Water Quality Changes in the Savannah Harbor Following Modifications

by
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History of the Savannah Harbor

The Savannah Harbor has a rich history with many changes that have affected the location of the saltwater-freshwater interface over the years starting officially in the late 1800s. The area just north and east of the Harbor was designated as a National Wildlife Refuge in 1927. Through the years, this refuge has grown to over 26,500 acres. The Harbor itself is heavily industrialized with paper mills, a sugar refinery, many chemical factories, and docking facilities. The riverfront area of Savannah is a tourist attraction rich in historic architecture with many shops and restaurants. The industrial, navigational, tourism, and wildlife interests are often found competing against one another for this multipurpose resource.

Location

The Savannah Harbor is located on the South Atlantic Coast, 75 miles south of Charleston Harbor, South Carolina, and 120 miles north of Jacksonville, FL. The Harbor comprises the lower 21.3 miles of the Savannah River that, with some of its tributaries, forms the boundary between South Carolina and Georgia. The dredged channel extends 11.4 miles across the bar to the Atlantic Ocean (U.S. Army Corps of Engineers 1992).

From the U.S. Highway 17 (Houlihan) Bridge to the Dixie Crystals Sugar Refinery, the river consists of three waterways: Front River on the South, Middle River and Little Back River on the North. Middle River rejoins Front River opposite the sugar refinery. Little Back River becomes Back River and continues parallel to Front River to their confluence near Fort Jackson, just east of the city. Onslow Island lies between Front River and Middle River. Hutchinson Island lies between Front and Back rivers. Approximately 1.5 miles seaward of the junction of Back and Front rivers, they split again into the North and South channels, and remain so until their confluence with the Atlantic Ocean. Elba Island lies between the North and South channels. The North Channel is the navigation channel for shipping vessels (See Figure 1).

Chronology of Corps of Engineers Projects on the Harbor

The existing project was originally authorized by the Act of June 23, 1874, and was modified by subsequent acts. In June of 1910, a 26-ft-deep channel from Fort Pulaski to the Seaboard Coast Line Railroad Bridge was authorized. In July of 1912, this channel was extended by adding a 21-ft channel from the Seaboard Coast Line Railroad Bridge to the foot of Kings Island at river mile 18. In August of 1917, a 30-ft-deep channel from Fort Pulaski to the sea was authorized. Further deepening and harbor extensions were authorized in 1927, 1930, 1935, 1945, 1946, 1954, 1962, 1965, 1976, 1984, 1989, 1992, and 1993 (U.S. Army Corps of Engineers 1991).

In 1977, the Tide Gate, New Cut, and Sediment Basin were constructed in Back River as a cost-saving project for maintenance dredging. It saved one million dollars per year while it was in use from 1978 to 1991. The gates opened on flood tide and closed on ebb tide, forcing the water through New Cut and down

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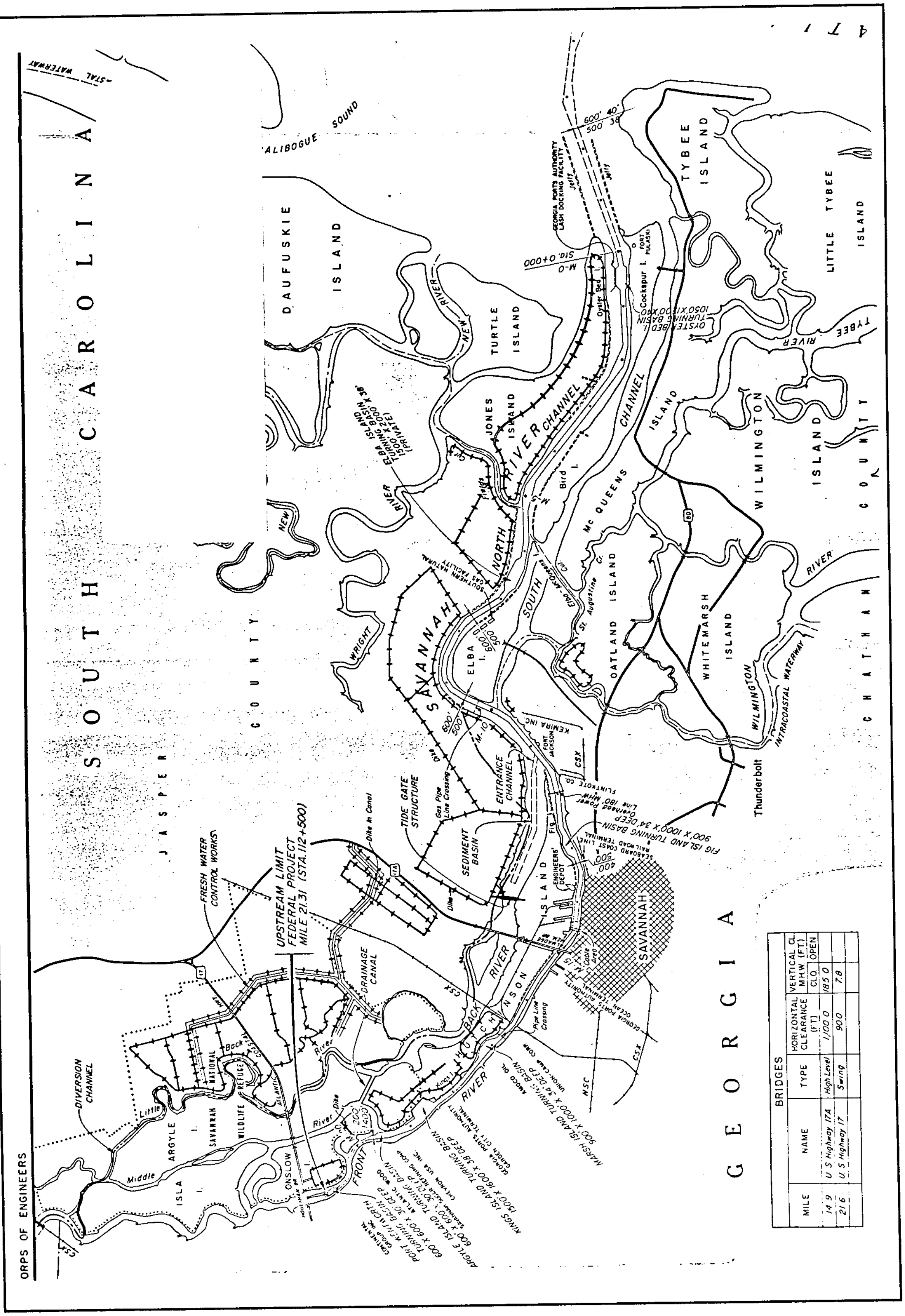

Figure 1. Savannah Harbor

Front River at high velocities, preventing sediment from falling out in Front River where it is most costly to dredge because of the distance to disposal areas. The cost benefits as well as the navigational safety of not having dredges and pipelines in the channel made the Tide Gate one of the most popular Corps projects of Savannah District's history. The project was designed such that the sediment fell out in the Sediment Basin where Back River meets Front River. It is much less expensive to dredge the Sediment Basin since the disposal areas are adjacent to the Basin. The project was taken out of operation and New Cut was filled in 1991.

The current channel geometry consists of a 38-ft-deep channel from stations 0+000 to 102+000 and a 36-ft-deep channel from 102+000 to 112+500. The 1993 Deepening project authorized a 44-ft channel from stations -60+000 to -14+000 and a 42-ft channel from stations -14+000 to 0+000. It also authorized a channel 42 ft deep from 0+000 to 24+000, a 44-ft-deep channel from 46+000 to 79+600, a 42-ft channel from 79+600 to 103+000, and a 38-ft-deep channel from 103+000 to 104+250 (U.S. Army Corps of Engineers 1992).

Reason for the Harbor Modifications

New Cut, which was constructed as a throughway for the water backed up by the Tide Gate, was filled in 1991 and the Tide Gate had all of its gates held open. The U.S. Fish and Wildlife Service and State Resource agencies required that this channel modification be made in order for the Savannah Harbor Deepening Project to be approved. Closing New Cut and opening the tide gate restored the navigation project back to pre-1975 conditions except for deepening and widening. Closing the cut prevents striped bass eggs from floating through the cut on ebb tide to Front River where they are exposed to higher pollutant concentrations. Prior to the closure, eggs could have been forced through the cut at ebb tide and flushed seaward to higher salinity concentrations where they do not survive.

The optimum salinity concentration for the striped bass eggs to thrive is about 1 to 3 parts per thousand (ppt) (Dudley and Black 1978). Eggs that are forced into the higher salinity concentrations of 10 to 20 ppt do not survive as well as those allowed to remain in lower salinity concentrations.

Little Back River, now with lower salinity concentrations, provides a safe haven for striped bass eggs except for periods of high flow, where they can be flushed into the lower reaches of the Savannah River where salinity concentrations are greater than 20 ppt.

Another reason for the channel modification was to restore saltwater marsh back to freshwater marsh. When the tide gate was operating, about 4,000 acres of freshwater marsh in the National Wildlife Refuge were gradually converted to saltwater marsh. Now that the gate has been opened, these acres are now converting back to freshwater marsh. Since there is a shortage of freshwater marsh in the United States, it is much more valuable than saltwater marsh; this conversion is welcomed by the U.S. Fish and Wildlife Service (Pearlstine et al. 1989).

Water Quality Conditions Before and After Modifications

The saltwater-freshwater interface location can be summarized according to Table 1. The locations of the salinity interfaces are shown on Figures 2-7.

Table 1
Comparison of Location of Salinity Interface Before and After Harbor Modifications

Flow, cfs		Location, River Mile	
		Front River	Back River
7,000	Before	24.5	23.5
	After	23.0	20.0
	Difference	1.5	3.5
9,000	Before	23.5	22.5
	After	22.0	16.0
	Difference	1.5	6.5
15,500	Before	19.5	18.0
	After	18.2	13.5
	Difference	1.3	4.5

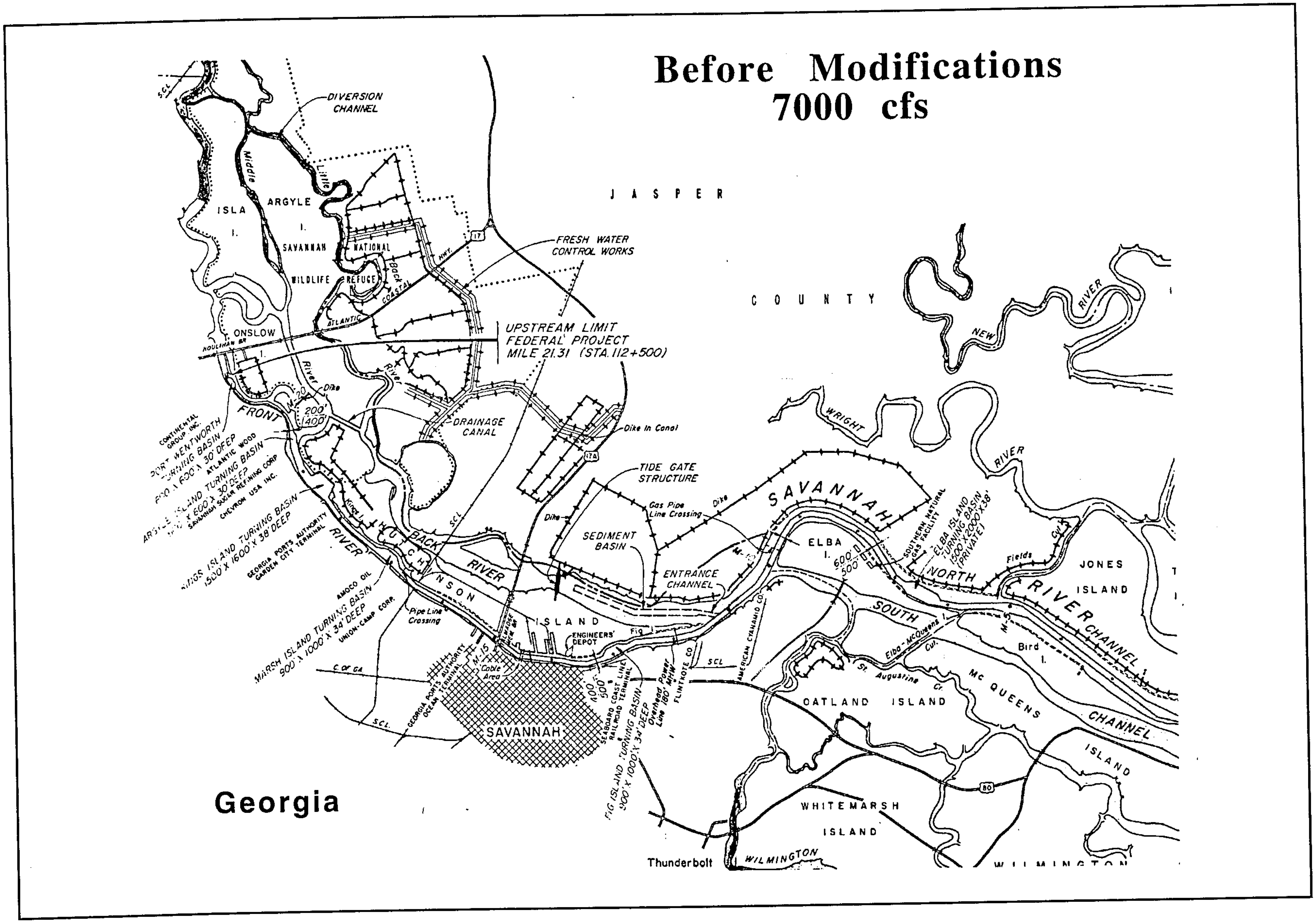

Figure 2. Salinity interface before modifications, 7,000-cfs flow

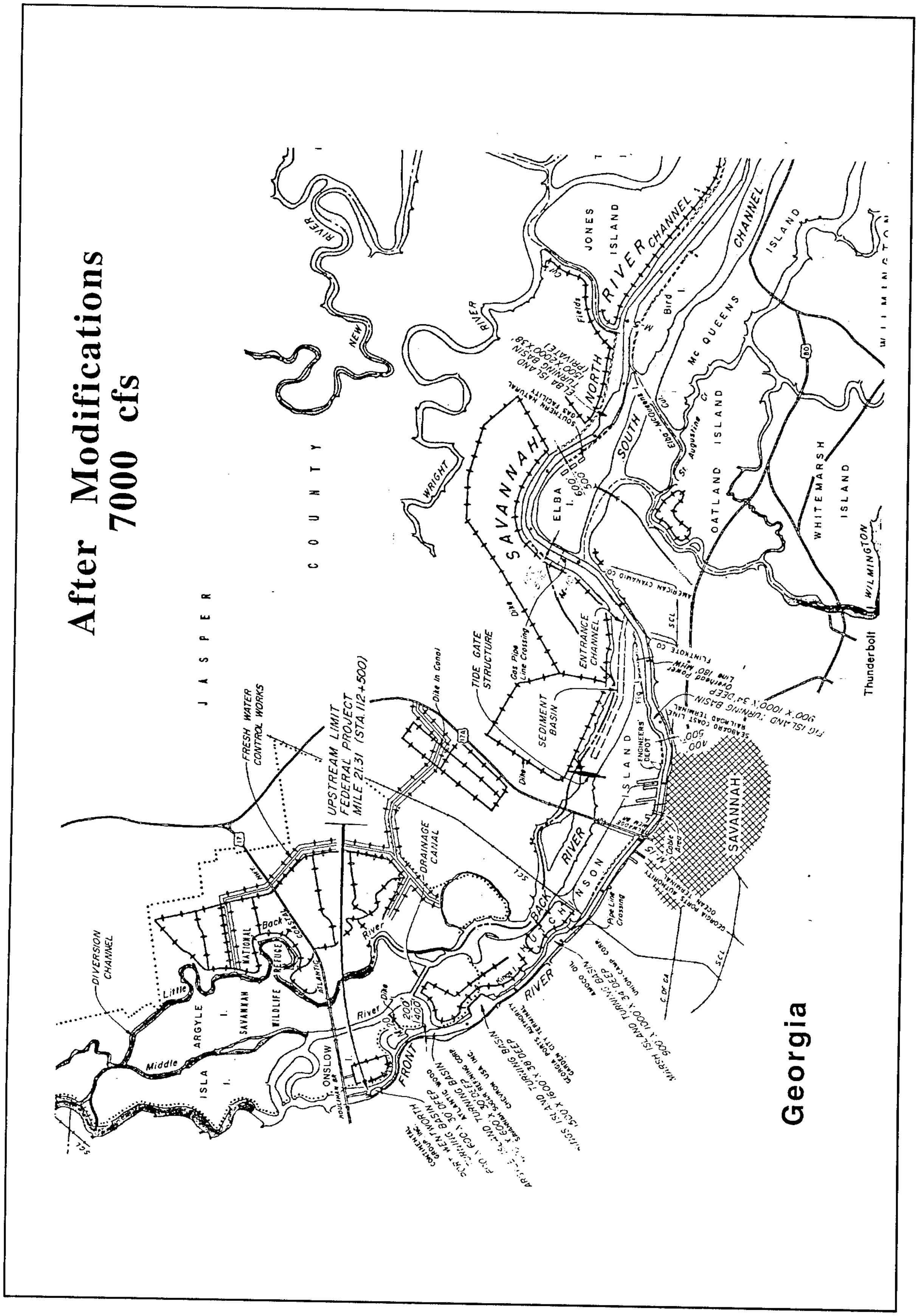

Figure 3. Salinity interface after modifications, 7,000-cfs flow

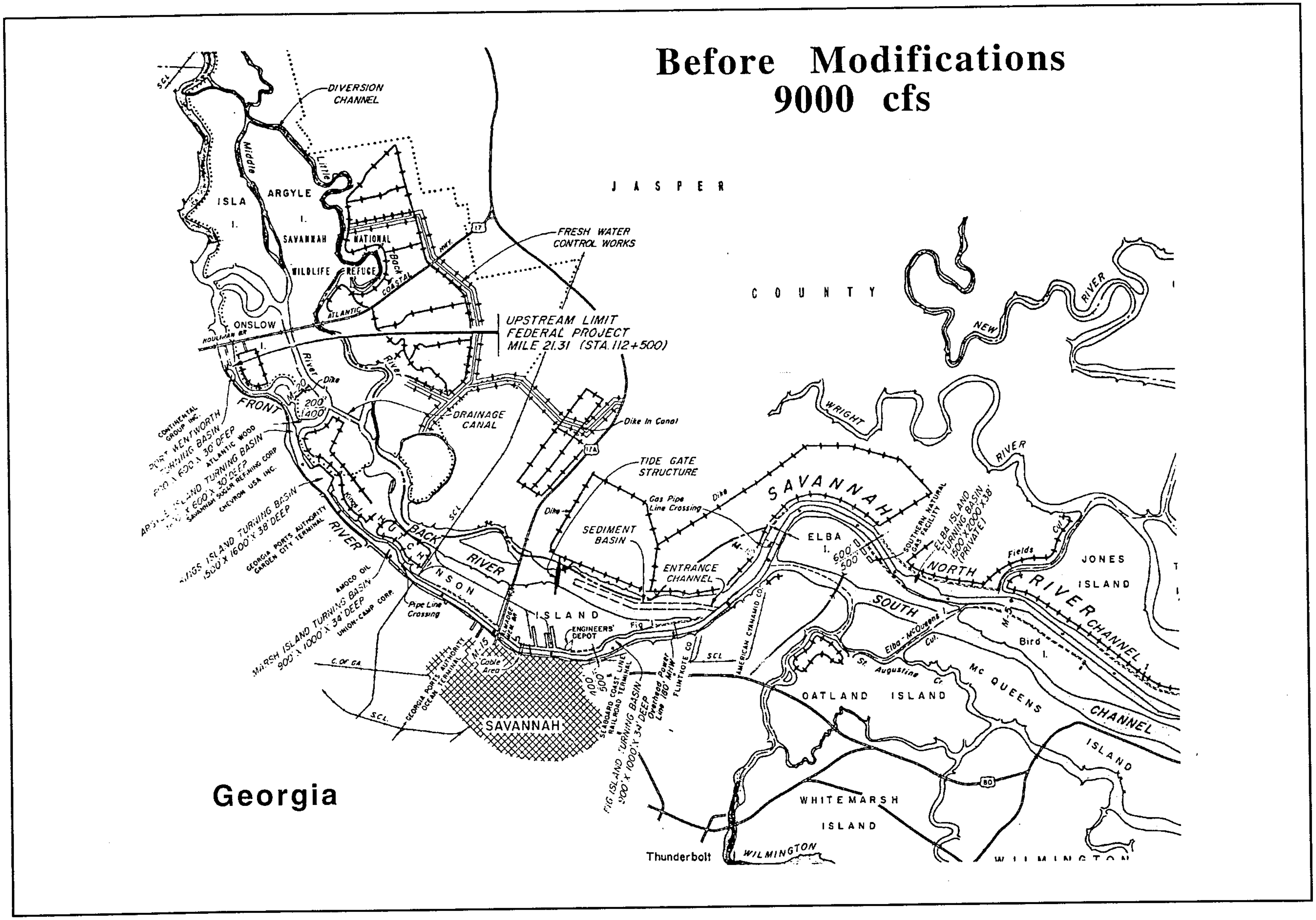

Figure 4. Salinity interface before modifications, 9,000-cfs flow

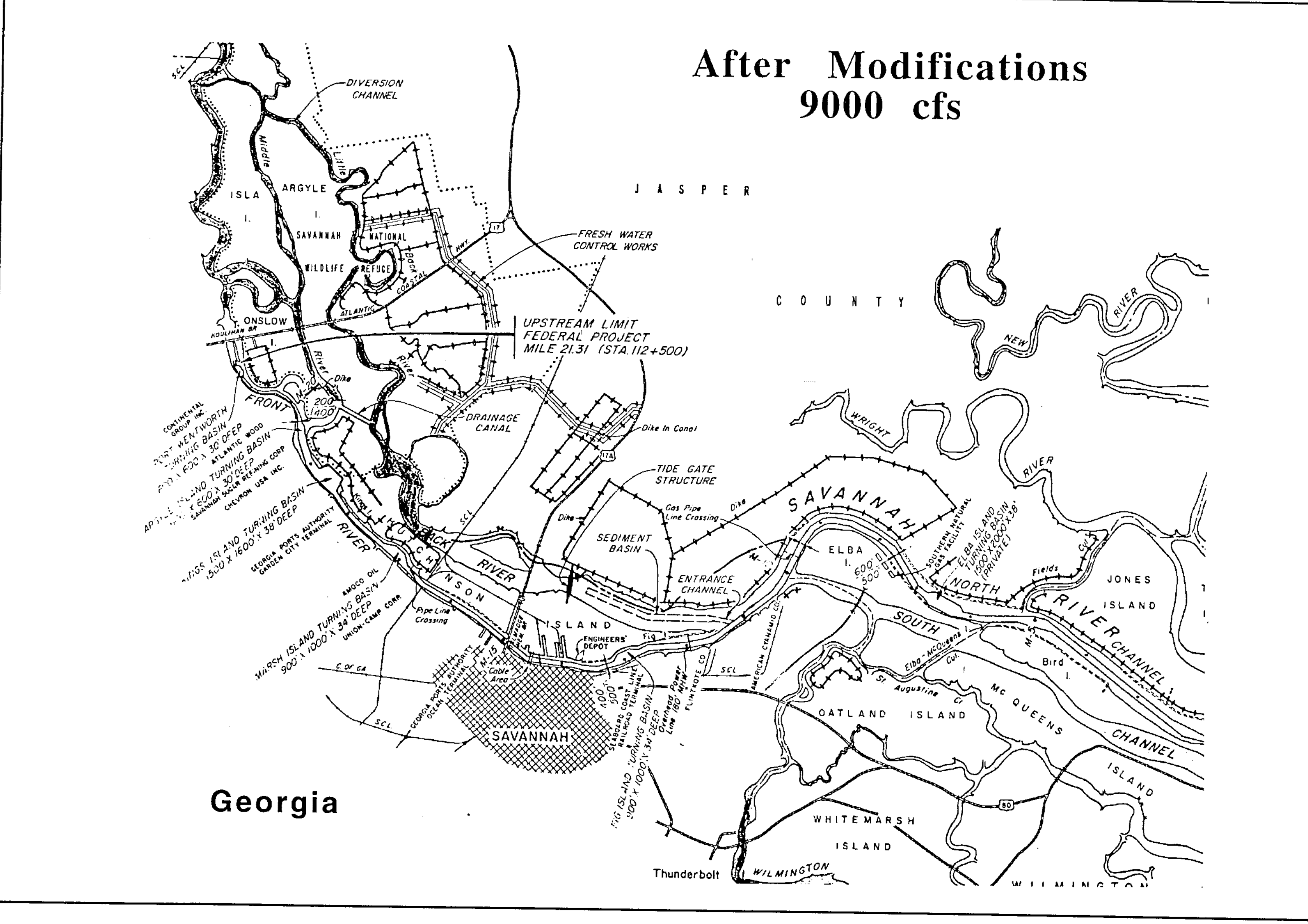

Figure 5. Salinity interface after modifications, 9,000-cfs flow

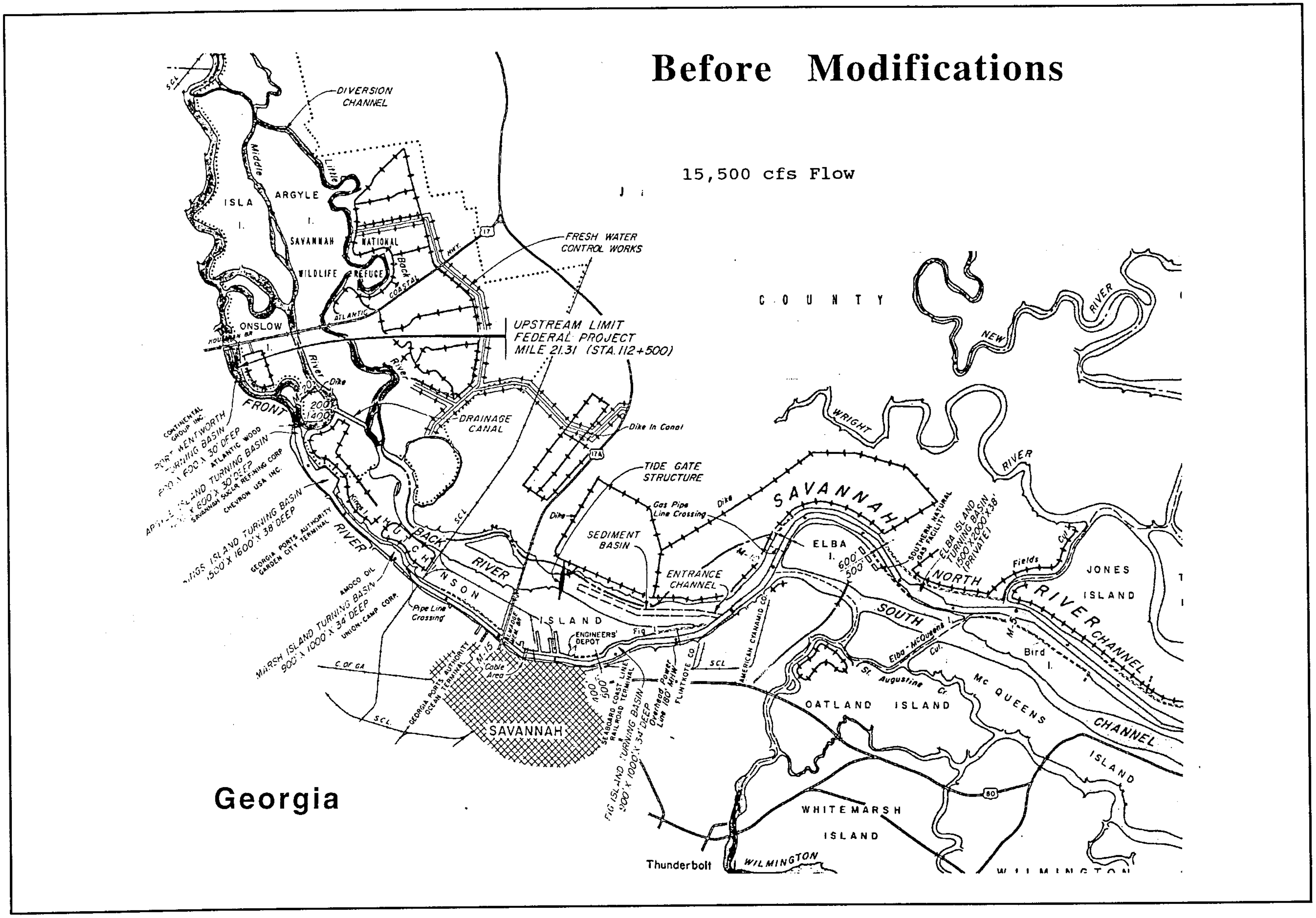

Figure 6. Salinity interface before modifications, 15,500-cfs flow

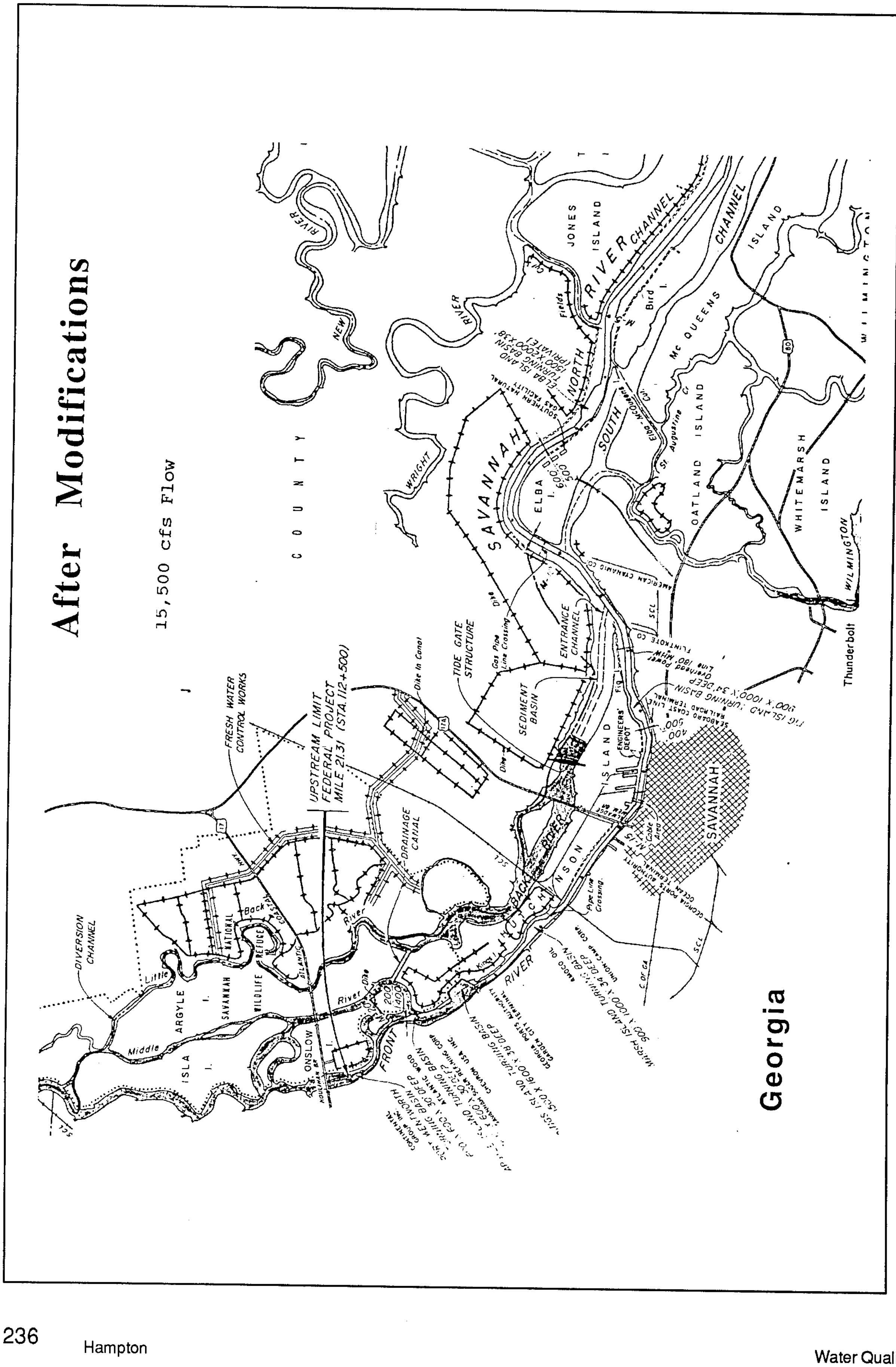

Figure 7. Salinity interface after modifications, 15,500-cfs flow

The modifications have had a significant change on the location of the saltwater-freshwater interface. The most notable change has occurred in Back River adjacent to the Savannah National Wildlife Refuge. Wildlife refuge personnel have noted that many acres of saltwater marsh vegetation are being replaced with freshwater vegetation. The locations found in the table were computed from actual field data that were used in "Curvefit," a computer program written by the U.S. Army Engineer Waterways Experiment Station. The polynomial of 1 deg (straight line) was chosen as the best and most logical curve for the data. The curves are shown on Figures 8-11. The data were taken at mid-depth using a hydrolab water quality instrument (or a YSI salinity meter in earlier years) for the location where salinity was 0.5 ppt. Data were collected over a 15-year period at various tides and river flow rates. The nearest flow gauge is at Clyo, and it was used for the flow rate parameter. Tide, wind, and flow have significant effects on location of the interface. Flow has more of a direct effect on salinity location. When fit with a curve with the Curvefit program, the flow versus river mile curves correlated better than tide versus river mile. The flow rates 7,000, 9,000, and 15,500 cfs were chosen for the table because of their exceedence probabilities. The flow rate 9,000 cfs is the average flow (or has a 50-percent chance of exceedence) for the period of record used, which is the time that the Savannah River has been under regulation of Thurmond Dam since 1954. The flow rate 7,000-cfs will be exceeded 80 percent of the time, and 15,500 cfs will be exceeded 20 percent of the time. At the lowest chosen flow for plotting (7,000 cfs), it can be seen that the salinity interface is kept well downstream of U.S. Highway 17, and this occurs at least 80 percent of the time. Prior to the modifications, the salinity interface was well upstream of the highway for the 7,000-cfs flow and within less than 0.5 miles of the freshwater intake for the impounded areas of the National Wildlife Refuge.

Future Plans

The Savannah Harbor continuously undergoes changes for navigation. The near future of the Harbor may entail extending the deepened channel upstream of U.S. Highway 17 (river mile 21.58). The salinity interface will most likely change its location to further upstream, but its location cannot be estimated without a model study incorporating the proposed channel geometry. There is a significant amount of environmental opposition to further development of the Harbor. If approved model studies can show that salinity changes will be insignificant, then such opposition should be eliminated or reduced. A model study using a three-dimensional finite element model will best illustrate the effect of deepening and extension because of the vast areas of marsh that undergo wetting and drying; however, such models are costly and funding is limited.

References

Dudley, R. G., and Black, K. N. (1978). "Effect of the Savannah River Tide Gate on striped bass eggs and larvae," University of Georgia School of Forest Resources.

Pearlstine, L. et al. (1989). "Lower Savannah River hydrological characterization," Cooperative Fish and Wildlife Research Unit, University of Florida, Gainesville, FL.

U.S. Army Corps of Engineers. (1991). *Project Maps, River and Harbor, Flood Control and Beach Erosion Control Projects.*

________. (1992). *Savannah Harbor, Georgia Comprehensive Study Main Report.*

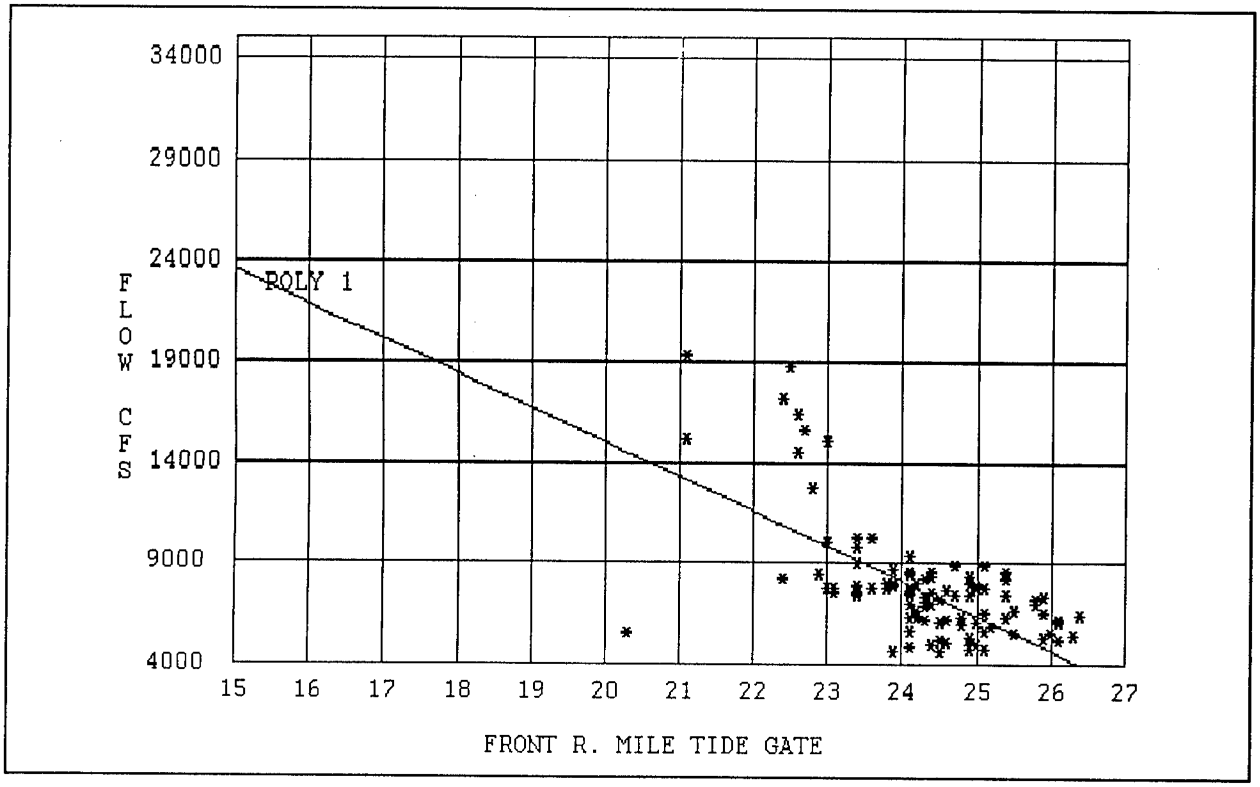

Figure 8. Salinity interface before modifications, Front River

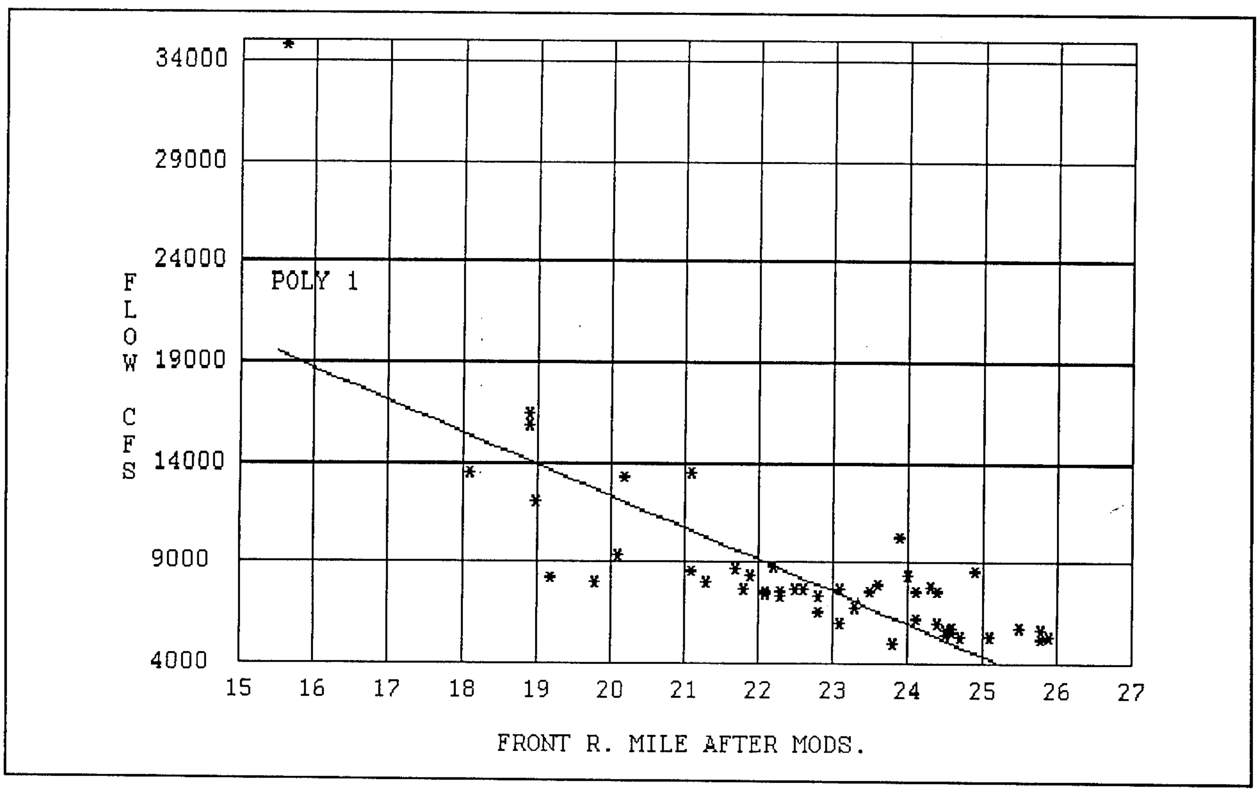

Figure 9. Salinity interface after modifications, Front River

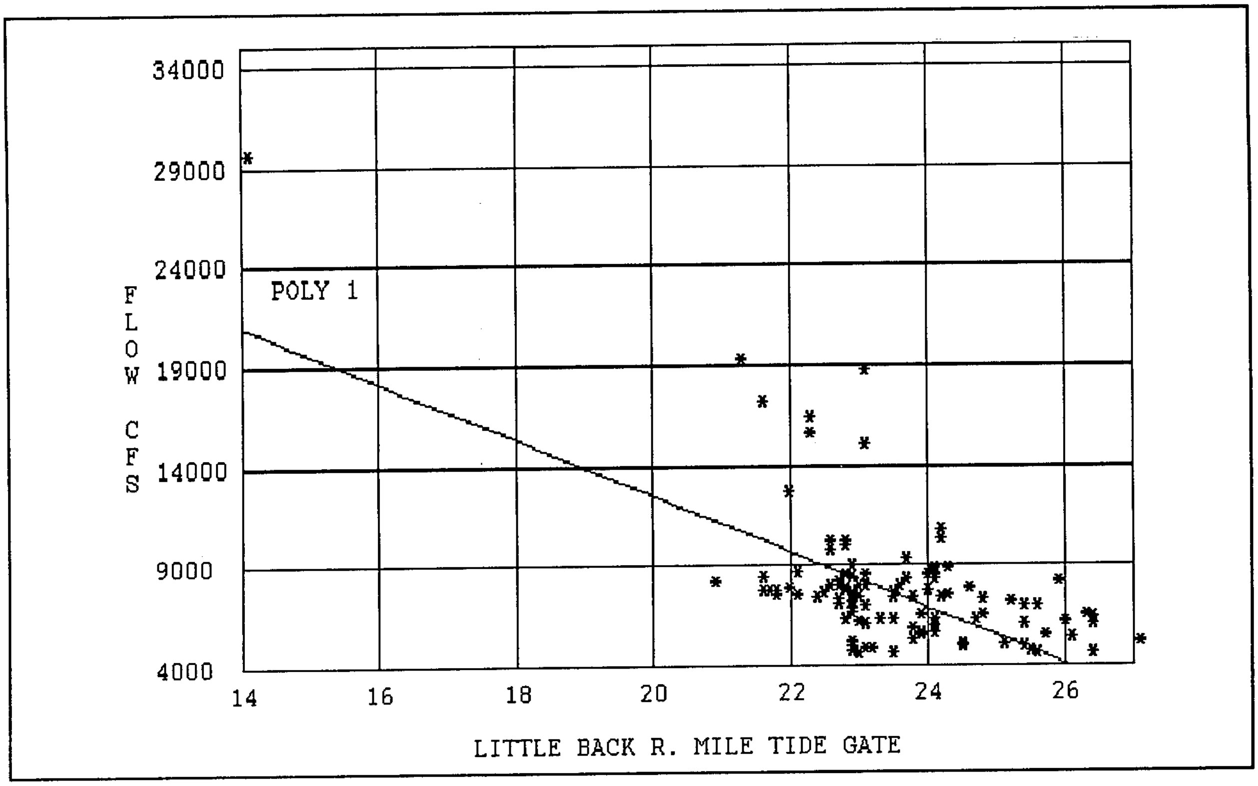

Figure 10. Salinity interface before modifications, Back River

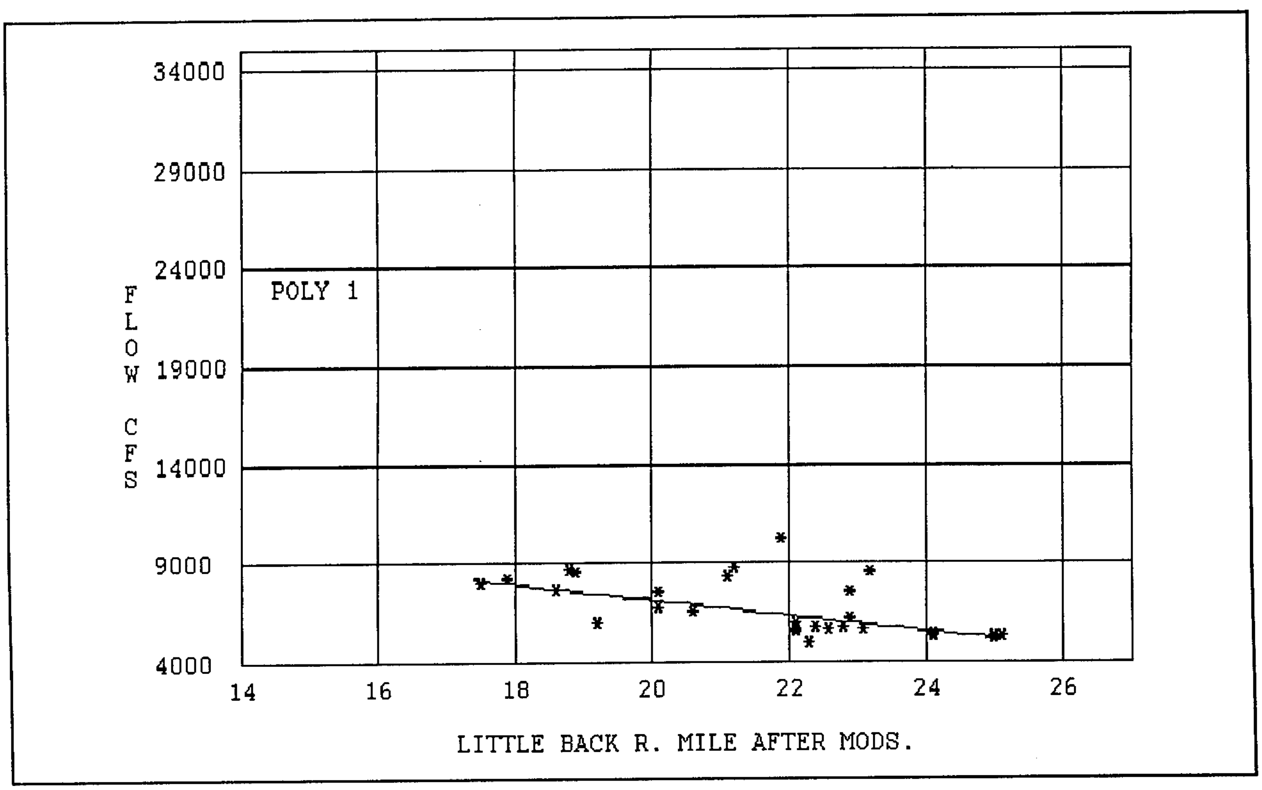

Figure 11. Salinity interface after modifications, Back River