saltmarsh. Based on calculations presented in the modeling report, approximately 8,021 acres of freshwater marsh, 3,467 acres of brackish marsh and 26,092 acres of saltmarsh were present in the Savannah Harbor estuary in 1854.

The US Fish and Wildlife Service presented estimates of the amount of tidal freshwater marsh that existed in the Savannah estuary in the Fish and Wildlife Coordination Act Report. Based on map estimates (Granger 1968), there were about 12,000 acres of tidal freshwater marsh in the Savannah Harbor estuary in 1875. Based on additional map estimates (Lamar 1940), the amount of tidal freshwater marsh present in 1940 had been reduced to about 8,000 acres. Based on estimates presented in the Final Environmental Impact Statement for the Operation and Maintenance of Savannah Harbor (Corps of Engineers, 1975), the amount of tidal freshwater marsh in the estuary in 1974 was about 6,000 acres.

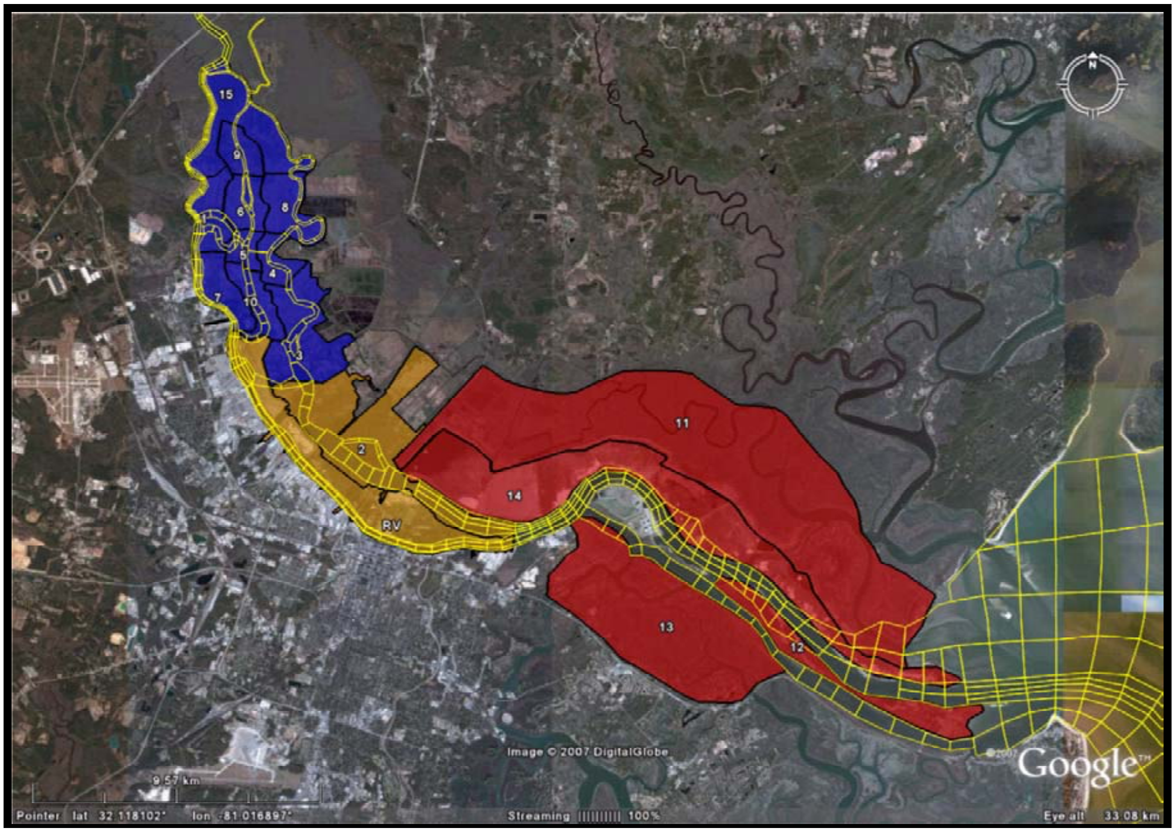

Figure 5. Savannah Harbor marsh distribution in 1854.

Other wetland losses stemmed from increased commercial and industrial development along the Savannah River. Construction of factories, water treatment lagoons, port related facilities, etc. impacted wetland areas along the harbor. The loss of wetlands to commercial and industrial development was greatly reduced by passage of the Clean Water Act in 1972, which gave the US Army Corps of Engineers authority to regulate development in wetlands under Section 404 of the Act.

Fresh water flow downstream to tidal freshwater wetlands was altered by various types of upstream development in the mid-1850s, the Augusta Diversion Dam (City dam) was constructed (RM 208.6). The New Savannah Bluff Lock and Dam was completed in 1939 (RM 188.3). These dams are both relatively small dams that are overtopped each year during high spring flows. The Stevens Creek Dam (RM 209.7), operated by the South Carolina Electric & Gas Corporation, was constructed in 1925. It is somewhat larger and does not get overtopped by flood flows. The larger dams (Hartwell, Richard B. Russell, and J Strom Thurmond) constructed by the Federal government in the upper river for hydropower and flood control purposes were built from 1946 to 1986. Those dams altered the river’s hydro-period by reducing flood peaks and raising low flows. These effects were felt all the way down river into the estuary.

Sea level rise has also played a part in the increase in upstream salinity levels and thus the conversion of tidal freshwater marsh into brackish or saltmarsh. A 1995 EPA publication indicates that a historic rate of sea level rise for this area (as measured at the Fort Pulaski gage) is 3 mm/year (0.011 feet/year). The 3 mm/year rate was taken from a NOAA publication titled "Sea Level Variations for the United States, 1855-1986", which quotes the rate at 3.0 mm/year (0.010 feet/year) for the period of 1935 through 1986 at Fort Pulaski and 3.4 mm/year (0.011 feet/year) for the period 1950 through 1986. The standard error in the trend was listed as being 0.3 mm/year (0.00098 feet/year) for the entire series and 0.5 mm/year (0.00164 feet/year) for the period 1950 through 1986. They define the standard error as being the "standard deviation from the line of regression". The 1996 Savannah District Corps of Engineers Annual Survey states that over the 51-year period from 1935 through 1986, mean sea level was observed to rise 0.628 feet at the Fort Pulaski gage (0.012 feet/year). Using that historic rate, sea level may have risen 3.4 feet since the City was settled in 1733.

Loss of wetlands in Savannah Harbor has also occurred from construction and operation of the Savannah Harbor Navigation Project. Direct loss of marsh can be attributed to excavation for channel widening, turning basins and deposition of dredged sediment. Over time, some tidal freshwater marsh has been converted to either brackish or saltmarsh because of increased upstream salinity levels caused by deepening of the harbor.

Maintenance of the navigation channel requires the removal of sediments that continuously settle and accumulate on the river bottom. In the 1900's, those sediments were typically deposited on the marshes that lined the riverbank. This unconfined deposition of sediments resulted in direct wetland losses. Construction of Confined Disposal Facilities (CDFs) starting in the late 1950's began to confine wetland impacts. Sites that would have been affected over time by the deposition of sediments were sealed off from tidal influence to contain the impacts of the sediment placement operation. This action was judged to have a lower total impact than the filling of those wetlands over time, when combined with water quality impacts that would occur from the annual unconfined deposition. Early unconfined deposition of dredged sediment and the later construction of eight CDFs along the harbor and Back River resulted in the loss of about 6,049 acres of wetlands. Most of the marshes affected by CDF construction were brackish or saltmarsh. However, some tidal freshwater marsh was probably impacted by construction of CDFs 2A, 1S and 1N in the upper harbor.

Other construction activities associated with the navigation channel also affected wetlands. Filling the Crosstides area in the upper harbor and other open-water areas between islands resulted in a short-term gain in wetlands. These and other changes were implemented to alter the hydraulics in the harbor by concentrating the river flow in one channel. This would increase the flow in the main shipping channel, thereby reducing the shoaling in that channel and the subsequent maintenance requirements. The changes were effective in producing their goals. However, they also reduced the braided nature of the estuarine river channels, thereby increasing the rate at which sediments were carried out of the river, thereby reducing the delta-building properties (marsh replenishment) of the estuary.

An 1855 hydrographic survey reveals that the lower Savannah River had a controlling depth of about 12 feet before substantial harbor improvements were implemented. Since that time, numerous changes have been implemented to improve the shipping channel. These improvements resulted in the current authorized navigation channel of 42-feet MLW. Deepening, widening, and straightening the original shipping channel made it more efficient for tidal saltwater to move upstream to the upper ends of the estuary. The freshwater interface is now located near the upstream limit (Mile 21.5) of the project.

As discussed in previous paragraphs, construction and operation of the Sediment Control Works Project also impacted tidal freshwater marshes in the SNWR. Although the project included a Freshwater Control System to provide freshwater to the SNWR and to offset anticipated salinity increases in Little Back and Middle Rivers, salinity levels in these streams were higher than expected. Consequently, the Tidegate was taken out of operation in 1991 and New Cut closed in 1992. Since these actions were taken, the US Fish and Wildlife Service has observed some conversion of brackish marsh back to tidal freshwater marsh.

Present Condition

Tidal freshwater wetlands (palustrine emergent wetlands) cover much of the SNWR in the vicinity of the harbor, and in contrast to the managed wetlands are flooded twice daily by tidal action. These marshes were either never diked or the dikes constructed for rice culture have eroded to marsh elevation allowing tidal flooding (USFWS, 2008). As discussed previously, the freshwater interface in Savannah Harbor has moved upstream over time and is currently considered to be located just downstream of the Georgia Highway 25 Bridge (Houlihan Bridge) near the upper end of the Savannah Harbor Navigation Project (Mile 21.5). Since 0.5 ppt salinity is the threshold between freshwater and brackish marsh, GA Highway 25 is the present separation between these two marsh types.

Various studies have been conducted relating to classifying marsh plant communities in the Savannah Harbor estuary and the SNWR. The results of those studies have not always agreed.

Figure 6 shows a model representation (Savannah Harbor Water Quality Model Update, Tetra Tech Inc., April 2010) of existing marshes (Figure 6). The BLUE color reportedly shows the location of the freshwater marsh, the ORANGE color shows the brackish marsh, and the RED shows the saltmarsh. Using this information, the largest percentage change since the 1850s is the loss of freshwater marsh. Saltmarsh has advanced upriver of the Talmadge (US Highway 17) Bridge.

Table 3 shows the changes in marshes that appeared to have occurred in the lower estuary over a 145-year period.

Table 3. Marsh Acreage Savannah Harbor 1999 (GA DNR-EPD)
Marsh Distribution
(GA DNR-EPD, 2008)

Marsh Type	1854	1999
Freshwater	8,021	2,118
Brackish	3,467	5,903
Saltmarsh	26,092	23,510

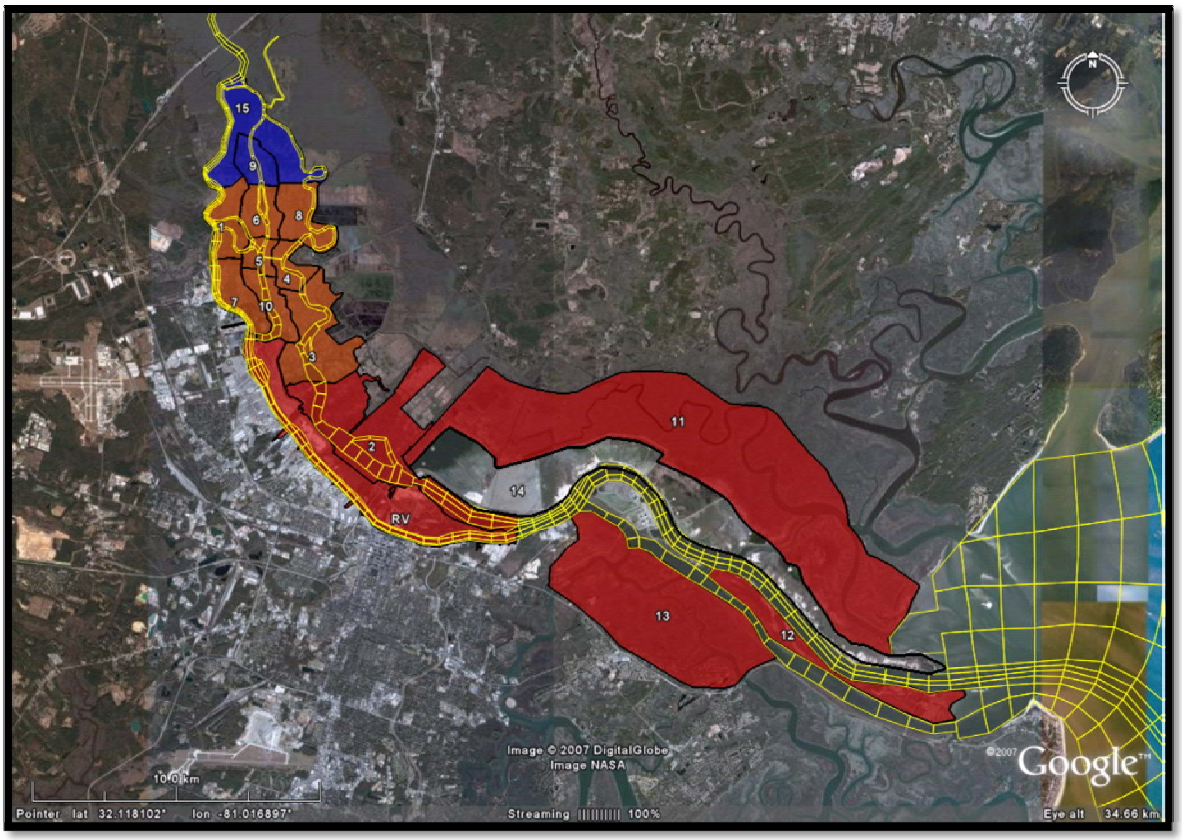

Figure 6. Savannah Harbor existing marsh distribution.

Several studies were conducted during the SHEP to establish baseline conditions in regards to the amount of tidal freshwater marsh remaining in the estuary. Both Applied Technology and Management (March 2003) and USFWS (Welch and Kitchens 2006) conducted studies to classify the various wetland communities in the study area (I-95 Bridge to mouth of Back River). Using a marsh succession model, the USFWS determined that wetlands in this area are characterized by about 3,269 acres of tidal freshwater marsh, 3,082 acres of brackish marsh, and 2,506 acres of saltmarsh (Welch and Kitchens 2006).

As discussed in previous paragraphs, the EFDC model was used during the SHEP study to evaluate both existing stream salinity levels and salinity levels that would occur with the various channel deepening alternatives in place. However, the EFDC model does not directly predict marsh salinity. Consequently, determining the existing wetland species composition in the estuary as well as predicting how these species would change with the various channel deepening alternatives, was accomplished using a method where marsh salinity contour lines are extrapolated from the river into the adjacent marsh areas. This method creates contours that divide the marsh into 5 salinity categories: 0-0.5 ppt, which is considered freshwater, 0.6-1.0 ppt, 1.1-2.0 ppt, 2.1-4.0 ppt, and >4.0 ppt. Using this method and river salinities predicted by the EFDC model, the following distribution of wetlands between I-95 and the mouth of Back River were calculated as shown in Table 4:

Table 4. Marsh Distribution EFDC Model
Marsh Distribution
Average River Flows

Marsh Type	Acreage
Freshwater	4,072
Brackish	2,253
Saltmarsh	2,506

SHEP study participants agreed that this marsh distribution acreage would be used as the baseline for the impact assessment of tidal freshwater marsh losses that could be caused by any of the harbor deepening alternatives under consideration.

Present Actions / Stresses

The remaining tidal freshwater marshes in the upper part of the Savannah River estuary are protected from direct development activity. The vast majority of tidal freshwater marshes are located in the SNWR. Those areas of tidal freshwater marsh outside of the SNWR could be filled after obtaining a Department of the Army Permit; such a permit would require mitigation for these impacts.

The primary stress to existing tidal freshwater marsh is the effects of prolonged droughts. As less freshwater enters the estuary, more saline waters can move further upstream. As a result, tidal freshwater marsh species become less able to compete with the more brackish marsh species of marsh resulting in loss of tidal freshwater marsh. An example of the potential effects of drought on tidal freshwater marsh can be seen in the results of the SHEP marsh impact studies. Modeling efforts indicate that about 4,072 acres of tidal freshwater marsh can be found in the study area during non-drought periods (average flows). However, the acreage of tidal freshwater marsh would drop to about 2,200 river acres during periods of drought (low flows).

Capacity to Withstand Stress

Tidal freshwater marshes exist in a very specific environment and are greatly controlled by ground elevation, river and tidal flows, and salinity levels. Maintaining salinity levels that are 0.5 ppt or less is critical to their survival. Droughts will continue to periodically occur, adversely impacting the remaining tidal freshwater marsh areas in the Savannah River estuary. However, as normal flow conditions return, tidal freshwater marsh species have the opportunity to out compete brackish marsh species, allowing the freshwater vegetation to recover. Tidal freshwater marshes will also be affected in the future as upstream salinity levels increase due to sea level rise. Because of their very specific habitat requirements (salinity of 0.5 ppt or less), tidal freshwater marsh has very little capacity to withstand the stress of increased salinity levels.

Future Actions / Stresses

Future potential stresses to tidal freshwater marsh include sea level rise, extended droughts and increased withdrawals of surface water from the Savannah River, and harbor development projects, such as the SHEP. EPA expects sea level rise to occur at least at the rate in the US that has been measured in the recent past. A 1995 EPA publication titled "The Probability of Sea Level Rise" states that the historic rate of rise at the Fort Pulaski gage is +3 mm/yr. This additional rise in sea level will result in the further conversion of freshwater wetlands to brackish marsh, and brackish marsh to saltmarsh. The results of the modeling conducted during the SHEP show the potential effects of a 25-cm rise in sea level and a 50-cm rise in sea level. With a 25-cm rise in sea level (surface salinity-50% exceedance values) and the existing 42-foot navigation channel, the estimated 4,072 acres of tidal freshwater marsh would be reduced to about 3,507 acres. With a 50-cm rise in sea level (surface salinity-50% exceedance values) and the 42-foot channel, the acreage of tidal freshwater marsh would be reduced to about 2,809 acres. Thus, a 50-cm increase in sea level would result in the loss of 31% of the remaining tidal freshwater marsh.

The effects of drought conditions on tidal freshwater marsh could increase in the future. Groundwater resources have become overused along the coast, as demands exceed the supply in Chatham County. State water resource managers have capped the total volume of water that can be withdrawn from the main water-bearing aquifer. As the population grows along the coast leading to an increase in water demands, there is increasing pressure to obtain additional M&I water from surface water sources. Savannah River is the prime target for that supply, as it is the only large river with a dependable flow during the summer. When these additional withdrawals waters from the Savannah River occur, less water will reach the estuary to keep out the salinity intrusion during droughts. This will stress the freshwater and brackish marshes the worst, possibly leading to their conversion to brackish marshes and saltmarsh.

The Georgia Power Company has begun to obtain the permits to expand the Plant Vogtle nuclear facility near Augusta, Georgia. The plan is to double the electrical generating capacity of the facility by constructing and operating two additional nuclear power units. Georgia Power's expansion would withdraw approximately 0.7% of the river during average flow conditions (8,830 cfs). This equates to a withdrawal of roughly 62 cfs. At the maximum plant pumping rate and drought river flows of 2,000 cfs, the intake structure would withdraw 3.4% of the river. The Corps discharges water from its reservoirs at a 3,600 cfs rate during severe droughts, so the 2,000 cfs river flow rate is a conservative one to use in an analysis. During the recent drought-of-record, the Corps released 3,600 cfs from the dams and the flow entering in the estuary reached a low of about 4,340 cfs. At the maximum removal rate of 93 cfs, construction and operation of the additional two units would result in the removal of 2.1% of the lowest recently recorded river flow. Removal of that percentage, which is within the range of error for the model predictions, would likely not result in substantial changes in salinity levels and wetland vegetation in the estuary.

Similarly, the Savannah River has been identified as a potential source of drinking water for the Atlanta region. Removal of water from the Savannah River basin for use in Atlanta and subsequent discharge to other river basins would be considered an inter-basin transfer. Such an action would have to be evaluated and approved by the Georgia DNR Environmental Protection Division. They would consider potential impacts on the ecology of the Savannah River, including wetlands in the estuary. Identifiable impacts in the estuary could occur if large volumes of water were removed from the Savannah River basin. The Georgia Governor's Water Contingency Planning Task Force rejected the concept of removing water from the Savannah River Basin to meet Atlanta's water supply needs in its December 2009 report, so at this point that action is considered speculative.

The remaining tidal freshwater marshes in the Savannah Harbor estuary are for the most part protected from port-related development such as warehouses, distribution centers, roads etc. since most of these wetlands are located in the SNWR. However, there are two known proposed port improvement projects (Jasper County Marine Terminal and the SHEP) which could impact tidal freshwater marshes by causing an upstream movement of saltwater from channel improvements.

As previously discussed, the potential exists that a container terminal in Jasper County could be constructed in what is now CDFs 14A and 14B, which are located just upstream of the Fields Cut intersection with Savannah Harbor (about River Mile 6). Although no detailed plans for this facility have been presented, its developers have stated that construction of this terminal would require a similar channel depth to that proposed for SHEP. If SHEP is constructed and that channel depth is determined to be adequate for a Jasper County terminal, then no additional channel improvements (other than an access channel) would be required. If SHEP is not constructed, a Jasper terminal would deepen the entrance channel and the interior channel up to about River Mile 6. If the navigation channel were deepened for a Jasper terminal, that deepening would likely have no direct impacts on the remaining tidal freshwater marsh in the Savannah Harbor estuary. This statement is based on the determination that construction of channel improvements to River Mile 6 (as compared to River Mile 18.8 for SHEP) would have very little impact on the upstream movement of the saltwater/freshwater interface (currently located at about River Mile 21.5).

Construction of any of the channel alternatives considered for the SHEP would further impact tidal freshwater marshes as described below.

Incremental impact

As previously discussed, many different activities have contributed to the decline of freshwater wetlands in the Savannah Harbor estuary including rice field construction, harbor construction and maintenance, construction of managed wetlands, and industrial and municipal development. The amount of tidal freshwater marsh has been reduced to approximately 4,072 acres (SHEP model estimates). In addition to the effects of sea level rise described above, the proposed SHEP presents the greatest threat to further reductions in tidal freshwater marsh in the Savannah estuary.

Model predictions indicate that deepening the harbor to 44, 45, 46, 47, or 48-feet without mitigation would result in the conversion of 469, 967, 1,057, 1,177, and 1,212 acres of tidal freshwater marsh, respectively (average flow, no sea level rise) to brackish marsh. These numbers would increase with a rise in sea level.

Alternatives to Mitigate for Cumulative Effects

If any of the channel deepening alternatives is implemented, totally avoiding increases in upstream salinity levels, and thus, impacts to tidal freshwater marsh would not be possible. However, the projected increases in upstream salinities can be greatly minimized by reducing the amount of salt water entering Little Back River and Middle River, and simultaneously increasing the amount of freshwater entering these streams.

As discussed previously, model studies were conducted to determine various ways to reduce the upstream movement of salinities that would result from deepening the harbor. Model studies were used to evaluate various hydraulic modifications that could be implemented in Back River, Little Back River, and Middle River to reduce higher salinity levels, and thus, impacts to tidal freshwater marsh. As a result of these model studies, Plan 6B (See Figure 3) was developed for the 44-foot project and Plan 6A (See Figure 4) was developed for the 45, 46, 47, and 48-foot projects to minimize the anticipated increase in upstream salinity levels. Plan 6B involves construction of a submerged berm in Back River and partially filling in the Sediment Basin with dredged material, removal of the Tidegate, closing Rifle Cut which links Little Back River and Middle River, construction of a diversion structure at McCoy Cut, and closure of the lower arm of McCoy Cut. This plan would result in additional freshwater entering the Back River system at McCoys Cut without exiting through the lower arm and flowing downstream through Middle, Back, and Little Back Rivers. It also limits saltwater intrusion to the Back River area through the Sediment Basin and Rifle Cut. Plan 6a involves the same modifications and adds channel deepening at McCoys Cut and in upper Middle River and Little Back River. The channel deepening increases the volume of freshwater flows entering the Back River system at McCoys Cut and flowing downstream through Middle, Back, and Little Back Rivers.

Table 5 shows the estimated marsh acreages for various salinity levels for the Without Project Condition and the five deepening alternatives considered (44-, 45-, 46-, 47-, and 48–foot depths) under alternate scenarios for river flow and sea level rise.

Table 5. Estimated Marsh Acreages

Salinity range for Basic Evaluation	**Existing No Deepening No Mitigation**	**44 ft Depth & Mitigation Plan 6B**	**45 ft Depth & Mitigation Plan 6A**	**46 ft Depth & Mitigation Plan 6A**	**47 ft Depth & Mitigation Plan 6A**	**48 ft Depth & Mitigation Plan 6A**
0.0 – 0.5 ppt	4072	4394	4040	3871	3849	3735
0.6 – 1.0 ppt	864	1137	1781	1650	1641	1340
1.1 – 2.0 ppt	555	749	588	862	889	1191
2.1 – 4.0 ppt	834	855	745	700	687	790
>4.0 ppt	2506	1698	1678	1749	1766	1776
Salinity Range for Sensitivity Analysis #1 (Low Flow)	**Existing No Deepening No Mitigation**	**44 ft Depth & Mitigation Plan 6B**	**45 ft Depth & Mitigation Plan 6A**	**46 ft Depth & Mitigation Plan 6A**	**47 ft Depth & Mitigation Plan 6A**	**48 ft Depth & Mitigation Plan 6A**
0.0 – 0.5 ppt	2208	3128	3111	2886	-	2570
0.6 – 1.0 ppt	767	459	674	825	-	845
1.1 – 2.0 ppt	1322	1342	981	822	-	786
2.1 – 4.0 ppt	1076	1564	1848	2009	-	2236
>4.0 ppt	3458	2339	2218	2291	-	2394
Salinity Range for Sensitivity Analysis #2A (25cm Sea Level Rise)	**Existing No Deepening No Mitigation**	**44 ft Depth & Mitigation Plan 6B**	**45 ft Depth & Mitigation Plan 6A**	**46 ft Depth & Mitigation Plan 6A**	**47 ft Depth & Mitigation Plan 6A**	**48 ft Depth & Mitigation Plan 6A**
0.0 – 0.5 ppt	3507	3659	3740	3594	-	3536
0.6 – 1.0 ppt	1118	1401	1500	1400	-	713
1.1 – 2.0 ppt	5551	972	1098	1283	-	1790
2.1 – 4.0 ppt	969	1000	758	796	-	977
>4.0 ppt	2687	1799	1737	1760	-	1815
Salinity Range for Sensitivity Analysis #2B (50cm Sea Level Rise)	**Existing No Deepening No Mitigation**	**44 ft Depth & Mitigation Plan 6B**	**45 ft Depth & Mitigation Plan 6A**	**46 ft Depth & Mitigation Plan 6A**	**47 ft Depth & Mitigation Plan 6A**	**48 ft Depth & Mitigation Plan 6A**
0.0 – 0.5 ppt	2809	3462	3554	3512	-	3297
0.6 – 1.0 ppt	1255	1099	793	484	-	558
1.1 – 2.0 ppt	927	1305	1641	1909	-	1874
2.1 – 4.0 ppt	977	785	988	1139	-	896
>4.0 ppt	2864	2181	1855	1787	-	2208

Table 5 includes four different scenarios; the basic evaluation (average flow, no sea level rise); Sensitivity Analysis #1 (low flow, no sea level rise); Sensitivity Analysis #2A (average flow, 25 cm rise in sea level); and Sensitivity Analysis #2B (average flow, 50 cm rise in sea level). The Basic analysis is used for purposes of mitigation determination because it best reflects the most likely future condition, particularly in the early years after a deepening project has been implemented. Because the ICT had already agreed the basic evaluation was the most likely future condition, sensitivity analyses were not run for the 47-foot alternative, an alternative that was examined later in the study process.

According to the estimated marsh salinity acreage impact analysis, construction of the 44-foot channel with Mitigation Plan 6B would result in a net increase in the amount of tidal freshwater marsh by about 322 acres. Construction of the 45, 46, 47, and 48-foot channels with Mitigation Plan 6A would result in the conversion of 32, 201, 223, and 337 acres of tidal freshwater marsh, respectively to brackish marsh.

From a sea level rise perspective (both 25 cm and 50 cm), the estimated marsh salinity acreage impacts shown in Table 5 indicate that there would be more tidal freshwater marsh remaining with any of the channel deepening alternatives (with mitigation) than with the existing 42-channel (without project condition). This can be attributed to the mitigation plans which reduce the amount of saltwater intrusion into these streams and increase freshwater inflow.

Freshwater marsh in the SNWR would be negatively impacted for the 45, 46, 47, and 48-foot channels even with implementation of mitigation Plan 6A. Consequently, it became apparent that some other form of mitigation would be required to compensate for the remaining anticipated effects to 32, 201, 223, and 337 acres of tidal freshwater marsh associated with the 45, 46, 47-foot and 48-foot channels, respectively.

The conversion of freshwater wetland to brackish marsh represents the only significant wetland conversion that is likely to be noticeable if the harbor is deepened to 45, 46, 47 or 48 feet. It is important to note that the ecological values of the impacted acres of freshwater wetlands would not be completely lost. Instead, those acres would convert to brackish marsh. The Corps' calculation of the number of acres of freshwater wetland that have the potential to convert to brackish marsh is based on a shift in the location of 0.5 ppt salinity, a traditional rule-of-thumb for differentiating between freshwater marsh and brackish marsh. However, data reported in the literature for Savannah Harbor suggest that a shift in vegetation (from freshwater marsh to brackish marsh) in this estuary does not occur until salinity concentrations approach 2.5 ppt (Latham et al., 1994). Even at oligohaline marsh sites with average salinity concentration of 2.1 ppt, a discriminant function (DF) analysis revealed that only 47% of cases resulted in the correct pairing of environmental variables with vegetative species composition and dominance. At those same oligohaline sites, 37% of the vegetative species composition and dominance were more closely aligned with a freshwater classification (Latham et al., 1994).

Deepening the harbor to 45, 46, 47 or 48 feet would result in a conversion of the dominant vegetative species typically observed in freshwater marsh (freshwater to brackish marsh scenario). It is important to note that many of the emergent plant species associated with freshwater marsh systems would still be readily observed in environments that have been defined as brackish marsh (Latham et. al., 1994). However, the overall basic wetland functions typically associated with these systems would not change. A comparison of potential changes in elements of wetland function for the conversion of tidal freshwater to brackish marsh is provided in the following table.

Table 6. Changes in Wetland Function as a Result of Wetland Conversion

Elements of Wetland Function	Freshwater to Brackish Marsh	Saltmarsh to Brackish Marsh
Water Purification	Negligible	Negligible
Flood Protection	Negligible	Negligible
Shoreline Stabilization	Negligible	Negligible
Groundwater Recharge	Negligible	Negligible
Streamflow Maintenance	Negligible	Negligible
Retention of Particles	Negligible	Negligible
Surface Water Storage	Negligible	Negligible
Subsurface Storage	Negligible	Negligible
Nutrient Cycling	Negligible	Negligible
Values to Society	Negligible	Negligible
Fish and Wildlife Habitat	Minor Adverse	Negligible

Negligible Effect – the effect on the resource would be at the lowest levels of detection, barely measurable, with no perceptible consequences, either adverse or beneficial, to the resource.

Minor Adverse Effect – the effect on the resource is measurable or perceptible, but it is slight.

Adverse Effect: the action is contrary to the interest or welfare of the resource; a harmful or unfavorable result

As illustrated in the table above, the only adverse effect the project would have on the function of these wetlands systems would be associated with fish and wildlife habitat. All other elements of wetland function associated with predicted shifts in wetlands classification would be negligible as a result of the anticipated increase in salinity. It should be noted that areas of the Savannah Harbor identified as saltmarsh or brackish marsh support similar fish and wildlife species (Jennings and Weyers, 2003). Any anticipated conversion of saltmarsh to a brackish marsh system would have a negligible impact on the overall function of the wetland system. The USACE recognizes that a comparison of fish and wildlife habitat between freshwater and brackish marsh systems yields fewer similarities. However, the conversion in fish and wildlife habitat will still be minor when considering the total function of the wetland and continued existence of some freshwater vegetation after deepening in wetland areas that would be classified as brackish marsh. For additional information pertaining to the functional assessment, please see Section VII of EIS Appendix C -- Consideration of Final Compensatory Mitigation Rule.

Since there would be a minor adverse effect to the fish and wildlife habitat function in tidal freshwater wetlands if the SHEP is implemented, an assessment was conducted to determine how to best mitigate for that impact. Once the extent of the impacts to wetlands was known, the

Corps consulted natural resource agencies, the Stakeholders Evaluation Group, and other NGOs. No sites could be identified where tidal freshwater restoration or creation was feasible. Consequently, the acquisition and preservation of lands that would be ecologically significant to the Savannah National Wildlife Refuge was determined to be appropriate mitigation.

The Corps completed its initial assessment of properties in the SNWR's Acquisition Plan to determine potential properties that could meet the wetland mitigation needs of the SHEP. This assessment (Consideration of 2008 USEPA/USACE Mitigation Rule) is in Appendix C. The lands proposed for preservation consist of bottomland hardwoods, maritime forest and uplands dominated by deciduous forest and regrowth. The bottomland hardwoods are classified as palustrine, forested, broad-leaved deciduous systems that are both temporarily and seasonally flooded. Preserving these areas would ensure wildlife habitat is protected in perpetuity. Moreover, the additional lands would buffer the SNWR from future threats of development such that changes in land use would not occur immediately adjacent to existing areas of the Refuge that do contain estuarine emergent wetland characteristics. Thus, the acquisition and preservation of wetland and upland buffer would provide a functional replacement for the minor conversion of the only wetland function (i.e., fish and wildlife habitat) that would be expected as a result of freshwater to brackish marsh conversion. Acquisition requirements for the 45, 46, 47 and 48-foot channel depths are 1,643, 2,188, 2,245, and 2,683 acres, respectively.

C. Saltmarsh and Brackish Marsh

The third wetland concern addressed in this cumulative impact analysis is the brackish and saltwater wetlands in the Savannah Harbor estuary.

Geographic Scope

The geographic scope of this analysis is the Savannah River estuary. Considering existing salinity regimes and average river flows, brackish marsh in the Savannah Harbor estuary exists from just above the upstream limit of the Navigation Project (River Mile 21.5 to about River Mile 17) at the International Paper Company waste water treatment lagoon. Saltmarsh constitutes the majority of wetlands from River Mile 17 to the sea.

Historic

From a state wide perspective, coastal wetlands along the coastline comprise about 700,000 acres or 13% of the 5,298,200 acres of wetland areas found in the State of Georgia (Georgia-Wetland Research). As discussed in previous paragraphs, about 26,090 acres of saltmarsh, and 3,467 acres of brackish marsh existed in the Savannah River estuary in 1854.

Past Actions/Stresses

As discussed in previous paragraphs, major actions contributing to marsh decline in the Savannah River estuary center around agriculture (rice production), construction of various harbor improvements (channel deepening, channel widening, turning basin construction, construction of the CDFs, etc.) necessary to maintain the project, and sea level rise.

Construction of CDFs resulted in the loss of over 6,000 acres of wetlands. Industrial and commercial development such as the construction of large wastewater treatment lagoons, roads, warehouses, distribution centers, etc. have also contributed to wetland losses in the harbor.

Present Condition

The amount of saltmarsh in the Savannah estuary appears to have declined from about 26,090 acres in 1854 to about 23,510 acres in 1999. The amount of brackish marsh in the estuary has actually increased from about 3,467 acres in 1854 to about 5,903 acres in 1999. The decline in saltmarsh would probably be greater if not for sea level rise and the increased upstream salinity levels caused by past harbor modifications. The increases in upstream salinities have caused freshwater and brackish marshes to be replaced by more saline marsh types. The increase in the amount of brackish marsh can also be attributed to the increase in salinity levels in the upper portions of the harbor.

Present Actions/Stresses

Development remains the primary threat to brackish and salt wetlands in Savannah Harbor. All marsh in the Savannah estuary is protected from development by the provisions of Section 404 of the Clean Water Act. Anyone who wishes to impact wetlands associated with development must apply for a Section 404 Permit from the US Army Corps of Engineers. As part of the permit process, the applicant must show through a detailed analysis that there is no practicable alternative to impacting wetlands. When wetland impacts cannot be avoided, the applicant must show what actions they will take to minimize those impacts and mitigate remaining wetland losses. In-kind mitigation (at a ratio of approximately 2:1) within the same watershed is required. Purchase of credits from a mitigation bank is the preferred method of compensatory mitigation. However, no commercial mitigation banks are presently operating near Savannah for brackish or saltmarsh wetlands.

As port development has increased, the Savannah District Corps of Engineers Regulatory Office has observed an increase in Section 404 permits for facilities (warehouses, distribution centers, etc.) which support port operations. Those who have obtained permits have been required to avoid wetland impacts where practicable and to provide in-kind mitigation where wetland losses are unavoidable.

Most of the permits that have been issued in the lower Savannah River Basin involve activities in non-tidal wetlands. Information from the Savannah District and Charleston District Regulatory data bases from 1990-2005 indicate that 1,197 acres of impacts have been permitted in non-tidal wetlands in the six counties (Chatham GA, Effingham GA, Screven, GA, Allendale, SC, Hampton, SC, Jasper, SC) that are at least partially in the lower Savannah River Basin. Approximately 6,300 acres of mitigation were required for these impacts.

Department of the Army Permits for activities in tidal (brackish and salt) wetlands are more difficult to obtain and mitigation is difficult because of the scarcity of saltmarsh mitigation banks and opportunities to restore saltwater marsh. According to the Savannah District Regulatory database, 17.5 acres of tidal marsh fills have been authorized in coastal Georgia over the last 10 years. Mitigation for these impacts has been at a ratio of approximately 2:1.

The US Army Corps of Engineers does not issue itself a Section 404 Permit when a Federal navigation project impacts wetlands. However, the agency is responsible for following the Section 404 permit procedures including avoiding wetland impacts where possible, minimizing impacts to the maximum extent practicable and providing mitigation for any remaining wetland losses.

Capacity to Withstand Stress

The States of Georgia and South Carolina still contain large expanses of saltmarsh and brackish marsh. However, past development actions have greatly impacted these resources. Although there are large amounts of saltmarsh and brackish marsh remaining in coastal Georgia and South Carolina, including the Savannah River estuary, the philosophy of the Corps of Engineers and state wetland protection programs is a "no net loss" wetland policy.

Future Actions/Stresses

Harbor improvements and development remain the most likely actions to adversely affect the salt and brackish marshes remaining in the Savannah River estuary. The only known, major harbor improvements that may occur in Savannah Harbor are construction of a container terminal in Jasper County and the SHEP.

Although no formal detailed plans for a Jasper County terminal are available, some conceptual plans for a facility have been presented over the years by various organizations. The most recent plan, presented by the Joint Project Office, was for a Jasper County container terminal located in what is now CDFs 14A and 14B. Although the Corps does not own those tracts in title, it maintains dredged material disposal easements in CDF 14A (728 acres) and CDF 14B (725 acres). At one time, these areas were saltmarsh. However, the construction of containment dikes and the deposition of dredged material into these areas removed these marshes from tidal influence, and much of the marsh vegetation is now gone.

Construction of a Jasper County terminal would require typical facilities associated with a marine container terminal, i.e., berths, docks, operation and maintenance facilities, container yard, parking, etc. Based on the conceptual plans, the construction of a terminal may be able to avoid significant wetland impacts resulting from construction of these facilities by staying within the footprints of CDFs 14A and 14B.

Construction of the required road and rail infrastructure would have the potential to impact extensive wetlands. Rail infrastructure would be required from the existing rail line to the Jasper site (about 7.5 miles) over marsh areas. Road access to the site from US Highway 17 (probably a four-lane road) would involve the construction of about 5.7 miles of new roadway. Impacts to wetlands resulting from construction of this road may be able to be minimized by building the road along the front and rear dikes of CDFs 12A, 12B, 13A and 13B. Improvements to US Highway 17 may also be required because of the anticipated truck volume expected at the facility. Such improvements could impact wetlands that are adjacent to and cross the highway. Wetland impacts would require a Section 10 and Section 404 Permit from the US Army Corps of Engineers (Charleston District) and a Critical Zone Permit from the Office of Coastal Resource Management in the South Carolina Department of Health and Environmental Control. Issuance of these permits would include appropriate mitigation measures to offset any wetland losses associated with the project.

Use of CDFs 14A and 14B for a container terminal would require the development of a sediment storage capacity replacement plan to compensate for the loss CDFs 14A and 14B. In accordance with the Project Cooperation Agreement for Savannah Harbor, the Local Sponsor (Georgia Department of Transportation) is required to present an acceptable alternative to the loss of disposal area capacity. The Corps would not release the existing dredged material disposal easements until the Federal Government is “made whole” with respect to dredged material disposal capacity for Savannah Harbor. Although not likely, the replacement of this loss of disposal capacity could further impact wetlands if the new disposal sites are located in such areas. In view of wetland protection laws and mitigation requirements for wetland losses, it is doubtful that environmental approvals could be obtained to construct new disposal sites completely in wetlands.

Construction of the SHEP would result in the loss of 15.68 acres of brackish marsh regardless of which alternative channel depth was constructed.   Approximately 3.0 acres of brackish marsh would be excavated due to the enlargement of the Kings Island Turning Basin, and approximately 4.2 acres of brackish marsh would be lost from excavation requirements of the project. Approximately 8.48 acres of brackish marsh would be lost as a result of excavation required to remove the Tidegate structure end walls. Additional impacts to brackish marsh and saltmarsh would occur as a result of SHEP-induced salinity changes. Brackish marsh would increase in acreage, while saltmarsh would decrease through conversion to brackish marsh. These impacts are fully described in Section 5 and Appendix C of the EIS.

Incremental Impact

The SHEP would result in the loss of 15.68 acres of brackish marsh.   When compared to the total amount of brackish marsh in the Savannah Harbor estuary, this marsh loss might seem insignificant. However, it is the incremental impact of many small losses over time that can lead to significant adverse impacts to a resource. Consequently, the SHEP will mitigate for these marsh impacts.

Saltmarsh would also be impacted by the flow routing since more freshwater would be introduced into Little Back and Middle Rivers, causing some areas of saltmarsh to shift to more brackish species. Predictions indicate that approximately 828, 757, 740, and 730 acres of saltmarsh would be converted to brackish marsh for the 45, 46, 47, and 48-foot projects, respectively. As previously discussed, the Corps used the EFDC model to evaluate both existing stream salinity levels and salinity levels that would occur with the various channel deepening alternatives in place. However, the EFDC model does not directly predict marsh salinity. Consequently, determining the existing wetland species composition in the estuary, as well as predicting how these species would change with the various channel deepening alternatives, was accomplished using a method where riverine surface salinity levels are extrapolated across the adjacent marshes. This method creates contours that divide the marsh into 5 salinity categories: 0-0.5 ppt, 0.6-1.0 ppt, 1.1-2.0 ppt, 2.1-4.0 ppt, and >4.0 ppt. In turn, distinctions between marsh types and acreage were defined based on the following salinity ranges: (0-0.5 ppt) Freshwater Marsh, (0.5-4 ppt) Brackish Marsh, and (>4ppt) Saltmarsh.

The results of the functional assessment concluded that the differentiation between salt marsh and brackish marsh recommended by the Wetland Interagency Coordination Team (ICT) and used in the EIS was somewhat constrained. The salinity range used in the SHEP to differentiate between brackish marsh (0.6-4 ppt) and salt marsh (> 4ppt) was restrictive, given that brackish marsh salinities have been reported with a range from 0.5-10 ppt (NOAA, 2010) and in other estuarine systems from 0.5-17 ppt (Judd and Lonard, 2004). An earlier assessment of wetland vegetation coinciding with the salinity range reported for brackish marsh systems (i.e., 5-10 ppt) which occur within the area of potential effect, also supports those findings. The EFDC value for saltmarsh (> 4.0 ppt) is approximately 2.5 times less than that reported by NOAA (2010). Additionally, the NOAA (2010) range for brackish marsh includes areas determined by the EFDC model to be saltmarsh. When considering values reported in the literature, the acreage of saltmarsh conversion which was calculated using the EFDC model is a very inclusive value and includes existing vegetative areas that would not transition to brackish marsh flowing deepening because these areas currently exist within the salinity range of a brackish marsh (0.5-10 ppt). Thus, the salinity range used to quantify salt marsh in the area of potential effect (i.e., > 4 ppt) over estimated the amount of saltmarsh in the system and under estimated the amount of brackish marsh. As such, the described conversion of salt marsh to brackish marsh, which would occur as a result of harbor deepening, would likely be much less if one takes into account vegetative characteristics for wetland environments with associated salinities that are more commonly associated with a brackish marsh (i.e., range between 0.5 and 10 ppt).

Given the wide range of salinity reported in literature for brackish marsh systems, the inherent variability in salinity that exists for all estuarine systems, and the modeling results that report post-deepening salinity concentrations consistent with the aforementioned range, Savannah District concluded that the conversion of saltmarsh to brackish marsh if the harbor is deepened t is conservative, with actual vegetative shifts unlikely to be identifiable *in situ* in Savannah. That said, the District was inclusive in its assessment of the potential for project-related effects and elected to include the saltmarsh and brackish marsh conversion in its calculation of minor impacts. Also, as shown in Table 6 above, changes in wetland functions when saltmarsh is converted to brackish marsh are negligible.

Mitigation - Brackish Marsh

As discussed above, the Corps of Engineers must go through the same procedures as a Section 404 permit applicant even thought the agency does not issue itself a permit. The SHEP was able to avoid significant impacts to saltmarsh and brackish marsh by not moving the channel side slopes. The improvements to the Kings Island Turning Basin, the excavation requirements of the project, and the removal of the Tidegate end walls are unavoidable requirements of deepening the harbor with any of the depth alternatives. Consequently, the SHEP must provide mitigation for the loss of 15.68 acres of brackish marsh. The resource agencies have requested in-kind restoration for the loss of these estuarine emergent wetlands.

To mitigate for the anticipated wetland losses, the SHEP would restore marsh in Disposal Area 1-S located on Onslow Island adjacent to Middle River. This disposal area has not been used in at least 20 years. Approximately 40.3 acres of dredged sediment deposits in Disposal Area 1S would be graded down to the original marsh elevation to allow tidal interchange to occur. Over time, this site would be expected to re-vegetate with estuarine emergent wetlands (brackish marsh). Using Corps of Engineers Regulatory Guidance, approximately 28.8 acres of marsh restoration would be required to satisfy SHEP wetland mitigation requirements. Therefore marsh restoration at this site would provide more mitigation than is required for the project.

Monitoring

The SHEP includes a Monitoring Plan and Adaptive Management Plan. The monitoring program would involve pre-construction, construction, and post-construction studies to determine actual project impacts in the field, as well as to develop any changes to the mitigation measures that might be necessary. The Adaptive Management Plan would permit modifications to be made to the various mitigation features of the project if required.

The wetland monitoring would focus on project impacts to tidal wetlands and the success of the marsh restoration efforts in Disposal Area 1S. In regards to the wetland impacts of the project, the SHEP includes the following monitoring activities:

Pre-construction Monitoring

Monitoring of 12 Marsh Sites. This would include sampling over two seasons and involve six of the seven sites that were evaluated during a 2000-2001 study conducted by the USFWS to define the environmental factors that determine plant distribution. In addition, six new marsh study areas would be added. The six new marsh locations were chosen to expand monitoring in highly sensitive marshes, in areas where significant changes are possible under a variety of scenarios, and to monitor community shifts both vertically (up and down river) and laterally (interior versus exterior). In addition to monitoring the distribution and density of wetland vegetation, continuous recording stations would be established at the 12 sites which would record water surface elevation, specific conductance of surface waters that flood the marsh, and specific conductance of waters in the root zone, and water depth every 30 minutes.

Monitoring During Construction

The same monitoring activities at the 12 marsh sites described above would be continued throughout the construction process, which is estimated to take 4 years.

Post-Construction Monitoring

The twelve wetland monitoring sites would continue to be monitored for ten years after project construction including measuring marsh salinities continuously and sampling vegetation twice a year.

At the end of the ten years of Post-Construction Monitoring of the 12 marsh sites, the data could then be compared to the data gathered during the pre-construction and construction period monitoring to determine project impacts to tidal marshes. The hydrodynamic and water quality models would also be used in conjunction with the field data that is collected to evaluate how the project is performing and the adequacy of the mitigation features. Even though the potential impacts of the project were evaluated under a range of conditions, the conditions that are experienced after construction are likely to be somewhat different than those evaluated in the feasibility phase of the project. Consequently, the hydrodynamic and water quality models would be used to permit an evaluation to be made of project performance under the actual conditions that occur after construction is complete. The performance of the hydrodynamic and water quality models would be assessed and the models recalibrated, if necessary. This would occur once during pre-construction monitoring and twice during post-construction monitoring. The objective of this model assessment is to improve the model accuracy to the maximum extent possible. Since post-construction field data would be available, the additional data should increase the accuracy of the models. At the end of this model assessment, the range of the models' uncertainty would be established based on the models' new accuracy limitations.

The Corps and the natural resource agencies would use the models after the post-construction assessment/calibration to evaluate the performance of the project and its mitigation features. Model runs would be conducted using conditions measured in the field and the results compared to monitoring data for the parameter being evaluated. In the case of tidal wetlands, salinity data gathered from the 8 continuous hydrologic and hydraulic recorders would be used with the models to evaluate project impacts. Data would also be available from the 12 continuous recording stations established at the marsh monitoring sites.

Monitoring of the marsh restoration site in Disposal Area 1-S would be conducted for seven years. A reference site would be identified to allow comparison to the restored area in Disposal Site 1S. Juvenile Spartina alterniflora would be planted if the site does not have 90% coverage compared to the reference site. Should the restored marsh not meet this success criterion, the ICT would identify/recommend corrective actions, including planting requirements and associated sprig densities. The need for corrective action(s) would be determined annually with agency involvement/concurrence.

The marsh restoration site in Disposal Area 1S would also be monitored for the presence of invasive species. An invasive species removal plan would be developed and implemented if needed.

9. Fisheries

Issue

The second major issue addressed in this cumulative impact analysis is fisheries. Over time, fishery resources in the basin in the estuary have been significantly degraded by various activities in the estuary as well as upstream activities that have altered flows and blocked fish migration. Harbor improvements and maintenance activities have resulted in significant changes over time. The estuary has become saltier; the flows of the river confined to fewer channels with higher average velocity; and wetlands have been filled, directly eliminating some habitats and reducing access to others. These changes have undoubtedly resulted in significant changes in the habitat value of the estuary to fishery resources.

Early in the study process, fishery experts from the NMFS, USFWS, GA DNR, and SC DNR agreed that the SHEP needed to directly evaluate potential impacts to the following species, as they would represent the most important fishery guilds that occur within the estuary and are relatively sensitive to the types of water quality changes expected to result from harbor deepening:

- Striped bass
- Shortnose sturgeon
- Southern flounder
- American shad

Shortnose sturgeon are discussed in the Endangered Species section of this Cumulative Effects Assessment.

Geographic Scope

The primary concern is for fishery communities that could be affected by changes that may result from deepening the harbor. Direct changes in habitat would occur within the existing navigation channel, while secondary effects would extend beyond those boundaries. The secondary effects would include areas where changes in hydrodynamics or water quality occur as a result of the project, such as any additional intrusion of salinity further into the estuary. The secondary effects would also include biological effects if physical changes within the river reduced the survivability of an estuarine life stage of a species. In that case, the effects of the impact could be felt throughout the entire geographic range of the affected species' population, as population levels could diminish throughout that range.

Since the Savannah River estuary supports fish species that move to upriver portions of the basin, as well as into the ocean and to other drainage basins, the geographic extent of the potential effects of the proposed project on fishery resources is quite large. However, since habitats used by Savannah River fisheries in other basins and in the ocean are not as much at risk as are habitats in the Savannah River, this Cumulative Effects Analysis will discuss only the estuary and the upriver portion of the basin that is available to migrating fish. The upper limit would be the J. Strom Thurmond Dam at River Mile 237.7.

The spawning habitat of Striped bass and American shad has been severely impacted by past activities in the Savannah River Basin. Over-fishing in Atlantic coastal states resulted in diminished populations of Southern flounder in the early 1990s. However, management regulations were implemented and populations of Southern flounder are no longer stressed. Consequently, much of the discussion in this section of the analysis is devoted to Striped bass and American shad.

Historic

Prior to construction of dams and intense exploitation of fisheries during the late 19th and early 20th centuries, the Savannah River and its tributaries supported large populations of diadromous fish species including Atlantic sturgeon *(Acipenser oxyrinchus),* Shortnose sturgeon *(Acipenser brevirostrum),* Striped bass *(Morone saxatilis),* American shad *(Alosa sappisissima),*Blueback herring *(Alosa aestivalis)* and American eel *(Anguilla rostrata).*

Prior to mainstream impoundment, shoals existed in the Savannah River from the city of Augusta upstream to the mouth of the Tugaloo River, a distance of approximately 177 km (Brown, 1988). Shoals typically harbor high species richness of fishes and mussels, owing in part to the complexity of habitats within them (USFWS, 2003). Striped bass and alosines ascended beyond the fall line to the Piedmont region of Georgia, South Carolina, and North Carolina. Some anadromous species annually migrated to the headwaters through the 49-mile long Tugaloo River to Tallulah Falls, Georgia, located on the Tallulah River about 10 miles upstream of the convergence of the Tallulah and Chattooga Rivers (Stevenson 1899, as cited by Mansueti and Kolb, 1953).

Although the size of diadromous fish populations in the Savannah River prior to exploitation and dam construction cannot be reliably determined, it is likely that annual migratory spawning populations of shad and herring numbered in the tens of millions (personal communication, NMFS).

Past Actions/Stresses

Historical accounts of the Savannah River fishery indicate that large declines in populations of shad and herring began in the late 1700s. Much of this population decline can be traced to overexploitation of the resource and the blockage of tributary rivers by gristmill dams. Large scale-land clearing for agricultural with the subsequent increased sediment load to the river also was a significant factor in the decline of fish populations.

Three major Federal projects (Hartwell, Richard B. Russell, and J. Strom Thurmond) were constructed in the upper Savannah River Basin for flood control and hydropower. These projects were started in the late 1950s and completed in the early 1980s. Below these projects at the City Of Augusta are three additional dams. The Augusta Diversion Dam was completed in the mid-1850s, Stevens Creek Dam was completed in 1925, and New Savannah Bluff Lock and Dam in 1939. Figure 7 from the Draft Fish and Wildlife Coordination Act Report for the Savannah River Basin Comprehensive Study shows the location of the J Strom Thurmond Project and the three dams located below it.

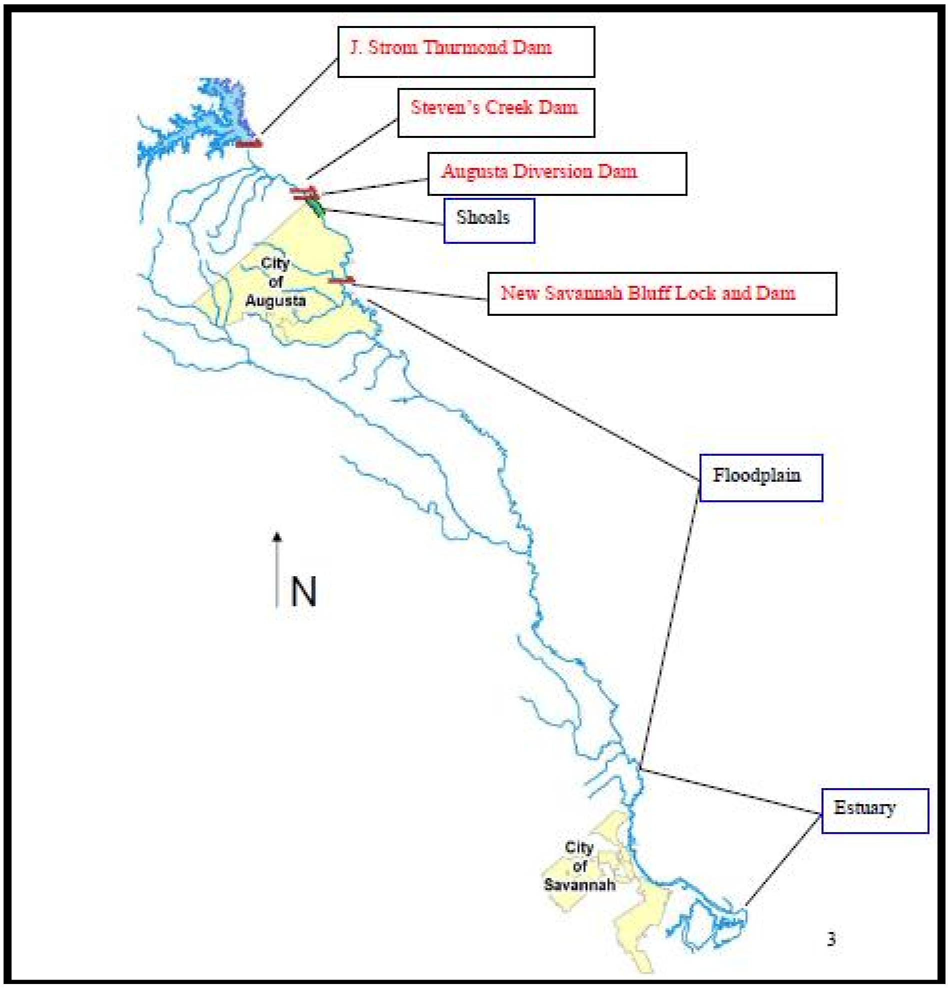

Figure 7. Dams on the Savannah River, J. Strom Thurmond and below

Dam and reservoir construction converted or blocked access to approximately half of the 384 miles of historical anadromous fish spawning and nursery habitat of the Savannah River. Practically 90 percent of the high quality anadromous fish spawning habitat (rapids complex: boulder, bedrock, cobble and gravel substrate) has been blocked or inundated by large reservoirs above the Augusta Diversion Dam. This may be even more significant since the majority of habitat that is no longer accessible was probably the most highly used, especially for the American shad. The NMFS estimates that 90 to 95 percent of the quality spawning habitat for rapids-dependent anadromous species has been lost. As shown in Figure 7, the only shoals remaining on the Savannah River is a small stretch (7.2 km) located below the Augusta Diversion Canal.

The New Savannah Bluff Lock and Dam was part of the Savannah River Below Augusta Navigation Project. In addition to the lock and dam, the project provided for a navigation channel 9 feet deep and 90 feet wide from the upper end of Savannah Harbor (Mile 21.3) to the head of navigation just below the 13th Street Bridge in Augusta, Georgia (Mile 202.2), a distance of 180.9 miles. Channel modifications including deepening, widening, snagging, construction of bend cutoffs (channel straightening) and construction of pile dikes to maintain the 9-foot depth.

This project has not been maintained since 1979. However, the bend cutoffs effectively removed large channel segments from the river at low flow periods (USFWS, 1996). The cutoff bends have accumulated sediment and organic matter since they were constructed in the late 1950s and early 1960s. Most of the cutoff bends have been substantially reduced in volume and surface area and some have completely filled with sediment reducing fish habitat during normal summer flow conditions. The USFWS considers these river bends to be biologically significant.

In addition to loss of riverine habitat, much of the fishery habitat in the Savannah River estuary has also been lost or adversely affected. Agricultural and industrial development has resulted in the loss of much of the historical fishery habitat. As previously discussed, many of the bottomland hardwood forests were converted to rice fields. Industrial development along the harbor has resulted in the filling of tidal wetlands.

Prior to passage of the Clean Water Act Amendments in 1972, Savannah Harbor was characterized by numerous unregulated discharges of various types of industrial wastewater as well as untreated municipal sanitary waste. The harbor was subject to low dissolved oxygen levels which severely restricted suitable habitat for many fish species.

Construction and operation of the Savannah Harbor Navigation Project has also had significant effects on fishery habitat. River flow through the estuary was originally distributed through several braided channels. That pattern has been significantly altered, with the majority of the flows now being confined to Front River. Those alterations included closing many of the connections between the braided channels. The concentration of flow has increased velocities in Front River. These actions have occurred in conjunction with deepening of the navigation channel from a roughly natural 12-foot deep river to the present authorized 42-foot channel. Deepening the harbor has allowed salt waters to move further up the estuary, altering the composition of wetlands along the river. Deepening the channel has also exacerbated naturally low dissolved oxygen levels in the summer months. Periodic removal of sediments from the channel reduces the benthic community within the shipping channel. Disposal of the dredged sediment has resulted in the loss of fishery habitat where approximately 6,000 acres of wetlands have been converted into diked disposal areas adjacent to the harbor.

Construction of the Sediment Control Works Project (Tidegate and Sediment Basin) impacted fishery habitat in the estuary, especially for the Striped bass. Studies in the early 1960s and 1970s indicated that the primary spawning area for Striped bass in the Savannah River system was the tidal freshwater zone located in Little Back River adjacent to the SNWR. Studies by Van Den Avyle et al. indicate that production of Striped bass eggs in the Savannah River estuary declined by about 95 percent between 1977 (when the Tidegate was put into operation) and 1989. Operation of the Tidegate Structure increased salinity levels in Striped bass spawning grounds and altered current velocities and pathways of water movement in the middle and lower estuary. Essentially, most Striped bass eggs spawned in the Savannah River estuary were transported downstream beyond Hutchinson Island into areas with toxic salinity levels (10 ppt or greater) within 30 to 48 hours of being spawned. Striped bass eggs hatch within 40 to 60 hours post spawning and thus the larvae were exposed to toxic salinity levels before they became strong enough to swim out of the area.

Present Condition

The Savannah River Estuary is one of the largest marsh ecosystems on the Atlantic Coast. The estuary encompasses about 290,000 acres and includes the 29,000-acre Savannah National Wildlife Refuge in the upper estuary near the freshwater/saltwater tidal interface. The Savannah River Estuary is a dynamic system characterized by high tidal fluctuation 6-7 feet, which causes spatial shifts in various salinity-defined habitats. Changes in habitat in many areas occur every six hours (high vs. low tide), and seasonal changes in river discharge also influence these habitats.

Significant progress has occurred throughout the basin to reduce or eliminate over-fishing, pollution and poor water quality.

The Clean Water Act was originally enacted in 1948 as the Water Pollution Control Act. The Act has been amended several times, with major revisions being made in 1972 and 1977. The 1972 amendment established a national goal of eliminating all pollutant discharges by 1985, with an interim goal of making the waters safe for fish, shellfish, wildlife and people by 1983. The Act established a number of regulatory programs and provides standards of enforcement. Water quality in Savannah Harbor has significantly improved from the 1970s.

Much of the tidal brackish and freshwater marsh is protected within the SNWR. Other wetlands in the estuary are protected from development by Section 404 of the Clean Water Act. Any party wishing to discharge dredged or fill material into wetlands must obtain a Section 404 permit from the US Army Corps of Engineers.

The Endangered Species Act was originally enacted in 1973 to conserve, protect, and propagate species that are at risk of becoming extinct. The law reflected a national desire to protect threatened species and increased the protection for specific identified species. It also established a policy that all Federal departments and agencies seek to conserve threatened and endangered species and use their authorities to further the goals of the Act. Federal action agencies must coordinate their activities with the US Fish and Wildlife Service and the National Marine Fisheries Service. This coordination and the law requiring it have resulted in the protection of fish species and populations whose future existence are threatened. The Shortnose sturgeon is the only endangered fish in the Savannah Harbor estuary.

The Magnuson-Stevens Fishery Conservation and Management Act (MSA) was originally enacted in 1990. The act is intended to conserve and manage the fishery resources found off the coasts of the US, the anadromous species, and the Continental Shelf fishery resources of the US. The Act ensures consideration of the effects of proposed Federal actions on estuarine and coastal fish habitats. The Act requires Federal action agencies to consult with NOAA Fisheries if a proposed action may adversely affect Essential Fish Habitat (EFH). The MSA provides for regional Fishery Management Councils and requires these Councils to develop Fishery Management Plans for marine and anadromous fish species that are fished in waters from 3 to 200 miles offshore. The Councils designate EFH in the management plans, minimize adverse effects on EFH from fishing, and identify other actions to encourage the conservation and enhancement of EFH. The South Atlantic Fishery Management Council (SAFMC) has developed the EFH requirements for some of the fishery management plans prepared by the

Atlantic States Marine Fisheries Commission. EFH has been designated for red drum, summer flounder, white shrimp and brown shrimp, all of which reside in the Savannah River estuary.

Although the Atlantic States Marine Fisheries Commission has prepared fishery management plans for American shad, Blueback herring, and Atlantic sturgeon, the SAFMC has not yet prepared their regional fishery management plans, so EFH has not been designated for those diadromous species. However, diadromous species such as American shad and other alosids are recognized as vital components of the prey base for essentially all managed predacious fish species and are significant components of fishery landings (South Atlantic Fishery Management Council, 1998 – Final Habitat Plan for South Atlantic Region).

The positive impacts of passage and implementation of these various water quality laws are evidenced by the fisheries present in the Savannah River estuary.

Several studies have been conducted to characterize fisheries in the Savannah Harbor estuary. As part of SHEP, the University of Georgia conducted a study for the Georgia Ports Authority in 2000-2002 titled "Temporal and Spatial Distribution of Estuarine-Dependent Species in the Savannah River Estuary". The study found that the estuary supports a diverse and abundant fish community that is dependent on the availability of specific salinity-defined habitat zones. The study identified fish from 91 species and 42 families within the salinity-defined habitats. Most of the fish abundance was comprised of relatively few species, but these species were important to commercial and recreational fisheries. Twenty-three species caught in samples (including the six most abundant) were protected species with Fishery Management Plans and comprised over 90 % of the total catch.

Most members of the fish community seemed to be estuarine generalists capable of tolerating a wide range of salinities (1.0-15.0 ‰). A smaller subset of the assemblage can be characterized as marine species whose distribution was limited to areas with higher salinities (> 10 ‰); these species occasionally invade the estuaries as the salt wedge moves inland during periods of low river discharge. The smallest component of the fish community in the estuary was the obligate freshwater species and those that could not tolerate salinities above 5.0 ‰.

Seasonal changes in abundance and diversity were evident and exceeded differences observed within a given season. The most important low-salinity period seemed to be late winter/early spring, and river discharge seemed to dominate the habitats during that time. Fish density and species richness were low in the fall; while almost all species declined in abundance and many species disappeared from sample reaches during that season. In the winter and early spring, drum and flatfish density and richness increased in low salinity habitats and were followed by clupeids and gobies in spring and early-summer. In the summer, the number of invading marine opportunist species increased, but the abundances of most of these species were low. Bay anchovy dominated fish abundance in the summer in the estuary, but the presence of all species made summer (especially in mesohaline habitat) the most abundant and speciose season both of the study years. Spatial trends in fish abundance were less evident than temporal trends. Definite peaks in abundance occurred for numerous species in low-salinity habitat, and for two species in high-salinity habitat. Atlantic croaker, Atlantic menhaden, and Southern flounder larvae seemed to use oligohaline and tidal freshwater habitats in the winter and spring. High river discharge probably is important to provide spatially-broad, low-salinity, tidal habitat. Increases in salinity might affect larval survival, but to what extent is unknown.

The South Carolina Department of Natural Resources conducted a parallel study in 2000-2002 also titled "Temporal and Spatial Distribution of Estuarine-Dependent Species in the Savannah River Estuary". A total of 85 species were identified. The most abundant species in the gillnet samples included longnose gar, Atlantic menhaden, and channel catfish. In trawl collections, the dominant species included star drum, white shrimp, Atlantic croaker, spot, bay anchovy, and Atlantic menhaden. Commercially- and recreationally-important species encountered were white shrimp, brown shrimp, blue crab, summer and southern flounders, red drum, spotted sea trout, striped bass, channel and white catfish, and weakfish. Protected species encountered included the Atlantic sturgeon and the Shortnose sturgeon. SC DNR stated that the estuary apparently plays an important role in the development and sustainability of many of these species. Dissolved oxygen levels were observed below 4 mg/L, a level that is considered critically low for many species.

SC DNR stated that despite extensive anthropogenic modifications and ongoing water quality (i.e., low dissolved oxygen) concerns, the lower Savannah River continues to function as a valuable, productive estuary. Rather than multiple discrete ecological communities in different portions of the estuary, the species composition appears to consist of a gradient structured by, among other parameters, salinity. The use of the estuary as a nursery habitat for many ecologically, recreationally, and commercially important species is apparent, including imperiled species such as the Atlantic sturgeon and the endangered Shortnose sturgeon. The scarcity of certain valuable species, such as Spotted sea trout, Red drum, and Striped bass, relative to other estuaries in the region suggests that the nursery (and perhaps other) functions of the estuary may have already been compromised to some degree. For example, much of what was once intertidal polyhaline/mesohaline marsh with dendritic creeks has now been either filled or used for deposition of dredged sediments. Further compression of this nursery habitat by saltwater intrusion, whether caused by continued low flows, sea level rise, or harbor deepening could exacerbate this problem.

It also appears that successful Striped bass natural reproduction has improved in the lower Savannah River. The Georgia DNR-WRD conducted a stocking program in the lower Savannah River from 1989-2002. Studies by Weyers (2003) reported that Striped bass larvae were collected in 2001-2002 ichthyoplankton samples from freshwater and low salinity habitats, thus indicating successful reproduction in the estuary. Collins et al. (2002) reported collecting a high proportion of juvenile Striped bass smaller than those stocked by the Georgia DNR, indicating natural reproduction. The Georgia DNR-WRD conducts regular Striped bass sampling using electrofishing. They have collected Striped bass spawned in 2003 and 2004 and the number of Striped bass age two years or more caught per hour has increased from two or less in the mid-1990s to more than 12 in mid-2000s. Limited recreational fishing is now allowed for this species. Maintenance of acceptable salinity limits in their spawning grounds has been demonstrated as critical to their ability to successfully spawn.

Although many of the past stresses on Striped bass and American shad have been removed, populations of these species still suffer from loss of spawning habitat. Most major rivers along the Atlantic coast have historically supported distinct spawning stocks of American Shad (NMFS, 2006). Stock abundances of American Shad are significantly below the historic levels of the early 20th century. Atlantic coast commercial landings have declined from over 22,000 metric tons in 1896 to between 100 and 1,000 metric tons annually since 1996 (NOAA, 2006). This reduction in landings is attributed to habitat loss and over-fishing. American shad are managed by the Atlantic States Marine Fisheries Commission under a Fisheries Management Plan for American shad and river herring. This plan was implemented in 1985 to facilitate cooperative management and stock restoration between the states. Restoration efforts involved habitat improvement, fish passage, stocking, and transfer programs. To prevent over-fishing, the traditional method of harvesting American shad by gillnets in a coastal intercept fishery was phased out between 2000 and 2004.

Coastal migratory stocks of Striped bass (Atlantic striped bass) are managed under a fishery management plan developed by the Atlantic States Marine Fisheries Commission under the authority of the Striped Bass Conservation Act. This legislation was passed in 1981 in response to declines in commercial Striped bass harvest and the perceived decline in production of juvenile Striped bass. The Savannah River population of Striped bass is considered riverine (spend their lives in the Savannah River) in contrast to the Atlantic striped bass which is anadramous (lives in the ocean, spawns in freshwater).

Southern flounder have not suffered the same habitat losses as the American Shad and the striped bass populations in the Savannah River. However, populations of this species have suffered from over-fishing in the past. Over-fishing resulted in the Atlantic States Marine Fisheries Commission reducing the creel limit for this species in the Atlantic coastal states as appropriate. Populations of this species have since recovered.

Present Actions/Stresses

The last major obstacle in restoring diadromous fish runs in the Savannah River is reducing the impacts of the upstream dams. These structures physically and biologically fragment river systems and alter river flows, bedload movements, water chemistry and aquatic habitat. They restrict or prevent the upstream and downstream passage of migratory fish, effectively isolating these populations from critical spawning and nursery habitats. The only remaining shoal habitat in the Savannah River is a 7.2 km reach extending downstream of the Augusta City Dam.

In 1994, the USFWS, NOAA Fisheries, SC DNR, and the GA DNR completed development of a plan to restore access to a portion of historical anadromous fish spawning habitat in the Savannah River. The plan was filed by the Service on behalf of the resource agencies in 1994, and was adopted by the Federal Energy Regulatory Commission (FERC) as a Comprehensive Plan pursuant to Section 10(a)(2) of the Federal Power Act. The plan is a guide for resource agency efforts and would restore access to approximately 35 miles of spawning and maturation habitat. The plan includes the following elements: (1) reliable passage of anadromous fish at the New Savannah Bluff Lock and Dam; (2) the design and implementation of an upstream fish passage mechanism and safe downstream (out-migrant) passage at the Augusta Diversion Dam; (3) the design and implementation of an upstream fish passage mechanism and safe downstream (out-migrant) passage at the Stevens Creek Dam; and (4) improvement of poor dissolved oxygen releases from the J. Strom Thurmond Dam during the summer months.

Three of the four elements of the plan to restore access to the 35 miles of the Savannah River between New Savannah Bluff Lock and Dam and J Strom Thurmond Dam are in place. In 2004, the NMFS and USFWS sent the Federal Energy Regulatory Commission (FERC) a joint prescription for fish passage at the Augusta Diversion Dam as well as minimum flow requirements necessary over the Augusta Shoals in regards to the proposed re-licensing of the Diversion Dam. When FERC issued the license for the Stevens Creek Hydropower Project in 1995, it reserved authority for the USFWS to prescribe a fishway at that project once upstream passage was achieved at the Augusta Diversion Dam. The Corps of Engineers began replacement of turbines at the Thurmond Dam in 2002 with new auto-venting turbines. Installation of the new units was completed in 2006. Since the new turbines have been used, dissolved oxygen levels in the summer discharges have increased, greatly improving fishery habitats in the 17-mile reach between Thurmond Dam and the Augusta Diversion Dam.

While plans are in place to provide fish passage at the Augusta Diversion Dam and the Stevens Creek Hydroelectric Project and dissolved oxygen concentrations have been improved below J. Strom Thurmond Dam, there is no need to require implementation of fish passage facilities at these two upstream dams until fish passage is achieved at the New Savannah Bluff Lock and Dam. Two fish passage measures have been attempted at New Savannah Bluff Lock and Dam with very limited success.

A pulse of water was released from J. Strom Thurmond Dam during the spawning season to overtop the spill gates at New Savannah Bluff Lock and Dam to allow opportunity for fish to pass over the dam. This method of fish passage proved ineffective. More than likely, the cold water released from Thurmond Dam may have cooled the water to the point where the fish were no longer inclined to spawn. Also, it is doubtful, that a benthic dwelling fish such as the Shortnose sturgeon would have been able to negotiate the 8-foot support walls at the bottom of the dam.

The New Savannah Bluff Lock and Dam is currently operated by the City of Augusta. A provision of their lease with the US Government requires that they lock fish through the dam twice a week during the spring spawning season. Some limited transmitter studies have been conducted to determine if fish are successfully locked through. Apparently, there is little movement of fish through the lock.

Capacity to Withstand Stress

It is obvious from studies that have been conducted that populations of American shad are already severely stressed. Steps have been taken to reduce fishing pressure on this species. However, loss of traditional spawning habitat will continue to limit population recovery for this species.

Populations of Striped bass in the Savannah River are predominantly riverine, meaning they remain in the Savannah River year round, unlike anadromous populations species of Striped bass which live in the ocean and return to freshwater only to spawn. Survival of the Savannah River population is dependent on access to suitable spawning grounds in the upper estuary. This species has shown signs of recovery since the Tidegate structure was taken out of operation in 1991 and New Cut closed in 1992. These two actions helped to restore acceptable salinity levels in Striped bass spawning grounds in the estuary. This species has recovered to the point that limited recreational fishing is now permitted. Continued propagation of this population is dependent on maintaining acceptable salinity levels in spawning areas.

Populations of Southern flounder have experienced stress due to over-fishing. Steps have been taken to reduce fishing pressure to allow this species to recover to more acceptable levels.

Future Actions/stresses

The impacts of dams on spawning habitat for diadromous species such as American shad will continue to contribute to low population numbers. Harbor improvement projects also have the potential to impact American shad, Striped bass, and Southern flounder populations. The only two potential harbor improvement projects known at this time are the SHEP and the Jasper County Marine Terminal.

The SHEP will impact habitat for the American shad, Striped bass and Southern flounder. Most of these impacts are centered on predicted impacts to the existing salinity and dissolved oxygen regimes caused by deepening the harbor. Implementation of any of the channel deepening alternatives would also result in the loss of 15.68 acres of fishery habitat (15.68 acres of brackish marsh).

As previously discussed, a marine terminal has been proposed for Jasper County, South Carolina. If that project is constructed, it would require deepening and extending the Savannah Harbor entrance channel and deepening the inner harbor navigation channel to the terminal site which is located at about River Mile 6. If the SHEP is constructed, no further dredging of the navigation channel would be required to support such a facility. If the SHEP is not constructed, deepening the navigation channel to River Mile 6 for a Jasper terminal would be expected to have only minimal impacts on the salinity and dissolved regimes in Savannah Harbor. Consequently, construction of a Jasper County container terminal would not be expected to adversely affect upstream habitat of species such as the Striped bass. Construction of a Jasper facility could adversely affect fish habitat due to marsh impacts resulting from road and rail infrastructure requirements. The exact extent of any marsh impacts as a result of the construction of this facility cannot be accurately predicted at this time because the project is in the conceptual stage.

The Corps manages three reservoirs upstream on the Savannah River. Periodically, the Corps makes revisions to the drought contingency plan for those reservoirs. The impacts from those revisions are evaluated and approved before changes are implemented. The revisions would only be implemented if they were found to be acceptable to fishery resources located downstream of the reservoirs.

Incremental Impact

Based on information presented in this analysis, it is obvious that incremental loss of upstream habitat and spawning areas has significantly impacted populations of American shad. Remaining populations of American shad undergo seasonal migrations moving from the ocean into southern rivers beginning in January. Past harbor improvements and sea level rise have raised salinity levels in the upper part of the Savannah estuary and limited Striped bass spawning habitat. Populations of Southern flounder on the Atlantic coast have recovered from past over-fishing. This species does not appear to have suffered from loss of traditional habitat.
NOAA fisheries resource management goals and objectives for the SHEP can be summarized as follows:

- **Conserve Species**. Avoid further declines and/or extinction and foster long-term survival and recovery of Savannah River Basin American shad, river herring, Striped bass, American eel, Atlantic sturgeon, and Shortnose sturgeon.

- **Riverine, Estuarine, and Marine Ecosystems.** Conserve the estuarine ecosystem and the vital link between the river and the marine environment, and the contribution to marine health provided by diadromous species.

- **Balance the Life Cycle Needs of Other Species.** Ensure that diadromous fish conservation measures are balanced with the management and conservation needs of other native fish and wildlife species.

- **Support Sustainable Recreational and Commercial Fisheries.** Provide for adequate fish passage; preservation of Essential Fish Habitats for Red drum, Summer flounder, White shrimp, and Brown shrimp; and support American shad and other alosids as vital components of the prey base of essentially all Federally-managed predacious fish species, and to a healthy estuarine and marine ecosystem.

To identify potential impacts to the Striped bass from harbor deepening, an interagency team developed criteria to describe acceptable habitat for Striped bass in the Savannah River. Criteria were developed for spawning, egg and larval habitat. Hydrodynamic and dissolved oxygen models were used to identify changes in salinity, dissolved oxygen, and velocity. The team identified the conditions under which the hydrodynamic and dissolved oxygen models would be run to identify potential impacts to those habitats. Average river flows were determined to be the most representative of conditions that would be experienced over the long-term. For the Striped bass, additional runs were made with high (80% exceedance) and low (20% exceedance) river flows to ensure unusual impacts would not develop during those less-typical years. Fish habitat modeling was used to identify areas in the harbor where suitable habitat exists as well as how that habitat would change under the various harbor deepening alternatives. A similar approach was used for American shad, Southern flounder, and Shortnose sturgeon.

Table 7 is a summary of project-related fishery impacts without mitigation. All of the deepening plans have a negative impact on striped bass spawning, eggs, and larvae habitat, with construction of the 48-foot channel resulting in the greatest impacts. Most of the negative impacts are centered on increases in salinity levels in the spawning grounds and downstream areas.

Table 7. Predicted Fishery Impacts Without Mitigation

	----------------------- DEPTH ALTERNATIVES -----------------------				
	44-Foot	**45-Foot**	**46-Foot**	**47-Foot**	**48-Foot**
Salinity	Move further into estuary	Same effect, but greater amount	Same effect, but greater amount	Same effect, but greater amount	Same effect, but greater amount
Dissolved Oxygen	Reductions at mid-depth and bottom	Same effect, but greater amount	Same effect, but greater amount	Same effect, But greater amount	Same effect, but greater amount
Fisheries	**Loss (-) of Acceptable Habitat**				
- Striped bass spawning	- 8.0 % (-83.0 acres)	- 12.2 % (-127.0 acres)	- 13.0 % (-135.0 acres)	-18.1 % (-188.0 acres)	- 19.7 % (-205.0 acres)
- Striped bass eggs	-9.7 % (-163.0 acres)	- 11.2 % (-188.0 acres)	- 15.9 % (-266.0 acres)	-20.5 % (-344.0 acres)	-24.5 % (-411.0 acres)
- Striped bass larvae	-13.5% (-76.0 acres)	- 18.6 % (-105.0 acres)	- 21.0 % (-119.0 acres)	-13.8 % (-78.0 acres)	- 13.8 % (-78.0 acres)
- American shad (Jan)	0 %	0 %	0 %	0%	0 %
- American shad (May)	0 %	0 %	0 %	0%	0 %
- American shad (Aug)	0 %	0 %	0 %	0 %	0 %
- Shortnose sturgeon adult (January)	- 0.5% (-20.0 acres)	- 0.5 % (-20.0 acres)	-0.8 % (-32.0 acres)	-0.8% (-32.0 acres)	-1.1 % (-44.0 acres)
- Shortnose sturgeon adult (August)	- 3.2 % (-45.0 acres)	- 6.4 % (-89.0 acres)	- 9.5 % (-132.0 acres)	-13.3 % (-185.0 acres)	- 15.80 % (- 220.0 acres)
- Shortnose sturgeon juvenile (January)	-5.0 % (-86.0 acres)	-10.4 % (-179.0 acres)	-15.9 % (-274.0 acres)	- 19.0 % (-328.0 acres)	- 21.6 % (-373.0 acres)
- Southern flounder	- 0.3 % (-6.0 acres)	- 2.4 % (-45.0 acres)	- 2.4 % (-45.0 acres)	-7.8 % (-146.0 acres)	0.0 %

As shown in Table 7, the various deepening alternatives do not impact American shad habitat. Southern flounder habitat would be negatively impacted by all the harbor deepening alternatives except for the 48-foot channel. In addition to project-related fishery impacts, approximately 15.68 acres of brackish marsh would be lost as a result of the construction of bend wideners, removal of the Tidegate and expansion of the Kings Island Turning Basin. These wetlands are considered important habitat for the Striped bass, American shad and Southern flounder. The reader needs to remember that the table above shows the impacts PRIOR to inclusion of the project's mitigation features. The effects WITH the mitigation features are described in the following pages.

Alternatives to Mitigate for Cumulative Effects

Based on the project-related fishery impacts model studies, it is apparent that mitigation measures are warranted to reduce impacts to salinity and dissolved oxygen levels that would occur as a result of implementing any of the various harbor deepening alternatives. Also, mitigation is warranted to offset the unavoidable loss of 15.68 acres of emergent wetlands.

From a broad perspective, general mitigation objectives for fishery impacts in the Savannah River can be described as:

- Removing impediments to spawning migrations of diadromous species to sustain those recreational and commercial fish populations.

- Restoring historic spawning areas of diadromous species within the Savannah River to foster the long-term survival and recovery of those species.

- Enhancing Essential Fish Habitats of Federally-managed species by constructing oyster reefs along tidal rivers.

- Restoring access to wetlands in the estuary through restoration of previous saltmarsh areas to improve the sustainability of estuarine-dependent species.

- Restoring conditions in the estuary that are favorable to spawning of Striped bass to support the recovery of that species.

- Enhancing habitats by reducing salinities in portions of Back and Middle Rivers through closing of cuts that allow higher salinity water to enter areas with otherwise lower levels of salinity.

- Enhancing habitats by reducing salinities or modifying velocities in specific estuarine waters through modifying flows into Back and Middle Rivers.

With these general objectives in mind, specific mitigation plans were developed to offset the predicted adverse impacts associated with the harbor deepening alternatives under consideration. As previously discussed, Mitigation Plans 6A and 6B were developed to minimize predicted increases in upstream salinity levels that would be caused by construction of the deeper channels.

Plan 6B would be implemented to offset expected salinity increases associated with construction of the 44-foot channel. This plan consists of constructing a diversion structure at McCoy Cut, as well as closing the lower arm; closing Rifle Cut; removing the Tidegate, and constructing a broad berm and a submerged rock sill across the mouth of the Sediment Basin; and placing dredged material behind the berm to partially fill in the basin. Plan 6A would be used to offset the predicted salinity increases associated with the 45, 46, 47, and 48-foot channels. It includes the same provisions, but also includes deepening the channels in McCoys Cut, Middle River and Little Back River.

Studies were conducted to determine the most effective way to minimize decreases in dissolved oxygen levels that would result from constructing the various channel deepening alternatives. These studies indicate that an oxygen injection system would be the most efficient means to increase dissolved oxygen levels in harbor. A system using Speece Cones was designed for use in Savannah Harbor. Further model studies revealed that three oxygen injection locations would be required for the SHEP. One oxygen injection site would be located in the Savannah River near Georgia Pacific and the other two sites would be located on Hutchinson Island with injection into the Front and Back Rivers (Figure 8).

Figure 8. Location of speece cones systems for oxygen injection.

Table 8 shows the summary of predicted project-related fishery impacts for the 44, 45, 46, 47 and 48-foot channels with Mitigation Plan 6A or 6B implemented and with injection of dissolved oxygen.

Table 8. Predicted Fishery Impacts With Mitigation

	---------------------- DEPTH ALTERNATIVES ----------------------				
	44-Foot	**45-Foot**	**46-Foot**	**47-Foot**	**48-Foot**
Salinity	Move further into estuary up Front River	Same effect, but greater amount	Same effect, but greater amount	Same effect, but greater amount	Same effect, but greater amount
Dissolved Oxygen	Minor net improvement	Same	Same	Same	Same
Fisheries	Loss (-) or Gain (+) of Acceptable Habitat				
- Striped bass spawning	- 2.9 % (-30.0 acres)	- 9.2 % (-96.0 acres)	- 10.0 % (-104.0 acres)	-13.5 % (-140.0 acres)	- 16.1 % (-167.0 acres)
- Striped bass eggs	- 9.4 % (-157.0 acres)	+5.2 % (+87.0 acres)	0 %	-11.1 % (-186.0 acres)	-10.8 % (-181.0 acres)
- Striped bass larvae	-5.6 % (-32.0 acres)	+ 1.7 % (+9.0 acres)	+ 5.6 % (+32.0 acres)	-5.0 % (-28.0 acres)	-3.5 % (-20.0 acres)
- American shad (Jan)	-0.2 % (- 9.0 acres)	-0.2 % (-9.0 acres)	- 0.2 % (-9.0 acres)	-0.2 % (-9.0 acres)	- 0.2 % (-9.0 acres)
- American shad (May)	- 0.2 % (-12.0 acres)	- 0.2 % (-11.0 acres)	- 0.2 % (-11.0 acres)	-0.2 % (-11.0 acres)	- 0.2 % (-11.0 acres)
- American shad (Aug)	-0.3 % (-16.0 acres)	-0.3 % (-15.0 acres)	-0.2 % (-11.0 acres)	-0.2 % (-11.0 acres)	-0.2 % (-11.0 acres)
- Shortnose sturgeon adult (January)	-3.9 % (-153.0 acres)	- 4.6 % (-179.0 acres)	-6.2% (-240.0 acres)	-6.9 % (-266.0 acres)	- 8.4 % (-326.0 acres)
- Shortnose sturgeon adult (August)	+ 19.0 % (+ 260.0 acres)	+9.8 % (+134.0 acres)	+7.3 % (+100.0 acres)	+6.5 % (+89.0 acres)	-+2.8 % (+39.0 acres)
- Shortnose sturgeon juvenile (January)	-6.7 % (-220.0 acres)	-7.0 % (-231.0 acres)	-7.3 % (-238.0 acres)	-7.6 % (-251.0 acres)	-11.5 (-376.0 acres)
- Southern flounder	+74.1 % (+1387.0acres)	+ 54.2 % (+1014.0acres)	+ 57.3 % (+1072.0acres)	+57.3 % (+1072.0acres)	+ 52.9 % (+989.0 acres)

Although the mitigation measures reduce the amount of Striped bass spawning habitat that would be lost from implementing any of the harbor deepening alternatives, there would still be a loss of spawning habitat ranging from 30.0 acres (-2.9%) with the 44-foot channel to 167.0 acres (-16.1%) with the 48-foot channel.

Implementation of the mitigation plan would eliminate adverse impacts to Striped bass egg habitat with the 46-foot channel and increase egg habitat by about 87.0 acres (-5.2%) with the 45-foot channel. However, approximately 157.0 acres (-9.4%) of egg habitat would be lost with the 44-foot channel and 181.0 acres (-10.8%) lost with the 48-foot channel.

With the mitigation plans in place, Striped bass larvae habitat would increase by about 9.5 acres (1.7 acres) with the 45-foot channel and about 31.5 acres (5.6%) with the 46-foot channel. Striped bass larvae habitat would be reduced for the 44-foot channel (31.5 acres-5.6%) and the 48-foot channel 19.5 acres-3.5%) even with mitigation.

Predictions regarding impacts to American shad habitat with the mitigation plans in place indicate there would be losses of 0.2% for the winter and spring months for all of the deepening plans under consideration.

Southern flounder habitat would be significantly increased for any of the alternative deepening plans with mitigation. Specifically, Southern flounder habitat for the 44, 45, 46, 47 and 48-foot depth alternatives increases by 1387 acres (+74.1%); 1014 acres (+54.2%); 1072 acres (+57.3%); 1072 acres (+57.3%); and 989 acres (+52.9%); respectively.

The remaining adverse impacts to Striped bass habitat with the channel modification and dissolved oxygen mitigation features in place were deemed sufficient enough to warrant consideration of additional mitigation. Additional structural modifications, such as timber or rock flow diverters were analyzed, but no measure could be identified that would improve habitat over the range of river flows that occur. The SHEP study team could not identify any other measures that could be implemented to restore or enhance Striped bass habitat in the basin. Consequently, implementation of a stocking program was deemed to be the most effective means of mitigating for the remaining loss of Striped bass habitat associated with each alternative deepening plan. As discussed in previous paragraphs, the Wildlife Resources Division of the Georgia Department of Natural Resources conducted a successful Striped bass stocking plan in the Savannah River estuary in the 1990s.

Determining the appropriate level of stocking was accomplished by the SHEP study team in coordination with the Georgia DNR-WRD. Most of the concern centers around salinity levels in spawning and early life stage habitats before the fish are mature enough (2 months) to find habitats with suitable salinity conditions. Consequently, stocking young of the year would be sufficient to meet this need. The Georgia DNR-WRD hatchery in Richmond Hill, Georgia produces that phase of fish each year. The project would fund a portion of the costs of WRD's operations in the same percentage as the project impacts to the Striped bass habitats. Modeling indicates the following losses from the deepening alternatives (Table 9).

Table 9. Combined Adverse Impact for Striped Bass

CHANNEL DEPTH ALTERNATIVE	SPAWNING 50% Flows	EGGS 50% Flows	LARVAE 50% Flows	COMBINED ADVERSE IMPACT
44-FOOT	-2.9 %	-9.4 %	-5.6 %	17.0 %
45-FOOT	-9.2 %	5.2 %	1.7 %	2.9 %
46-FOOT	-10.0 %	-0.0 %	5.6 %	5.0 %
47-FOOT	-11.1 %	-5.0 %	-13.5 %	26.9 %
48-FOOT	-16.1 %	-10.8 %	-3.5 %	27.8 %

With that combined adverse impact value and the costs of a complete stocking program, one can calculate the compensation required to mitigate for each depth alternative. The GA DNR-WRD provided information on the costs to rehabilitate and operate some of GA DNR-WRD's facilities at their Richmond Hill hatchery to conduct a Striped bass stocking program capable of producing

40,000 Phase II fish each year. The costs included initial expenses of $3.1 million, annual expenses of $203,000 to operate the program, and recurring costs of between $30,000 and $50,000 for equipment replacement. The Corps used those values and calculated them to represent an annualized cost of roughly $504,000 for a complete Striped bass stocking program. Based on that average annual value, the following compensation would be required:

Table 10. Annual Funding Levels for Striped Bass

CHANNEL DEPTH ALTERNATIVE	COMBINED ADVERSE IMPACT	ANNUAL PROGRAM FUNDING
44-FOOT	17.0 %	$85,383
45-FOOT	2.9 %	$14,461
46-FOOT	5.0 %	$25,039
47-FOOT	26.9 %	$135,348
48-FOOT	27.8 %	$139,908

Monitoring

An evaluation of the impacts of the SHEP on Striped bass habitat would be conducted during years 2, 4, and 9 of the Post-Construction Monitoring. The data from the 8 continuous hydrologic and hydraulic recorders would be used with the updated hydrodynamic and water quality models to assess project impacts to Striped bass habitat. This analysis would determine if impacts to Striped bass habitat are beyond those expected, and if so, what additional mitigation might be warranted.

10. <u>Dissolved Oxygen</u>

Issue

The third major issue evaluated in this cumulative impact analysis is the dissolved oxygen regime in Savannah Harbor. Although water quality in the Savannah Harbor estuary is generally good, the harbor is characterized by low dissolved oxygen levels in the summer months.

Geographic scope

The primary area of concern for dissolved oxygen is the Savannah River estuary. More specifically, it is the portion of the Savannah River between Fort Pulaski (River Mile 0.0) and the Seaboard Coastline Railroad Bridge (Mile 27.4). This section of the Savannah River estuary is the area that would be affected by the SHEP. Evaluation of impacts to the dissolved oxygen regime is critical, because this segment of the river is on the State of Georgia's Section 303(d) list as impaired for dissolved oxygen.

Historic

Dissolved oxygen levels in the harbor have changed over the years. When Savannah was originally settled, presumably the quality of the water in the river was good. Early writings commonly refer to the rivers supporting substantial fisheries and the settlers benefiting greatly from those resources. After the city became highly industrialized, the river received substantial volumes of untreated industrial and municipal waste. Water quality in the Savannah Harbor estuary was further degraded because of similar unregulated discharges from upstream municipalities and industries located in the Augusta, Georgia area.

Water quality decreased in this river in the 1900s as it did in many others across the country. In the early 1970's, concerns were raised and Congress passed laws to protect and improve water quality. The Clean Water Act Amendments provided the authorization for the establishment of the National Pollutant Discharge Elimination System (NPDES) which now regulates point source discharges. It is generally acknowledged that the quality of the water in Savannah Harbor is much better now than it was before point source discharge controls were instituted.

In addition to the changes that have occurred over time, changes also occur on a seasonal and even hourly basis. The seasonal changes result from varying flow volumes down the Savannah River (summer and fall low flows, etc.). The hourly variation is cause by the large diurnal tide.

Since the issue of water quality is so driven by data – by knowing the actual concentrations of specific chemicals at specific locations and points in time – there is not a great deal of value discussing water quality in detail unless specific data is available. In addition, since water quality in the harbor is -- at a minimum not degrading – but likely to be stable or improving as tighter discharge standards are instituted and new industrial controls implemented, the present day conditions will be used as the baseline for this analysis. This approach is the most useful because of the availability of data to assess the impacts of any changes to the current baseline conditions. Discussions can still be included in a qualitative way about conditions that existed previously.

Past Actions / Stresses

Past actions that have degraded water quality in the Savannah estuary are numerous and include both upstream activities as well as development in the estuary. From an upstream perspective, massive clearing of land for agricultural purposes and large scale timber harvesting were heavy contributors to the silt load in the river. As the use of fertilizers, herbicides and pesticides became more prevalent, non-point sources of pollution became a major factor in water quality degradation. As development grew around the City of Augusta, unregulated discharges from industries and municipalities contributed to the water quality problems in Savannah Harbor. Construction of upstream dams further aggravated water quality problems by reducing peak flows. The more dependable flows from the dams increased the average water from the river for municipal water supply systems and industrial process water further detracted from the ability of the river to handle waste loads.

Some of the water quality issues in the Savannah Harbor can be traced to the growth of the City of Savannah and extensive industrial development adjacent to the river. Untreated municipal and industrial waste was discharged into the river up until the late 1960s. After pollution control laws were passed in the early 1970's, municipal and industrial treatment facilities were constructed that reduced the pollution loads discharged into the river.

As more water quality data was gathered and stresses to water quality became better understood, the States of Georgia and South Carolina issued standards for dissolved oxygen and as other parameters to protect aquatic life in the Savannah River and its estuary. These standards formed the basis for the states' decisions on whether to allow certain activities to occur that could damage water quality or aquatic life.

The Savannah estuary is similar to other nearby tidal creeks and rivers in that it suffers from low water quality during the summer months. The warmer temperatures coupled with the high organic loads from adjacent tidal marshes lead to substantial decreases in dissolved oxygen levels. This phenomenon is seen in both natural and deepened rivers, and is not dependant on the existence of adjacent development with its point sources discharges. Recent studies conducted by Georgia DNR-EPD concluded that the estuary could not meet the State's standards for dissolved oxygen during the summer even if all point source discharges were removed from the basin.

The operation and maintenance of the Savannah Harbor Navigation Project has contributed to degradation of water quality conditions in Savannah Harbor. The harbor has been deepened from about 12 feet MLW in the mid 1850s to its current authorized depth of 42 feet mean low water. As the channel became deeper, it became more difficult for dissolved oxygen to diffuse the greater distance down to the bottom of the channel. This reduced the average dissolved oxygen levels in the water column near the bottom of the river during the summer months.

Maintenance of the navigation channel is performed on essentially an annual basis. Dredges, typically hydraulic cutterhead dredges in the inner harbor, are used to remove sediments that have settled within the authorized channel dimensions. Sediments removed from the river are placed in upland confined disposal facilities. This operation re-suspends a small volume of sediments into the water column. The re-suspension of these sediments can cause dissolved oxygen levels to drop. Monitoring indicates that the effects of this resuspension on dissolved oxygen levels are small, temporary, and localized.

In addition to the large-scale channel deepening, two segments of the harbor were deepened equal to or beyond the depth of the navigation channel. The Sediment Basin was designed (operating in conjunction with the Tide Gate structure) to trap sediments that would normally settle in the navigation channel. The Sediment Basin was constructed adjacent to CDFs 12A and12B so the material could be easily removed and deposited into these two disposal sites. The tide gates have been taken out of operation causing the Sediment Basin to functions at a lower level of efficiency. However, the basin still provides an area of relatively low current in which suspended sediments readily settle out from the water column. The high sediment deposition rate in the basin and the annual maintenance period lead to large depths of fine-grained sediment residing in that location for an extended period of time. Those conditions lead to large sediment oxygen demands, with resulting low dissolved oxygen levels typically occurring within the basin during the summer months.

The Kings Island Turning Basin was deepened in 1997 by 6 feet to produce an 8-foot deep advance maintenance section. As with the Sediment Basin, this area also experiences high deposition of fine-grained sediments and is maintained annually. Low dissolved oxygen levels regularly occur within the basin during the summer.

Maintenance of berths along the length of the harbor is commonly performed through agitation dredging, where the sediments are moved from the berth by dragging them into the main river. These sediments can then be removed during the maintenance dredging of the navigation channel. This procedure re-suspends sediments in the water column, to some degree, and causes dissolved oxygen levels to drop. Detailed studies were conducted on this procedure in 1993 and 2002. Those studies documented the level of these effects and found them to be localized in extent and temporary in duration. Overall, the studies revealed that this procedure does not degrade the quality of the river to unacceptable levels. This procedure is not performed when background dissolved oxygen levels in the river are at or below Georgia water quality standards.

Present Condition

Water quality in the harbor is generally good as evidenced by its water use classification (Coastal Fishing). However, low levels of dissolved oxygen are experienced during the summer months as result of several factors. The dissolved oxygen levels can drop to concentrations that do not adequately support aquatic life.

The designated water use classification for the Savannah River from Fort Pulaski to the Seaboard Coastline Railroad Bridge is Coastal Fishing. This segment of the river failed to meet the dissolved oxygen criterion that the State established for the Coastal Fishing water quality use designation based on data collected in the summers of 1997 and 1999 (EPA 2006). Therefore, the State identified it in its Section 303(d) list of impaired waters.

In 1989, the US Environmental Protection Agency disapproved the State of Georgia's dissolved oxygen criteria as not protective of coastal fishing aquatic life. EPA believed the criteria were under-protective of aquatic species in the upper part of the water column and over-protective of aquatic species in the lower part of the water column. EPA went on to state that a concentration of 3 mg/l of DO in the lower part of the water column cannot be obtained without oxygen injection even if all discharges of oxygen demanding wastes were removed. Even though the criterion was disapproved, the EPA allowed them to remain in effect until a replacement criterion could be adopted.

Subsequently, a consent decree was established in Sierra Club v. EPA (Civil Action No. 94CV-2501-MHS (N.D.G.A.) which required the Georgia DNR-Environmental Protection Division or the EPA to propose Total Maximum Daily Loads (TMDLs) for waterbodies identified as impaired on the 2002 Section 303(d) list in the Savannah and Ogeechee River Basins. In response to the consent decree obligation, EPA established a TMDL in 2006 for dissolved oxygen for the Savannah Harbor from Fort Pulaski to the Seaboard Coastline Railroad Bridge.

The TMDL assessment took into consideration the known potential sources of pollution of concern in the watershed, including point source discharges regulated under the NPDES program, non-point sources, other sources of pollution, and background levels of pollutants in the waterbody.

Permitted point source discharges in both Savannah and Augusta that contribute to the oxygen demanding load were identified and taken into account. The vast majority of non-point sources of oxygen demanding substances was determined to be from natural background sources including detritus transported downstream in the river, detritus from marsh areas flowing directly into the harbor, and tidally transported detritus from the ocean. The assessment also established the critical segment of the Savannah Harbor system which is the segment with the lowest daily dissolved oxygen levels. This segment was determined to be a five mile segment around the Sediment Basin (Mile 9.3-14.3).

Based on this analysis, the EPA determined that Savannah Harbor cannot accept any discharges of oxygen demanding substances and still attain the applicable criterion during critical periods. The Georgia DNR Environmental Protection Division considers appropriate critical conditions to represent the event that would occur once in ten years on the average or less often. The TMDL established by EPA for Savannah Harbor established a 100% reduction of oxygen-demanding substances from all continuous NPDES-regulated discharges in the watershed (from the Thurmond Dam near Augusta, Georgia to the Savannah Harbor) in order to attain the existing, applicable site-specific criterion. However, the EPA further noted that even if this TMDL were fully implemented, a concentration of 3mg/l dissolved oxygen in the lower part of the water column cannot be obtained without injecting oxygen into Savannah Harbor.

The State of Georgia has since revised the dissolved oxygen standard for streams designated as Coastal Fishing. The revised standard is "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."

EPA published a Revised Draft TMDL for dissolved oxygen in Savannah Harbor in April 2010. This TMDL requires a reduction in loading from about 600,000 lbs/day Ultimate Oxygen Demand (UOD) to about 130,000 lbs per day.

Present Actions/Stresses

The present stresses on dissolved oxygen levels in Savannah Harbor continue to be point source discharges of oxygen demanding substances from sources between J Strom Thurmond Dam and Savannah Harbor and non-point sources, including loads from the river upstream of the harbor, the marsh and the ocean Table 11 (taken from the EPA Revised Draft TMDL for Savannah Harbor for Dissolved Oxygen, April 2010) shows the NPDES permitted dischargers to the

Savannah River from the Augusta, Georgia area through Savannah Harbor and their permitted wasteloads.
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Table 11. NPDES-Permitted Dischargers for the Savannah River

Table 6 NPDES Permitted Dischargers BOD5 and Ammonia Loads to River Facility Name	Receiving Water	Permit Number	Effluent Flow Rate (MGD)	BOD5 (mg/L)	Ammonia (mg/L)	BOD5 (lbs/day)	Ammonia (lbs/day)
Aiken PSA/Horse Creek WWTF	River	SC0024457	26	30	11	6,505	2,385
Allendale	River	SC0039918	4	25	20	834	667
Augusta -James B. Messerly WPCP	River	GA0037621	46	30	17	11,534	6,690
Clariant Corp/Martin Plant	River	SC0042803	--	--	--	564	2,000
Columbia County - Crawford Creek WPCP	River	GA0031984	2	12	1	150	15

The summary of the Ultimate Oxygen Demand (UOD) loads from NPDES Dischargers to the Savannah Harbor and River System is listed in Table 12.

Table 12. Summary of the Permitted UOD Loads for the Harbor and the River Receiving Water

	CBODu (lbs/day)	NBODu (lbs/day)	UOD (lbs/day)
Harbor	300,551	32,407	332,958
River	204,491	63,899	268,390
TOTAL	505,042	96,306	601,347

As discussed above, the EPA has issued a Revised Draft TMDL for dissolved oxygen for Savannah Harbor. This TMDL directs a reduction in the UOD loads to the Savannah River from about 600,000 lbs/day to 130,000 lbs/day.

As discussed previously, construction of the Savannah Harbor Navigation Project has also contributed to the depression of dissolved oxygen levels in the harbor. Model results from the EPA TMDL study for Savannah Harbor indicate that the Savannah Harbor Navigation Project has resulted in a 1mg/l depression of dissolved oxygen in the upper water column. This estimate was obtained by using a model to estimate dissolved oxygen levels using the 1854 bathymetry and then comparing those to current dissolved oxygen levels with the 42-foot navigation channel.

Annual maintenance dredging also contributes to temporary and localized depressed dissolved oxygen conditions in Savannah Harbor. Prior to dredging being initiated in the summer months, monitoring is performed to determine the levels of dissolved oxygen in the river. If the background levels are near or below Georgia water quality standards, the dredging is not performed unless a waiver is obtained from the state. This ensures that activities will not be conducted which would further exacerbate stressful conditions for aquatic life.

Capacity to Withstand Stress

The dissolved oxygen regime in Savannah Harbor is stressed during summer months. The existing criteria for dissolved oxygen in the lower part of the water column cannot be met during critical periods. The EPA has issued a Revised Draft TMDL for Savannah Harbor for dissolved oxygen. From a dissolved oxygen standpoint, Savannah Harbor has reached its capacity to withstand any additional stresses.

Future Actions/Stresses

Point-and non-point source, thermal and stormwater discharges will continue to occur, reducing levels of dissolved oxygen in the estuarine waters. As the Revised TMDL for Savannah Harbor is implemented, UOD loading to the Savannah Harbor estuary will be significantly reduced, and the dissolved oxygen regime should be greatly improved.

The continued maintenance of the Savannah Harbor Navigation Project as well as future harbor development projects could also impact the dissolved oxygen regime in Savannah Harbor. Potential future harbor development projects include the SHEP and a container terminal in Jasper County.

Conceptual plans have been developed for a Jasper County container terminal located in what is now CDFS 14A and 14B. This terminal would require similar channel improvements as the SHEP including deepening and extending the Savannah Harbor Entrance Channel and deepening of the inner harbor channel to the facility. Consequently, construction of a terminal could impact the dissolved oxygen regime in Savannah Harbor. If the SHEP is constructed prior to a Jasper County terminal, no additional entrance channel or inner harbor channel dredging would be required. Some dredging would be required to provide a channel between this facility and the navigation channel and to construct the container ship berths. This dredging would be minor in nature and the effects on the dissolved oxygen regime would be negligible and temporary. If the SHEP is not constructed, dredging would be required to make the required improvements in the entrance channel and to deepen the inner harbor channel to River Mile 6 where the Jasper facility would be located. Deepening the Savannah Harbor channel to River Mile 6 would be expected to have only negligible effects on the dissolved oxygen regime in the harbor.

A Jasper County container terminal could require periodic maintenance dredging for the container ship berths and the access channel to the Savannah Harbor Navigation Channel. The

effects of periodic maintenance dredging for this facility on the dissolved oxygen regime in the harbor would be expected to be minor and temporary.
The Savannah Harbor Navigation Project will continue to be maintained at its authorized depth of 42 feet MLW. Dredging and disposal operations have a minimal short-term effect on dissolved oxygen levels in the harbor.

The other known potential additional stress to the dissolved oxygen regime in Savannah Harbor is the SHEP.

Incremental Impact

Many facets of a harbor deepening project have the potential to adversely affect the water quality regime. From a construction perspective, the dredging and disposal of sediments alters turbidity and dissolved oxygen, thereby potentially impairing water quality. However, the studies that were conducted to analyze the impacts associated with the SHEP indicate that dredging and sediment placement activities will not have major impacts on the water quality regime in the estuary. These findings are presented in Chapter 5 of the EIS.

Harbor deepening would have substantial effects on the salinity regime in the estuary. Increases in upstream salinity levels would adversely affect tidal freshwater marsh and fishery habitat. These types of impacts and the methods to ameliorate those impacts have been previously discussed in this cumulative impact analysis and in Chapter 5 of the EIS.

The remaining water quality issue is the effects of harbor deepening on the dissolved oxygen regime. Model studies indicate that all of the channel deepening alternatives under consideration would decrease dissolved oxygen levels without mitigation. Degradation of the dissolved oxygen regime in Savannah Harbor has the potential to adversely affect numerous aquatic species.

Dissolved oxygen concerns relating to harbor deepening can be divided into three issues: (1) as the channel depth increases, the ability of oxygen to reach the river bottom decreases, causing lower average concentrations of dissolved oxygen at the bottom, (2) as the channel prism enlarges, additional saltwater is moved to the upper portions of the harbor and into the estuary, decreasing the ability of those waters to accept oxygen from the air, and (3) as the channel prism enlarges, the average velocity decreases, reducing the mixing of oxygen throughout the water column. If dissolved oxygen concentrations decrease to unacceptable levels, it could have deleterious effects on fish and other aquatic organisms. Lower dissolved oxygen concentrations also reduce the ability of the estuary to handle the point- and non-point source loads of pollutants entering the estuary.

The SHEP is evaluating five deepening plans which would deepen the harbor to 44, 45, 46, 47 or 48 feet MLW. Implementation of any of these harbor deepening plans could cause negative impacts to the dissolved oxygen regime if not mitigated.

Two models were used during the SHEP to evaluate the impacts of the harbor deepening alternatives on the dissolved oxygen regime in Savannah Harbor. The Environmental Dynamics

Code (EFDC) model was used to develop the hydrodynamic data and then linked to the Water Quality Analysis Simulation Program Version 7.0 (WASP7) to predict dissolved oxygen concentrations. Evaluations were conducted based on average (August 1997) and drought (August 1999) river flow conditions. The study evaluated 26 spatial zones within the estuary and they extended from Clyo, Georgia (61 miles above Fort Pulaski) to the Atlantic Ocean (17 miles offshore from Fort Pulaski). Figure 9 shows the 26 zones, which include 11 zones for Front River (FR), 6 zones for Middle River(MR), 3 zones for Back River (BR), 3 zones for Little Back River (LBR), 2 zones for South Channel (SC), and 1 zone for the Savannah River (SR). The South Carolina standards for dissolved oxygen were used to evaluate the severity of impacts, because they were the most restrictive at the time of the study (daily average of 5mg/l, with an instantaneous minimum of 4.0 mg/l, applied throughout the water column).

From a general perspective, the model shows that harbor deepening without mitigation would result in insignificant (1-2%) increases in the percentage of dissolved oxygen in the harbor's waters with violations of existing dissolved oxygen standards. There would be upstream shifts of lower dissolved oxygen zones in bottom and surface layers of the estuary as the channel deepening increases in magnitude. The studies also indicate that deteriorations of the lowest dissolved oxygen values along critical cells (the cell with the lowest dissolved oxygen concentrations during specified simulation period) of major parts of the estuary increase proportionately to the amount of deepening.

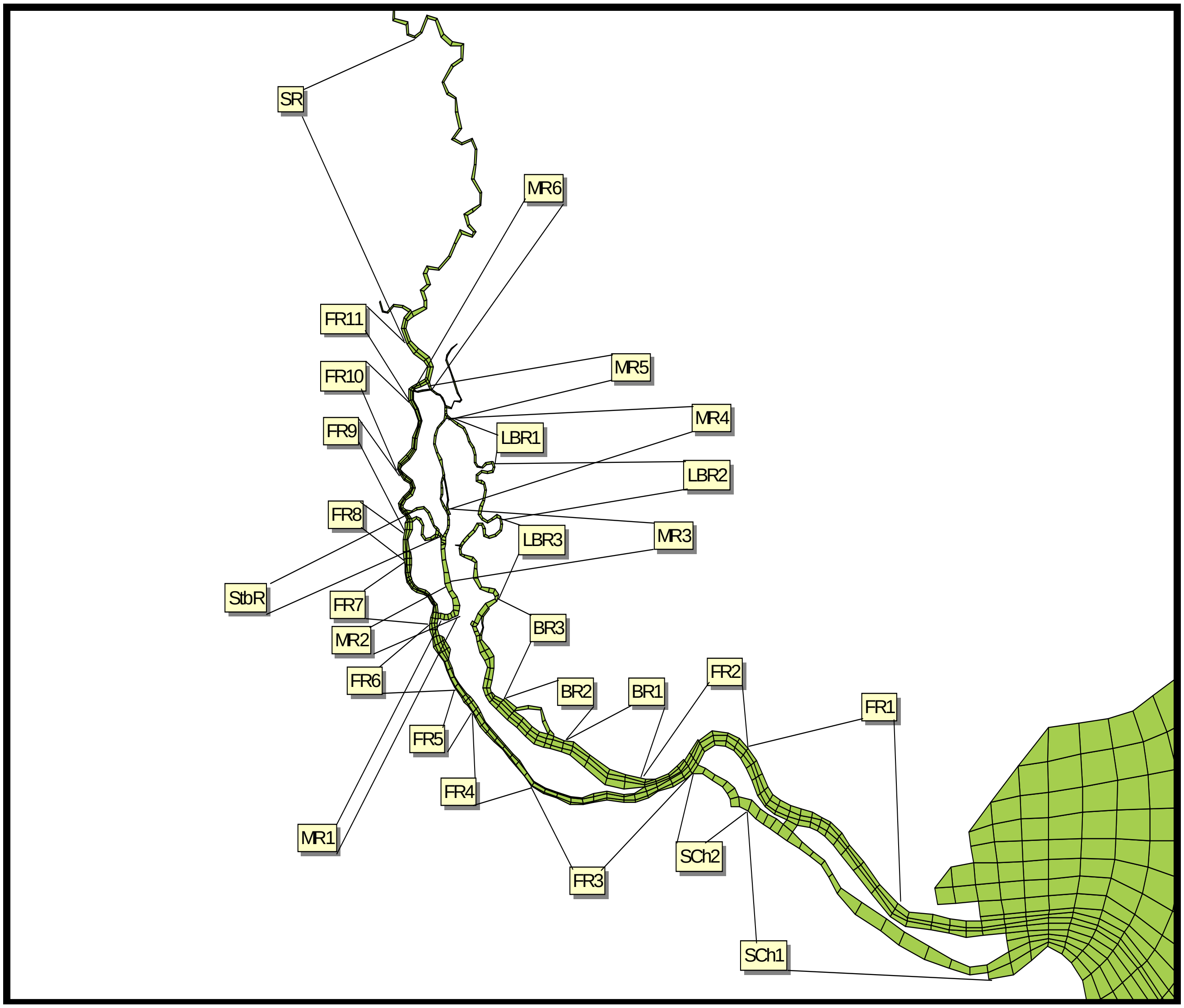

Figure 9. 26 Spatial Zones-SHEP Dissolved Oxygen Study

NOTE: The following data show dissolved oxygen levels without mitigation for D.O., but with the flow re-routing components of the harbor deepening alternatives. These data also reflect conditions in the bottom half of the water column (i.e., bottom 3 layers of the 6-layer model), where dissolved oxygen levels are lower. For the data shown in Tables 13-17, the Corps identified a decrease in dissolved oxygen as substantial when values reported in the 10%-tile Project Baseline Difference category were reduced by 0.25 mg/l.

Table 13 shows the predictions for the dissolved oxygen regime deterioration for the 48-foot channel project (1999 drought conditions). The most dissolved oxygen deterioration would occur with the 48-foot channel project. Critical cells of Front River Zones FR6, FR-7, FR8 and FR11, Middle River Zone MR1, as well as critical cells in Back River Zones BR1, BR2 and BR3 show a substantial decrease in dissolved oxygen levels, while dissolved oxygen would increase in Front River Zones FR2, FR3, FR4, FR5, FR9, FR10, Middle River Zones MR 2, MR3, MR4, MR5, MR6, and Lower Back River Zones LBR1 and LBR2.

Table 13. Predicted Dissolved Oxygen Decreases: 48-foot Channel (No Mitigation)

Zone Name	Relative Percent Difference from Existing Condition								
	1%	5%	10%	25%	50%	75%	90%	95%	99%
FR1	0.8	0.5	0.0	0.0	-0.7	-0.9	-2.2	-2.4	-3.0
FR2	-0.8	8.5	8.8	7.4	5.6	4.4	3.4	3.5	-2.2
FR3	4.5	2.6	2.9	2.2	-0.5	-2.9	-5.7	-2.9	-4.7
FR4	5.1	3.8	2.9	1.1	-0.8	-5.0	-9.6	-8.0	-1.9
FR5	4.6	4.2	2.7	0.8	-1.2	-8.1	-13.9	-11.6	-10.0
FR6	1.7	1.1	-0.5	-0.3	-3.3	-10.8	-14.1	-11.6	-9.7
FR7	-4.5	-3.2	-3.1	-6.6	-11.9	-21.4	-11.7	-5.5	-3.1
FR8	-7.4	-8.0	-11.0	-15.0	-11.5	-7.2	-5.4	-4.2	-5.8
FR9	6.4	11.3	6.5	5.2	1.3	0.6	1.0	2.0	4.2
FR10	8.8	5.4	5.9	4.3	-0.2	-1.6	-1.3	-2.3	-0.8
FR11	0.2	-2.6	-2.4	-2.3	-0.2	0.0	-1.4	0.3	-2.8
MR1	-5.5	-5.3	-5.6	-5.9	-5.5	-9.1	-8.6	-8.1	-4.2
MR2	4.2	4.4	3.0	0.9	-2.4	-6.8	-5.2	-4.8	-4.8
MR3	12.8	10.6	11.9	10.6	9.2	3.0	-6.0	-7.3	-9.1
MR4	11.6	10.2	10.5	8.5	9.6	9.0	10.9	10.7	11.1
MR5	47.7	35.8	29.5	26.6	7.8	-0.6	-0.8	-1.6	-1.3
MR6	191.0	153.0	114.0	89.2	23.0	13.9	9.1	6.4	4.0
LBR1	14.0	10.8	7.6	7.2	7.0	8.2	5.9	6.2	3.6
LBR2	16.3	18.1	18.1	18.6	17.4	17.4	16.4	17.1	10.9
LBR3	-13.5	-19.5	-19.4	-18.0	-15.8	-16.0	-18.9	-21.2	-21.8
BR1	-43.5	-35.4	-23.3	-7.0	3.4	12.3	12.0	11.3	10.8
BR2	-40.7	-33.1	-29.7	-23.2	-13.9	-3.1	2.2	3.2	4.2
BR3	-41.8	-38.1	-38.9	-36.8	-32.9	-24.5	-15.5	-13.5	-11.1
SCh1	-7.1	-0.8	1.2	1.9	4.5	17.9	13.6	14.7	11.5
SCh2	-0.8	-2.6	-2.1	-1.0	-0.7	-1.1	-1.3	-1.5	-2.3
SR	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
StbR	-4.7	2.1	-0.9	0.4	-1.8	-3.1	-3.2	-3.9	-3.2

Table 14 shows the predictions for the dissolved oxygen regime deterioration of the 47-channel project. For the 47-foot channel, a substantial decrease in dissolved oxygen would occur in the critical cells of Front River Zone FR7, FR8, FR11, Middle River Zone MR1, Little Back River Zone LBR3, and Back River Zones BR1, BR2 and BR3. Dissolved oxygen would increase in Front River Zones FR1, FR2, FR3, FR4, FR5, FR9, F10, Middle River Zones MR2, MR3, MR4, MR5, MR6, and Lower Back River Zones LBR1 and LBR2.

Table 14. Predicted Dissolved Oxygen Decreases: 47-foot Channel (No Mitigation)

Zone Name	Relative Percent Difference from Existing Condition								
	1%	5%	10%	25%	50%	75%	90%	95%	99%
FR1	0.5	0.5	0.3	0.2	-0.7	-0.9	-1.8	-1.9	-1.9
FR2	-2.8	7.9	8.6	6.9	5.6	4.4	3.6	3.8	-2.4
FR3	4.5	2.3	2.6	1.9	-0.3	-2.4	-4.6	-0.2	-2.9
FR4	5.1	3.5	2.6	0.8	-0.5	-4.5	-8.2	-6.0	0.6
FR5	4.6	3.1	1.4	0.0	-2.2	-11.3	-12.2	-11.8	-10.4
FR6	2.0	1.6	0.0	0.3	-2.9	-9.2	-11.7	-9.9	-8.1
FR7	-4.3	-2.7	-2.9	-6.4	-11.3	-18.7	-7.7	-4.3	-2.8
FR8	-6.5	-6.9	-10.2	-14.0	-9.0	-5.8	-4.9	-4.0	-5.6
FR9	1.1	6.2	2.9	5.5	1.9	1.7	2.5	3.0	2.5
FR10	8.8	5.4	5.7	4.3	-0.3	-1.7	-1.3	-2.3	-0.8
FR11	0.2	-2.3	-2.4	-2.5	-0.2	0.0	-1.4	0.3	-2.7
MR1	-4.7	-4.6	-5.4	-5.1	-5.0	-8.3	-7.6	-6.7	-3.7
MR2	4.5	5.1	3.5	0.0	-4.2	-7.5	-5.9	-5.5	-1.7
MR3	12.8	11.1	12.2	11.1	9.6	3.8	-5.5	-6.6	-8.1
MR4	12.1	10.2	11.2	8.7	9.8	8.8	10.5	10.5	11.1
MR5	47.7	36.3	29.5	26.6	7.8	-0.6	-0.5	-1.6	-1.1
MR6	191.0	153.4	114.3	89.2	23.0	13.9	9.0	6.4	4.0
LBR1	13.7	10.8	7.8	7.2	6.8	8.0	5.9	6.2	3.4
LBR2	21.5	18.4	18.1	18.3	17.4	17.2	16.4	16.7	10.7
LBR3	-12.2	-18.9	-18.5	-17.4	-15.3	-16.0	-18.7	-21.6	-22.6
BR1	-46.3	-38.7	-26.5	-8.1	2.9	11.9	12.4	11.8	11.0
BR2	-43.6	-36.8	-32.5	-25.4	-15.2	-4.2	0.8	2.4	4.5
BR3	-44.6	-41.3	-41.9	-39.4	-35.3	-27.4	-17.3	-15.5	-13.1
SCh1	-4.0	-2.9	0.8	3.4	1.7	-4.5	-3.8	-3.2	-5.9
SCh2	-1.4	-2.6	-2.1	-1.0	-0.7	-1.1	-0.7	-1.3	-1.3
SR	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
StbR	-2.6	1.9	0.2	1.2	-0.5	-2.4	-2.6	-2.9	-2.8

Table 15 shows the predictions for the dissolved oxygen regime deterioration of the 46-channel project. For the 46-foot channel, a substantial decrease in dissolved oxygen would occur in the critical cells of Front River Zone FR1, FR8, FR9, FR11, Middle River Zone MR 1, Little Back River Zone LBR3 as well as Back River Zones BR1, BR2 and BR3. Dissolved oxygen would increase in Front River Zones FR2, FR3, FR4, FR5, FR6, FR7, FR10, Middle River Zones MR2, MR3, MR4, MR5, MR6 and Lower Back River Zones LBR1 and LBR2.

Table 15. Predicted Dissolved Oxygen Decreases: 46-foot Channel (No Mitigation)

Zone Name	Relative Percent Difference from Existing Condition								
	1%	5%	10%	25%	50%	75%	90%	95%	99%
FR1	0.5	-0.3	-0.5	0.0	-0.7	-0.5	-1.5	-1.5	-2.1
FR2	-5.1	7.4	7.8	6.9	5.6	4.7	3.6	3.8	-2.0
FR3	3.9	1.7	2.3	1.9	0.0	-1.7	-2.8	2.0	-2.0
FR4	3.6	2.9	2.3	0.8	-0.5	-4.0	-6.9	-3.7	2.1
FR5	4.1	3.1	2.2	0.8	-1.0	-6.4	-9.9	-6.9	-5.8
FR6	2.3	1.6	0.3	0.8	-2.1	-7.5	-8.1	-6.7	-5.2
FR7	6.0	7.4	8.7	8.2	10.5	-0.3	1.0	1.7	9.4
FR8	-5.1	-6.3	-9.0	-12.4	-7.4	-4.5	-3.7	-3.2	-4.6
FR9	-6.1	-7.4	-10.2	-11.9	-6.9	-3.2	-2.8	-3.6	-2.5
FR10	8.8	5.4	5.5	4.5	-0.2	-1.9	-1.2	-2.3	-1.0
FR11	0.2	-2.8	-2.4	-2.5	0.0	0.0	-1.4	0.3	-2.8
MR1	-4.0	-4.1	-4.3	-4.2	-4.0	-7.8	-5.9	-5.4	-2.1
MR2	5.2	5.3	3.5	1.5	-1.4	-5.3	-3.7	-2.9	-3.3
MR3	14.1	10.3	11.4	11.5	9.2	3.2	-6.2	-8.4	-9.6
MR4	12.4	10.4	11.2	9.2	9.8	9.2	10.5	10.3	10.9
MR5	47.7	36.3	29.0	26.6	7.6	-0.6	-0.5	-1.6	-1.1
MR6	191.0	153.4	114.3	89.2	23.0	13.9	9.0	6.4	4.0
LBR1	12.6	10.6	8.0	7.0	6.8	8.0	5.9	6.3	3.2
LBR2	0.0	17.9	17.9	18.6	17.4	17.0	16.4	16.9	10.7
LBR3	-10.8	-18.9	-18.2	-16.9	-15.3	-16.0	-19.1	-21.4	-22.2
BR1	-48.6	-42.7	-29.9	-10.0	1.8	11.4	12.4	12.0	11.0
BR2	-48.6	-40.4	-36.4	-27.7	-16.1	-5.1	0.3	2.1	4.2
BR3	-47.7	-44.2	-43.7	-40.8	-36.4	-29.5	-19.1	-16.5	-14.8
SCh1	-5.3	-3.7	1.6	3.0	1.0	-4.2	-4.9	-2.6	-4.2
SCh2	-0.6	-1.1	-1.3	-1.2	-1.0	-1.1	-1.1	-0.9	-0.9
SR	-0.2	0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
StbR	-0.8	2.6	1.3	2.0	-0.5	-1.3	-2.0	-2.4	-2.8

Table 16 shows the predictions for dissolved oxygen regime deterioration for the 45-foot channel. For the 45-foot channel, a substantial decrease in dissolved oxygen would occur in the critical cells of Front River Zones FR7, FR8, FR9, and FR11, Middle River Zone MR 1, Little Back River Zone LRB3 as well as Back River Zones BR1, BR2 and BR3. Dissolved oxygen would increase in Front River Zones FR2, FR3, FR4, FR5, FR6, FR10, Middle River Zones MR2, MR3, MR4, MR5, MR6 and Lower Back River Zones LBR1 and LBR2.

Table 16. Predicted Dissolved Oxygen Decreases: 45-foot Channel (No Mitigation)

Zone Name	Relative Percent Difference from Existing Condition								
	1%	5%	10%	25%	50%	75%	90%	95%	99%
FR1	0.8	0.0	0.0	0.2	-0.5	-0.5	-0.9	-1.1	-1.5
FR2	-7.9	7.9	8.3	6.9	5.9	4.7	4.0	4.0	-1.8
FR3	3.9	1.7	2.3	3.0	0.5	-0.7	-2.0	2.4	-1.3
FR4	3.6	2.3	2.3	2.1	0.8	-1.9	-3.6	0.8	3.0
FR5	4.1	2.5	0.8	0.0	-1.7	-11.5	-8.4	-7.6	-6.7
FR6	2.3	2.2	0.8	1.5	-1.0	-4.8	-4.5	-4.3	-2.4
FR7	-3.0	-1.7	-2.4	-4.5	-8.2	-11.8	-3.4	-2.5	-1.9
FR8	-4.5	-5.4	-7.6	-10.2	-5.1	-3.6	-3.6	-2.5	-3.5
FR9	-5.3	-6.4	-8.8	-9.8	-5.4	-2.4	-2.3	-3.6	-2.5
FR10	8.8	5.4	5.5	4.3	-0.2	-1.9	-1.2	-2.3	-1.0
FR11	0.2	-2.3	-2.4	-2.5	0.0	0.0	-1.4	0.2	-2.7
MR1	-3.1	-3.2	-3.4	-3.4	-3.0	-6.4	-4.3	-3.5	-1.3
MR2	5.2	5.6	4.0	1.7	-0.8	-4.2	-2.8	-1.9	-2.8
MR3	13.9	12.1	12.4	11.5	10.3	4.6	-4.1	-4.9	-7.2
MR4	13.2	10.4	11.7	9.2	9.8	8.8	10.5	10.3	10.8
MR5	48.3	37.3	29.0	25.9	7.6	-0.6	-0.6	-1.6	-1.1
MR6	191.0	153.8	114.6	89.2	23.0	13.7	9.0	6.4	4.0
LBR1	12.3	10.8	8.2	7.0	6.6	7.8	5.7	6.2	3.1
LBR2	21.5	18.7	18.1	18.6	17.1	17.2	16.4	17.3	23.5
LBR3	-10.1	-17.7	-17.6	-16.9	-14.8	-15.5	-18.7	-21.4	-22.2
BR1	-53.0	-46.3	-33.7	-11.4	1.6	10.9	12.9	12.0	11.7
BR2	-51.4	-41.5	-38.1	-30.5	-17.6	-5.9	-0.3	1.6	3.1
BR3	-52.6	-47.1	-46.4	-42.5	-38.6	-31.6	-20.6	-18.5	-15.5
SCh1	-7.1	1.2	0.0	2.2	7.3	19.7	16.0	15.5	12.0
SCh2	0.0	-1.1	-0.5	-0.7	-0.5	-0.9	-0.9	-0.9	-0.4
SR	-0.2	-0.2	-0.2	-0.2	0.0	-0.2	-0.2	-0.2	-0.2
StbR	2.3	3.8	2.4	2.4	-0.2	-1.0	-1.7	-2.0	-1.6

Table 17 shows the predictions for the dissolved oxygen regime deterioration of the 44-foot channel project. For the 44-foot channel, a substantial decrease in dissolved oxygen would occur in the critical cells of Front River Zones FR1, FR5, FR6, FR7, FR8, FR11, Middle River Zones MR1 and MR5, Lower Back River Zone LBR 3 as well as Back River Zones BR1, BR2 and BR3. Dissolved oxygen would increase in Front River Zones FR2, FR3, FR4, FR9, FR10, Middle River Zones MR2, MR3, MR4, MR6, Lower Back River Zones LBR1 and LBR2 and Back River Zones BR1, BR2, and BR3. The changes in dissolved oxygen profiles for the 44-foot depth alternative are considerably different from the other alternatives since the flow rerouting components are different with this channel depth alternative.

Table 17. Predicted Dissolved Oxygen Decreases: 44-Foot Channel (No Mitigation)

Zone Name	Relative Percent Difference from Existing Condition								
	1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
FR1	-0.3	-0.8	-1.0	-0.5	-0.7	-0.2	-0.9	-0.4	-1.3
FR2	-9.0	7.4	7.0	6.4	5.9	4.9	4.0	4.4	-1.8
FR3	3.0	0.9	1.4	2.4	0.8	0.0	1.3	3.9	-0.2
FR4	3.3	1.7	2.0	1.3	0.5	-1.9	-2.9	-1.8	0.9
FR5	3.2	1.7	-0.5	-0.8	-2.7	-11.1	-7.0	-6.0	-4.9
FR6	1.4	0.3	-1.1	0.5	-1.9	-6.0	-4.0	-2.9	-1.7
FR7	-2.5	-1.7	-1.9	-3.9	-7.2	-6.7	-2.6	-2.2	-1.5
FR8	-3.6	-4.1	-6.3	-8.5	-3.1	-2.0	-2.8	-2.5	-3.5
FR9	7.0	14.0	10.0	9.1	3.4	2.4	3.2	2.7	2.4
FR10	7.0	4.8	4.0	3.0	-1.0	-2.6	-1.6	-3.6	-1.1
FR11	-13.9	-12.8	-11.6	-9.0	-0.7	-1.1	-2.2	-1.7	-4.1
MR1	-2.6	-2.5	-2.5	-2.8	-2.6	-6.0	-2.6	-1.9	-0.6
MR2	3.7	4.1	2.1	0.4	-2.6	-4.2	-1.6	-1.0	-1.5
MR3	11.4	7.7	9.6	8.2	6.7	1.6	-7.4	-8.4	-9.6
MR4	-0.8	16.2	19.5	19.0	19.0	18.3	20.2	21.4	24.7
MR5	-6.0	-23.5	-24.5	-16.4	0.8	-1.9	-1.7	-2.5	-2.0
MR6	157.3	134.9	104.7	86.0	21.2	12.4	8.4	5.8	3.4
LBR1	-10.9	-3.4	1.7	2.3	1.5	2.7	1.8	2.3	0.6
LBR2	3.8	6.5	6.0	6.0	5.9	5.9	5.0	6.4	8.4
LBR3	-39.6	-41.2	-40.8	-35.1	-30.4	-28.8	-29.8	-30.7	-32.0
BR1	-70.5	-57.6	-49.1	-32.9	-19.1	-3.7	-3.3	-3.5	-3.1
BR2	-79.0	-72.1	-64.3	-46.9	-33.3	-29.1	-24.0	-21.4	-19.1
BR3	-75.6	-68.3	-66.6	-60.3	-54.8	-41.6	-28.8	-24.8	-22.3
SCh1	-3.1	-1.7	0.4	0.7	1.0	-3.0	-3.5	-1.6	-3.9
SCh2	0.0	-1.1	-0.8	-0.7	-0.5	-0.9	-0.9	-0.9	0.0
SR	-0.2	-0.2	-0.2	-0.2	0.0	-0.2	-0.2	-0.2	-0.2
StbR	5.7	5.7	3.5	3.2	0.4	-0.6	-1.4	-1.1	-0.9

Model scenarios were also run for average flow conditions (1997). The deterioration of the dissolved oxygen regime is not as pronounced as for drought conditions, and most of the major decreases in dissolved oxygen levels are predicted to be in the critical cells of Front River Zones FR7, FR8 and FR9.

Alternatives to Mitigate for Cumulative Effects

As discussed in previous sections of this analysis, Mitigation Plan 6B would be implemented with the 44-foot channel project to help offset expected increases in upstream salinity levels while Mitigation Plan 6A would be used for the 45, 46, 47 and 48-foot channel projects. Basically, these plans reduce the anticipated increase in salinity levels by reducing salt water flows into Back, Little Back River, and Middle Rivers, while providing more freshwater inflow to these streams. While increasing freshwater into these streams would reduce salinity levels and thus improve dissolved oxygen levels, the increase in dissolved oxygen levels would not be sufficient to offset the expected impacts. Also, Mitigation Plans 6B and 6A would not help to ameliorate predicted adverse effects to the dissolved oxygen regime in Front River. Consequently, an additional mitigation measure was required to offset expected decreases in dissolved oxygen levels that would result from the harbor deepening plans.

An evaluation of mitigation alternatives with respect to the dissolved oxygen regime revealed that injection of oxygen into the river was the most efficient and feasible means to mitigate for adverse effects to the dissolved oxygen regime in Savannah Harbor. Further investigations indicated that use of the Speece Cone would be the most appropriate method to mitigate impacts associated with harbor deepening. This device was originally used to add oxygen to the bottom of lakes to enhance downstream fisheries. Basically, the technology involves super-oxygenating a portion of the river water and then reintroducing it back into the river, where it mixes with and is diluted by the main flow.

The SHEP models were further used to determine the quantities of oxygen that would be needed and the locations of the dissolved oxygen facilities for each harbor deepening alternative. Two evaluations were conducted. The first investigation was to determine how much oxygen would be required to meet the existing dissolved oxygen levels for the five harbor deepening plans under consideration. The conditions of August 1997 (average flow year) were selected as the flow and meteorological conditions for this evaluation. An average flow year was selected over the drought year (1999) because there would be a greater amount of oxygen needed to treat the increased volume of water that would occur in an average flow year.

Table 18 shows a summary of dissolved oxygen loads and costs associated with mitigation for each of the alternative channel depths under consideration. As expected, the requirements for the 48-foot channel are substantially greater than those for the 44-channel. The costs for operating the oxygen injection systems are based on their continued operation for a period of 4 months per year. The operation period could vary depending on actual conditions from year to year.

Table 18. Dissolved Oxygen Needs To Meet Existing Dissolved Oxygen Levels

Scenario Description	D.O. Discharge Location	Cell (I,J,K) Coordinates	Load (kg/day)	Sum	Volume mitigation (%) for the percentiles:			
				1000 kg/day	5%	10%	25%	50%
Plan 6A	IP (FR)	14, 66, 6	7000					
6 ft deepening	IP (BR)	31,70, 6	2000	18000	97.9	97.8	98.1	97.3
(GP+IP_13m)	Georgia-Pacific	14, 171, 6	9000					
Plan 6A	IP (FR)	14, 66, 6	3000					
5 ft deepening	IP (BR)	31,70, 6	2000	16000	98.2	97.5	97.9	97.3
(5F-5m)	Georgia-Pacific	14, 171, 6	11000					
Plan 6A	IP (FR)	14, 66, 6	2000					
4 ft deepening	IP (BR)	31,70, 6	2000	14000	97.6	97.2	97.4	97.7
(4F-3m)	Georgia-Pacific	14, 171, 6	10000					
Plan 6A	IP (FR)	14, 66, 6	1000					
3 ft deepening	IP (BR)	31,70, 6	2000	13000	98.1	97.4	97.7	98.5
(3F-3m)	Georgia-Pacific	14, 171, 6	10000					
Plan 6B	IP (FR)	14, 66, 6	1000					
2 ft deepening	IP (BR)	31,70, 6	4000	15000	97.2	97.3	97.6	97.8
(2B-6m)	Georgia-Pacific	14, 171, 6	10000					

Study investigations indicate that oxygen would have to be injected at three locations. All three injection locations (near Georgia Power's Plant McIntosh, Hutchinson Island – west, Hutchinson Island –east) would be needed for each channel depth alternative. The systems would be land-based, with water being withdrawn from the river through pipes, then super-saturated with oxygen and returned to the river. The water intake structure would include screens to reduce the intake of trash and other suspended solids. The screens would be sized to keep flow velocities from exceeding 0.5 foot per second to minimize entrainment of fish larvae. The intake and discharge would be located along the side of the river and not extend into the authorized navigation channel. The systems would be operated to provide the needed amount of oxygen for that depth alternative during the months of July, August, and September. The Corps would begin to operate the systems on 15 June to allow the dissolved oxygen to be fully distributed throughout the estuary by 1 July.

With all oxygen injection designs, dissolved oxygen levels are higher near the injection site and taper off to lower levels as distance from the injection site increases. Removing the incremental adverse project effect at a great distance from an injection site requires large amounts of oxygen. This becomes a tradeoff between the amount of oxygen required (operating expense) and the number of injection locations (capital expense). As the number of injection locations increases, the complexity (and cost) of maintaining numerous systems also increases. The oxygen injection system configuration is designed to remove the incremental effect of a deeper channel in 97 percent of the cells in the hydrodynamic model. The minor impact at distances away from the injection location is balanced by the higher dissolved oxygen levels that would occur close to where the oxygen is added. The Corps believes the 97 percent level of performance recognizes both the higher dissolved oxygen levels close to the injection sites and the limitations of the model at distinguishing small differences between different run conditions.

Monitoring

Extensive monitoring would be conducted to verify model predictions relative to both post-deepening dissolved oxygen concentrations and oxygen injection needs. The mitigation plan includes ten years of Post-Construction data to be collected from the 8 continuous hydrologic and hydraulic data recorders. The dissolved oxygen data collected in the field would be used with the updated hydrodynamic and water quality models to evaluate how the oxygen injection systems are performing with respect to removing the incremental effects of the project on the dissolved oxygen regime in Savannah Harbor.

The monitoring program for the oxygen injection system also includes a Transfer Efficiency Study which would be conducted after the systems become operational. This study would identify the efficiency at which the systems add oxygen to estuarine waters. This efficiency rate would be used to determine how the systems should be operated to add the amount of oxygen determined by the modeling to be needed to compensate for the impacts of the SHEP.

11. Groundwater

Issue

The potential for additional saltwater to enter the Upper Floridan aquifer is the next major concern addressed in this cumulative impact analysis. The Upper Floridan aquifer is the primary source of groundwater for Chatham County, Georgia as well as other areas of Coastal Georgia and South Carolina

Geographic Scope and Geological Setting

The Floridan aquifer system underlies parts of Alabama, Georgia, South Carolina, and Florida and supplies approximately 50% of the groundwater in Georgia (Kressler et. al., 2001). The aquifer system is divided into two main aquifers: the Upper Floridan and Lower Floridan. Within Chatham County and the study area, the Upper Floridan aquifer is the primary source of ground-water. The immediate area of concern is the project area where the dredging for harbor deepening would occur which is from Mile 18.8 (Kings Island Turning Basin) of Savannah Harbor to what would be about Mile 18.6 of the bar channel.

Eastern Chatham County is underlain by approximately 2,000 feet of sedimentary Coastal Plain sediments ranging in age from Holocene to Cretaceous (Miller, 1986). From land surface to a depth of about 500 feet, the sediments (in descending order) are described as Pleistocene-Recent (surficial aquifer), Upper and Middle Miocene (the upper confining unit of the aquifer), and Late and Early Oligocene (Upper Floridan aquifer).

The Pleistocene Recent unit contains fluvial sands, silts and clays that overlie the Miocene unit. These sediments, typically about 60 to 75 feet thick but locally as much as 130 feet thick, contain mainly low-permeability confining beds but contain thin permeable sands in some areas.

Groundwater within these sands occurs under both water table (unconfined) and artesian (confined) conditions, and the elevation of the water table is typically higher than the heads of underlying aquifers. Daily withdrawals of ground-water from this surficial aquifer are estimated to be 120,000-855,000 gallons per day in the Savannah area (Clark et al., 1990).

The Miocene unit (confining unit of the Upper Floridan aquifer) consists of green-colored clays, silts, clayey silts, and sandy or silty clays. The top of the Miocene unit in the study area occurs at an average depth of -45 feet MLW, and its thickness ranges from less than 30 feet near the Tybee high (an anticlinal structure along the navigation channel between Stations 20+000 and -23+000B) to 160 feet near downtown Savannah.

The Oligocene unit (the uppermost unit of the Floridan aquifer) is composed of limestone. The elevation of the top of the Oligocene unit ranges from -95 feet MLW near the Tybee high to about - 200 feet MLW near downtown Savannah. Consequently, the Tybee high is the feature of most concern since the top of the Miocene confining unit and the Oligocene unit is nearest the land surface.

Historic

Prior to industrial and agricultural development, the flow system was considered steady state. Recharge was equal to natural discharge (artesian springs, streams, etc.), and ground water levels showed little fluctuation.

Past Actions/Stresses

Since the 1800s, increasing withdrawals of water from the Upper Floridan aquifer to support development in the coastal region have caused a cone of depression to form in the Savannah area and lowered the water level in the aquifer to as much as 100 feet below sea level (Peck et al., 1999). Consequently, this has resulted in an unbalance of recharge and discharge rates. The increased pumping has lowered water levels, induced additional recharge and reduced natural discharge, and increased total flow through the system (Krause and Randolph, 1989).

The long-term pumping of the Upper Floridan aquifer in the Savannah area and surrounding coastal areas has lowered groundwater levels and reversed the seaward hydraulic gradient that existed before development (Garza and Krause, 1996; Krause and Randolph, 1989). Figure 10 illustrates the effects of long-term pumping. The increased withdrawal of water from the Upper Floridan aquifer has resulted in radial flow toward the center of pumping and a cone of depression beneath Savannah.

This reversal in hydraulic gradient has resulted in lateral encroachment of seawater that has been observed in two ways. First, lateral encroachment is expressed by the westward movement of the freshwater/saltwater interface toward the center of pumping (Savannah). Second, lateral encroachment is seen at Port Royal Sound in South Carolina where the confining unit is completely absent and the aquifer is directly overlain by saltwater. Saltwater enters the aquifer and moves southward (laterally) toward the center of pumping. This effect has been well documented as elevated chloride levels in Floridan wells at the north end of Hilton Head, South Carolina (Smith, 1988; Ransom et al., 2006).

Sustained pumping in the Savannah area has also resulted in a downward hydraulic gradient and induced significant head differences between the surficial aquifer and the confined Upper Floridan aquifer (Clark et al., 1990). This effect has resulted in the downward intrusion of water through the Miocene into the aquifer. The Savannah District US Army Corps of Engineers (1998) and Clark (1999) documented downward hydraulic gradients through the upper confining unit at four well locations in the Savannah area. These studies indicate that downward leakage of water through the confining unit contributes a significant amount of water to the flow system.

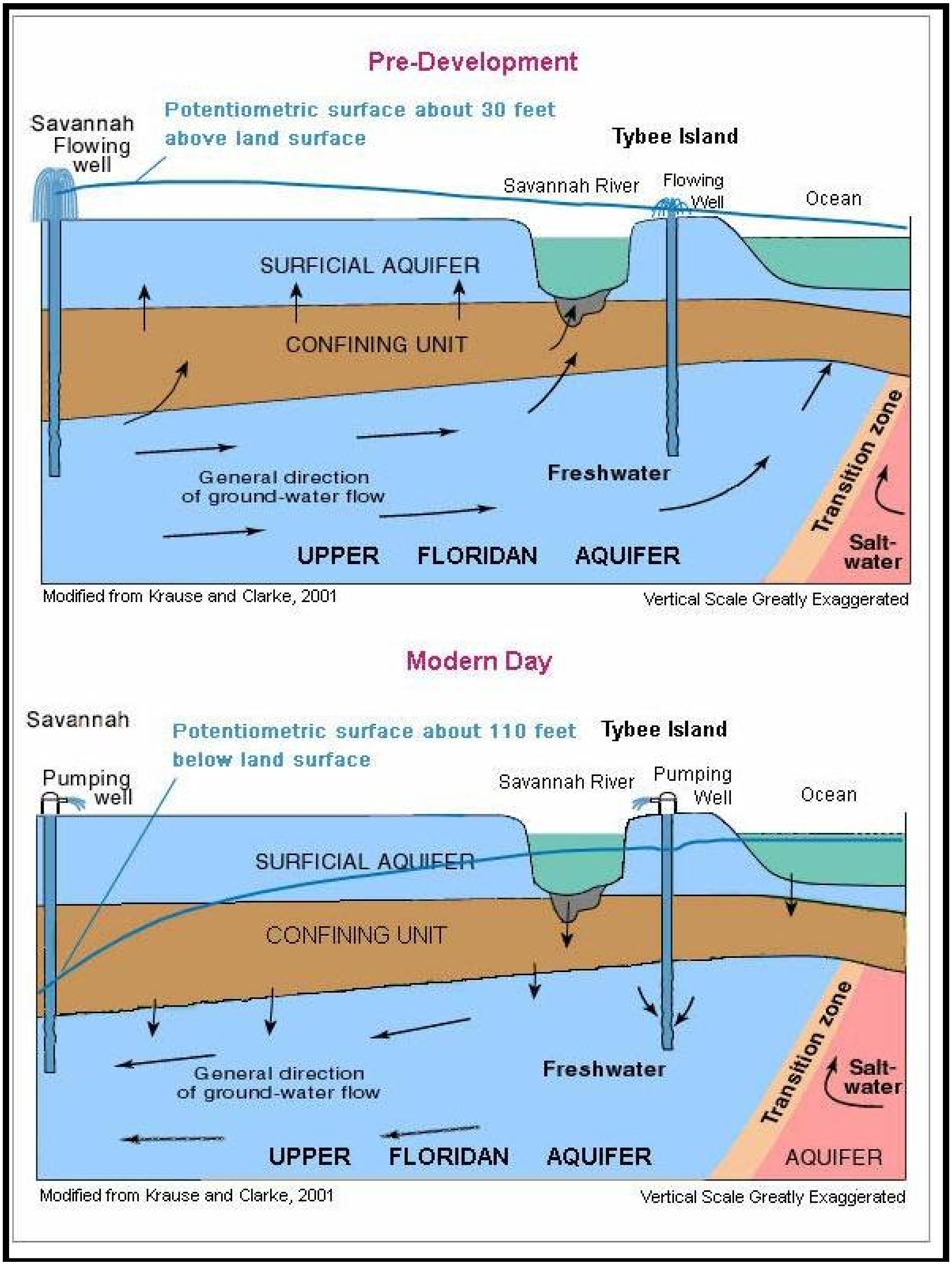

Figure 10. Pre-development and present ground-water flows.

Improvements (deepening) and maintenance of the Savannah Harbor Navigation Project have also had some impact on the downward migration of water through the confining unit into the aquifer. Channel dredging has removed portions of the Pleistocene sands and Miocene clays that reside above the upper Floridan aquifer. The Miocene is exposed in some portions of the bottom of the navigation channel. Significant exposure of the Miocene in the navigation channel is a fairly recent event. GIS studies conducted as part of the SHEP indicate that exposure of large stretches of Miocene along the Bight Channel (Elba Island) and near the Kings Island Turning Basin appeared to have occurred between 1992 and 1998. Completion of the dredging of the existing 42-foot channel in 1994 may at least partially explain this observation.

Present Conditions

The upper Floridan aquifer serves as the most important source of ground water in the study area, providing some 82 million gallons per day (MGD) of ground water in Chatham County. This withdrawal rate is down from a maximum of 88 MGD in 1990 due to a reduction in industrial pumping. This pumping has created a cone of depression, greatly reducing or eliminating the artesian pressure that had previously existed in the Savannah area. Previous studies indicate that a withdrawal of 82 MGD at Savannah produces about a 90-foot drop in head in the upper Floridan aquifer. Lowering of the artesian pressure has resulted in a landward movement of the saltwater/freshwater interface in this aquifer (saltwater intrusion).

Depressed groundwater heads in the Upper Floridan aquifer due to Savannah area pumping also induce downward flow of water through the Miocene to the aquifer. The downward leakage of water through the confining unit contributes a significant amount of water to the flow system in the area. The leakage has been estimated to represent nearly half the water budget for the Savannah area, or 40 MGD (Garza and Krause, 1996). Some of this downward flow of water is saltwater. Thus, these vertical head gradients are the dominant forces that cause the downward movement of saltwater through the Miocene confining unit.

Pumping of groundwater from the upper Floridan aquifer is expected to continue in the future. In Chatham County, this water is used for municipal and industrial purposes. Demands for this water are expected to increase as the population of the County grows.

The GA DNR-EPD "Interim Strategy for Managing Salt Water Intrusion in the Upper Floridan Aquifer of Southeast Georgia" (1997 – 2005) called for reducing total permitted volumes for pumping in Chatham County from the upper Floridan aquifer by 10 MGD. This policy was implemented. While this action limits the permitted level of withdrawals -- not necessarily the amount actually being withdrawn, it effectively caps groundwater use rates at 1997 levels. By the summer of 2001, GA DNR-EPD had fully allocated the 36 MGD of groundwater that was available for permitting. Since then, they have issued no new permits for withdrawal in this area.

Another component of the Interim Strategy is that GA DNR-EPD will not issue any new withdrawal permits for the upper Floridan aquifer in Chatham County and the southern portions of Bryan and Effingham Counties – the counties located westward and immediately adjacent to Chatham County.

The Coastal Sound Science Initiative (CSSI) was initiated by the GA DNR-EPD in 1998. This was the second stage of the interim strategy. It included an array of scientific and engineering investigations intended to generate the information and data required to develop a more well-founded plan for managing saltwater intrusion in the 24 coastal Georgia counties under the interim plan. Three sub-regions were established for purposes of implementing region specific policies and permitting requirements to stop saltwater intrusion, manage wastewater and implement water conservation and reuse practices.

Chatham, Bryan, and Liberty Counties, as well as the portion of Effingham County south of Georgia Highway 119, were included in Sub-region-1. The primary management tool for the revised plan involves no net increases in Upper Floridan aquifer withdrawals above amounts withdrawn in 2004 and a reduction in actual withdrawals by least an additional 5 MGD at the end of 2008. This plan also included water conservation and reuse and a move towards diversification of resources (a blend of surface and ground-water sources versus ground-water only).

In 2004, GA DNR-EPD modified the interim strategy by stating that it would not approve any new groundwater pumping (from any aquifer) in the capped area where surface water is reasonably available. Elsewhere, aquifers other than the upper Floridan are still available for permitting. More recently, work from the CSSI has been integrated into the development of the State Water Plan.

As discussed above, construction and maintenance of the Savannah Harbor navigation project has also contributed to the downward migration of water through the confining layer to the aquifer. The Miocene is exposed in some portions of the navigation channel. GIS analysis conducted as part of the SHEP studies indicate that approximately 5 feet of confining material has been removed from some portions of the navigation channel. Underneath the navigation channel, the overall thickness of the confining unit ranges from about 30 feet thick near the Tybee high to over 150 feet thick near downtown Savannah. GIS analysis of the removal of confining material through time and groundwater model studies conducted during SHEP studies indicate that historic dredging has probably had minimal influence on the rate of saltwater intrusion.

SHEP studies also identified eight significant paleochannels that had incised deeply into the Miocene confining layer between Stations 30+000 and Stations -30+000B. Table 19 shows the Paleochannel (described as Relic Cut and Fill (RCCF)) locations and formation elevations. RCCF 4 located near Station 9 is the area of the navigation channel with the minimum thickness (26 feet) of Miocene confining material underlying the navigation channel.

Table 19. Paleochannel Locations and Elevations

Feature Designation	Location (River Station)	Elevation of Paleochannel/Miocene Contact at Maximum Incision Depth (ft MLW)	Average Elevation of Miocene/Oligocene Contact (ft MLW)	Minimum Thickness of Miocene Confining Layer (ft)
RCCF 1	22+000	-80	-116	36
RCCF 2	20+000	-64	-116	55
RCCF 3	15+000	-74	-112	42
RCCF 4	9+000	-83	-108	26
RCCF 5	1+500	-70	-107	38
RCCF 6	-3+000	-70	-98	28
RCCF 7	-11+000	-67	-99	34
RCCF 8	-21+000	-73	-110	36

Analysis conducted during the SHEP studies indicate that the Savannah Harbor project area is not likely characterized by joints or fractures which could serve as pathways for enhanced downward flow. The absence of observable vertical joints in Miocene-aged surface exposures and subsurface cores of the Miocene show no evidence of joints or fractures. Also, there is no historical evidence (springs, etc) of joints or fractures in the area. These findings support the conclusion that fracture or joints are not a factor in the hydraulics of the confining layer in the Savannah area. If joints or fractures existed in the past, the in-situ conditions (-42 feet MLW and under considerable lithostatic pressure, considerable clay content and plasticity) would not allow joints or fractures to remain in the Miocene indefinitely.

Capacity to Withstand Stress

Users of groundwater in coastal Georgia (and adjacent South Carolina and Florida), to varying degrees, contribute to saltwater intrusion in the upper Floridan aquifer in coastal Georgia. In order to minimize further degradation of the Floridan aquifer, the GA DNR-EPD has capped the total withdrawal of groundwater from the aquifer. The restrictions on withdrawal of ground-water illustrate the importance of preventing or minimizing any additional activities that would increase the chloride content in the Upper Floridan aquifer.

Future Actions / Stresses

Increases in population levels are expected to result in demand for greater volumes of treated water. For growth to continue, government officials must either provide more water or re-use the water that is already withdrawn.

Increases in the volumes of water permitted to be withdrawn from the upper Floridan aquifer in Chatham County is not expected, since GA DNR-EPD has capped the total withdrawal volume for the county. Therefore, the cone of depression near Savannah and saltwater intrusion near Tybee Island are not expected to rapidly worsen.

Re-use of water is relatively low in the coastal region, with that re-use concentrated mainly in the pulp and paper production and electrical power production industries. Re-use is higher in South Carolina and Florida. Some golf course irrigation occurs in coastal Georgia using treated effluents, but the level of that re-use is relatively low. Any re-use of water that has already served the intended use reduces the demand on new sources.

GA DNR-EPD indicates that there appear to be more water conservation opportunities in the fields of agriculture (irrigation) than the field of public water supply. They believe there are limited water conservation opportunities in the pulp and paper industries.

The lowering of the water level in the Floridan aquifer has reversed the natural pre-development flow of ground-water from the aquifer upward through the confining layer to a downward flow of water from above through the confining layer and toward the center of pumping for in Savannah. Since much of the area within the drawdown cone of depression is overlain by saltwater, chloride levels in the Upper Floridan aquifer in the Savannah area are expected to increase.

Harbor channel improvements also have the potential to affect saltwater intrusion into the aquifer. Potential harbor channel improvement projects include the SHEP and a Jasper County container terminal in what are now CDFs 14A and 14B at about River Mile 6. A Jasper County terminal could have similar dredging requirements in the entrance channel as the SHEP. Construction of a Jasper County terminal would not be expected to exacerbate the movement of chlorides through the Miocene into the Upper Floridan aquifer.

The SHEP has the potential to impact chloride levels in the Upper Floridan aquifer. The concern is that excavation required to deepen the harbor would allow saltwater to enter that freshwater aquifer, degrading its quality and rendering it unacceptable for drinking purposes. The EPA has established drinking water standards of 500 mg/l for total dissolved solids and 250 mg/l for the chloride ion. Water having chloride levels of less than 250 mg/l is considered safe and palatable to drink. This potential impact to the aquifer from channel deepening could occur in three different ways:

1. Deepening of the channel would require removal of the some of the aquifer's protective layer (Miocene cap). Since most of the water over the Miocene layer in the navigation channel is saltwater, this could result in saltwater intrusion into the aquifer.

2. Removal of sediments from paleochannels (former Pleistocene-age stream channels that have eroded into the Miocene cap) would increase the potential for saltwater intrusion into the aquifer. These areas generally represent those portions of the navigation channel with the minimum thickness of the confining layer over the aquifer. SHEP studies indentified eight significant RCCFs where the thickness of the remaining Miocene layer ranges from 26 feet to 55 feet.
3. Water with increased salinity levels could enter the aquifer via fracture or joints in the Miocene cap.

Incremental Impact

The incremental impact of long-term groundwater withdrawals on chloride levels in the Floridan aquifer has been well documented. Water levels in the aquifer have dropped to the point where both lateral and vertical intrusion of saltwater occurs. Using year 2000 pumping rates, SHEP model studies predict that this rate of pumping will cause total breakthrough of seawater to occur regardless of any channel deepening at some downstream locations in approximately 100—300 years depending on hydraulic conductivity of the confining layer. The GA DNR-EPD is aware of this possibility and has taken steps to reduce groundwater pumping that affects the Upper Floridan aquifer. The GA DNR-EPD is also conducting additional studies to determine what other steps can be taken to prevent further degradation of the Upper Floridan aquifer.

Although not as severe as massive pumping of groundwater, the Savannah Harbor Navigation project has had some impacts on chloride levels in the Upper Floridan aquifer. Construction and maintenance of the existing deep-draft navigation channel has not contributed to the cone of depression or loss of artesian pressure that has resulted in both lateral and downward intrusion of saltwater into the aquifer. However, GIS analysis conducted during the SHEP studies indicate that about 5 feet of the confining layer that protects the aquifer has been removed by project improvements and maintenance in some reaches of the channel. The removal of 5 foot of confining materials would make it easier for water to move downward through the Miocene into the aquifer. Since most of the navigation channel is saltwater, this could increase chloride levels in the aquifer. However, GIS analysis of confining material through time and groundwater model studies indicate that historical dredging has probably had minimal influence on the rate of saltwater intrusion.

Initial studies (1998 Potential Groundwater Impacts for the Savannah Harbor Expansion Feasibility Study) to evaluate the impacts of harbor deepening on the aquifer were conducted in support of the Tier I EIS. Following the release of that report, the SHEP study group developed a study plan to address additional issues relating to the aquifer. The primary objective of the additional study plan was to further evaluate potential impacts of harbor deepening on chloride levels in the aquifer. The 48-foot channel was selected to be analyzed since it would represent the worst case scenario. Deepening the channel to 48 feet would impact materials between -42 feet and -58 feet MLW which are comprised primarily of Miocene sediments. Consequently, the study focused on the Miocene layer (confining layer) along the navigation channel, especially from Fields Cut (Mile 5.0) to approximately two miles offshore of Tybee Island, where the confining layer naturally thins and RCCFs have incised into the confining layer.

Additional studies conducted during the SHEP relating to impacts on the aquifer included six major tasks which were: seismic surveys, land and marine drilling that incorporated porewater and hydraulic testing, development of a groundwater model, determining the feasibility of conducting an aquitard test, and incorporating data (past and present) into a comprehensive Geographic Information System.

The porewater data obtained from the additional studies indicate that, as expected, seawater is moving downward through the Miocene confining layer toward the Oligocene limestone (Upper Floridian aquifer), and, in some locations, low concentrations of chlorides appear to have migrated entirely through the confining layer and into the limestone. Chloride concentrations in the Miocene decrease with depth from top to bottom. Chloride concentrations ranged from a high of 20,000 mg/l near the top of the layer to a low of 15 mg/l near the bottom of the layer.

The results of the three-dimensional model runs indicate that the expected increase in the downward flow of saline water from the area underlying the navigation channel due to channel deepening would be very low. The area that would have to be dredged to deepen the channel to 48 feet MLW accounts for a total downward flow between 50 to 250 gallons per minute depending on the hydraulic conductivity assigned to the confining unit. Dredging the navigation channel to 48 foot MLW increases the downward flow between 2-7 gallons per minute which translates to a 3-4 % increase. This contribution is negligible when compared to groundwater production in the Savannah area from the aquifer which is about 80 million gallons per day (55,555 gallons per minute). The results of this analysis represent only the contribution from the river and the navigation channel. Other water sources (salt marshes, offshore) were not simulated in order to determine the explicit impacts of dredging.

The potential for increased saltwater intrusion into the aquifer is less in the upstream areas of the harbor where surface water quality modeling predicts minimum increases in chloride concentrations. The location of the maximum head gradient, i.e., the center of the cone of depression (Savannah), would seem to be the area that would pose the greatest potential for enhanced saltwater leakage through the confining layer. However, the porewater data and the model results show that the thickness of the confining unit (>100 feet) and the lower salinity of the river water in the upper harbor minimize potential adverse impacts to the aquifer and production wells located in and around Savannah.

The three-dimensional model was used to simulate chloride concentrations in the Upper Floridan aquifer for the years 2000, 2050, and 2200 for both dredging and no dredging scenarios. In the year 2200 (based on the year 2000 pumping rates); the upstream chloride concentrations in the Upper Floridan aquifer beneath the river were predicted to be 0 mg/l for low-value hydraulic conductivity simulations and up to 100 mg/l for the mid-range hydraulic conductivity simulations. The difference between simulated chloride conditions in the top of the Floridan aquifer between the dredging and the no dredging scenarios were minor.

The downstream areas, however, specifically near the Tybee high, showed a gradual increase in chloride concentrations in the Upper Floridan aquifer. Chloride levels directly beneath the river approached 500 mg/l after 200 years for the low-value hydraulic conductivity simulations. For the mid-range hydraulic conductivity simulations, total breakthrough (when simulated chloride concentrations in the top 50 to 60 feet of the upper Floridan aquifer initially exceed 250 mg/l) occurred after approximately 100 years. The enhanced salt-water intrusion in this area is attributed to the induced negative head gradient from pumping in Savannah, the high salinity of the overlying water with minimal freshwater input from the Savannah River, the naturally thin confining layer (40-60 feet), and the paleochannels that have further removed Miocene material. The model results show that harbor deepening would have little effect on this process.

Dredging in the areas where the eight significant RCCFs were documented would have only minor impacts on the downward movement of chlorides through the confining unit into the aquifer. Groundwater model results indicate that any additional contribution of chloride by the paleochannels is negligible when compared to the total contribution from other adjacent saltwater sources outside paleochannels along the river bottom. The impacts of dredging in the sediments within the paleochannels were small when compared to the impacts of dredging elsewhere in the channel where the Miocene confining unit is impacted. The bottom of the paleochannels represents the areas of minimum thickness of the Miocene confining area in the harbor. Dredging would not be required at these depths.

Alternatives to Mitigate for Cumulative Effects

There are no known, practical means to remedy the saltwater intrusion that has occurred in the Upper Floridan aquifer from past groundwater pumping practices. However, as discussed in previous paragraphs, GADNR-EPD is very proactive in taking actions to halt the intrusion of additional saltwater into the aquifer as a result of ground-water withdrawal.

The proposed deepening of the Savannah Harbor Navigation Project raised concerns about the potential for additional saltwater to enter the aquifer through removal of a portion of the Miocene confining unit or through the paleochannels that cross portions of the channel. SHEP Tier II studies (using the 48-foot channel) show that the predicted increases in salinity levels in the harbor or the reduced thickness of the confining layer due to dredging will not significantly affect the timing of the breakthrough of chlorides along the navigation channel in the Upper Floridan aquifer. Study results also indicate that the proposed dredging would have minimal impacts on water quality in production wells that tap the Upper Floridan aquifer in and around the City of Savannah. No mitigation actions are proposed for the minimal impacts identified to chloride levels in the aquifer. However, monitoring would be conducted to confirm model predictions.

Monitoring

As a condition to the Georgia Section 401 Water Quality Certification for the SHEP, the Georgia DNR-EPD requested a detailed monitoring plan for early detection of potential chloride migration into the aquifer. Monitoring of chloride levels in the Upper Floridan aquifer must be conducted along critical groundwater flow paths to ensure there the SHEP does not result in the significant migration of chlorides downward through the confining layer that could move towards production wells in the Savannah area. The monitoring would involve the establishment of sentry wells along critical groundwater flow paths. These wells would be installed near the top of the aquifer to monitor downward migration of chlorides through the confining unit and deeper in the aquifer to monitor how horizontal flow of freshwater within the aquifer mixes with and dilutes the chloride. The sentry wells are to be located west of exploratory borings SHE-11 and SHE-13 and on Cockspur Island near Fort Pulaski.

Monitoring wells would also be established upgradient of critical groundwater flow paths to provide information on background chloride concentrations associated with groundwater withdrawals in the Savannah area independent of SHEP dredging activities. Background wells would be established near the top of the aquifer and deeper in the aquifer to establish background chloride concentrations. Annual monitoring of these wells would be required for the life of the project, and differences in the long-term trends of chloride concentrations in the sentry and background wells used to evaluate impacts of SHEP from impacts of groundwater withdrawal on chloride concentrations in the aquifer.

Groundwater monitoring also includes the establishment of benchmark chloride concentrations for each sentry well. The benchmark chloride concentrations must protect the Savannah area production wells which include industrial, commercial, municipal, agricultural, and other un-permitted wells. Mitigation would be required if sampling of monitoring wells indicates that the Savannah area production wells may be affected by downward migration of chloride confining unit as a result of SHEP dredging activities.

12. <u>Endangered Species</u>

Issue

Endangered species in Savannah Harbor was another resource that the Corps decided to address in the cumulative impact analysis for the project. More specifically, the Corps felt that Shortnose sturgeon be considered in the analysis of cumulative impacts.

As required by the Endangered Species Act, the Corps prepared a Biological Assessment of Threatened and Endangered Species (BATES) for the SHEP. Protected species that reside in the area were identified in the Biological Assessment of Threatened and Endangered Species (BATES) which is included in the EIS as Appendix B. North American right whales, humpback whales, sperm whales, leatherback turtles, loggerhead turtles, Kemp's ridley turtles, hawksbill turtles, green sea turtles, West Indian manatee and Shortnose sturgeon are species that are protected by Federal law that are commonly thought of as being at risk from harbor operations. The potential impacts of harbor deepening on these species are addressed in the BATES. Based on evaluations conducted in the BATES, a determination was made that harbor deepening "may affect but is not likely to adversely affect" these species. This finding was subject to review by the US Fish and Wildlife Service and the National Marine Fisheries Service. The USFWS has issued a letter of concurrence with the BATES' findings with respect to those species for which they have responsibility. The National Marine Fisheries Service has submitted the results of their review of the BATES in a Biological Opinion (BO). Both the USFWS Report and the BO are included in this document in Appendix Z.

The potential impacts to the endangered species identified in the BATES. . In view of the past adverse incremental impacts to Shortnose sturgeon habitat and the small population of these species remaining in the Savannah River, an analysis of further potential cumulative adverse impacts that could be caused by harbor deepening was deemed appropriate.

Geographic Scope

The Shortnose sturgeon is an anadromous species restricted to the east coast of North America. They have been recorded from New Brunswick to northern Florida. Throughout its range, Shortnose sturgeon occur in rivers, estuaries, and the sea. However, Shortnose sturgeon prefer lower salinity than pure seawater, typically in the range of 30-31 ppt (Holland and Yelverton 1973: Dadswell et al. 1984). The greatest abundance of this species is found throughout most of the year in the lower portions of the estuary of their respective river.

The NMFS considers Shortnose sturgeon from different river systems to be reproductively isolated, with the loss of a single Shortnose sturgeon population segment possibly risking the permanent loss of unique genetic information that is critical to the survival and recovery of the entire species. Therefore, the NMFS manages each Shortnose sturgeon population as a distinct population segment for the purposes of the ESA. Under this policy, actions that could adversely affect a Distinct Population Segment are evaluated in terms of their potential to jeopardize the continued existence of an individual population segment (as opposed to the existence of Shortnose sturgeon range wide). Shortnose sturgeon residing in the Savannah River have been found in nearby river systems, so some movement between sturgeon populations does occur in this area.

NMFS has divided the Shortnose sturgeon populations into 19 management units based on presumed reproductive isolation (Center for Biological Diversity, 2009). Seven large populations (>= 1,000 fish) are located in the Saint John River (New Brunswick), Kennebec System Maine, Connecticut River (Connecticut and Massachusetts), Hudson River, New York, Delaware River (Delaware, New Jersey, and Pennsylvania), Savannah River and Altamaha River ,Georgia. Two small populations (< 1,000 fish) are located in Winyah Bay, South Carolina and Ogeechee River, Georgia. Ten very small populations (< 100 fish) are located in Penobscot Maine; Merrimack River, Massachusetts; Chesapeake Bay (Maryland and Virginia); Cape Fear River, North Carolina; Santee River, South Carolina; Cooper River, South Carolina; "ACE Basin", South Carolina; Satilla River, Georgia; St. Mary's River, Florida; and St. Johns River, Florida.

Since the NMFS considers the Savannah River Shortnose sturgeon to be a distinct population based on reproductive isolation, the Savannah River will be the geographic scope of this analysis. Although Shortnose sturgeon are an anadromous species of fish, Shortnose sturgeon in the Savannah River appear to be primarily riverine.

Historic

There is no estimate of the historical population size of Shortnose sturgeon (NOAA Fisheries, Office of Protected Resources, 2009). Atlantic and Shortnose sturgeon fisheries began with native American Indians prior to the arrival of European settlers. Colonist's records indicate exports of sturgeons to Europe as early as 1628 (NOAA, 2009). Shortnose sturgeon were rarely the target of commercial fisheries and were taken primarily as incidental by-catch in other fisheries (NOAA, 2009). The USFWS placed the Shortnose sturgeon on the endangered species list in 1967. The Shortnose Sturgeon Final Recovery Plan was completed in 1998.

Shoals in the Savannah River served as prime spawning habitat for the Shortnose sturgeon in this basin. Prior to mainstream impoundment by dams, shoals existed in the Savannah River from Augusta, Georgia upstream to the mouth of the Tugaloo River (177 miles). Some anadromous species continued up the Tugaloo River for another 49 miles to the headwaters at Tallulah Falls, Georgia.

Shortnose sturgeon were first studied in the Savannah River system in the mid-1970's (Dadswell et al. 1984). During 1984-1992, over 600 adults were collected by shad fishermen and researchers using gillnets and trammel nets (Collins and Smith 1993). The ratio of adults to juveniles in this study was very high, indicating that recruitment is low in the river (Smith et al. 1992). No reliable adult population estimates were calculated since not all basic assumptions were met (M. Collins, South Carolina Department of Natural Resources, personal communication).

A 1991 study indicates that two probable spawning sites for sturgeon are from River Mile 112 to 119 and from River Mile 172 to 174 (Hall et al., 1991). The study also found juvenile Shortnose sturgeon in the upper end of the harbor, particularly the Kings Island Turning Basin (River Mile 18.9). The criteria the fish used to choose that location were not fully understood, as that area regularly experiences low levels of dissolved oxygen in the summer.

Between 1984 and 1992, approximately 97,000 Shortnose sturgeon (19% tagged) of various sizes were stocked in the Savannah River to evaluate the potential for Shortnose sturgeon stock enhancement (Smith and Jenkins 1991). Subsequent investigation showed that stocked fish were at large for an average of 416 days and comprised 41 % of all juvenile sturgeon collected (Smith et al. 1995).

Surveys of the 1999-2000 population indicated many more adults than in 1992 which was attributed to stocked fish. There was little evidence of reproduction. The 1999 population in the Savannah River was estimated at 3,000 fish.

Past Actions/Stresses

Construction of mainstream dams on the Savannah has blocked access to traditional Shortnose sturgeon spawning grounds in shoal areas located above Augusta, Georgia. Over-fishing, starting in colonial times and continuing into the 1950s, also contributed to population declines of this species. Although the Shortnose sturgeon was rarely a targeted fishery, many were taken as a byproduct of other fisheries such as Atlantic sturgeon and American shad.

Access to traditional spawning grounds is now blocked by a series of six dams with the New Savannah Bluff Lock and Dam below Augusta, Georgia being the first obstacle to traditional spawning grounds. Dam and reservoir construction converted or blocked access to approximately half of 384 miles of historical anadromous fish spawning and nursery habitat of the Savannah River. Practically 90 percent of the high quality anadromous fish spawning habitat (rapids complex: boulder, bedrock, cobble and gravel substrate) has been blocked or inundated by large reservoirs above the Augusta Diversion Dam. The majority of the habitat that is no longer accessible was the most heavily used. The NMFS estimates that 90 to 95 percent of the quality spawning habitat for rapids-dependent anadromous species has been lost. As previously shown in Figure 7, the only shoals remaining on the Savannah River consists of a small 7.2 km stretch located below the Augusta Diversion Dam.

In addition to the loss of traditional upstream spawning habitat, riverine habitat below the dams has been affected by contaminants from both point source discharges and non-point sources (urban and agricultural run-off, timber harvesting, etc.). In lieu of natural flows, flow in the river is now controlled by releases from J. Strom Thurmond Dam.

Construction of the Savannah River Below Augusta Navigation Project also affected spawning habitat below the dams. The project provides for a navigation channel 9 feet deep and 90 feet wide from the upper end of Savannah Harbor (Mile 21.3) to just below Augusta, Georgia (Mile 202.2), a distance of 180.9 miles. Channel modifications included channel dredging, widening, snagging, construction of bend cutoffs (Channel straightening) and construction of pile dikes. This project has not been maintained since 1979. The cutoff bends have accumulated sediment and organic matter since they were constructed in the late 1950s and the early 1960s. Most of the cutoff bends (there are 40 such bends along the project) have been substantially reduced in volume and surface area and some have completely filled with sediment, reducing fish habitat during normal summer flow conditions. The USFWS considers these river bends to be biologically significant.

The estuarine habitat of Shortnose sturgeon in the Savannah Basin has also been extensively modified. A significant amount of wetland habitat has been lost to agriculture, industrial development, and from dredged material disposal operations associated with the construction and maintenance of the Savannah Harbor Navigation Project. Water quality has been altered by non-point and point-source discharges as well as harbor modifications. Harbor construction and maintenance has had major impacts on the dissolved oxygen and salinity regimes in the estuary.

Present Condition

The present population of Shortnose sturgeon in the Savannah River is unknown. The 1999 population was estimated to be 3,000 fish. The fish are readily found by resource agencies when sampling is specifically targeted for them. Although the Savannah River Shortnose population is considered to be improving since the species was placed on the endangered species list in 1967, the apparent low level of recruitment remains a major concern.

Shortnose sturgeon are found in the Savannah River estuary throughout the year within the area from about River Mile 17.5 to 31.7. Juvenile and adult Shortnose sturgeon use the area located about 1-3 miles above the freshwater interface throughout the year as a feeding ground. During the summer, this species tends to use deep holes at or just above the freshwater interface.

In a recent study of Shortnose sturgeon on the Savannah River conducted by the SCDNR, all juveniles were found upriver of the Kings Island Turning Basin (Mile 18.8). Juvenile sturgeon were found just downstream of the Houlihan Bridge (Mile 21.5) during the spring. During the winter months, they were found just inside the mouth of Middle River (River Mile 19.4) in a deep hole just downriver of New Cut. The small size of the fish captured in Middle River suggests that this location is an important nursery area for juvenile Shortnose sturgeon. The juveniles moved upriver (Mile 29.5) during the summer months.

Adults were found throughout the estuary, extending from River Mile 3.4 to 30.4. They also exhibited an upstream movement during the warmer summer months. The species' general pattern of seasonal movement appears to involve an upstream migration from late January through March when water temperatures range from 9 C to 12 C. Two probable spawning sites for Shortnose sturgeon are from River Mile 112 to River Mile 119 and River Mile 172 to 174 (Hall et al, 1991). Spawning fish begin moving back downstream in March, returning to the estuary area of the river in late May.

Present Actions / Stresses

The Recovery Plan lists habitat degradation or loss, and mortality as being the principal threats to the species' survival.

Habitat degradation or loss on the Savannah River is mainly attributable to the construction of upstream dams. These dams prevent Shortnose sturgeon from using traditional upstream spawning habitat. An inability to move above dams and use potentially beneficial spawning habitats may restrict the size of the Savannah River population.

Hydroelectric dams may also affect Shortnose sturgeon habitat by altering river flows or temperatures necessary for successful spawning and/or migration. The major dams on the main stem of the Savannah River – Hartwell, Richard B. Russell, and Thurmond Dams – substantially alter river flows and temperatures. Since sturgeon require adequate river flows and water temperatures for spawning, alterations that dam operations pose on a river's natural flow pattern (including increased or reduced discharges) can be detrimental to sturgeon reproductive success. Shortnose sturgeon are known to spawn downstream of the New Savannah Bluff Lock and Dam.

New Savannah Bluff is located some distance downstream of the last of the major dams on the river, and discharges from New Savannah Bluff are evened out quite a bit from the peaking characteristics of the flows that leave Thurmond Dam.

Construction and maintenance of the Savannah Harbor Navigation Project also affects Shortnose sturgeon habitat in the estuary. The navigation channel allows salinity to move further into the estuary and decreases dissolved oxygen concentrations in the harbor.

Loss of cool water habitat for Shortnose sturgeon during the summer months may also be a problem. During summer months, especially in southern rivers, Shortnose sturgeon must cope with the physiological stress of water temperatures that often exceed 28°C. Flournoy et al. (1992) suspected that during these periods, Shortnose sturgeon congregate in river regions that support conditions that relieve physiological stress. In southern rivers where sturgeon movements have been tracked, sturgeon refrain from moving during warm water conditions and are often captured at release locations during these periods (Flournoy et al. 1992; Rogers and Weber 1994; Weber 1996). Gulf sturgeon are reported to fast at high water temperatures and occupy river reaches of the Suwannee River (Florida) near flowing spring heads (Mason and Clugston 1993). Flournoy et al. (1992) suggest that in the Altamaha River, Shortnose sturgeon also seek deep, artesian spring-fed habitats that provide thermal refuge. Although a relatively new finding, the loss and/or manipulation of these discrete habitats may limit or be limiting population survival, particularly in southern river systems. For instance, Krause and Randolph (1989) report that subterranean aquifers are severely depleted in the Savannah and Ogeechee Rivers (Georgia) and Satilla and St Mary's Rivers (Florida). Other portions of the EIS for this project discuss how excess pumping of groundwater has decreased or eliminated the historic artesian springs in the Savannah area.

Shortnose sturgeon mortality can be caused by numerous factors. The USFWS identified over-harvesting in commercial fisheries as one of two primary reasons for initially listing Shortnose sturgeon as endangered. Directed harvest of Shortnose sturgeon is prohibited by the ESA. However, Shortnose sturgeon are taken incidentally by shad fishermen on the Savannah River. Collins et al. (1996) reported that the shad gillnet fishery accounted for 83% of Shortnose sturgeon take in Georgia coastal fisheries.

In most cases, these fish are returned to the river, presumably unharmed. However, Moser and Ross (1993) found that captures of Shortnose sturgeon in commercial shad nets disrupted spawning migrations in the Cape Fear River, and Weber (1996) reported that these incidental captures caused abandonment of spawning migrations in the Ogeechee River, Georgia. Incidental take of Shortnose sturgeon by American shad fisherman has been greatly reduced. The traditional method of harvesting American shad by gillnets in a coastal intercept fishery was phased out between 2000 and 2004.

Contaminants can also contribute to Shortnose sturgeon mortality. Contaminants, including toxic metals, polychlorinated aromatic hydrocarbons (PAHs), pesticides, and polychlorinated biphenyls (PCBs) can have substantial deleterious effects on aquatic life. These impacts can include production of acute lesions, growth retardation, and reproductive impairment (Cooper 1989; Sindermann 1994). Ultimately, toxins introduced to the water column become associated with the benthos and can be particularly harmful to benthic organisms (Varanasi 1992) like sturgeon. Point-source discharges (i.e., municipal wastewater, paper mill effluent, industrial or power plant cooling water or waste water) may also contribute to impacts stemming from poor water quality. Compounds associated with discharges, including metals, dioxin, dissolved solids, phenols, and hydrocarbons, can alter the pH of receiving waters, which may lead to mortality, alterations in fish behavior, deformations, and reduced egg production and survival (Heath 1987). Dioxins and furans were detected in ovarian tissues of Shortnose sturgeon collected in the Sampit River/Winyah Bay ecosystem (South Carolina). Pulp mill, silvicultural, agricultural and sewer discharges which contain elevated temperatures or high biological demand can reduce dissolved oxygen levels. Low dissolved oxygen levels (below 5 ppm) are known to be stressful to aquatic life and, presumably, sturgeon are adversely affected by levels below this limit. Research indicates that juvenile Shortnose sturgeon experience relatively high mortality (86 %) when exposed to dissolved oxygen concentrations of 2.5 mg/l. Older sturgeon (> 100 days) could tolerate dissolved oxygen concentrations of 2.5 mg/l with < 20 % mortality, indicating an increased tolerance for lowered oxygen levels by older fish. Shortnose sturgeon may be less tolerant of low dissolved oxygen levels in high ambient water temperatures and show signs of stress in water temperatures higher than 28°C. At these temperatures, concomitant low levels of dissolved oxygen may be lethal. In Georgia, several rivers exhibit low oxygen levels (< 2.5 mg/l) during the summer at the saltwater/freshwater interface, an area that normally aggregates both juveniles and adults.

Although there are numerous point source discharges into the Savannah River from the Augusta and Savannah areas, water quality in the river is generally considered good. The water use classification for the Savannah River from Augusta (Mile 202) to the US Highway 301 Bridge (Mile 129) is fishing. Dissolved oxygen requirements provide for a daily average of 5.0 mg/l and no less than 4.0 mg/l at all times for waters supporting warm water species of fish. In regard to point source discharges, at no time can the receiving waters be increased more than 5 degrees Fahrenheit.

The stretch of the Savannah River from the US 301 Bridge to the Seaboard Coastline Railroad Bridge (Mile 27.4) is classified as Drinking Water. Dissolved oxygen and temperature requirements are the same as for those waters classified as Fishing.

The portion of the Savannah River between the Seaboard Coastline Railroad Bridge and Fort Pulaski (Mile 0.0) is classified as Coastal Fishing. Dissolved oxygen requirements provide for 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 is allowed if it can be demonstrated that resident aquatic life shall not be adversely affected. Since this stretch of the river is in an estuary, the temperature of the receiving waters cannot be raised more than 1.5 degrees F.

Although the section of the Savannah River between the Seaboard Coastline Railroad Bridge and Fort Pulaski generally meets the standards for waters classified as Coastal Fishing, it is on the

State of Georgia's Section 303 (d) list of impaired waters because of recurring low levels of dissolved oxygen.

Shortnose sturgeon are also susceptible to impingement on cooling water intake screens. Electric power and nuclear power generating plants can affect sturgeon by impinging larger fish on cooling water intake screens and entraining larval fish. Without better data on current population sizes, it is not possible to assess the extent to which power plant impacts adversely affect a given sturgeon population.

Dredging operations have the potential to cause Shortnose sturgeon mortality as well. Maintenance dredging of Federal navigation channels can adversely affect or jeopardize Shortnose sturgeon populations. In particular, hopper dredges can lethally harm sturgeon by entraining sturgeon in dredge dragarms and impeller pumps. NMFS observers documented the take of one Atlantic sturgeon in a hopper dredge operating in King's Bay, Georgia (C. Slay, New England Aquarium, personal communication). In addition to direct effects, dredging operations may also impact Shortnose sturgeon by destroying benthic feeding areas or disrupting spawning migrations.

In addition to hydraulic hopper dredging, other dredging methods may also adversely affect sturgeon. Atlantic sturgeon have been killed in both hydraulic pipeline and bucket-and-barge operations.

Maintenance of the Savannah Harbor Navigation Project is believed to have only minimal impacts on Shortnose sturgeon in Savannah Harbor. Maintenance dredging is performed well downstream of known Shortnose sturgeon spawning habitat. Maintenance dredging operations are also downstream of areas where juvenile Shortnose sturgeon have been most recently observed. Adult Shortnose sturgeon are capable of avoiding maintenance dredging activities. There have been no observed instances of Shortnose sturgeon mortality associated with either hydraulic pipeline or hopper dredges working in Savannah Harbor. See Appendix B for the full discussion of potential impacts of dredging to Shortnose sturgeon.

Capacity to Withstand Stress

The capacity of the Shortnose sturgeon population in the Savannah River to withstand stress is unknown, as the population size, population distribution, and any critical habitats are unknown. However, these fish are mobile and recent studies indicate that they move to sites with more favorable conditions during the warmer summer months. This reveals at least some ability to move from preferred areas to locations that provide less favorable, but acceptable conditions. The biological cost of such relocation -- whether it stem from considerations such as fewer available food resources or crowding into smaller suitable habitats -- on specific individuals and its long-term effect on the entire population are unknown. But the total number of this species in the Savannah River is believed to be relatively small. Loss of a single well-used habitat could have major and/or long term effects on the survivability of this population. In the same way, restoration or enhancement of a single previously-valuable habitat could greatly aid in the recovery of this population segment.

Future Actions / Stresses

The long-term recovery objective for the Shortnose sturgeon is to recover all discrete population segments to levels of abundance at which they no longer require protection under the ESA. Establishing the population size thresholds in the Savannah River is a Priority 1 recovery task. To achieve and preserve the minimum population size for this population segment, essential habitats must be identified and maintained, and mortality must be monitored and minimized. Accordingly, other key recovery tasks are to define essential habitat characteristics, assess mortality factors, and protect Shortnose sturgeon through applicable federal and state regulations.

Factors identified in previous paragraphs that may adversely affect sturgeon in the Savannah River include the paucity of adequate spawning habitat, operation of hydroelectric dams and power plants, discharges of contaminants and maintenance dredging operations. Additionally harbor channel improvement projects have the potential to affect Shortnose Sturgeon and their habitat. Potential harbor improvement projects include the SHEP and a Jasper County container terminal.

Incremental Impact

Although studies on loss of Shortnose habitat and mortality factors in the Savannah River are somewhat limited, it is clear that protection of existing habitat is important to the survival of this population. Spawning habitat appears to be limited to a few areas between River Mile 112 to just below New Savannah Bluff Lock (about River Mile 215). Although classified as anadromous, the Shortnose sturgeon in the Savannah River are riverine. Other than the spring spawning migration, these fish appear to spend their entire life cycle in the Savannah River estuary. Juvenile Shortnose sturgeon spend most of the early part of their lives just above the freshwater interface. As juveniles grow into adults, they become more tolerant of low dissolved oxygen concentrations and higher salinities and venture well down into the estuary, with adults being recorded downstream as far as River Mile 3.4. Although no portion of the Savannah River estuary has been declared official critical habitat under the Endangered Species Act, the importance of preserving existing habitat in this basin is obvious.

Many measures have been implemented to protect the Shortnose sturgeon as well as other aquatic and marine life in the Savannah River estuary.

Over-fishing of Shortnose sturgeon has been eliminated as a causative factor in the decline of the Savannah River Shortnose sturgeon population. The Shortnose sturgeon has been on the endangered species list since 1967, and it is illegal to kill or possess this species. The phasing out of the traditional method of catching American shad (gillnets in a coastal intercept fishery) has greatly reduced the number of Shortnose sturgeon inadvertently caught by Shad fisherman. In turn, this has greatly reduced the interruption of Shortnose sturgeon migrations in the late winter and early fall.

Point source discharges in the Savannah River are regulated under the NPDES program by the GA DNR-EPD in coordination with the US EPA. Since the NPDES is a Federally-mandated program, all permits issued under the program are subject to review per the provisions of the Endangered Species Act.

As discussed in the section on dissolved oxygen, EPA established a TMDL for the Savannah River to improve dissolved oxygen conditions in the Savannah Harbor. The TMDL requires a reduction in oxygen demanding substances (over time as the various NPDES permits come up for renewal) in point source discharges. This impacts NPDES permit holders in the Augusta, Georgia area, as well, since their waste loads contribute to the dissolved oxygen deficiencies in Savannah Harbor. This is but one example of how implementation and management of the NPDES program protects aquatic life, including the Shortnose sturgeon from adverse cumulative effects from the discharge of pollutants.

Dam construction, removal and re-licensing actions are also subject to review for compliance with the provisions of the Endangered Species Act and other Federal laws protecting fish and wildlife through the approval process of the Federal Energy Regulatory Commission (FERC). There are no imminent plans for any dam construction or removal on the Savannah River. However, re-licensing actions have provided opportunity for input from Federal and state natural resource agencies concerning reducing the cumulative adverse effects of existing projects on aquatic habitat.

Power plant construction and operation is also regulated by FERC. Physical structures necessary to operate the plants such as intake and outfall structures require a Department of the Army Permit from the US Army Corps of Engineers. As such, power plant construction and operation are subject to the provisions of the Endangered Species Act. Water intakes and any associated potential Shortnose sturgeon entrainment issues would be reviewed by the USFWS and the NMFS, to determine what avoidance or mitigation measures would be required.

Dredging operations in the Savannah River also have the potential to impact Shortnose sturgeon. Any non-Federal dredging on the Savannah River requires a Department of the Army Permit from the US Army Corps of Engineers. The Corps of Engineers' permit review process includes full and close coordination with the USFWS and the NMFS to determine potential effects of any proposed dredging on endangered species.

The annual maintenance dredging of the Savannah Harbor Navigation Project has been evaluated for impacts to endangered and threatened species through various documents including a BATES. It has been concluded that maintenance of the harbor has very little impact on the Shortnose sturgeon. Dredging required to maintain authorized project depths is conducted well downstream of known Shortnose sturgeon spawning areas and below juvenile Shortnose habitat that is located just above the freshwater interface.

There are no current restrictions on maintenance dredging activities specifically relating to protection of the Shortnose sturgeon. Turtle observers on hopper dredges that maintain the bar channel are required to report any Shortnose sturgeon that are entrained by the dredge, in addition to sea turtle entrainment. There have been no reported cases of Shortnose sturgeon entrainment in the Savannah Harbor Entrance Channel.

Dredging is not conducted when dissolved oxygen levels are below State standards unless a waiver is obtained from the Georgia DNR-EPD. This restriction protects both Shortnose sturgeon and other aquatic and marine life in the harbor.

There are two potential major dredging projects that could occur in Savannah Harbor.

A. Conceptual plans have been developed to construct a major container terminal in Jasper County, South Carolina. The facility would be located on what are now CDFs 14A and 14B. Channel deepening would be required in the entrance channel and in the inner harbor navigation channel to about River Mile 6.0. This dredging would be well below known Shortnose sturgeon spawning grounds and juvenile Shortnose sturgeon habitat, but includes locations where adult Shortnose sturgeon have recently been found. Since the project would require dredging only to about River Mile 6.0, the anticipated effects on upstream dissolved oxygen and salinity levels would be minimal. Construction of this facility would require appropriate Department of the Army Permits which would be subject to review to determine compliance with the provisions of the Endangered Species Act.

B. The SHEP also has the potential to impact the Shortnose sturgeon. Impacts could vary from direct, short-term impacts from dredging and disposal operations to more long-term impacts caused by loss of habitat.

Potential impacts to the Shortnose sturgeon resulting from dredging and disposal of the dredged sediment are evaluated in Chapter 5 of the EIS and the BATES. All dredging and sediment placement activities would be conducted well below Shortnose sturgeon spawning grounds and downstream of juvenile habitat which is near the freshwater interface. Construction activities would be carried out in accordance with any special provisions directed by the NMFS in the BO. The dredging and sediment placement activities are expected to have only minor impacts on the Shortnose sturgeon.

Model studies conducting during the SHEP indicate that harbor deepening could adversely impact Shortnose sturgeon habitat. More specifically, harbor deepening would adversely impact adult and juvenile winter Shortnose sturgeon habitat in the upper harbor because of increases in salinity levels. However, the proposed harbor deepening is expected to improve Shortnose sturgeon summer habitat through increases in dissolved oxygen concentrations.

Fishery habitat modeling was conducted involving model runs developed around important times for several life cycle stages of the Shortnose sturgeon. Since spawning occurs well upstream of Savannah Harbor, the impacts of harbor deepening were not evaluated with respect to egg and larvae habitat. The impacts of harbor deepening on juvenile and adult Shortnose sturgeon were evaluated. Habitat suitability criteria were developed by the SHEP Fisheries Interagency Coordination Team. EFDC model runs were used to predict hydrodynamics and salinity and WASP model runs were used to predict dissolved oxygen levels. The Post-Processor Habitat

Analysis Module combined the output from the EFDC and WASP models to determine habitat suitability based on criteria for each life stage and time of year.
Table 20 summarizes the results of the model runs for project impacts on winter and summer habitat for adult Shortnose sturgeon and winter habitat for juveniles without mitigation. As would be expected, the volume of suitable habitat for Shortnose sturgeon (without mitigation) decreases as harbor deepening increases. Reductions in the volume of juvenile Shortnose sturgeon winter habitat are the most noticeably affected and range from -5.0% with the 44-foot channel to -21.61% for the 48-foot channel. Decreases in adult Shortnose sturgeon winter habitat ranged from -0.5% for the 44-foot channel to -1.1% for the 48-foot channel while decreases in adult Shortnose summer habitat ranged from -3.2% for the 44-foot project to -15.80% for the 48-foot channel.

Table 20. Summary of Project-Related Impacts Without Mitigation

	----------------------- DEPTH ALTERNATIVES -----------------------				
	44-Foot	**45-Foot**	**46-Foot**	**47-Foot**	**48-Foot**
	Loss (-) of Acceptable Habitat				
- Shortnose sturgeon adult (January)	- 0.5% (-20.0 acres)	- 0.5 % (-20.0 acres)	-0.8 % (-32.0 acres)	-0.8% (-32.0 acres)	-1.1 % (-44.0 acres)
- Shortnose sturgeon adult (August)	- 3.2 % (- 45.0 acres)	- 6.4 % (- 89.0 acres)	- 9.5 % (- 132.0 acres)	-13.3 % (-185.0 acres)	- 15.80 % (- 220.0 acres)
- Shortnose sturgeon juvenile (January)	-5.0 % (-86.0 acres)	-10.4 % (-179.0 acres)	-15.9 % (-274.0 acres)	- 19.0 % (-328.0 acres)	- 21.6 % (-373.0 acres)

Again, this table presents the impacts that could be expected if mitigation is not included in the project.

Alternatives to Mitigate for Cumulative Effects

The factors causing the historic decline of the Shortnose sturgeon population in the Savannah River have been discussed in previous paragraphs. Loss of access to traditional spawning areas in upstream shoal areas is a major factor in the decline of the species. Despite the stocking of 97,000 juvenile Shortnose sturgeon, no major reproduction trends have been observed.

There is opportunity to restore access to 35 miles of spawning habitat between the New Savannah Bluff Lock and Dam and J. Strom Thurmond Dam. The USFWS and NOAA (fisheries) in conjunction with the state natural resource agencies developed a plan to restore access to a portion of historical anadromous fish spawning habitat in the Savannah River. The plan was filed by the USFWS on behalf of the State resource agencies in 1994 and was adopted by FERC as a Comprehensive Plan pursuant to Section 10(a)(2) of the Federal Power Act. If implemented, the plan would restore access to approximately 35 miles of anadromous fish spawning and maturation habitat between New Savannah Bluff Lock and Dam and J. Strom Thurmond Dam. The plan contains four major provisions: (1) reliable passage of anadromous fish at the New Savannah Bluff Lock and Dam; (2) design and implementation of an upstream passage mechanism and safe downstream (out-migrant) passage at the Augusta Diversion Dam; (3) design and implementation of an upstream fish passage mechanism and safe downstream passage at the Stevens Creek Dam; and (4) improvement of poor dissolved oxygen releases from the J. Strom Thurmond Dam during the summer months.

The Cops has attempted two fish passage methods at New Savannah Bluff Lock and Dam. Flows from J. Strom Thurmond were increased to overtop the spill gates during the spawning season. This method of fish passage proved ineffective for Shortnose sturgeon. More than likely, the cold water released from Thurmond Dam may have cooled the water at the dam to the point where fish were no longer induced to spawn. Also, it is doubtful that Shortnose sturgeon were able to negotiate the 8-foot high support walls at the bottom of the dam.

The New Savannah Bluff Lock and Dam is currently operated by the City of Augusta. As a requirement of their lease, the Corps requires the County to lock fish through twice a week during spawning season. Some limited transmitter studies have been conducted to determine if fish are successfully locked through. Apparently, there is very little movement of fish through the lock. Again, the 8-foot high supporting walls of the New Savannah Block and Dam probably deter any meaningful use of the lock by Shortnose sturgeon.

In 2004, the NMFS and the USFWS sent FERC a plan for fish passage at the Augusta Diversion Dam (the next dam upstream of the New Savannah Bluff Lock and Dam) including minimum flow requirements over the Augusta Shoals. This plan was sent in response to the proposed re-licensing of the dam.

When FERC re-licensed the Stevens Creek Dam in 1995, it reserved authority for the USFWS to prescribe a fishway once upstream passage was achieved at the Augusta Diversion Dam.

Measures to provide fish passage facilities at both the Augusta Diversion Dam and the Stevens Creek Dam are in place. However, construction of such devices at these two facilities is not warranted until dependable fish passage is provided at New Savannah Bluff Lock and Dam. Based on previous fish passage attempts at New Savannah Bluff Lock and Dam, it is obvious that some type of fish passage structure specifically designed for Shortnose sturgeon would be required.

Removal of the New Savannah Bluff Lock and Dam would provide even more benefit than a fish passage device. However, loss of the pool area behind the structure could adversely affect recreation activities and water withdrawal for industrial users in the Augusta, Georgia area.

In regards to the fourth element of the plan, the Corps began replacing turbines at J. Strom Thurmond Dam with auto-venting in 2002 and completed that construction in 2006. Dissolved oxygen concentrations in the releases from the dam have increased, enhancing downstream fishery habitat. Further increases are expected when the Corps begins injecting oxygen in Thurmond Lake. Construction of those facilities at Modoc, South Carolina is now underway and is scheduled to be complete in 2011.

There are additional opportunities to enhance Shortnose sturgeon habitat below the New Savannah Bluff Lock and Dam. As discussed previously, construction of the Savannah River Below Augusta Navigation Project involved various navigation cuts to straighten the channel, leaving the old river channel as an oxbow. The project has not been maintained since 1979. Depletion of the natural flow through these cutoff bends has led to rapid deposition of silt and organic material in the bends. This deposition of sediment has also resulted in lower flows to creeks originating in the bends that are the water source for adjacent forested wetlands.

The Lower Savannah River Basin Environmental Restoration Reconnaissance Report completed by the Savannah District in 1992 investigated 40 navigation cuts along the Savannah River. The report concluded that there are feasible environmental restoration solutions with a Federal interest at 26 of those sites. The Lower Savannah River Basin Environmental Restoration Study was completed in 1996 and which resulted in restored flows into Bear Creek at Cut #3 as well as Mill Creek. This particular project was more designed to increase flows to Bear Creek and Mill Creek and thus provide additional water to bottomland hardwoods, rather than restoring fishery habitat in Cut #3. However, there may be more opportunity to provide additional Shortnose sturgeon habitat at the other 25 navigation cuts. This type of project falls under the US Army Corps of Engineers' Environmental Restoration Program, and a non-Federal project sponsor would be required.

In addition to these mitigation features which could be to used offset the effects of past incremental impacts to Shortnose sturgeon habitat in the Savannah River, mitigation would be required to ameliorate predicted adverse impacts to Shortnose sturgeon habitat from the proposed harbor deepening. Deepening would increase upstream salinity levels and decrease dissolved oxygen levels, which would adversely affect both adult and juvenile Shortnose sturgeon habitat.

As discussed in previous paragraphs, two mitigation plans (Plans 6B and 6A) were developed to offset anticipated upstream increases in salinity levels and decreases in dissolved oxygen concentrations from harbor deepening. These plans basically would increase flows in Middle, Back and Little Rivers to reduce salinity levels. Oxygen would be added at three locations on the Savannah River. Table 21 summarizes impacts to adult and juvenile Shortnose sturgeon habitat with either Mitigation Plan 6B or 6A in place along with the injection of dissolved oxygen.

Table 21. Summary of Project-Related Impacts With Mitigation

	---------------------- DEPTH ALTERNATIVES ----------------------				
	44-Foot	**45-Foot**	**46-Foot**	**47-Foot**	**48-Foot**
	Loss (-) or Gain (+) of Acceptable Habitat				
- Shortnose sturgeon adult (January)	-3.9 % (-153.0 acres)	- 4.6 % (179.0 acres)	-6.2% (-240.0 acres)	-6.9 % (-266.0 acres)	- 8.4 % (-326.0 acres)
- Shortnose sturgeon adult (August)	+ 19.0 % (+ 260.0 acres)	+9.8 % (+134.0 acres)	+7.3 % (+100.0 acres)	+6.5 % (+89.0 acres)	+2.8 % (+39.0 acres)
- Shortnose sturgeon juvenile (January)	-6.7 % (-220.0 acres)	-7.0 % (-231.0 acres)	-7.3 % (-238 acres)	-7.6 % (-251.0 acres)	-11.5 % (-376.0 acres)

With the mitigation features in place, there is a loss of adult Shortnose sturgeon winter habitat for all channel depth alternatives due to increased salinity levels. However, there would be a significant increase in Shortnose sturgeon adult summer habitat because of the injection of oxygen during the summer months when dissolved oxygen levels are low. With the exception of the 44-foot project, the mitigation features minimize the adverse effects of channel deepening on juvenile Shortnose sturgeon winter habitat.

Since implementation of either Mitigation Plan 6B or 6A with oxygen injection would not totally mitigate for loss of Shortnose sturgeon habitat, an attempt was made to identify measures that could be used in the estuary to restore sturgeon habitat or enhance existing habitats. No such measures could be identified by the SHEP study team or the natural resource agencies. The habitat suitability analysis indicates that the reduction in volume of acceptable habitat is mainly due to increases in salinity levels in areas that currently provide suitable habitat. The fish could adapt by moving upstream to areas with lower salinity levels. The Corps investigated the bottom substrate that exists in the Savannah River from its junction with Middle River (River Mile 19.7) to the Interstate 95 Bridge (River Mile 27.8). That reach of the river is where Shortnose sturgeon are expected to go if habitat conditions are unacceptable lower in the estuary. The reach is also where Shortnose sturgeon have been observed during the summer when dissolved oxygen levels decrease in the harbor. Sandy substrates are known to support substantial and diverse benthic communities, while silty substrates generally do not support viable benthic communities. Dial-Cordy (2010) found this section of the river to possess predominantly sand substrates (94% of total area). Therefore, this 8.1-mile reach just upstream of the 42-foot depth draft harbor is believed to provide sufficient benthic feeding habitat for the relatively small number of Shortnose sturgeon that presently exist in this population. However, the SHEP Fisheries Interagency Coordination Team believed that additional mitigation was warranted for the loss of Shortnose sturgeon habitat.

Consequently, the Corps began to evaluate other means to improve Shortnose sturgeon habitat including upstream spawning habitat. The Corps acknowledged that removal of the lowest dam on the river, the New Savannah Bluff Lock and Dam (NSBL&D) at Augusta, Georgia, would be the preferred method to allow sturgeon and other anadromous fish to access upstream habitat. The Corps also acknowledged that removal of the lock and dam would benefit the ecosystem. The Corps had proposed such an action in 1999, but local governments opposed it, citing adverse impacts to recreational uses of the pool upstream of the dam. In response, the Corps proposed rehabilitating the structure and adding a fishway to allow fish to move pass the structure. In 2000, Congress authorized construction and operating a fishway at NSBL&D as part of a lock and dam rehabilitation project. That project has not been funded. Coordination with local governments indicates they continue to oppose removal of the structure. Consequently, removal of the New Savannah Bluff Lock and Dam is not a feasible mitigation alternative for the following reasons:

1) The lock and dam is a Congressionally-authorized project; therefore, the Corps is obligated to maintain the project as Congress provides funding for such actions.

2) The current authorization language (WRDA 2000), amended in Omnibus Act 2001 calls for repair and rehabilitation of the lock and dam structure, construction of a fish passage, and conveyance of Lock and Dam to the City of North Augusta.

3) Removal of the structure would adversely impact the freshwater supply of eight major users.

Since removal of the NSBL&D is not feasible, the Corps suggested that a fish bypass structure be considered as mitigation feature for the SHEP impacts to Shortnose sturgeon habitat. A fishway around the structure would allow migrating fish to move past the dam and allow Shortnose sturgeon to access historic spawning areas at the Augusta Shoals. The structure would also open up the river to American shad and other anadromous fish species, thereby helping those populations. There is also evidence that some of the Savannah Harbor Striped bass population spawn in upstream areas near the fall line which could also benefit from the fishway.

The previously approved horseshoe rock ramp design was proposed as a means of allowing Shortnose sturgeon and other anadromous species of fish to move pass the NSBL&D during spawning season. The fishway would be located around the South Carolina abutment of the dam. It would be designed to operate continuously and pass 600 cubic feet per second (CFS) during low flow conditions (95% exceedance). The 600 CFS minimum attraction flow is 5 percent of the mean river flow during upstream spawning migration period of February through June. Higher attraction flows are probably better, but Parasiewicz et al. 1998 indicated that 5% of the river flow should be an adequate attraction flow for most fish. The fishway would pass higher flows when the river flows are higher. Flows in the fishway are designed to be self-regulating over a two-foot headwater variation, including a range of river flows from 3,600 to 20,000 CFS. The horseshoe rock ramp would have roughly a 75-foot width across the base and use boulder weirs at approximately a 25-foot spacing. There would be roughly a 9-inch drop per weir along the length of the fishway. The water depth would range between 3.5 and 5.5 feet in the fishway.

In June 2007, representatives of the resource agencies confirmed that the fishway appears to be the only measure within the basin to effectively compensate for the predicted loss in Shortnose sturgeon habitats. The Corps conducted a preliminary review of the 2001 fishway design and confirmed that conditions had not changed that would reduce its effectiveness or implementability. Also, in 2010, the Corps consulted the Federal and State regional natural resource agencies to determine if the state-of-the-art had advanced substantially since the design was completed for the fish passage structure at the NSBL&D. No fishery experts in the natural resource agencies identified any specific change to the proposed design that should be made as a result of recent documented fish passage research. The rock ramp design was provided to the cost estimators, who updated the cost for constructing the fishway. That fishway was added as a feature of the mitigation plan at an estimated ROM cost of $4.3 million (2006 price levels).

A horseshoe rock ramp bypass design was presented in the DEIS. The horseshoe rock ramp bypass design would also allow fish to move downstream, thereby ensuring young fish spawned upriver could access other habitats needed in later life stages. The horseshoe rock ramp bypass was designed to capture 5 percent of the river flow. Based on some of the comments received on the EIS, some of the agencies believe the bypass would need to carry more of the river flow to successfully pass Shortnose sturgeon.

Consequently, the Corps convened an interagency workshop on April 25-27 2011 to discuss and evaluate mitigation options available. Numerous options were evaluated in regards to fish passage at the NSBL&D. Using the input from the agencies at the workshop, the Corps screened the potential fish passage options and prepared preliminary designs for three fish passage alternatives: (1) Full River Rock Ramp, (2) Off-Channel Rock Ramp, and (3) Hybrid Rock Ramp. Although not specifically considered at the interagency workshop, the Corps considers the Off-Channel Rock Ramp to be a variation of the Full River and Hybrid Rock Ramp designs since they would all transport roughly the same amount of water for Shortnose sturgeon to use while moving through that location of the river. These alternatives differ by their location across the channel's cross-section. Once upstream passage occurs, successful downstream passage is critical to ensure the adult breeding population can return to its traditional foraging habitats in the estuary. For all three alternatives, a rock ramp would be constructed to allow Shortnose sturgeon to swim to the upstream pool. In each design, large boulders would be used to create pools with local areas of lower velocities. All three designs would also accommodate the larger Atlantic sturgeon and readily pass other anadromous species, such as American Shad and Striped bass.

Table 22 shows a comparison of three designs. The Full River Rock Ramp would capture all of the river flow (up to 10,000 cfs) 73% of the time from February-June which is the Shortnose sturgeon spawning season. Flows over 10,000 cfs would flow through the flood bypass channel and the ramp. The Off-Channel Rock Ramp Design would capture all of the river flow (up to 8,000 cfs) 64% of the time from February-June while the Hybrid Rock Ramp Design would capture all of the river flow (up to 9,000 cfs) 70% of the time. Since all three designs would achieve the objective of Shortnose sturgeon passage at the NSBL&D, the Off-Channel Rock Ramp Design was selected as the preferred design because it is the most cost effective. Figure 11 shows the initial design for the Off-Channel Rock Ramp. A complete discussion of the analysis of fish passage alternatives at NSBL&D can be found in Appendix C.

Table 22. Comparisons of Potential Fishway Designs at NSBL&D

Parameter	Full River Rock Ramp	Off-Channel Rock Ramp	Hybrid Rock Ramp
100% of flow through ramp up to X cfs	10,000 cfs	8,000 cfs	9,000 cfs
Crest elevation of Rock Ramp	109 ft	109 ft	109.5 ft
Number of gates operational	0	5	3
Modification to existing Lock & Dam structure	Major	Minor	Moderate
Modification to existing Lock & Dam project	Major	Minor	Moderate
Percent of time ramp captures all of river flow (February - June)	73%	64%	70%
Effectiveness in fish passage (Upstream)	90%	75%	80%
Effectiveness in fish passage (Downstream)	100%	85%	90%
Effectiveness in fish passage (Overall)	Acceptable	Acceptable	Acceptable
ROM cost	$100 mil	$32 mil	$41 mil
Cost Effectiveness (Cost /% SNS passage effectiveness)	$1,050,000	$325,000	$480,000

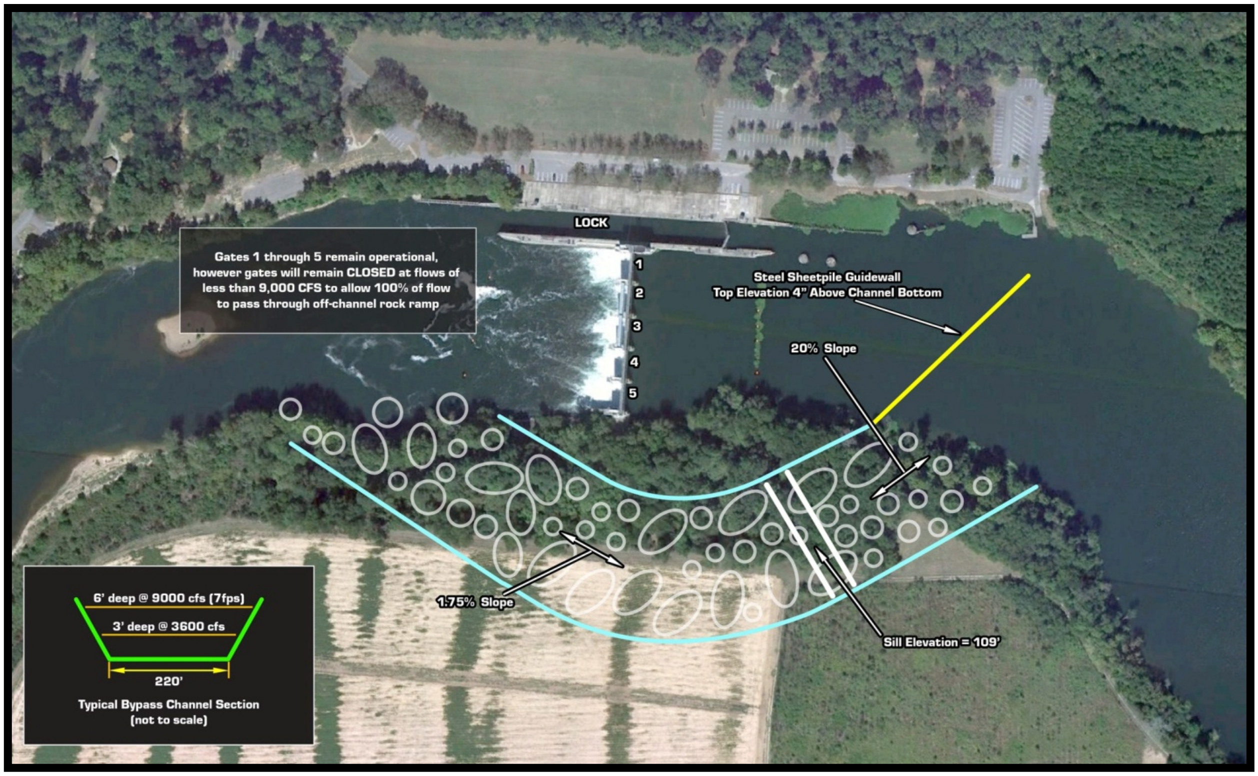

Figure 11. Conceptual design of off-channel rock ramp

Construction of the Off-Channel Rock Ramp fish bypass would provide access to the historic spawning area at the Augusta Shoals. Monitoring would be performed to ensure the success of the structure in providing dependable upstream fish passage. If the results of the monitoring indicate that the fishway provides dependable fish passage, this could trigger the construction of fish passage structures at both the Augusta Diversion Dam and Stevens Creek Dam. In this event, access would be provided to traditional spawning grounds from the New Savannah Bluff Lock and Dam to the base of the J. Strom Thurmond Dam (about 35 miles). If successful, this mitigation measure would meet one of the criteria in the Shortnose sturgeon Recovery Plan, which is to rehabilitate Shortnose sturgeon populations and habitats. Providing access to traditional spawning areas would expand the sturgeon spawning area and, thereby, enhance the potential for reproduction and recruitment of Shortnose sturgeon in the Savannah River.

Monitoring

The monitoring plan for the SHEP includes two specific studies to address the impacts of the project on Shortnose sturgeon. These studies include a study to determine the distribution of Shortnose sturgeon in the Savannah Harbor estuary, and a study to evaluate Shortnose sturgeon passage at the NSBL&D.

The distribution of Shortnose Sturgeon in the Savannah Harbor estuary would be studied during the one-year of pre-construction monitoring and the four years of monitoring during construction to provide background data. This monitoring would include capturing, tagging and tracking both juvenile and adult sturgeon. Water quality would be measured and documented where the sturgeon are captured and later found. Monitoring would be performed each season. The study area would include Front, Middle, and Back Rivers. The bottom substrate would be identified when fish are found to intensively use a specific area. Water quality data would also be collected at receiver location.

The study of Shortnose sturgeon distribution in the Savannah Harbor estuary would be conducted during years 1-5 of the Post-Construction Monitoring and again in year 9. The data collected from this effort would then be compared to the data collected during the Pre-construction and Construction Monitoring to determine if there have been any changes in the distribution of Shortnose sturgeon, and if so, how those changes in distribution might be attributable to the project. Field data (salinity, dissolved oxygen) would also be used with the updated hydrodynamic and water quality models to assess the impacts of the project on Shortnose sturgeon habitat.

The second study would involve an assessment of Shortnose sturgeon distribution at the NSBL&D. This study would also focus on fish passage at the NSBL&D after construction of the fishway. The movement of fish at the NSBL&D would be monitored for one year (during the Pre-Construction studies). The monitoring would include capturing, tagging, and tracking Shortnose sturgeon and possibly other representative species of the NSBL&D area fish community (Striped bass, Robust redhorse, and American Shad). Based on availability, up to 25 Shortnose sturgeon (and a total of 75 fish) would be collected and implanted with combined radio and acoustic transmitters. If possible, fish would be captured within 1 km of the dam by electrofishing, hook and line, or gill net.

The fish would be monitored continuously in the vicinity of the NSBL&D using a fixed station radio receiver. In addition, the river would be searched weekly during migration season between the dam and the Jackson, SC landing and the Augusta Diversion Dam for fish with transmitters. On a monthly basis, the Savannah River would be searched from the Savannah Harbor Kings Island Turning Basin to the NSBL&D, and above to the Augusta Diversion Dam. When located, species identification, number, and location would be recorded. Temperature would be recorded several times daily using temperature loggers established at fixed locations at NSBL&D, 1, 10, 50, 100 and 200 km below the dam, and 1 km above the dam. Dissolved oxygen concentration, turbidity, and river stage at NSBL&D would be recorded at least weekly. Dam discharge would be recorded daily.

This study would be conducted again during years 1-5 and year 9 of the Post-Construction Monitoring. However, this part of the study would include the installation and use of a series of infrared video cameras to monitor fish movement within the fish bypass structure. The system would operate continuously and collect images of fish at the upper end of the passage facility. The recorded video would be reviewed to determine the species composition, fish orientation (upstream versus downstream) and abundance. The results of this study would be used to determine the success of the fish passage study and whether further mitigation might be warranted for the Shortnose sturgeon.

It should be noted that construction and operation of a fish bypass at NSBL&D would adversely affect the economic feasibility of generating hydropower at that location, should some entity desire to do that in the future. With the proposed bypass design, most of the flow would pass around the dam through the bypass, resulting in little flow being available to generate power by passing the dam.

Findings of the BO

As previously discussed, the Corps prepared a BATES which evaluated the impacts of the SHEP on threatened and endangered species. In regards to the Shortnose sturgeon, the BATES concluded that construction of the SHEP may affect but is not likely to adversely affect the Shortnose sturgeon. However, the BO prepared by the NMFS determined that construction of the SHEP would likely adversely affect the Shortnose sturgeon.

The "likely to adversely affect" determination for Shortnose sturgeon is primarily based on adverse effects (increase in salinity) to important estuarine foraging winter habitats for both juvenile and adult fish. While the NMFS expects these effects to be sub-lethal for individual sturgeon of the existing population, these effects could reduce the Savannah River's overall carrying capacity and ability to provide optimal habitat for the Shortnose sturgeon to forage. The NMFS believes that both adults and juveniles will move to suitable habitats further upriver once the SHEP is constructed. However, the NMFS also points out that there may be a transitional period as the habitat adjusts to the new, higher salinity. They expect sturgeon to use these areas for foraging once their prey have colonized and stabilized to the new environmental conditions. The NMFS also determined that construction of the SHEP would not likely cause a long-term reduction in reproduction. There may be a reduction (1-2 years, maybe longer) in spawning due to lack of fitness of spawning adults resulting from lower foraging success during the transitional period as the habitat adjusts to a new, higher salinity. However, the NMFS expects that construction of the fish passage facility at the NSBL&D will result in the addition of 20 miles of spawning habitat that is expected to increase spawning activity over the long-term. Based on these determinations, the NMFS concluded that construction of the SHEP is not likely to jeopardize the survival and recovery of the Shortnose sturgeon in the Savannah River.

For sturgeon, the BO includes five Reasonable and Prudent Measures that must be implemented for the Corps to be exempt from the provisions of Section 9 of the ESA. These five Reasonable and Prudent Measures and the terms and conditions to implement those measures are as follows:

1. Implement Safe and Effective Fish Passage in a Timely Manner.

    a. Develop a plan for safe and effective fish passage. The plans shall be coordinated with the NMFS, USFWS, SCDNR, and GADNR. The COE shall conduct a comparison analysis of the performance of existing rock ramps located in other parts of the country with similar characteristics to the proposed New Savannah Bluff Lock and Dam fish passage conditions to review information on the spatial variation of velocities across the width of rock ramp designs. The COE will coordinate the results of that effort with the natural resource agencies within 6 months of receiving all of the environmental approvals to implement the project. The goal of the fish passage alternative is to achieve at least 75 percent upstream passage effectiveness for both Shortnose and Atlantic sturgeon, at least 85 percent downstream passage effectiveness, and cause no serious injury to sturgeon that come into contact with the passage or dam structures. The fish passage would maintain velocities comparable to those found in the upstream habitat that the sturgeon are expected to access upon completion of the fish passage facility.

b. Fish passage construction shall commence prior to or concurrently with inner harbor dredging and be complete within two years.

c. The COE shall purchase any additional land necessary for the fish passage and for an access road to the site. The land acquisition process must be initiated prior to, or concurrent with, commencement of entrance channel dredging.

d. To protect spawning sturgeon and their offspring, no in-water fish passage construction downstream of the New Savannah Bluff Lock and Dam shall occur during the late winter/spring period and early summer larval period between February 1 and May 31 of any year.

e. The COE shall adhere to protective measures during construction of the fish passage including appropriate erosion and turbidity controls. Additionally, the Corps will ensure passage throughout the habitat. Adequate pathways must be provided at all times so that fish can migrate between foraging habitat and spawning habitat; no blocking of the channel is allowed. Normal water flows must be maintained throughout the construction areas. The COE shall not reduce flows during the spring/early summer to aid in the construction of the fish passage.

f. The COE shall develop a Monitoring and Adaptive Management Plan specifically for the fish passage that will, to the maximum extent practicable, ensure the performance criteria will be achieved. The plan will also identify triggers for passage modification. Post-construction monitoring shall be designed and conducted to assess the effectiveness of the fish passage in safely passing sturgeon upstream and downstream. The COE shall consult with the NMFS and the other natural resource agencies to complete the plan within 6 months of receiving all environmental approvals to implement the project. If it is determined that sturgeon are not safely and effectively passing upstream and downstream through the fish passage, measures shall be taken to rectify the problem.

2. Protective Measures for Sturgeon during Construction in the SHEP Project Area.

a. The construction of the diversion structure associated with the flow re-routing modifications shall be conducted between May 15 and November 1 while most sturgeon are congregated upstream of the construction area.

b. During construction of the various flow diversion measures, the COE will adhere to appropriate erosion and turbidity controls. No blocking of the channel is allowed, except where included as part of the flow re-routing modifications.

3. Ensure Appropriate Monitoring and Adaptive Management Within the Lower Savannah River Project Area. A comprehensive monitoring and adaptive management plan shall be developed for assessing project impacts associated with the deepening, the flow-re-routing modifications, the injection of oxygen, the fish passage and for implementing corrective actions. The plan shall identify success criteria and triggers. The plan shall be completed within 6 months of receiving all environmental approvals to implement the project. The Plan shall include monitoring to determine whether the predicted amount of habitat loss is being exceeded. If the monitoring indicates habitat loss to any species within NMFS' ESA authority is being exceeded, this will trigger re-initiation of consultation with the NMFS.

4. Ensure Appropriate Dissolved Oxygen Levels. Monitoring and adaptive management for dissolved oxygen levels shall ensure that the dissolved oxygen systems perform as expected to offset harbor deepening impacts and ensure the amount of suitable habitat as predicted in the modeling of the three-level summer habitat suitability criteria for sturgeon are not reduced. If dissolved oxygen excursions below minimum levels in the modeled river cells are longer in duration than specified in the criteria, corrective action (increasing or adjusting the operation of the Speece cones, cessation of dredging in the area of concern, etc.) will be taken immediately. If short-term response is not practicable, solutions shall be implemented as soon as possible, and not later than July 1, following identification of the poor oxygen levels.

5. Tissue Sampling, Tags and Reporting Take. A tissue sample shall be taken of any sturgeon handled or stranded. All sturgeon encountered shall be scanned for a PIT tag. If a lethal take occurs, the COE shall arrange for containment analysis of the carcass. Sonic tags, or some other state-of-the-art tracing device shall be placed on sturgeon captured during relocation trawling, or alive by the hopper dredge by NMFS-approved personnel only. Observer reports of incidental take by hopper dredges and relocation trawls will be reported to the NMFS' Southeast Regional Office.

The BO submitted by the NMFS is included in this document as Appendix Z.

13. Tybee and Nearshore Area

Issue

Questions have existed for many years on whether construction and maintenance of the Savannah Harbor Navigation Project, especially the entrance channel portion, plays a major role in beach erosion on Tybee Island. A study completed in 2008, "Impact of Savannah Harbor Deep Draft Navigation Channel on Tybee Island Shelf and Shoreline" confirmed that the entrance channel and the two large jetties near the mouth of the harbor has disrupted the north to south movement of sediment across the channel. The major impacts of this disruption are loss of sand from the Tybee shelf which would be available to move towards Tybee Island and subsequent erosion of the Tybee shoreline.

During the SHEP study, additional concerns surfaced concerning possible impacts that harbor deepening might have on this condition, including the potential for further adverse, incremental impacts on the Tybee Island sand budget.

Geographic scope

The primary area of concern is the ocean shoreline of Tybee Island. This area must also be placed in the larger context of changes to the nearshore sand sharing system because this system has a major impact on whether a shoreline is eroding or accreting. The Corps of Engineers typically examines potential impacts from its proposed projects for 10 miles along each direction of a coast. Hydraulic modeling indicates that such a distance is more than adequate to identify potential impacts from the Savannah Harbor Navigation Project. Figure 10 shows the geographic area of this analysis which is bounded by Hilton Head Island, South Carolina to the north and Little Tybee Island to the south.

Historic

When the City of Savannah was founded in 1733, the controlling depth across the bar was about 13 feet at low water. Black (1893) states that prior to 1763, the depth on Tybee Knoll (located 1/2 mile east of Fort Pulaski) was 15 feet, and a good, clear channel was reported as far upriver as Savannah. Review of the 1855 survey conducted by the U.S. Coast Survey shows controlling depths of 15 feet MLW over Tybee Knoll and 13 feet near Oyster Bed Island.

In the 1800s, Congress authorized Savannah Harbor as a Federal navigation project. The first obstruction in the navigation channel was two and a half miles above Tybee Point (one half mile off Fort Pulaski), which was referred to as the "Knoll." The USACE Annual Report of the Chief of Engineers indicates that dredging in this area began in 1873.

As part of the Federal project, two 12,000-foot long jetties were constructed at the mouth of the Savannah River entrance to stabilize the two river channels (Savannah River and South Channel) and stabilize their associated sand bars. The North Jetty (Oyster Bed Jetty) was completed in 1890 and the South Jetty was completed in 1896 (Cockspur Jetty) (Sargent 1988). Additionally, a submerged offshore breakwater was completed at the south end of Barrett Shoals in 1897 to provide a shelter for vessels entering Tybee Roads.

Records indicate that the first significant dredging of the entrance channel occurred in 1910 when 1,640,000 cubic yards of sediment were removed from the ocean bar, Tybee Roads, Tybee Knoll and near Quarantine Station (Oyster Bed Island). The navigation channel of Savannah Harbor was deepened to 22 feet MLW in 1902, to 26 feet MLW in 1912, to 30 feet MLW in 1936, to 34 feet MLW in 1945, to 38 feet MLW in 1972 and to 42 feet MLW in 1994. It should be noted these depths are the authorized depths of the inner harbor channel. The entrance or bar channel depth is two feet deeper.

A general north to south littoral drift exists along the Georgia coast. Tybee Island is located directly down-drift of the Savannah Harbor entrance channel. The island has experienced shoreline recession especially along the north-south oriented oceanfront between 1st Street and 6th Street. Historical maps and information indicate that the erosion of the shoreline on Tybee Island is linked to deepening of the navigation channel and construction of the two large jetties at the mouth of the river.

The shoreline positions of Tybee Island were mapped in studies by Oertel et al. (1985) and Griffin and Henry (1984). Based on analysis of beach ridge formations, Oertel hypothesized that prior to 1854, the ocean shoreline of Tybee Island was characterized by significant periods of accretion. The regularly-spaced dune ridges on the southern end of the island suggest that accretion was continuous over the recent past. Development of the north end of the island was apparently much more irregular, as indicated by the truncations between beach ridge sets. The shoreline positions illustrate two major trends in shoreline evolution: net accretion between 1859-63 and 1900, and net erosion between 1900 and the present.

Between 1900 and 1920, the shoreline shows rapid erosion. Griffin and Henry (1984) observed the erosion between the 1913 and 1925 shorelines and hypothesized that because this atypical erosion took place prior to dam construction, adoption of soil conservation practices, and occurred during a period in which the majority of other island systems in Georgia were rapidly accreting, the losses may be related to the dredging activities initiated in 1919. Maps showing the shoreline location in 1920 indicate that this erosion occurred too soon to be caused by navigational dredging conducted in 1919 and later. However, substantial dredging in the harbor had occurred between the 1890s and 1920, indicating that dredging may have contributed to some degree to erosion of the Tybee Island shoreline.

Shore protection structures were constructed at various places along the beach starting in 1912, with varying degrees of success. However, the beach continued to erode. By the late 1960s, the MHW shoreline had eroded to the seawall at the northern end of the island and use of the beach was restricted to periods of low water.

Shore protection operations involving beach nourishment started in 1975 as authorized by the Tybee Island Shoreline Protection Act of 1974. The most recent shore protection efforts include placing sand on the beach five times between 1986-2009, construction of an 800-foot long north terminal groin in 1975 to trap sand that is being transported north, a 600-foot long south terminal groin completed in 1987 to trap and hold fill sand on the southern end of Tybee Island, and two additional T-head groins and an L-head groin further to the south in 1994 to retain sand at the very southern end of the island.

Past actions / stresses

The Corps conducted a study in 2007 to determine if the Savannah Harbor Navigation Project is adversely impacting or has in the past adversely affected the shores of Tybee Island. The study was conducted by the Savannah District in cooperation with the City of Tybee Island. The study was completed and the results of the study were presented in a report "Impact of Savannah Harbor Deep Draft Navigation Project on Tybee Island Shelf and Shoreline" (April 2008).

The study included both numerical modeling and sediment budget components. The modeling included waves, currents, water levels, and sediment transport rates for pre-project bathymetry and post-project bathymetry. The model output was used to identify sediment pathways and changes to wave, current, and sediment transport patterns resulting from the existing navigation project. Sediment budgets were developed for pre-project and post-project conditions. The sediment budget was used as an accounting of sediment transport pathways and magnitudes in the pre-and post- project time periods. Sediment budgets were developed for the period 1854-1897 and 1897-2007. Bathymetry changes were calculated over both of these time periods.

Figure 12 shows the study area. The main barrier islands to the north of the Savannah Harbor entrance channel are Hilton Head, Daufuskie and Turtle. Cockspur Island separates the main navigation channel from the South Channel of the Savannah River. Tybee Island is located to the south of the Savannah Harbor entrance channel. Islands south of Tybee Island include Little Tybee and Wassaw.

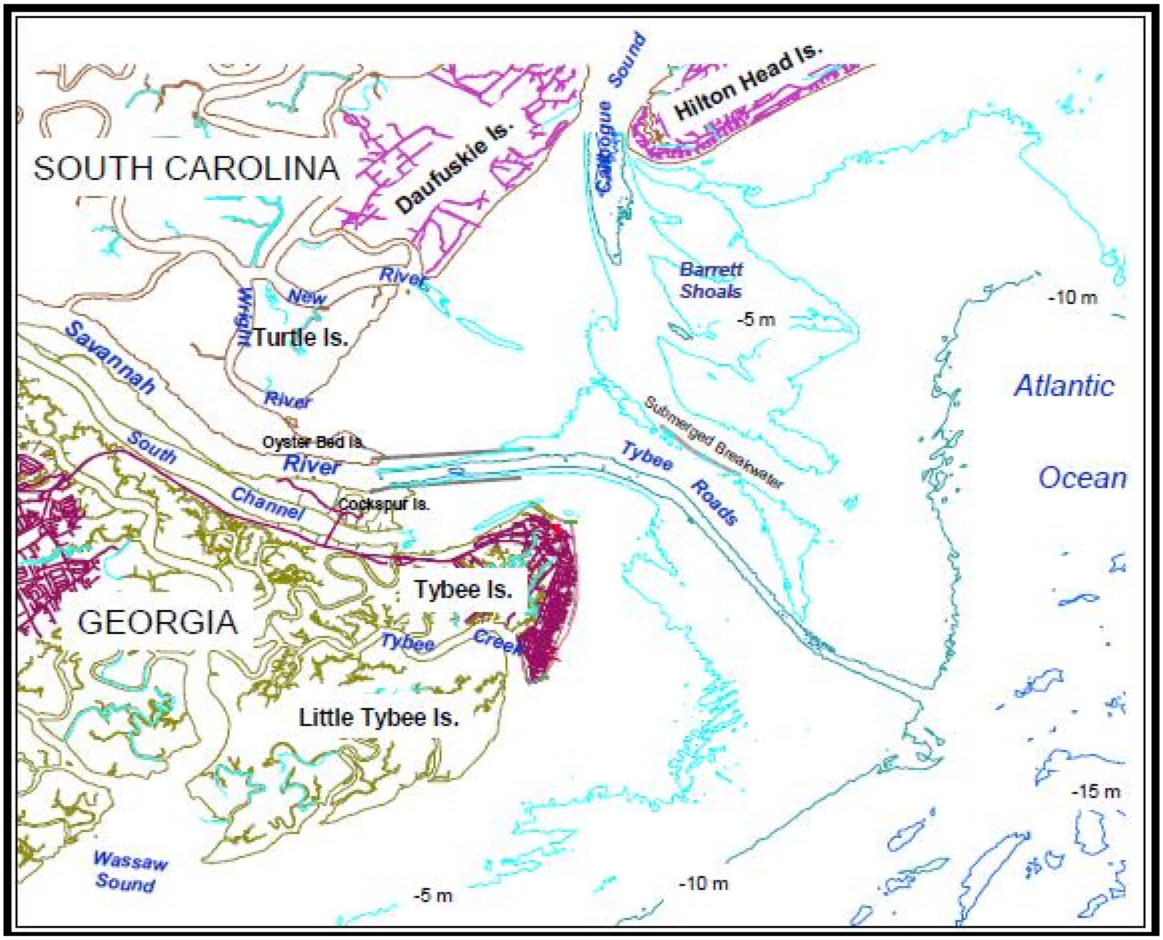

Figure 12. Tybee Island study area.

The post-project bathymetry change showed a pattern of ebb shoal deflation on the Tybee shelf, which is a typical consequence of removing sediment from the nearshore sand sharing system. The ebb shoal deflation is a direct result of the disruption of normal sediment pathways across the navigation channel. The magnitude (historical average of approximately 700,000 cubic yards) and frequency (annual) of maintenance dredging in the entrance channel indicates that the bar channel is an efficient trap for wave-and current-induced sediment transport. Ebb shoal deflation results in the loss of sand from the Tybee shelf and in shoreline change on Tybee Island.

The Tybee shelf is part of a large ebb shoal complex associated with the Savannah River inlet. Ebb shoals form as a balance of sediment that is jetted out of an inlet by offshore (ebb) currents and sediment that is returned to the inlet by onshore (flood) currents and waves. These ebb shoals are the pathway for sediment to travel around an inlet to the down-drift beaches (Tybee Island) as well as up-drift beaches (Oyster Bed Island) during periods of reversal in sediment transport direction. Disruption of these pathways and deflation of the ebb shoal lead to erosion of the down-drift (and possibly up-drift) beaches because natural sand bypassing around the inlet is interrupted.

Prior to construction of the project, transport patterns showed recirculation onto the Tybee shelf from the margins of the South Channel. This compares to post-project conditions where sediment transport is directed north along the Tybee shoal and toward the Tybee Knoll Channel, with very little re-circulating to the Tybee Island shelf. With project conditions also show more of a tendency for offshore transport on the outer edges of the Tybee island shelf. In general, the project does not change the magnitudes of transport, but the pathways.

The most significant change in the calculated circulation pattern was the increase in current speed through the navigation channel. The South Channel of the Savannah River entrance hugged the north end of Tybee Island in 1854, and there was a circulation cell that was centered on the south side of the channel. This circulation cell would naturally circulate sediment onto the Tybee shelf. With the existing project, the circulation cell is shifted north to the south edge of the Tybee Knolls Channel. It has the potential to push sand off the Tybee Island shelf and into the north Tybee shoal. Current magnitudes tended to increase for the existing bathymetry on the north end of Tybee Island. Tidal and storm surge levels are not significantly impacted by the existing navigation project.

Deepening the bathymetry in front of the Tybee Island shoreline allows larger waves to propagate closer to shore. The maximum increase in wave heights is on the northern end of the island. The average increase in wave height is 0.5 meters during a simulated hurricane, 0.25-0.5 meters for a stormy month, with no increase observed for a fair weather month.

Sediment pathways were further evaluated through the sediment budget. The sediment budget was developed based on historical volume changes in five sediment budget cells (Barrett Shoals Platform, Breakwater shoal, etc.), shoreline change rates on Tybee Island, beach nourishment volumes, dredging volumes, pathways, and relative rates provided by the numerical sediment transport modeling.

Post-project sediment budget analysis shows only pathways leaving the Tybee Island Shoal (with the exception of the beach nourishment actions). Consequently, the Tybee Island Shoal and shoreline can only be losing sand. Some of the erosion experienced on the shoal and shoreline is part of the natural process, since there was deflation of the Tybee Island Shoal and shoreline erosion prior to construction of the project. The primary difference in the pre-and post-project budgets for the Tybee Island Shoal is the loss of bypassing from Barrett Shoals across the entrance channel. Channel dredging cuts off the natural bypassing mechanism. Deposition of those sediments outside the nearshore sand sharing system effectively removes those sediments from Tybee's natural renourishment processes. Construction of jetties and channel dredging generally cause deflation of the ebb shoal and eventual down-drift erosion.

The impact of the Savannah Harbor Navigation Project on the Tybee Island Beach is evaluated as the difference in volume loss rates (post-project minus pre-project) for the Tybee Island shelf cell of the sediment budget plus the estimated shoreline change (erosion) rate (converted to a volume). The estimated combined shelf and shoreline impact at Tybee Island was calculated to be 78.5%. This means that an estimated 78.5% of the reduction in sand volume on the Tybee shelf and shoreline is due to the existing navigation project. The remainder of the erosion is attributed to natural processes. In volumetric terms, the volume change rate for the Tybee Island shelf and shoreline due to the existing project is approximately 227,000 cubic meters (297,000 cubic yards) of sand per year. The reduction in sand volume has mainly occurred on the Tybee shelf, with both losses of sand on the Tybee beaches (northern end) and gains (southern end). The reduction of sand bypassing from the north to the Tybee shelf is estimated at -207,000 cubic meters/year.

From a general study area standpoint, the volume change rates north of the entrance channel (Barrett Shoals, Calibogue Sound, Breakwater Lee, Daufuskie and Turtle Island Shelves) have changed from -76,000 cubic meters/year to +76,000 cubic meters, indicating the impact north of the channel is net accretion. Similarly, the net volume change rate south of the channel has changed from +101,000 cubic meters/year to -220,000 cubic meters/year (north Tybee shoal and Tybee Island shelf) indicating net erosion.

Sea level rise would have affected both the location and rate of wave-induced erosion of the Tybee shoreline. As the sea level has increased the depth of water in the nearshore area would have increased, allowing waves to break closer to the shoreline, thereby increasing the shoreline erosion rate. As the sea level increased, the location of the natural long-term erosion would move landward, closer to any man-made structures located along the shoreline.

Present Condition

The present Federal Navigation Project includes an entrance channel that is approximately 11.4 miles long. The entrance channel is maintained at 44-feet deep and 600-feet wide for the first 8.7 miles and 42-feet deep and 500 feet wide for the remaining 2.7 miles. A rock jetty along each side of the channel at the river entrance confines the tidal flows.

Analysis of the 1999 After Dredging and 2000 Before Dredging entrance channel surveys shows the major sedimentation areas are: (1) the north side of the seaward bend of the channel where it intercepts sediments from Barrett Shoals (Stations –29+000(B) to –41+500(B)), and (2) closer to the inlet on the southern side of the channel (Stations –24+000(B) to –32+000(B)).

Approximately 1,000,000 cubic yards of O&M sediment (mostly sand) are removed from the bar channel on an annual basis. Those sediments from the entrance channel are typically removed by hopper dredge and taken to the Offshore Dredged Material Disposal Site (ODMDS). The ODMDS was designated and approved by the US EPA in 1987. The 4.26 square mile site is located about 3.7 nautical miles east of the coastline and about 0.25 nautical miles south of the entrance channel (Figure 11).

In addition to the ODMDS, there are other areas available to be used for placement of maintenance dredged sediment from the bar channel which were approved as part of the LTMS process. These placement areas include sites in the nearshore off Tybee Island and sites located just south of the entrance channel for construction of submerged feeder berms. Placing dredged sediment at these sites would provide the opportunity for the material to eventually move towards Tybee Island Beach as a result of wave action. If constructed, the berms created at these sites would also serve as a protective barrier to the beach since waves would expend energy moving sediment from the berms before the waves reach the beach.

To date, two of the sites designed for submerged feeder berm construction adjacent to the entrance channel have been used. Generally, the sites are too shallow for use of a conventional hopper dredge. A conventional hopper dredge could be used if it was equipped with pump-out capability so that it could pump the sediment directly to the site. Since this would greatly increase dredging costs, sites with the shallow depths would more than likely only be used in those instances when the entrance channel is maintained by hydraulic pipeline dredge since this type of dredge could place the sediment directly into the sites. A hydraulic pipeline dredge would be used to maintain the entrance channel only in those instances when a hopper dredge could not normally be used. An example of this type of situation is the eight month period out of the year when hopper dredging is prohibited in the entrance channel due to the presence of endangered sea turtles.

The LTMS also authorized suitable maintenance material from the Savannah Harbor Navigation Project to be placed directly on the beach at Tybee Island. However, most of the material removed during maintenance dredging operations in the entrance channel is not suitable for direct placement on the beach. From a beach compatibility standpoint, sediment removed from the entrance channel averages about 13 percent fines, which is more suitable for nearshore placement than direct placement on the beach. However, hopper dredges must have pump-out capability to put material into the nearshore off Tybee Island or directly on the beach. This type of placement operation greatly increases project costs.

The “Base Plan” for Savannah Harbor as defined in Corps of Engineers policy is the dredged material placement alternative or alternatives identified by the Corps which represent the least costly alternatives consistent with sound engineering practices and meeting the appropriate environmental standards. The Base Plan for the maintenance of Savannah Harbor entrance channel is to place the material into the ODMDS or Site 2 and Site 3 (See Figure 11 below) just south of the entrance channel. If placement at alternate locations is found to be more desirable for environmental or other reasons but would be more costly than the Base Plan, it can be pursued with appropriate cost sharing.

Erosion of the Tybee Island shoreline continues to be a problem. The initial shore protection measure involving placement of sand on the Tybee beaches was completed in 1975. Four other sand placements occurred from 1986-2009. The latest placement of sand on the Tybee Beaches was completed in 2009 and involved placing about 1.25 million cubic yards of sediment.

Present Actions / Stresses

As determined in the ERDC report, existing conditions are characterized by deflation of the Tybee Island shelf and erosion of the north end of Tybee Island. The current entrance channel (including the entrance channel jetties) causes a pattern of ebb shoal deflation on the Tybee Shelf and appears to be nearly a complete littoral sink for any sediment moving from north to south along the Tybee shelf. These studies estimated that the combined shelf and shoreline impact at Tybee Island to be 78.5%. This means that an estimated 78.5% of the reduction in sand volume on the Tybee Island shelf and shoreline can be attributed to the existing project with the remainder of the erosion attributed to natural processes.

The major sedimentation areas on the entrance channel are: (1) the north side of the seaward bend of the channel where it intercepts sediments from Barrett Shoals (Stations –29+000(B) to –41+500(B)), and (2) closer to the inlet on the southern side of the channel (Stations –24+000(B) to –32+000(B)).

Periodic removal of sediments to maintain adequate depths in the navigation channel will continue. Since hopper dredges are the lowest cost equipment available to perform channel maintenance, deposition of the excavated sediments is likely to continue to be in the ODMDS or Sites 2 and 3. Such placement removes those sediments from the nearshore sand sharing system of the inlet and Tybee Island.

As stated above, an estimated 78.5% of the reduction in sand volume on the Tybee Island shelf and shoreline can be attributed to the existing project. Any mitigation for this effect would be the responsibility of the existing Savannah Harbor Navigation Project.

To obtain mitigation for these impacts to the shoreline and shelf of Tybee Island due to operation of the Savannah Harbor Navigation Project, the Corps must follow the civil works planning process as outlined in ER 1105-2-100. A specifically authorized study, known as the Tybee Channel Impacts Study, provides the authorization for the Corps to study the impacts (Phase I) and determine appropriate mitigation measures (Phase II). Phase I of the study was completed in 2008. The Corps was working with the City of Tybee as recently as 2010 to continue with Phase II of the study, however, the City of Tybee Island has indicated they did not have a source of matching funds required to continue the study as the non-Federal cost-sharing partner. Should the City of Tybee find a source of matching funds, the cost-shared study could be resumed. Under the normal civil works process, a feasibility report, Record of Decision, and Chief's Report must be completed. The Chief's Report would be provided to Congress, who could then authorize the Corps to implement mitigation measures.

Capacity to Withstand Stress

Construction and maintenance of the Savannah Harbor Navigation Project impacts the Tybee Island nearshore area and the beaches. In addition to the effects of the navigation channel, natural coastal processes (waves, storms, etc) also contribute to the erosion of the Tybee Beaches. Shore protection (beach nourishment) has been required five times between 1986 and 2009. Based on the current erosion characteristics of the north end of Tybee Beach, this resource has little capacity to withstand further stress.

Future Actions / Stresses

Maintenance of the Savannah Harbor Navigation Channel will continue. As discussed in previous paragraphs, construction and maintenance of the project is a major factor in depletion of the sand budget for the Tybee shelf and the erosion of the Tybee beaches.

Sediments removed during periodic maintenance of the entrance channel would likely continue to be deposited in the ODMDS or Sites 2 and 3. Placement in the ODMDS removes those sediments from the nearshore sand sharing system of the inlet and Tybee Island. The sediments may still be available in the sand sharing system on a larger geographic scale.

Periodic renourishment of the Tybee Island shoreline is expected to continue. This should keep the ocean shoreline between the north and south groin relatively stable, keeping the shoreline away from the seawall and adjacent oceanfront properties. Sediments are likely to continue to be borrowed from the nearshore area off the southern end of the island. That general area was used in recent nourishments and contains sediments that are suitable for this purpose.

Natural processes will also continue to erode the Tybee beaches. These processes include wind and wave and current action, especially during certain types of storm events.

Sea level is expected to continue to rise in the future. This would have similar effects as in the past, where both the location and rate of wave-induced erosion of the Tybee shoreline could increase. This could lead to an increase in the rate of shoreline erosion and concern about its potential effects on man-made structures located along the shoreline.

Concern has also been raised about the potential for harbor deepening to further exacerbate erosion of the Tybee Island beaches. If constructed, the harbor deepening project would involve deepening the entrance channel from its existing authorized depth of -44 feet MLW to -49 feet MLW.

Likewise, construction of a Jasper County container terminal could have similar concerns in regard to Tybee Island. Although no detailed plans are available for that project, it is assumed the entrance channel dredging requirements would be comparable to that for the SHEP since similar vessels would use both facilities.

Incremental Impact

The incremental impact of the Savannah Harbor Navigation Project on the Tybee Island beaches has been discussed in previous paragraphs. In order to address the concern that harbor deepening could have adverse effects on the erosion of the Tybee Island beaches, the Corps conducted studies during the SHEP to address that potential issue.

Channel maintenance volumes are not expected to increase for the entrance channel between Stations 0+000 and -60+000B. Some increase in dredging volume would result from extending the channel from Stations -60+000B to -97+680B. However, based on sedimentation patterns in the existing entrance channel, the sedimentation in that additional offshore channel length is expected to be comparatively small.

The current navigation channel appears to be a nearly a complete sink for any sediment moving from north to south along the shelf (suggested by pre- and post-dredging surveys and the consistency of dredging volumes following past deepening projects). Placement of dredged O&M sediment, back in the nearshore zone of Tybee Island would be a means for restoring this supply of sand to the Tybee beach system.

ERDC evaluated the impact of the proposed deepening of the Savannah Harbor navigation channel. They conducted bathymetry and volume change analyses to obtain the historical perspective of the Savannah nearshore evolution. They also performed numerical modeling of circulation, waves, and sediment transport to compare pre- and post-deepening of the channel impacts on the coastal processes.

The GTRAN modeling reflects conditions in deeper water where waves tend to agitate and suspend sediment and currents tend to move the sediment, not the shallow surf zone region along the Tybee Island shoreline. The very shallow nearshore region is much more wave dominated than the offshore region for which GTRAN was applied. ERDC did not conduct shoreline change modeling of the inner surf zone region, but the minor changes in the nearshore wave results indicate that the proposed deepening would have little impact on the shoreline.

The circulation and wave modeling indicate very small changes associated with the proposed deepening. The GTRAN results provide insight about what the proposed deepening would do in terms of sediment transport regime, which is expected to be similar to that of past harbor deepening projects. GTRAN results for the existing condition and the with-deepened-channel condition indicate that the additional channel deepening will not change the general overall pattern of sediment transport in the region. The most noticeable changes were computed in the channel.

Transport in the Tybee Knoll Bar Channel reach showed decreases in magnitude for all four of the typical months of simulation, but conditions remain strongly ebb-dominant. The magnitude of change was greatest in this reach (15-20 percent), compared to changes throughout the rest of the system (changes elsewhere were generally quite small, several percent). Some small increases to shoaling rates in this reach of the channel might be expected in light of these decreases in flow, but gradients in transport (which dictate accumulation rates) do not appear to be altered very much.

Transport in the Tybee Roads Channel reach consistently shows increases for each of the typical months, but only very slight increases (a few percent). No significant changes in sedimentation are expected in this reach of the navigation channel. Transport rates increase in this portion of the channel for a hurricane event (simulations used a re-tracked Hurricane Hugo) (about a factor of 2 greater), as they do for all sections of the main channel. Transport remains strongly ebb dominant in this reach.

In the Tybee Range Channel reach (the outer limits of the navigation channel), changes in transport rate would also be very small. The deepening would increase rates for one month, show zero change for one, and show slight decreases for two of the months. All increases or decreases are small (a few percent). For re-tracked Hurricane Hugo, the deepening would increase transport by about 20%, compared to a factor of 2 in the other channel reaches. This section of channel remains ebb-dominant. These changes do not suggest any significant changes in channel shoaling and they suggest that the channel region will remain strongly ebb-dominant in terms of sediment transport direction.

Average transport within the Tybee Island Shelf region consistently shows slight increases or no change for each of the four typical months, and an increase for the extreme event. No decreases were computed. Patterns appear unchanged and the net direction of movement appears to remain to the northwest. Slight increases suggest a tendency for sediment to be transported from the shelf region to the northwest at a higher rate. This would be consistent with the hypothesized model for how sand has been moving to the northwest in response to initial project construction and subsequent deepening. The proposed deepening seems to produce a result consistent with that hypothesis. However, the magnitudes of change are quite small, in the range from 0 to 2 percent for all months and even for the extreme hurricane event. Zero change was computed for two of the four months. Computations show that channel deepening would have negligible effect on the Tybee Island Shelf.

For the North Tybee Shoal region, computations show a consistent decrease in transport rate for all four months, about 5 percent or less; however, for the extreme hurricane event transport rates are increased by about 40%. These changes suggest that sediment being transported into the North Tybee Shoal region will have less of a tendency to leave the region, but this is more dictated by changes to the transport gradients. Such a trend would be consistent with historic accumulation of sediment in these shoals.

The ERDC report concluded that the existing navigation channel essentially acts as a complete littoral sink. As such, construction of SHEP will not cause additional impacts to the littoral supply downdrift of the navigation channel. In summary, the proposed harbor deepening alternatives are expected to produce minimal adverse impacts to the nearshore area or the Tybee Island shoreline.

Alternatives to Mitigate for Cumulative Effects

Substantial changes have occurred over time in the sediment transport patterns at the Savannah River entrance. Construction of the jetties and deepening of the navigation channel have concentrated ebb tidal flows through the center of the inlet. The increased tidal velocities push sediments that would deposit at the inlet further out into the ocean.

The changes that have occurred over time along Tybee Island have primarily been located offshore. The island’s ocean shoreline has been relatively stable, advancing in some areas, eroding in others, and structurally protected or nourished along the majority of its length. However, the subaqueous platform offshore of Tybee has deflated and deepened somewhat, increasing the wave climate that reaches the shoreline.

Maintenance of the navigation channel and the subsequent deposition of those sediments at the ODMDS remove sediments from the nearshore sand sharing system. The current navigation channel appears to be nearly a complete sink for any sediment moving from north to south along the shelf (suggested by pre- and post-dredging surveys and the consistency of dredging volumes following channel deepening). Mitigation to date has included construction of various groin structures and beach re-nourishment.

Additional mitigation could be achieved by placing dredged sediment back into the nearshore zone of Tybee Island to restore the supply of sand to the Tybee beach system. Suitable sediment removed during normal maintenance of the entrance channel could be placed in the nearshore area off Tybee Island to construct feeder berms. This would function as a form of sand bypassing and could (1) restore depths in the nearshore area off of Tybee Island, (2) create and maintain submerged berms, or (3) create and maintain emergent islands. Re-inflating the nearshore platform, the submerged berms, and the emergent islands could reduce the wave climate experienced at the beach.

Provisions were included in the LTMS for the use of such sites. Site 2 Extension, MLW 500, MLW 200, and ERDC Nearshore (Figure 11) provide sites for the construction of feeder berms. Suitable sediment from the entrance channel could be placed into these sites providing opportunity for these sediments to be subsequently dispersed as part of the sand sharing system for the Tybee Island beaches. However, use of these sites in most cases would be more expensive than present maintenance practices. The increased costs of using these sites on a routine basis would have to be borne by a non-Federal sponsor.

If constructed, the SHEP would provide an opportunity to place suitable new work sediments in the sand sharing system for Tybee Island. Using the concepts developed in the LTMS, plans for the harbor deepening project included the use of nearshore sites for suitable material from the entrance channel that could benefit the Tybee Island beaches. Suitable material is generally defined as material with a fines content of less than 20 percent. Figure 11 shows the sites that were proposed for placement of suitable dredged sediment from deepening and extending the entrance channel.

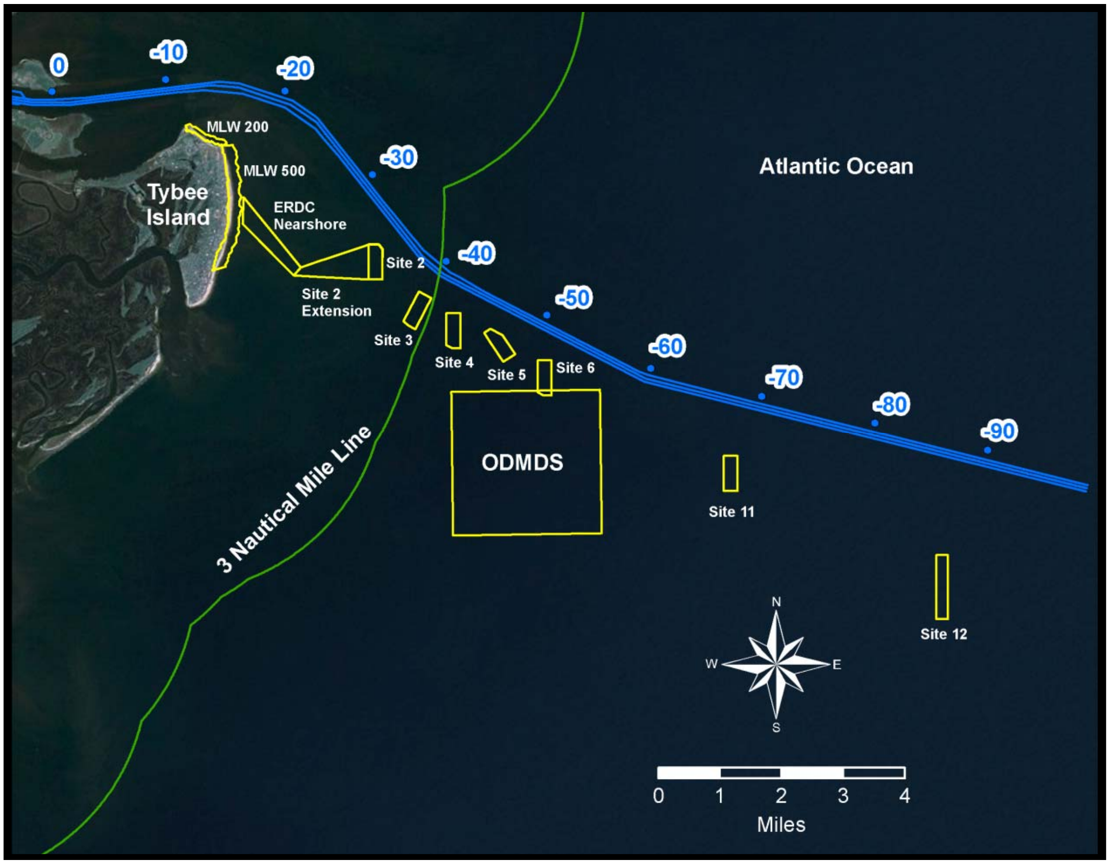

Figure 13. Savannah Harbor Deepening Offshore Disposal and Nearshore Placement Sites as Initially Proposed

Two of the sites would involve placement of suitable dredged sediments close to the beach. MLW 200 would be located northwest of the North Groin on Tybee Island. Sediment would be deposited at the mean low water (MLW) line and allowed to mound up to mean seal level (MSL) or mid-tide. When filled to capacity, this site has a capacity of 217,000 cubic yards creating a mid-tide berm about 200-feet wide and 3,200 feet long. Site MLW 500 would be located south of the North Groin on Tybee Island. Sediment would be deposited at the MLW line and allowed to mound up to MSL or mid-tide. This site has a capacity of 1,896,000 cubic yards which would create a berm about 500-feet wide and 11,000 feet long.

Three of the sites designated to receive suitable dredged material from deepening of the entrance channel would be located in nearshore areas east of the beach. ERDC Nearshore would be located below the MLW contour. When filled to capacity (1,165,000 cubic yards), the top elevation of the site would be -5 feet MLW so as not to interfere with boaters while still providing opportunity for movement of sediment towards the shoreline through wave action. Site 2 would be located below the MLW contour east of the southern end of the beach. At total capacity (3,225,000 cubic yards), the top elevation of the site would be +8 feet MLW permitting it to serve as bird and shallow water and shoreline fish habitat as well. Site 2 extension would extend from Site 2 to below the ERDC nearshore site. When filled to capacity (4,251,000 cubic yards) the top elevation of the placement would be at -5 feet MLW.

The remaining placement sites initially proposed to receive new work dredged sediments are four sites (Sites 3-6) just south of the entrance channel designed for submerged berm construction previously approved during the LTMS. The other two sites are designated Sites 11 and 12 and which were to be used to place suitable material from the outer most portions of the entrance channel. Placement of material at those two sites would not help the sand budget for Tybee Island Beach, but use of these sites would provide additional fish habitat.

Based on DEIS review comments received from the Georgia Department of Natural Resources, Coastal Resources Division and the City of Tybee Island, the use of these nearshore dredged material placement sites has been removed from the project. The City of Tybee Island and the CRD are concerned that the sediments that would have been placed in these sites are not of beach quality. Consequently, sediments that would have been placed in these nearshore sites (As well as Sites 11 and 12) would, instead, be deposited in the Jones/Oysterbed CDF or the ODMDS. Additionally, the EPA has indicated that any site beyond the 3-mile line is considered an ocean dredged material disposal site. Consequently, Sites 4, 5, 6, 11, and 12 would have to be evaluated using Section 103 (MPRSA) criteria and site designation approval requested from the EPA.

In addition to the SHEP, conceptual plans for a Jasper County container terminal have been developed. This facility may be located in what is now CDFs 14A and 14B at about River Mile 6. Dredging requirements for this facility would be similar to the SHEP project with the exception that improvements to the inner harbor channel would only be required to River Mile 6. As with the SHEP, the main potential for impacts to the Tybee Island Beach would be associated with the entrance channel deepening, widening, and extension. Since entrance channel improvement requirements are similar for the two projects, construction of a Jasper County terminal would have very little impact on either the Tybee Shelf or the Tybee Island Beach.