Sedimentation Analysis

List of Tables

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Figure 7-122 Wrecks Channel Range Advance Maintenance Increase.

4. REFERENCES

The following manuals, reports, and documents were used in the design and cost estimating for the expansion project.

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2.2 "Savannah Harbor Sediment Testing Chatham County, Georgia, Jasper County, South Carolina", Final Report, Gulf South Research Corporation, July 2000.

2.3 "Savannah Harbor O&M Sediment Testing, Sampled December 1998" by Dr. Dan Bearden, Dr Geoff Scott, Mr. J. Edward Buxton, and Dr. Walter J. Sexton, June 1, 1999.

2.4 "Savannh Harbor Investigations, Results from the Tide Gate Operation Study", Corps of Engineers, Savannah, Georgia, June 1982.

2.5 "Results of Tests of Increased Channel Dimensions", by H. J. Rhodes and H. B. Simmons, U. S. Army Engineer Waterways Experiment Station, Corps of Engineers, Technical Report NO. 2-580, March 1965.

2.6 "Savannah Harbor Investigation, Results from the Tide Gate Operation Study", U. S. Army Corps of Engineers, Savannah District, June 1982.

2.7 "Results of Supplemental Tests", U. S. Army Engineer Waterways Experiment Station, Technical Report NO. 2-580, November 1963.

2.8 "Channel Depth as a Factor in Estuarine Sedimentation", by H. B. Simmons, Committee on Tidal Hydraulics, U. S. Army Corps of Engineers, Technical Bulletin No. 8, March 1965.

2.9 "Fresh Water-Salt Water Density Currents, a Major Cause of Siltation in Estuaries", bye E. A. Schultz and H. B. Simmons, Committee on Tidal Hydraulics, U. S. Army Corps of Engineers, Technical Bulletin No. 2, April 1957.

2.10 "Coastal Engineering Manual. Engineer Manual 1110-2-1100", U.S. Army Corps of Engineers, Washington, D.C. (in 6 volumes), 2002.

2.11 1984. "Manteo (Shallowbag) Bay, North Carolina," General Design Memorandum, Phase II, Appendix 5, U.S. Army Engineer District, Wilmington. 1980..

Introduction

The Savannah Harbor deep draft navigation channel is located on the lower 21.3 miles of the Savannah River and 11.4 miles of channel through the ocean bar in the Atlantic Ocean, Figure 7-1. The shoaling in the upper 18 miles of the river channel is primarily silt and clay while the lower river channel has sand shoals derived from an ocean source.

In order to predict the effect of future channel depth increases on the shoaling, the effects of past construction activities were analyzed to gain an understanding of how the system responds to changes. This understanding of how the system responded to past changes was used as the basis to make predictions of future changes.

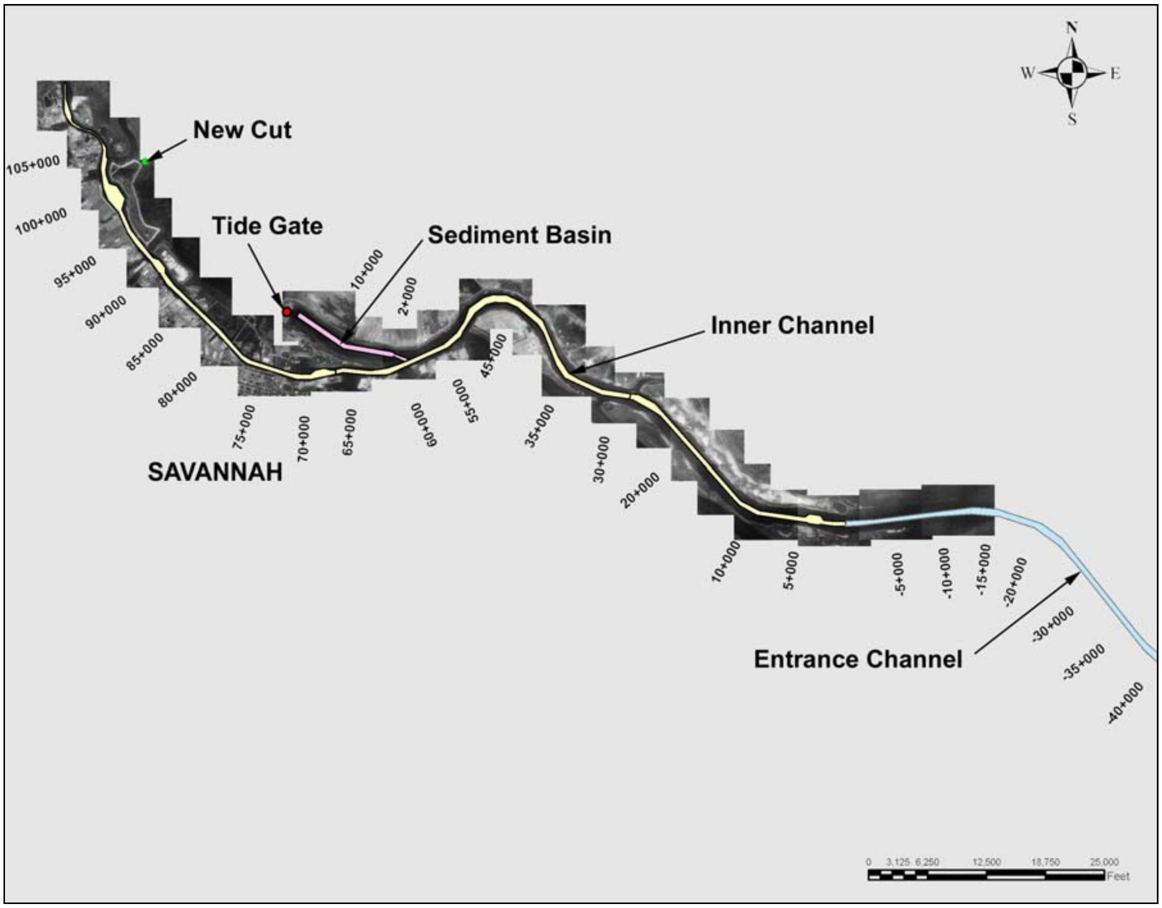

Figure 7-1 Savannah Harbor.

Above station 28+000, the inner harbor channel captures all of the clay and silt which enters the harbor from an upstream source. The amount of sediment entering the harbor is dependent on river discharge while current velocities and the location of the mixing zone between fresh and salt-water influence the distribution of the shoaling. Past channel depth increases have improved the channel conveyance to the point where the full tidal prism reaches the upstream limit of the harbor. The last channel deepening did not change the shoaling volume or distribution. Since the channel already captures all of the sediment that enters the harbor, future depth increases with not increase the volume dredged in the channel. An additional feature of future channel deepening, which supports the prediction of no dredging volume increases is that the future depth increases will extend down along the existing channel side slopes. Deepening along the existing side slopes actually decreases the bottom width of the channel.

The inner harbor below station 28+000 to the mouth of the harbor shoals with material from an ocean source. The shoaling in the lower harbor did not increase after the last channel deepening and the shoaling is not predicted to increase due to future channel depth increases.

The entrance channel is a sediment sink that is a total interdiction of the littoral transport. Increases in depth will not increase the channel's ability to capture sediment. The average annual shoaling volume record did show an apparent increase in shoaling after the last deepening but this was due to the short post-deepening record not including both a high and low shoaling period as did the pre-deepening record. A small volume increase was predicted based on an increase in channel length.

Advance maintenance areas, with the exception of the Kings Island range, are generally allowing an annual maintenance cycle without unacceptably encroaching above the authorized channel depth. The shoaling pattern is not predicted to change with future depth increases and therefore present advance maintenance areas do not need to be shifted due to future depth increases.

7.2.3 Shoaling Conditions With and Without Project Conditions.

7.2.3.1 Inner Harbor

7.2.3.1.1 Sediment Sources.

The major sources of sediment to Savannah Harbor are the Savannah River and the offshore sediments carried into the harbor by tidal currents, Reference 2.1. The sediment supplied by the Savannah River is primarily fine silt and clay. An analysis of a suspended sediment sample taken at Clyo, GA is listed in Table 7-1. Clyo is located about 65 miles above the mouth of the Savannah River.

Clyo Sample	Sand Coarser than 0.074 mm	Silt	Clay
Flocculated	1%	17%	82%
Not Flocculated	5%	9%	86%

Table 7-1 Quantitative Analysis of Suspended Sediment at Clyo, GA. (Ref 2.1)

The bed load material transported by the Savannah River is deposited in the extreme upper reaches of the Savannah Harbor above station 103+000. The shoal material in these reaches are principally sand and account for no more than 5 % of the total volume material dredged from the harbor.

Grain size distributions for the inner harbor and entrance channel are listed in Table 7.2 and are displayed in Figures 7.2 and 7.3. The inner harbor sediments are primarily silts and clays from station 56+000 to station 103+000. The reach from station 25+000 to station 56+000 is a transition reach that has a higher percentage of sand in its distributions than the sediment distributions of the upstream reach. A notable exception is in the vicinity of station 36+000, which has a high percentage of silt and clay and almost no sand. This location is near the confluence of the inner harbor channel with both Elba Island and Fields Cuts. This location will have significance in the following dredging and velocity analyses. The inner channel sediment distributions from station 25+000 to the mouth of the Savannah River are primarily sand, which indicates that the source of sediment from this reach is offshore.

The upstream source of sediment for the upper river reaches and the ocean source for the lower river reach are consistent with the observation in Reference 2.8 that essentially all of the shoaling material from upstream sources is being trapped within the system.

The entrance channel sediments are primarily sand with exceptions between the jetties and at station 45+000, which have large silt and clay components.

ID	Station	Channel	% SAND	% SILT	% CLAY
NB-13 *	-45+000	Entrance	8.7	66.8	24.5
NB-12 *	-35+000	Entrance	83.9	0	16.1
NB-11 *	-25+000	Entrance	78.2	5.8	15.8
NB-10 *	-15+000	Entrance	67.1	12.3	20
NB-9 *	-5+000	Entrance	30.8	53	16
IH-8 *	5+250	Inner	94.4	4.4	0.3
IH-7 *	15+000	Inner	88.2	2	9.1
IH-6 *	25+000	Inner	93.7	0	2.5
IH-5 *	35+000	Inner	12.1	62.4	25.5
SH-7 **	36+000	Inner	0	65.3	34.7
IH-4 *	44+000	Inner	32.2	32.3	35
IH-3 *	55+750	Inner	27.2	45.5	27
SH-6 **	56+000	Inner	10.6	75.7	13.7
SH-5 **	61+500	Inner	13.4	53.5	33.1
IH-2 *	64+000	Inner	2.7	59.8	37.5
SH-4 **	67+250	Inner	78.4	13.5	8.1
IH-1 *	75+000	Inner	5.7	49.8	44.5
SH-3 **	90+000	Inner	9.6	55.6	34.6
SH-1 **	99+000	Inner	14.4	54	31.6
SH-8 **	2+750	Sediment Basin	17.5	49.4	33.1
SH-9 **	5+250	Sediment Basin	0	72.8	27.2
SH-10 **	8+000	Sediment Basin	0	66.9	33.1
SH-11 **	10+500	Sediment Basin	17.6	46.2	36.2

Table 7-2 Sediment Grain Size Distributions. *Reference 2.3 ** Reference 2.2

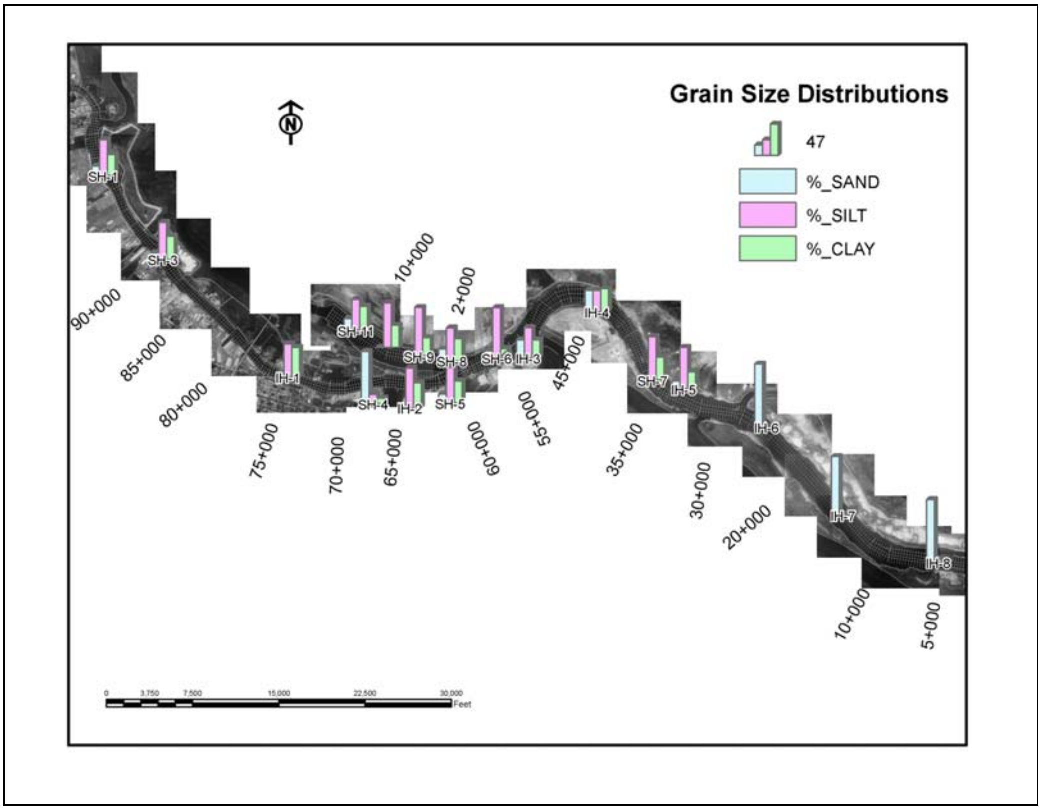

Figure 7-2 Inner Harbor Grain Size Distributions.

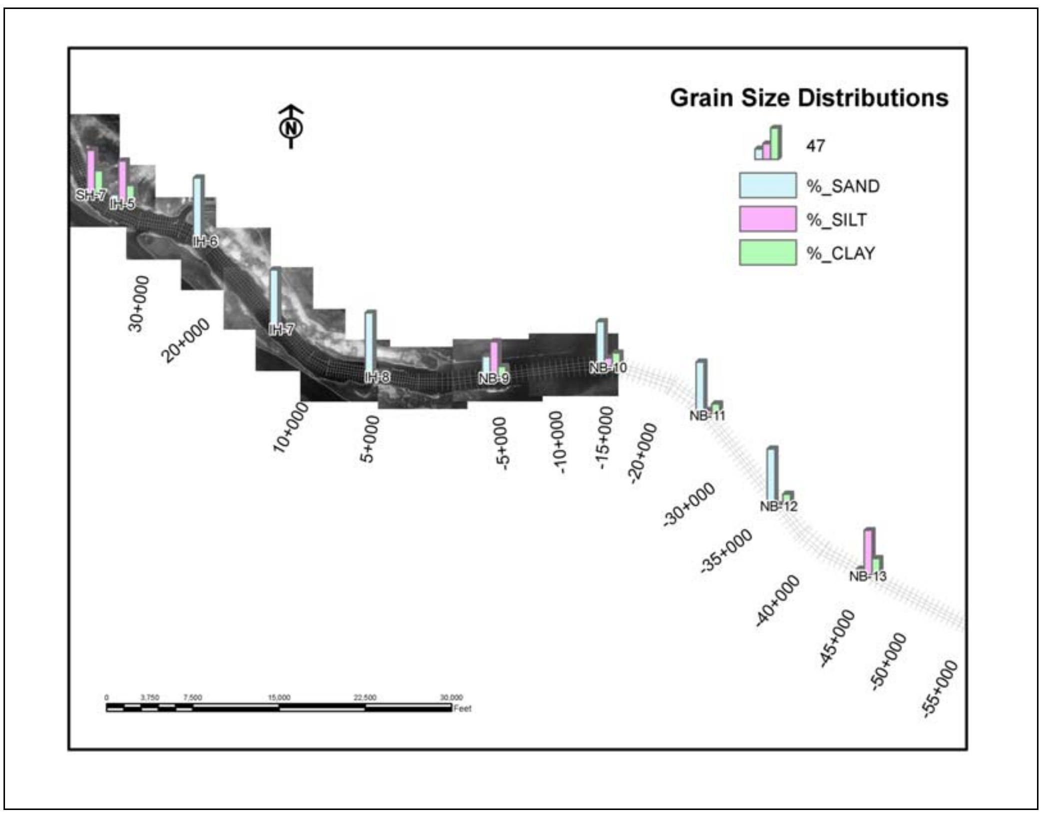

Figure 7-3 Entrance Channel Grain Size Distributions.

7.2.3.1.2 The Shoaling Process.

In the mid harbor reach, stations 28+000 to 67+000, and upper harbor reach, stations 67+000 to 103+000, silts and clays form low-density shoals in areas with low velocities or eddies. Areas with low velocities have low bottom shear stresses which allow deposition and the circular flow of the eddies promote flocculation and trap sediment. Salinity affected currents cause a flow converging area at the location of zero net bottom flow, which becomes an area of high shoaling. The salinity effects also cause the bottom flows in the lower harbor reach to have a net upstream flow, which traps ocean derived sand.

The source of shoaling material in the upper and mid reaches of the harbor is silt and clay eroded by rain runoff in the piedmont. The clay particles have a negative charge and a diffuse layer of positive ions surrounds the particle. The diffuse layer that surrounds the clay particles makes them mutually repulsive. The individual clay particles have an extremely slow settling rate, which allows them to travel hundreds of miles downstream from the piedmont to the estuary. The saline water of the estuary has a high ionic concentration, which compacts the diffuse layer and allows the particles to come closer together. When the particles enter a mixing flow they collide and the attractive forces, which exist between all colloidal particles (van der Waals' forces), enables the particles to form aggregates. The aggregates can become relatively large and settle rapidly. When the aggregates are carried to areas with weak currents, they form low-density shoals. These shoals are more than 80% water, Reference 2.1. The delicate structure of the aggregates and low density of the shoals make them responsive to the strength of the flow velocities. An area that has weak currents or eddies will be high shoaling area and an area of strong currents will be a low shoaling area. The nature of these low-density shoals can make volumetric analysis of shoaling patterns difficult. If a low-density shoal were disbursed and the aggregates broken up, new shoals that form from the shoal material could be denser or so thinly spread out that they are not recorded at all.

Savannah Harbor is in a partially mixed estuary in which the vertical mixing of salt and freshwater is not complete over the length of saltwater intrusion, Reference 2.8. Surface salinities are appreciably less than the bottom salinities and there is a large zone of mixing between fresh and saltwater. Seaward of this mixing zone, the net bottom flow over a tidal cycle is upstream. Landward of this mixing zone, the net bottom flow is downstream. The converging bottom flows carries shoaling material to the location of no net bottom flow, which tends to be an area of high shoal volumes.

Shoaling in the Savannah inner harbor channels below station 28+000 is due to sand carried into the channel from the ocean by the strong bottom flood currents. The shoal material in the lower river is almost entirely sand while the shoal material upstream of station 28+000 is silt and clay, Figure 7-2. The sand is deposited during slack tide and the weaker bottom ebb currents cannot carry the sand back to the ocean source. Results from the physical model tests, Reference 2.5, indicate that the bottom flood currents at station 4+000 are a foot per second faster than the bottom ebb currents and that the net bottom flow in the lower portion of the harbor is upstream.

7.2.3.1.3 Major Construction Activities

The major construction activities that have influenced shoaling in Savannah harbor since 1975 are listed in Table 7-3.

Activity	Date
New Cut Opened	1975
Kings Island Turning Basin Enlarged	1976
Tide Gate Begin Operation	1977
Sediment Basin - Maintenance	1977
Tide Gate Ceased Operation	1991
New Cut Closed	1992
Savannah Harbor Widening	1990 - 1992
Savannah Harbor Deepening 38 ft to 42 ft.	1993 - 1994
Advance Maintenance	Sporadic Implementation

Table 7-3 Major Construction Activities.

7.2.3.1.3.1 New Cut, Tide Gate and Sediment Basin

The first three activities of opening New Cut, operation of the Tide Gate, and construction of the Sediment Basin were components of a plan to reduce the annual cost of maintenance for the harbor and provide better maintained navigation channels, Reference 2.4. These three construction activities increased the bottom velocities in front channel by as much as 3 feet per second and initially trapped 2.8 million cubic yards of sediment in the Sediment Basin.

The location of the Sediment Basin, the Tide Gate and New Cut are shown on Figure 7-1. The Tide Gate consisted of 14 flap gates across a 600-foot span. It allowed flow to pass through the gates on the flood tide into Back River, Figure 7-4, and prevented the flow from passing through the gate on ebb tide.

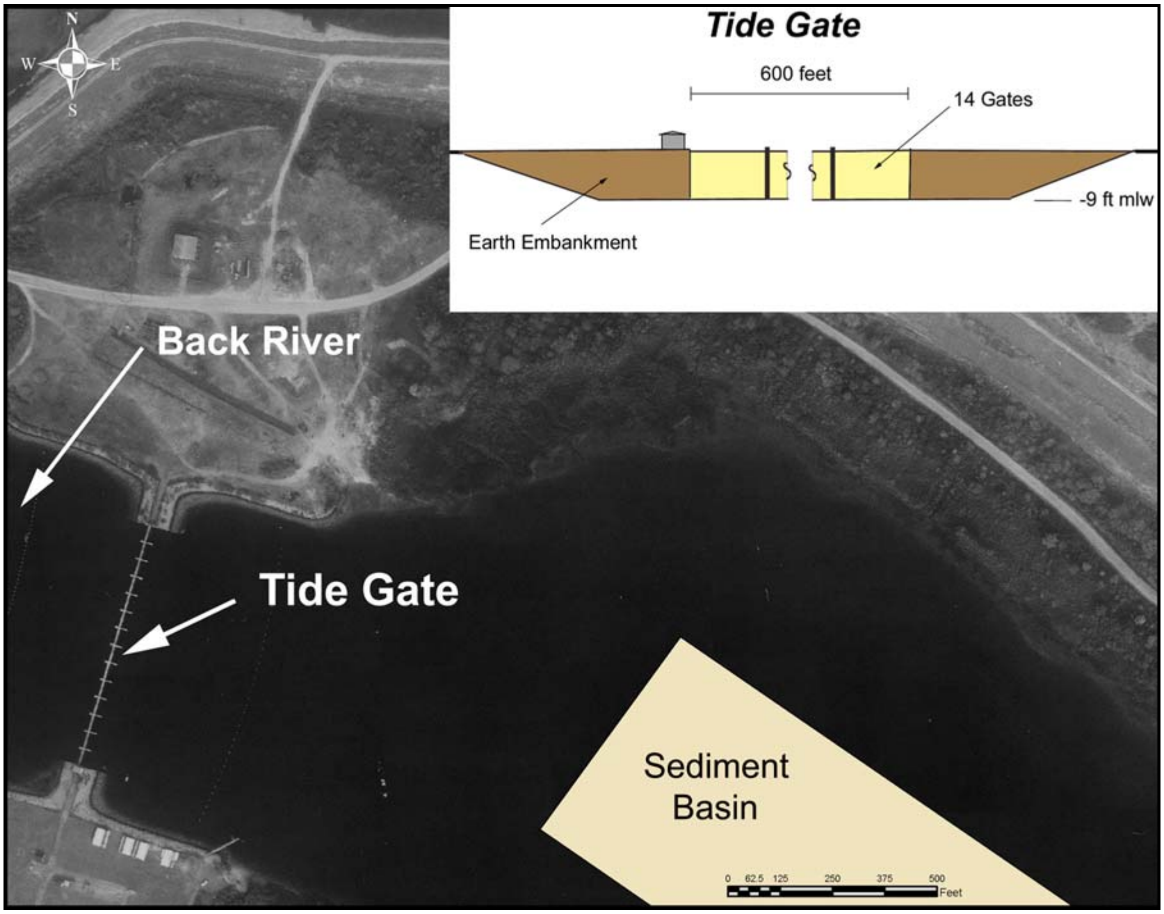

Figure 7-4 Tide Gate.

The Back River tidal prism was force to flow out through New Cut into the inner harbor channel. New Cut had a width of 300 feet and a depth of 15 feet.

Physical model tests for the design of the Tide Gate were conducted at the U. S. Army Engineer Waterways Experiment Station and Figures 7-5 through 7-7 are results from those tests, Reference 2.1. Figure 7-5 is a drawing of a plan similar to the one constructed but with the Tide Gate located further upstream. Plots of model velocities indicate that the bottom flows in the inner harbor channel upstream of the confluence with the Sediment Basin increased from 1.5 feet per second at station 95+000, Figure 7-6, to 3.0 feet per second at station 74+000, Figure 7-7.

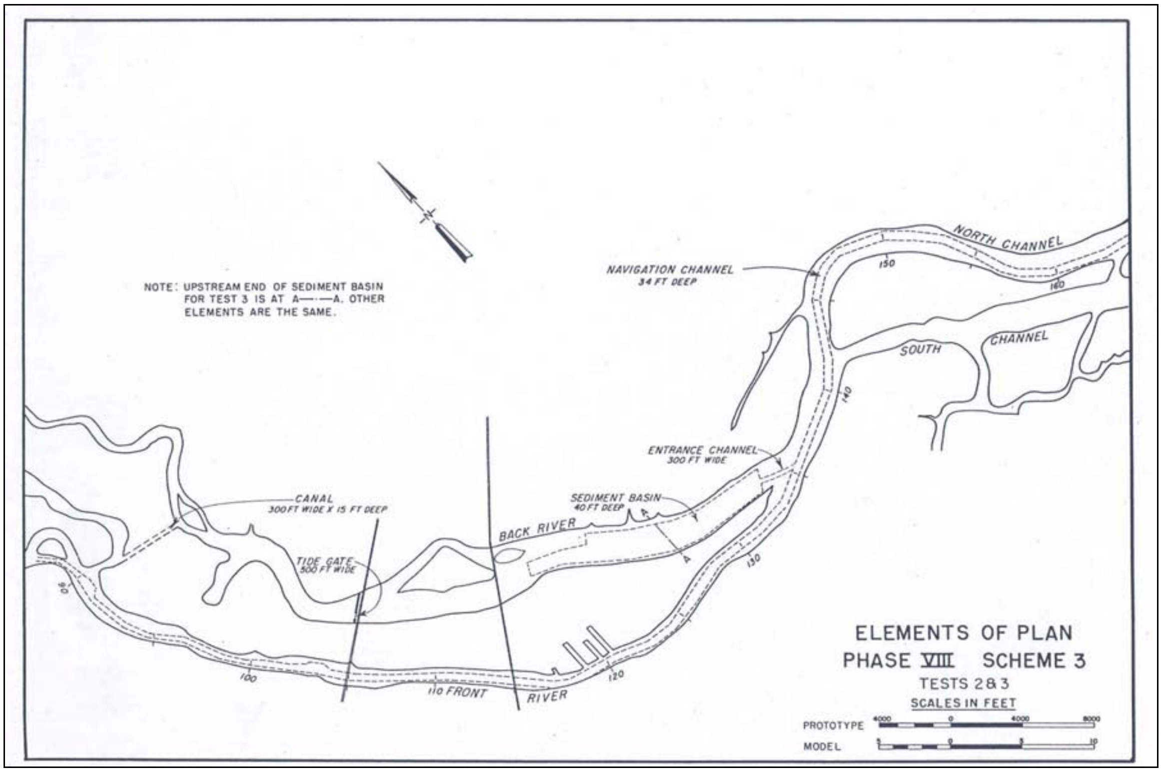

Figure 7-5 Physical Model Test Scheme for a Tide Gate, Drainage Canal, and Sediment Basin.

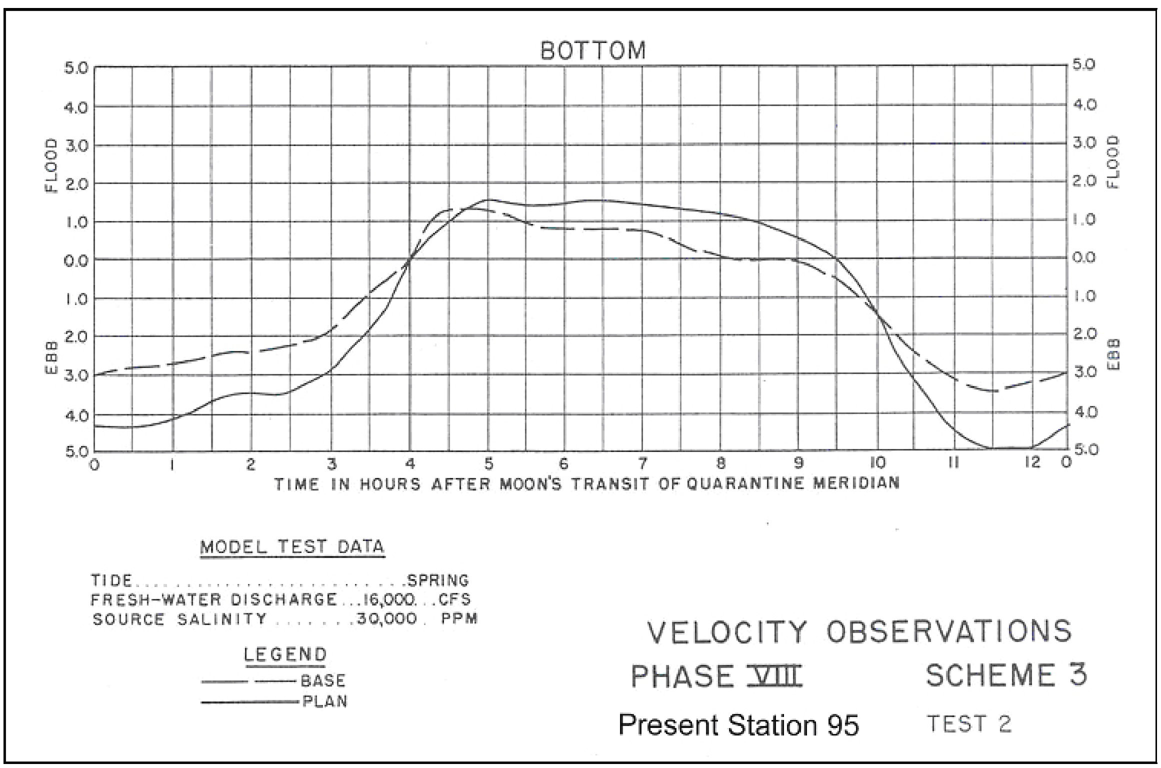

Figure 7-6 Velocity Observations Station 95+000.

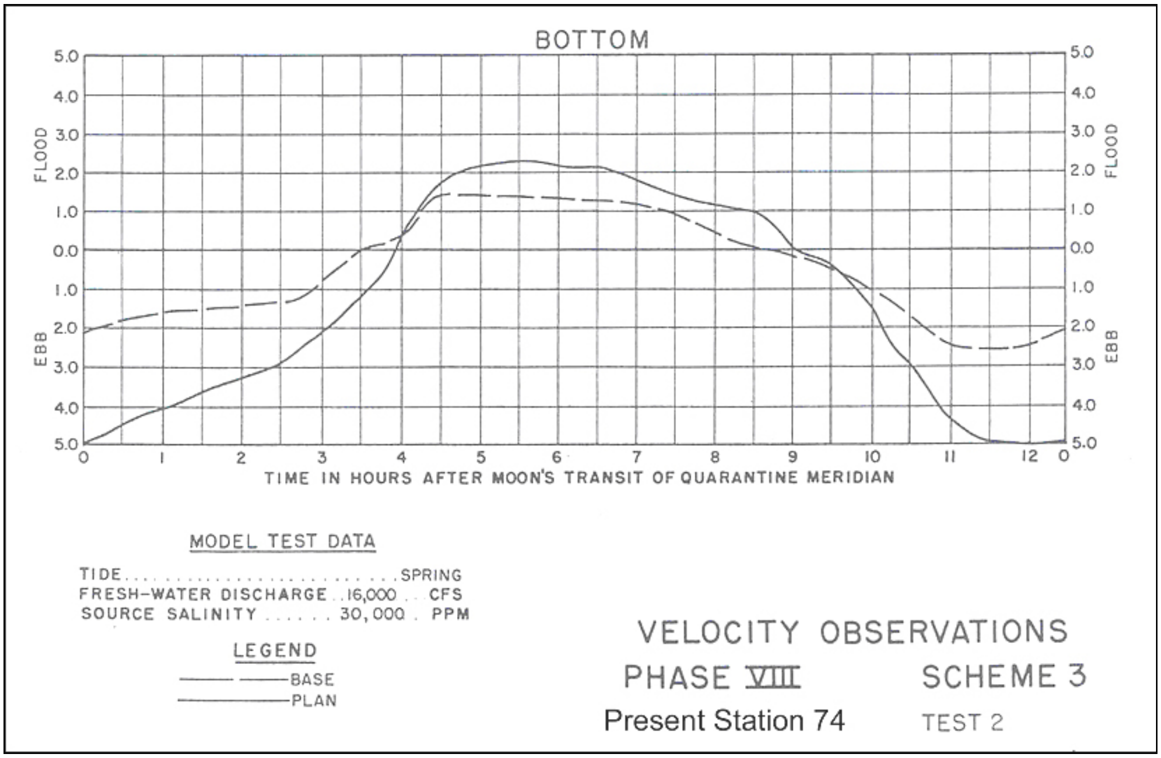

Figure 7-7 Velocity Observations Station 74+000.

The velocities below the confluence of the inner harbor channel and the Sediment Basin responded with smaller increases of 0.5 feet per second at station 51+000, Figure 7-8, and a decrease of 1.0 feet per second at station 41+000, Figure 7-9.

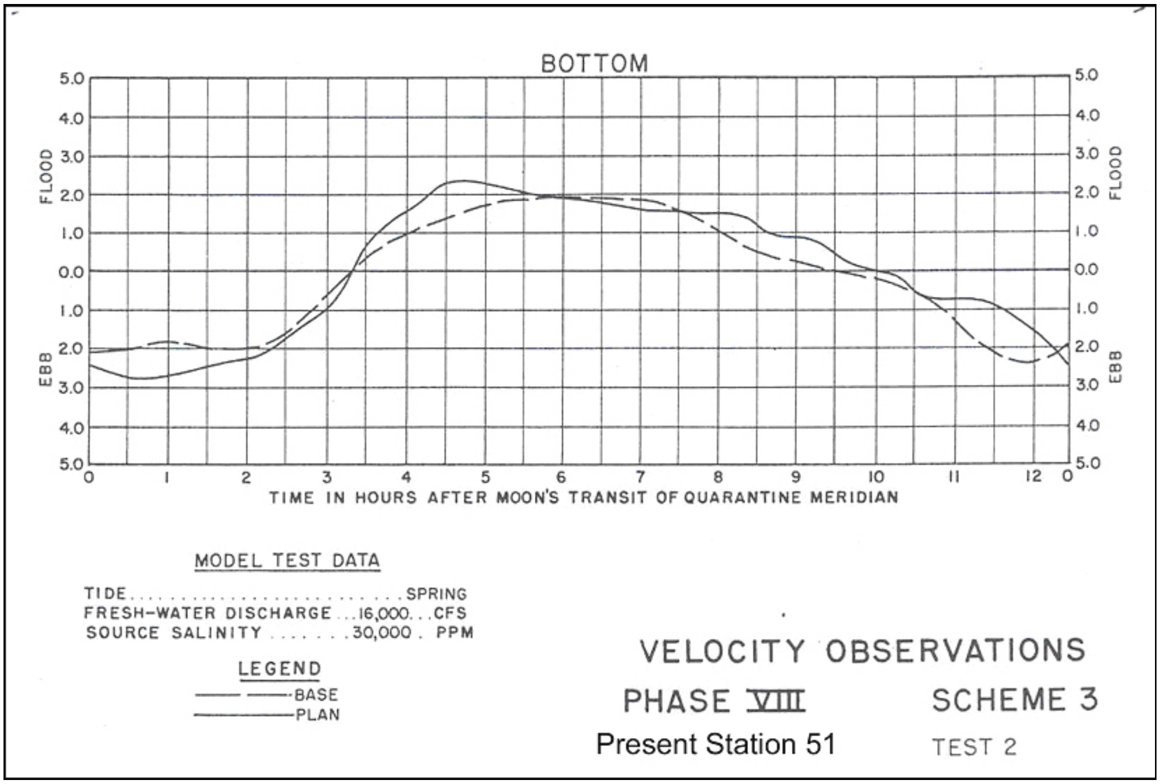

Figure 7-8 Velocity Observations Station 51+000.

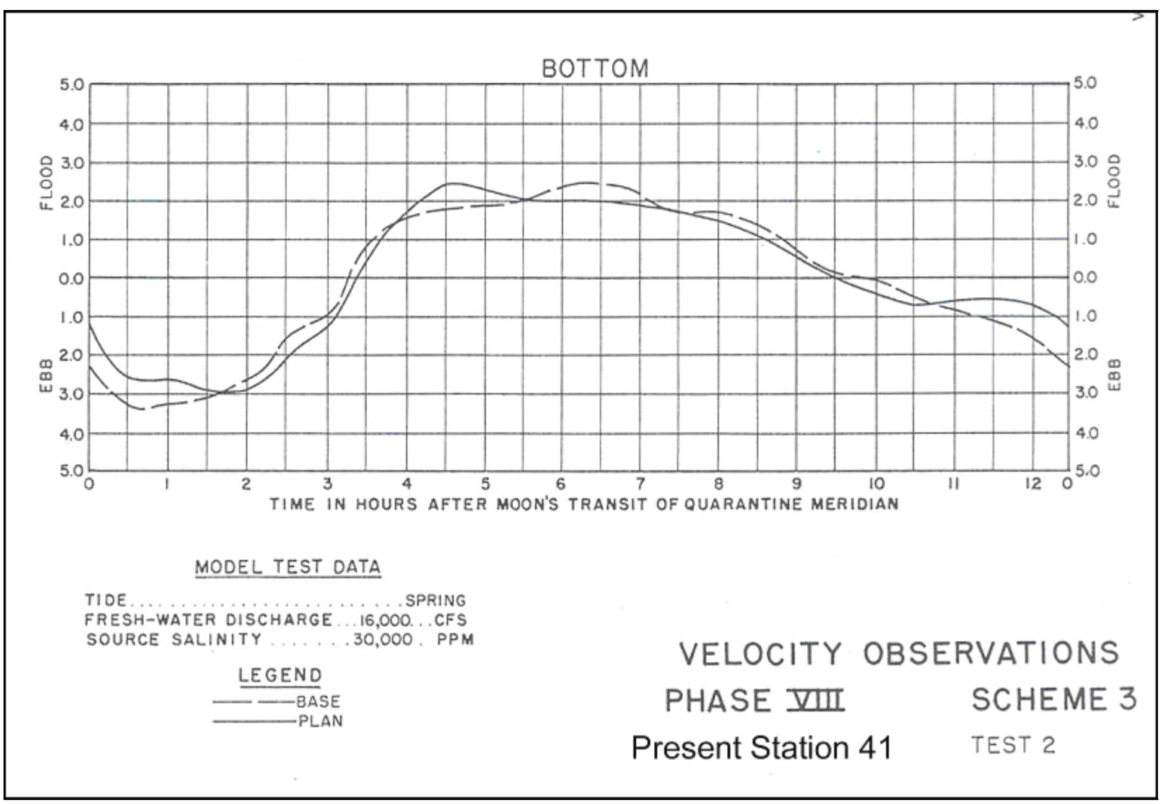

Figure 7-9 Velocity Observations Station 41+000.

The Sediment Basin, Figure 7-10, consists of an entrance channel, which is 1,600 feet long and 300 feet wide. The entrance channel depths vary from -38 feet mlw at the entrance to -40 feet mlw in the trap. The sediment trap is 2 mile long and 600 feet wide. The Sediment Basin was initially dredged in 1972 but regular maintenance of the Sediment Basin did not begin until 1977. Physical model tests were performed prior to construction to determine the effectiveness of the Sediment Basin, Reference 2.5. The plan tested is shown in Figure 7-11. Note that the stations shown are different from those that are presently in use. The old stationing decreased in an upstream direction and the confluence of the Sediment Basin with the inner harbor channel was approximately at old station 134+000.

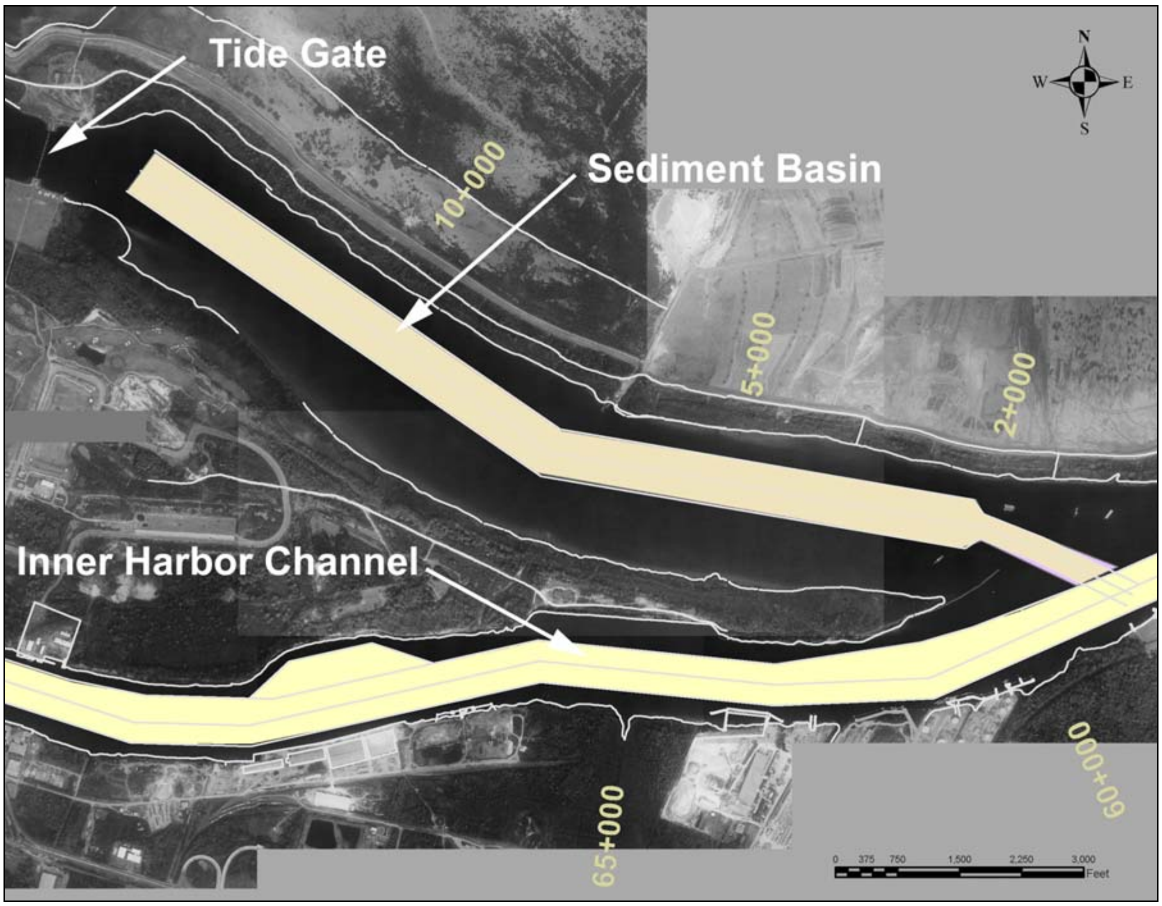

Figure 7-10 Sediment Basin.

The shoaling tests were conducted using gilsonite as a model shoaling material. One third of the shoaling material was introduced into Front River above the old station 143+000 and the remainder was introduced below station 143+000. The results of the test after 29 tidal cycles are shown in Figure 7-12. There was a large reduction in the shoaling in the upper reaches where the current velocities had increased due to the operation of the Tide Gate. The reduction in the mid-river reaches was not proportionately as large. A second test was performed for

119 tidal cycles and the result from this test is shown in Figure 7-13, Reference 2.7. For the longer duration test, there was a large reduction of shoaling in the mid-river reaches and an increase in shoaling in the Sediment Basin. This result indicates that the Sediment Basin is acting as filter for the mid-river reaches, which continues to trap sediment for months after the sediment is initially carried into the harbor.

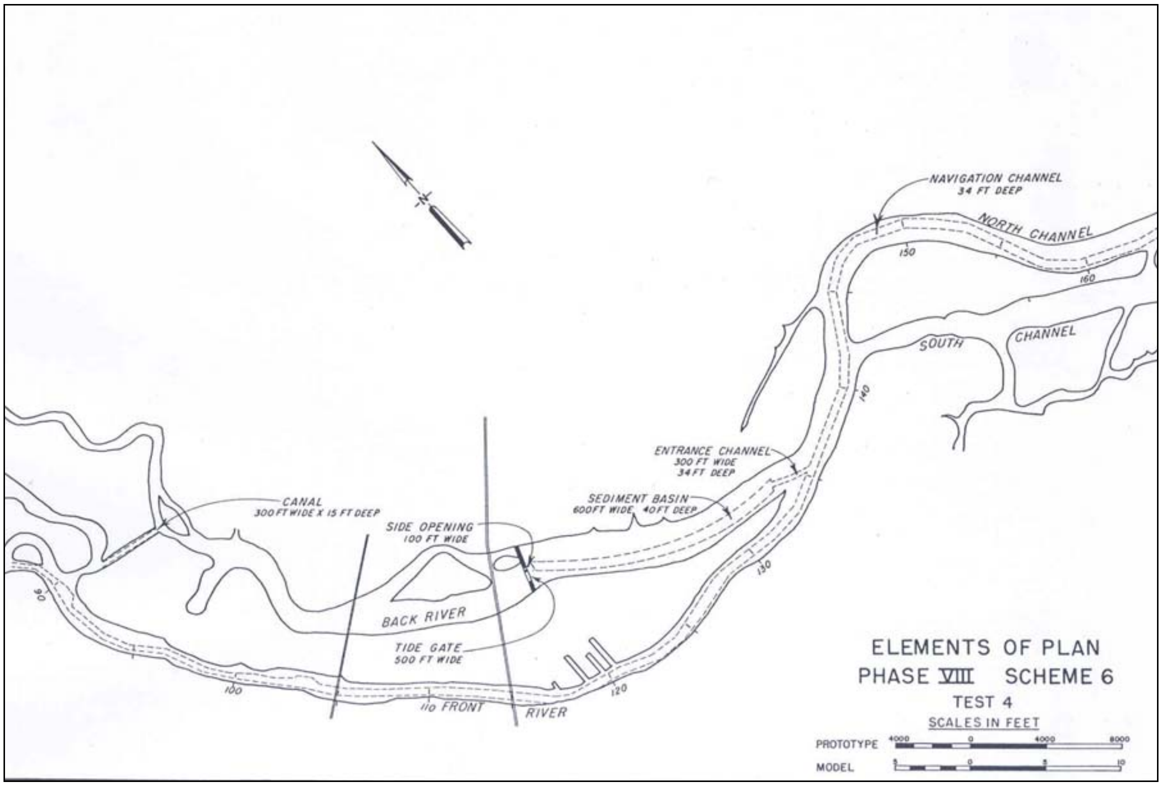

Figure 7-11 Sediment Basin Test Plan.

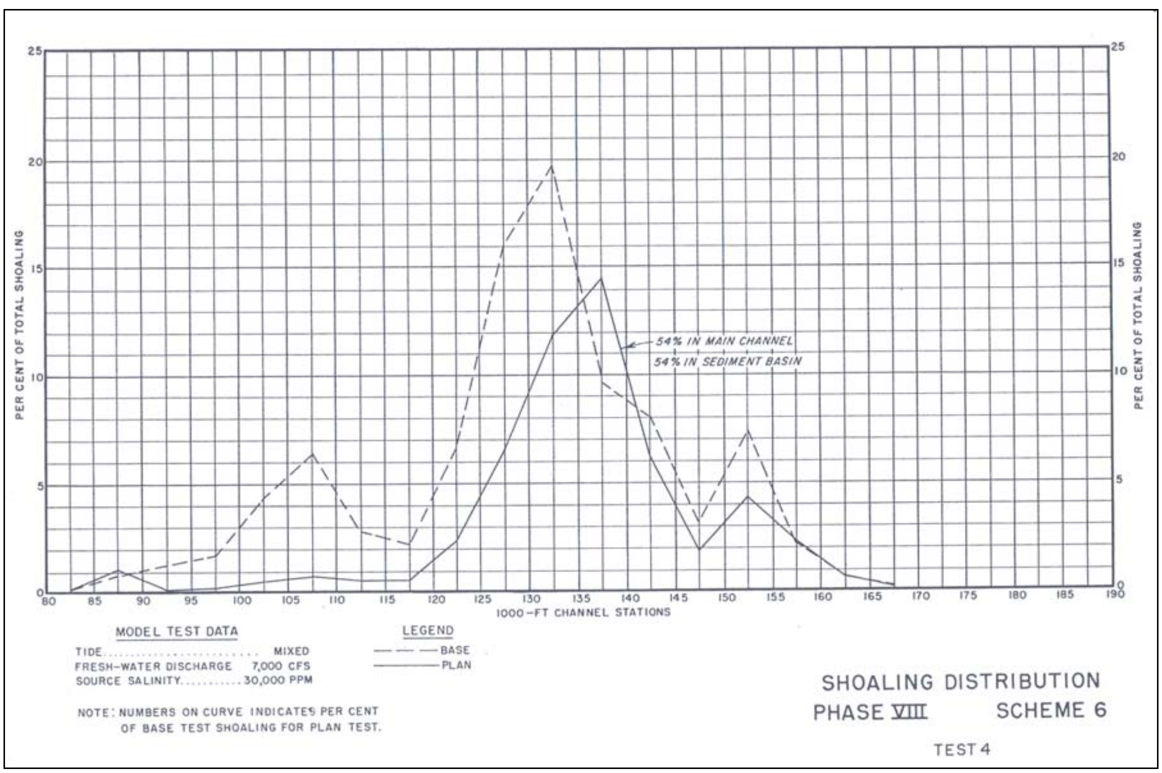

Figure 7-12 Result of the Shoaling Test After 29 Tidal Cycles.

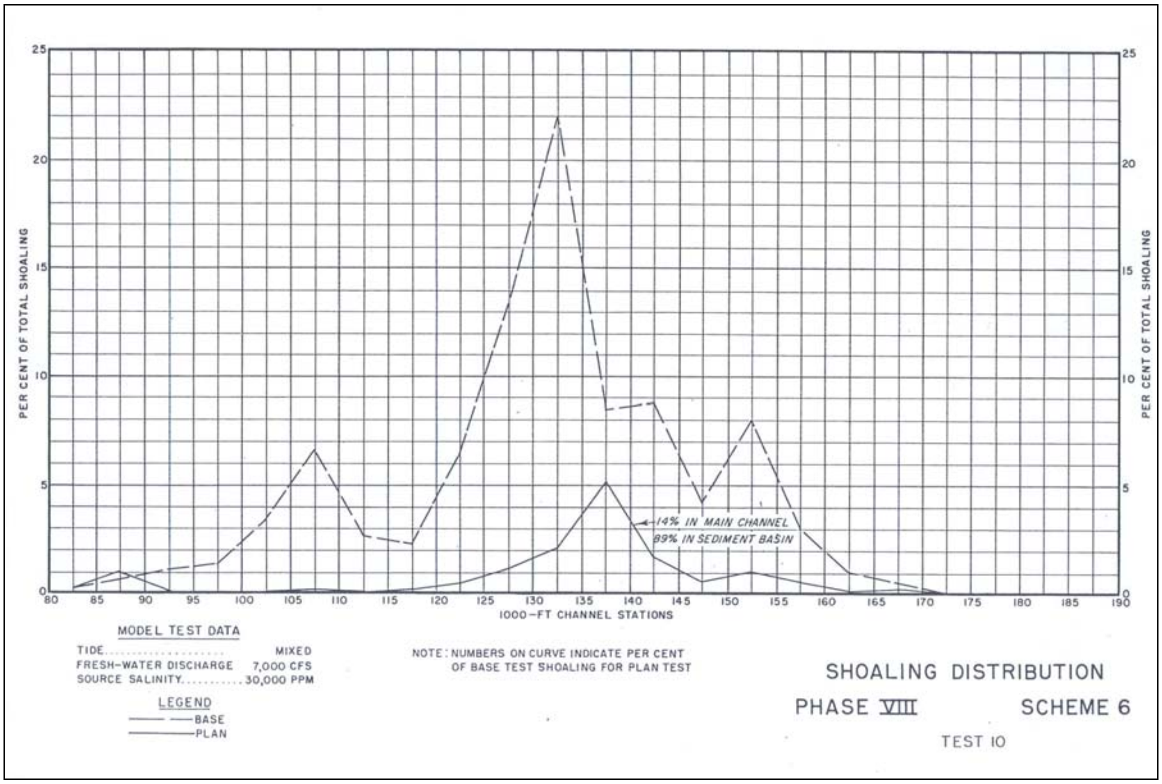

Figure 7-13 Shoaling Test Results After 119 Tidal Cycles.

As part of a Section 1135 project to restore the fresh water plant species and associated fish and wildlife populations in the Savannah National Wildlife Refuge, operation of the Tide Gate ceased in 1991, New Cut was closed in 1992 and the tide gates were removed in 1996. These actions should have reduced the current speeds in the upper reaches of the inner harbor channel to strengths near the pre-1977 values.

7.2.3.1.3.2 Kings Island Turning Basin Enlarged

In 1976, the Kings Island Turning Basin was increased from 900 x 1,000 feet to 1,500 x 1,600 feet, which more than doubled its size.

7.2.3.1.3.3 Savannah Harbor Widening

Between 1990 and 1992 the navigation channel was widened from 400 to 500 feet between Fig Island Turning Basin (Station 70) and Kings Island Turning Basin (Station 100).

7.2.3.1.3.4 Savannah Harbor Deepening 38 ft to 42 ft

Under WRDA 1992, the authorized depth in the entrance channel was increased from 40 feet to 44 feet and the inner harbor authorized depth between Stations 0+000 and 103+000 was increased from 38 feet to 42 feet. Construction was completed in June 1994.

7.2.3.1.3.5 Advance Maintenance

Over the years, advance maintenance changes to the Savannah Harbor Project have been implemented sporadically. Table 7-4 lists the present advance maintenance sections.

BEGIN STATION	END STATION	AUTHORIZED ADV. MAINT. (FT)	REQUIRED CONTRACT DEPTH (FT, MLLW)
Inner Harbor			
112+500	105+500	2.0	32.0
105+500	103+000	2.0	38.0
103+000	102+000	0.0	42.0
102+000	100+000	2.0	44.0
100+000	79+600	2.0	44.0
79+600	70+000	2.0	44.0
70+000	50+000	4.0	46.0
50+000	37+000	4.0	46.0
37+000	35+000	6.0	48.0
35+000	24+000	4.0	46.0
24+000	0+000	2.0	44.0
Port Wentworth TB		0.0	30.0
Argyle Is TB		0.0	30.0
Kings Is TB		8.0	50.0
Marsh Is TB		0	34.0
Fig Is TB		4.0	38.0
Entrance Channel			
0+000	-14+000(B)	2	44.0
-14+000(B)	-60+000(B)	0	44.0

Table 7-4 Advance Maintenance Locations.

7.2.3.1.4 Shoaling Response to Major Construction Activities

7.2.3.1.4.1 Shoaling Response to New Cut, the Tide Gate, and the Sediment Basin

To determine the shoaling response to past construction activities in Savannah Harbor, the dredging records going back to 1970 were analyzed. The construction of New Cut and the Tide Gate decreased the shoaling in the upper river reach by increasing the velocities and shifting the location of the no net bottom flow into the mid-river reach. Some of the shoaling decrease in the mid-river reach due to the Sediment Basin was offset by the increase in shoaling associated with the location of no net bottom flow being shifted into the reach. The lower river reach, which accounts for 5 to 10% of the inner harbor shoaling and is controlled by sediment transport from the ocean showed a slight increase in shoaling. The total inner harbor shoaling showed a decrease from the pre construction period to the post construction period due to a decrease in river discharge.

The annual volume dredged, as calculated from the dredging records, is plotted in Figure 7-14. The gap in the record is due to the new work dredging associated with the harbor deepening from 38 to 42 feet mlw. A 3-year moving average has been applied to the data to smooth out variations due to dredging contracts spanning more than one year. The smoothed data shows a range of annual dredged volumes from 3 to 9 million cubic yards. To help explain some of the variations in dredged volumes the average

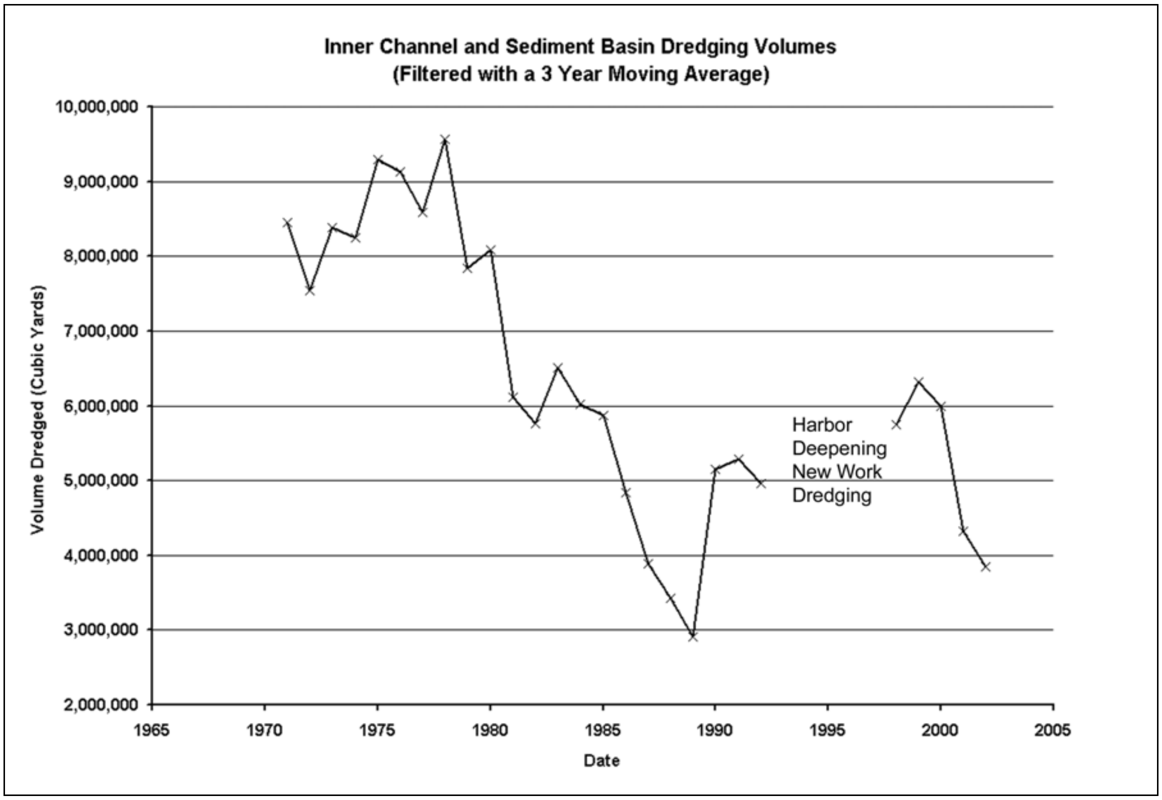

Figure 7-14 Inner Harbor Channel and Sediment Basin Annual Dredge Volumes.

annual stream flow discharge at Clyo, GA was plotted along with the average annual dredge volumes in Figure 7-15. It is apparent from the plot that the annual volume dredged rises and fall with the annual river discharges. The annual volume dredged versus annual river discharge is plotted in Figure 7-16 and listed in Table 7-5. The plot of volume dredged versus discharge contains widely dispersed data points. The R squared values for the linear and power trend lines fitted to the data indicate that less than half of the variation in the volume dredged can be attributed to river discharge.

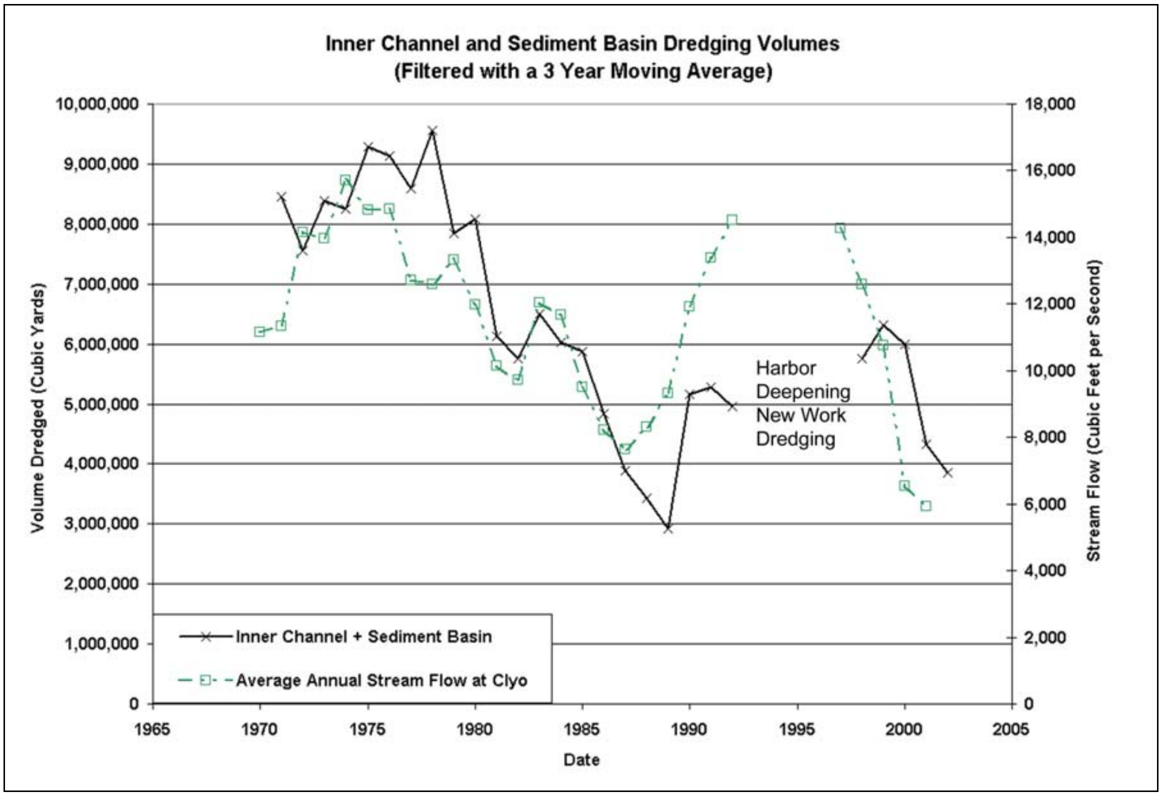

Figure 7-15 Dredged Volumes and River Discharge.

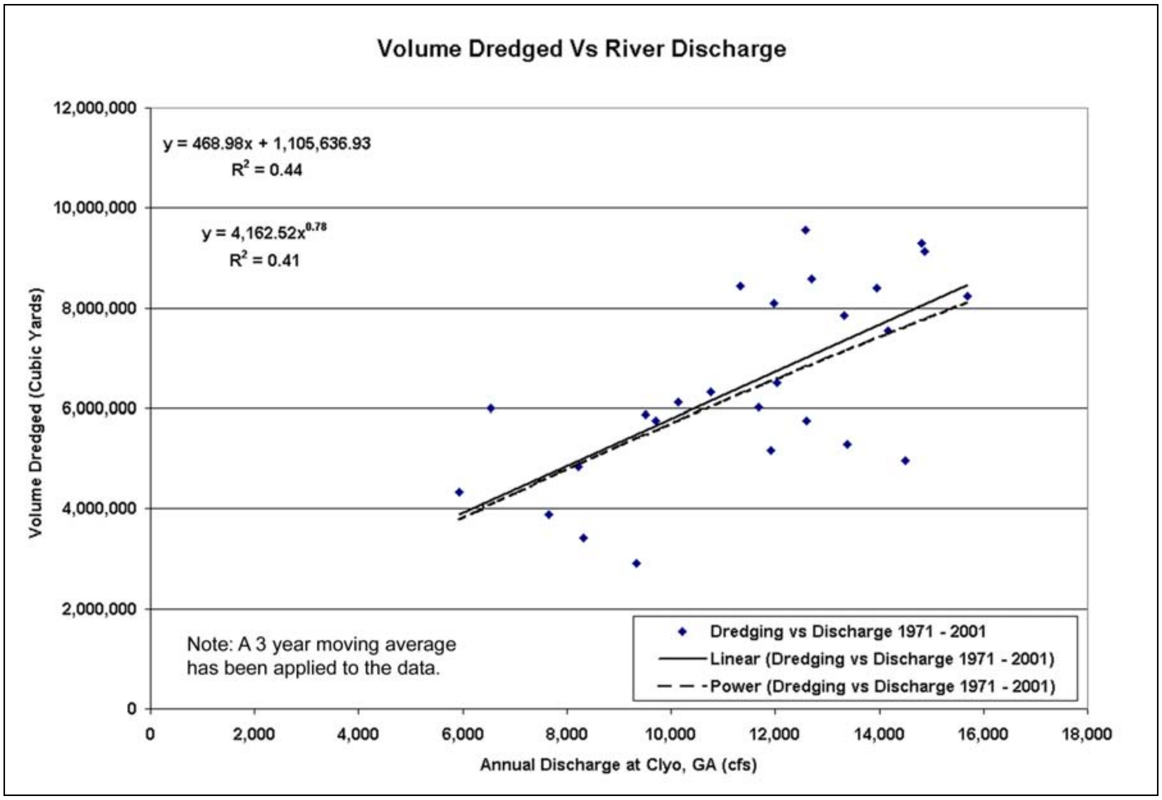

Figure 7-16 Volume Dredged Versus River Discharge.

Year	Annual Discharge at Clyo, GA (cfs) *	Annual Volume Dredged (Cubic Yards)*
1971	11,323	8,448,212
1972	14,163	7,547,415
1973	13,953	8,390,344
1974	15,697	8,245,671
1975	14,810	9,293,157
1976	14,860	9,131,699
1977	12,700	8,587,769
1978	12,577	9,565,055
1979	13,320	7,842,043
1980	11,979	8,086,702
1981	10,137	6,121,163
1982	9,703	5,758,349
1983	12,038	6,508,602
1984	11,685	6,023,986
1985	9,501	5,876,340
1986	8,208	4,845,292
1987	7,644	3,891,766
1988	8,313	3,421,242

1989	9,333	2,913,855
1990	11,908	5,157,454
1991	13,373	5,281,491
1992	14,507	4,957,658
1998	12,593	5,754,487
1999	10,760	6,318,380
2000	6,541	5,999,601
2001	5,921	4,323,270
		*Moving Average Applied.

Table 7-5 Annual River Discharge and Annual Volume Dredged.

To aid in identifying changes in the dredging record that can be attributed to construction activities, the annual volume dredged in the Sediment Basin is separated out from the inner harbor dredging volumes and the average annual dredging distribution was calculated for periods before and after construction. The volumes dredged from the inner harbor channel and the volumes dredged from the Sediment Basin are plotted separately in Figure 7-17 as unfiltered data and in Figure 7-18 as filtered data. The averaged data is listed in Table 7-6. The unfiltered data has large yearly fluctuations, which can be attributed to parts of separate dredging operations being performed in the same calendar year, while the averaged data is smoothed and it is easier to see trends. Of interest in Figure 7-18 is that from 1975 to 1977 the volume dredged in the inner harbor decreased by over 3 million cubic yards while the combined volume dredged in the inner harbor and Sediment Basin followed a gradual decrease that coincided with the declining river discharge. The period 1975 to 1977 is the same time period that New Cut, the Sediment Basin and the Tide Gate became operational and the decrease in channel shoaling and the lack of a decrease in total shoaling reflects the successful shift of shoaling from the channel to the Sediment Basin.

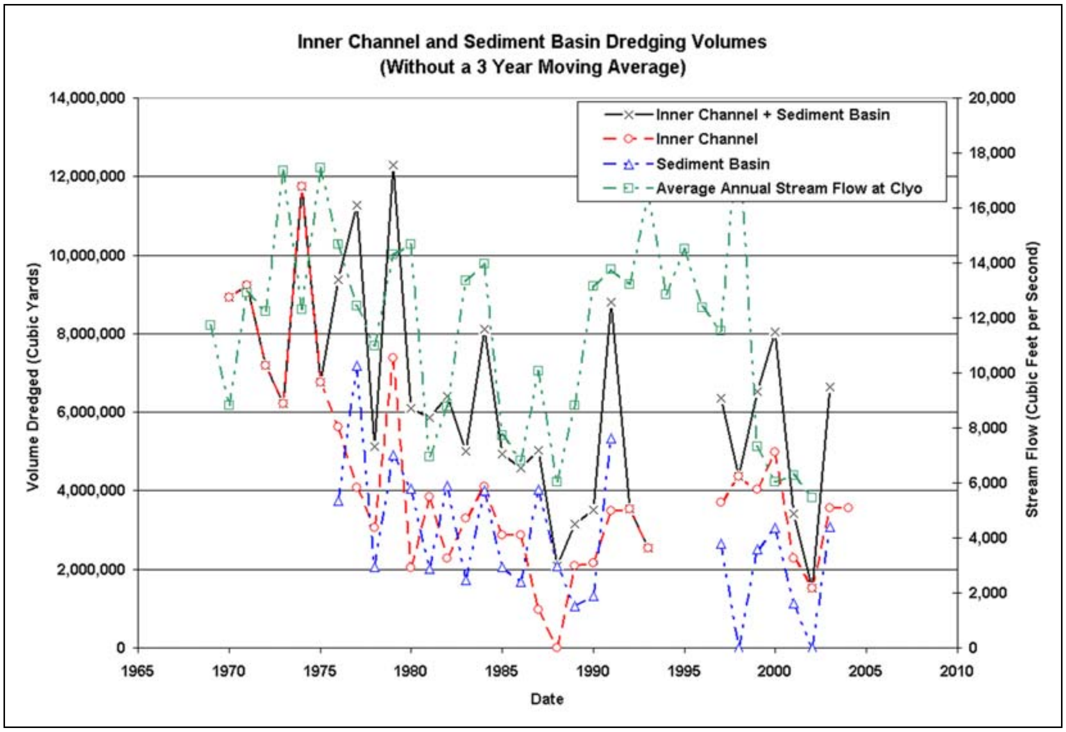

Figure 7-17 Inner Harbor and Sediment Basin Dredging Volumes without a 3-Year Moving Average.

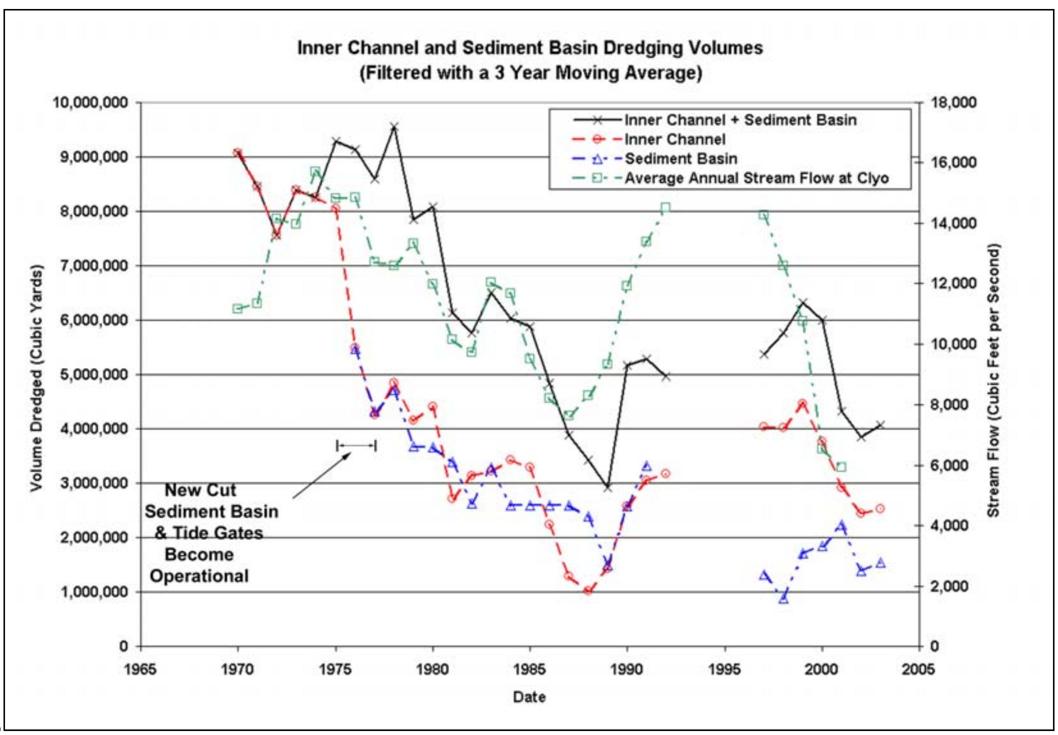

Figure 7-18 Inner Harbor and Sediment Basin Dredging Volumes with a 3-Year Moving Average.

Year	Inner Channel	Sediment Basin	Total	Discharge
1970	9,073,965	-	9,073,965	11,156
1971	8,448,212	-	8,448,212	11,323
1972	7,547,415	-	7,547,415	14,163
1973	8,390,344	-	8,390,344	13,953
1974	8,245,671	-	8,245,671	15,697
1975	8,046,098	-	9,293,157	14,810
1976	5,490,999	5,461,050	9,131,699	14,860
1977	4,260,213	4,327,556	8,587,769	12,700
1978	4,844,191	4,720,863	9,565,055	12,577
1979	4,162,833	3,679,209	7,842,043	13,320
1980	4,421,446	3,665,256	8,086,702	11,979
1981	2,719,019	3,402,144	6,121,163	10,137
1982	3,133,631	2,624,718	5,758,349	9,703
1983	3,219,862	3,288,740	6,508,602	12,038
1984	3,421,527	2,602,459	6,023,986	11,685
1985	3,286,302	2,590,038	5,876,340	9,501
1986	2,243,737	2,601,555	4,845,292	8,208
1987	1,286,672	2,605,094	3,891,766	7,644
1988	1,023,680	2,397,562	3,421,242	8,313
1989	1,420,997	1,492,858	2,913,855	9,333
1990	2,580,020	2,577,434	5,157,454	11,908
1991	3,058,664	3,334,240	5,281,491	13,373
1992	3,178,568	-	4,957,658	14,507
1993	-	-	-	14,203
1994	-	-	-	14,630
1995	-	-	-	13,240
1996	-	-	-	12,800
1997	4,033,331	1,329,811	5,363,142	14,280
1998	4,031,815	886,540	5,754,487	12,593
1999	4,462,466	1,722,671	6,318,380	10,760
2000	3,765,651	1,855,915	5,999,601	6,541
2001	2,925,451	2,233,950	4,323,270	5,921
2002	2,447,147	1,397,819	3,852,376	5,868
2003	2,532,901	1,540,792	4,073,693	-

Table 7-6 Inner Harbor, Sediment Basin Dredging Volumes, and Discharge at Clyo with a 3-Year Moving Average.

In addition to the shift of shoaling from the inner harbor channel to the Sediment Basin, there was shift in shoaling distribution within the inner harbor channel. A plot of the volume-dredged distribution in the inner harbor for periods before and after New Cut, the Sediment Basin and the Tide Gate became operational is presented in Figure 7-19. The before period was chosen to be 1970 to 1975, which was the period for which dredging data was available prior to the construction activities. The after period was chosen as 1981 to 1985. From Figure 7-18, it can be seen that in 1981 the rapid decline in volume dredged stabilized and after 1985 there was a drought, which greatly reduced the volume dredged. The volume-dredged distribution can be divided into three regions. (1) The upper river region, upstream of station 67+000, is characterized by turning basins in which large volumes of sediment are dredged. The total volume dredged from this reach for the 1970 to 1975 period is 3,982,000 cubic yards, Figure 7-20, and the shoaling material in this reach is primarily silts and clays. (See Figure 7-2)

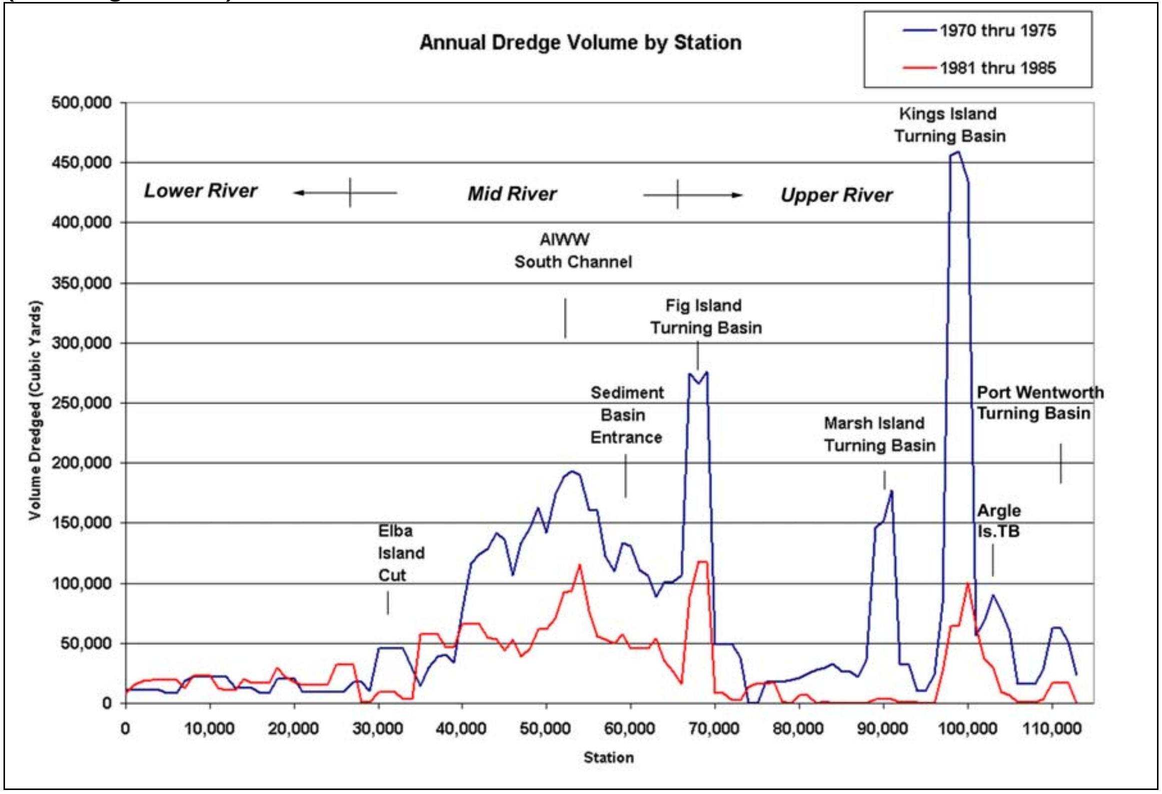

Figure 7-19 Annual Volume Dredged by Station 1970 thru 1975 and 1981 thru 1985.

(2) The mid-river reach is from station 28+000 to 67+000 and it shoals with a mixture sand, silt and clay. The total volume for this reach for the 1970 to 1975 period is 3,972,000 cubic yards and is approximately equal to the volume dredged from the upper river reach. The location of the highest volume dredged in the mid-river reach is at station 53+000, which is the confluence of the AIWW South Channel with the inner harbor channel. This reach also contains the entrance to the Sediment Basin.

(3) The lower river reach, which is downstream of station 28+000 to the mouth of the Savannah River, is characterized by a relatively low volume dredged, 409,000 cubic yards. The sediment is primarily sand, and as discussed in section **7.2.3.1.1** the source of the sediment is off shore.

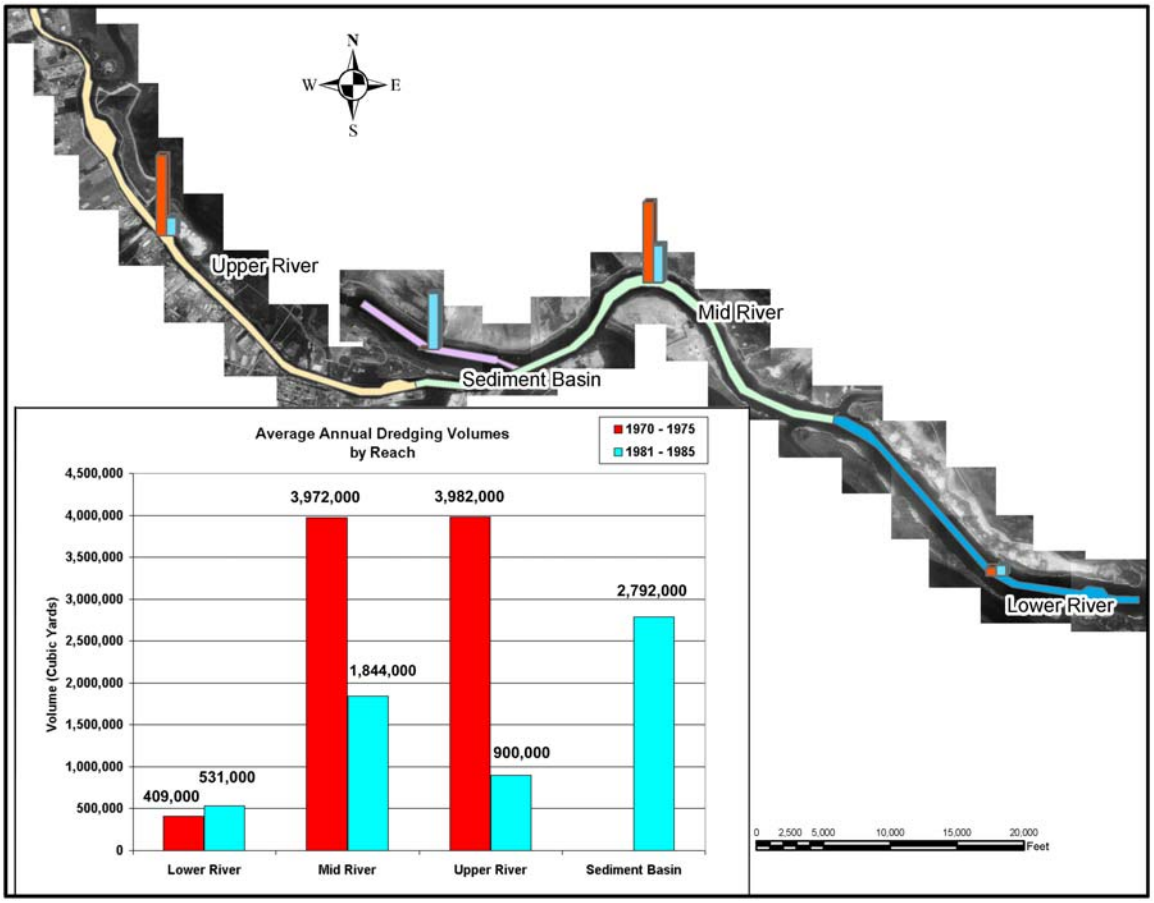

Figure 7-20 Average Annual Dredge Volumes by Reach 1970 to 1985.

The changes in volume dredged by station from the period 1970 through 1975 to the period 1981 through 1985 are plotted in Figure 7-21. The upper river reach had a general decrease in the volume dredged with major reductions occurring in the turning basins. The one area that did not show a decrease in the upper river reach was around station 75+000. A possible explanation for the localized increase is the agitation dredging performed by Savannah Marine Services, which may have increased the shoaling in this area. Unfortunately, quantitative agitation dredging records are unavailable for this time period and this explanation cannot be confirmed. There are two factors that contributed to the general decrease in the upper river dredge volume. First is the 1.5 to 3.0 feet per second increase in the current speed due to the opening of New Cut and the operation of the Tide Gate, section **7.2.3.1.3.1**. The higher velocities would have re-suspended the low density shoals and kept the sediment in suspension until it reached a lower energy environment where it could be deposited and not re-suspended. The second factor is the location of zero bottom flow predominance. Partially mixed estuaries like the Savannah River Estuary have a transition zone between fresh and saline water. The net bottom flow downstream of the transition zone is upstream and the net bottom flow upstream of the transition zone is downstream. The converging bottom flows carry sediment to the location of the transition zone or zero net bottom flow, which has been shown in References 2.8 and 2.9 to be associated with the region of heaviest shoaling. The model tests that were conducted for the design of New Cut and the Tide Gate indicated that these features would push the location of zero net bottom flow downstream. Documentation for the physical model tests are contained in Reference 2.7, and test results are shown for a plan similar to the one constructed in Figure 7-22. The test results show that the opening of New Cut and operating of the Tide Gate pushed the location

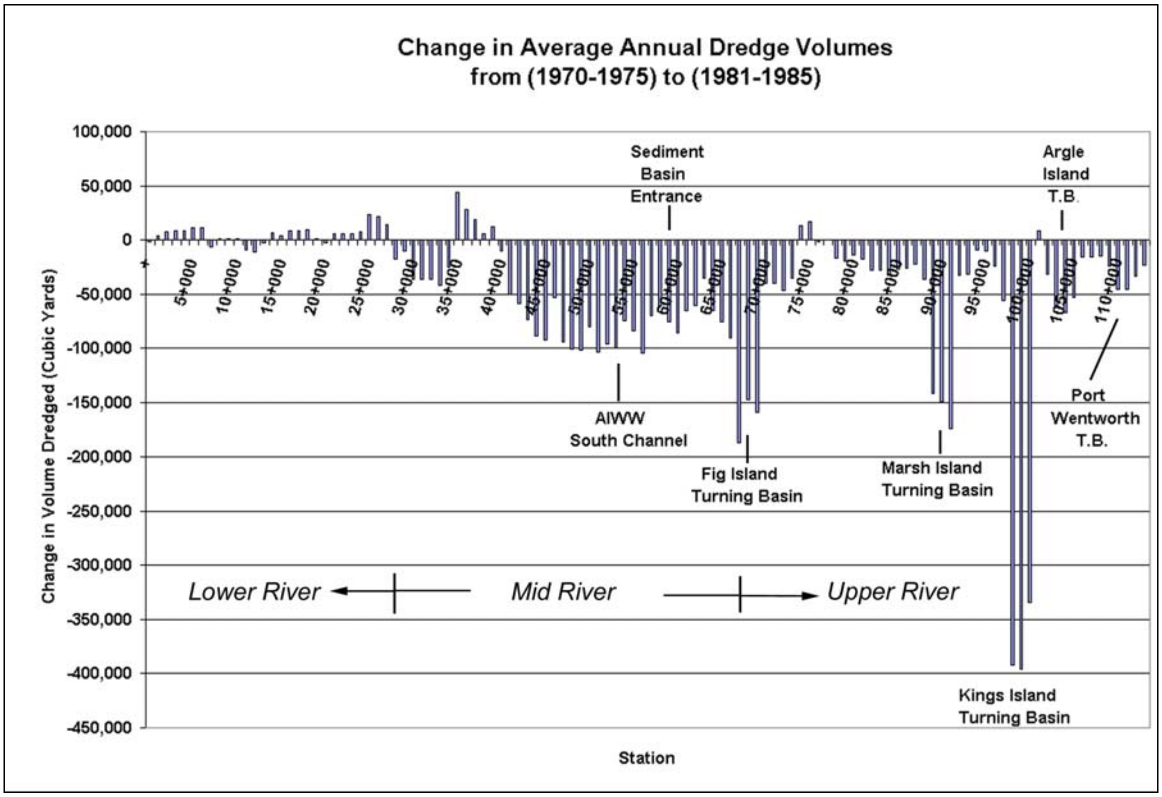

Figure 7-21 Changes in Average Annual Volume Dredged by Station from 1970-1975 to 1981-1985.

of zero net bottom flow from around station 77+000 in the upper river reach to about station 60+000 in the mid-river reach. Stations 77+000 and 60+000 in the present stationing corresponds to stations 116+000 and 133+000 in the old stationing used in the model tests. The shift in zero net bottom flow is in agreement with the measured 10,000-foot shift in Front River of the poorly defined saltwater wedge caused by the operation of the Tide Gate, Reference 2.6. The shift in zero net bottom flow from the upper river reach to the mid-river reach would have been expected to be accompanied by a shift in shoaling from the upper river reach to the mid-river reach.

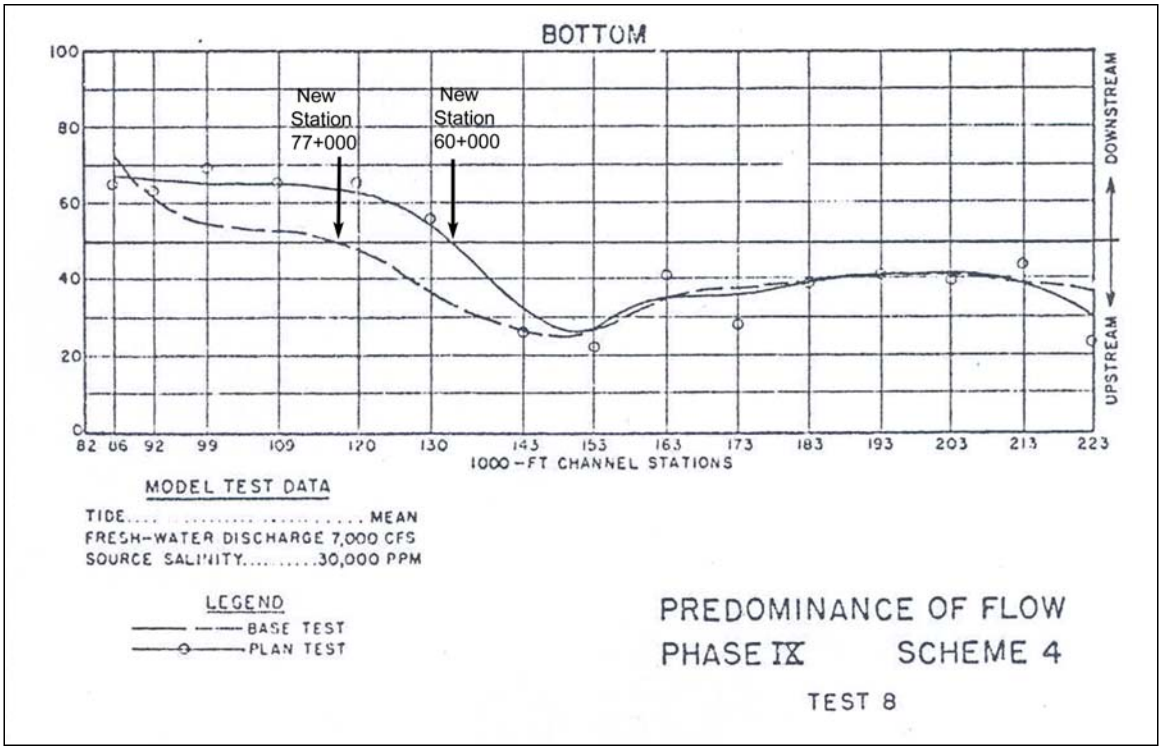

Figure 7-22 Shift in Zero Net Flow Location for the Tide Gate and New Cut Plan.

However, even with the shift in shoaling from the upper river reach to the mid-river reach, the mid-river reach exhibited a general decrease in the volume dredged due to sediment being trapped in the Sediment Basin. One exception to the general decrease in dredging was between stations 35+000 to 39+000. In the sediment source section **7.2.3.1.1,** the sediment samples taken in this area had high silt and clay components which defied the along channel trend of higher sand components. The shoaling in this area does not conform to the along channel trends because it is controlled by the converging flows of multiple channels since it is close to the confluence of the inner harbor channel with both Elba Island and Fields Cuts. The overall shoaling reduction for the mid-river reach cannot be attributed to velocity increases since model test results indicate small or no velocity increases, Figures 7-8 and 7-9. And since the location of zero net bottom flow was pushed into this area, the reduction cannot be attributed to changes in salinity-controlled currents. Dredging of the non-Federal Southern Liquid Natural Gas (SLNG) turning basin at station 40+000, removed an average annual volume of 361,000 cubic yards from 1981 to 1985, Table 7-7. Taking the SLNG dredging into account leaves an unaccounted for volume reduction of 1,767,000 cubic yards in the mid-river reach. The only other major change during these time periods was the construction of the Sediment Basin. The Sediment Basin has already been shown in section **7.2.3.1.3.1** to filter the sediment in the mid-river area. The location of the mid-river reach is plotted on Figure 7-23 to show the predicted effect of the Sediment Basin on the shoaling in the mid-river reach. From the process of elimination and the physical model tests it is evident that the reduction in the volume dredged in the mid-river reach is due to the Sediment Basin.

Year	Volume Dredged
1978	1,536,131
1979	1,352,951
1980	1,734,440
1981	1,443,417
1982-2000	0
2001	839,038
2002	400,000
2003	1,762,990
2004	895,133

Table 7-7 Volume Dredged in the Southern Liquid Natural Gas Turning Basin.

The lower river reach, which has an offshore sediment source, showed minor increases in shoaling and was not affected by upstream changes.

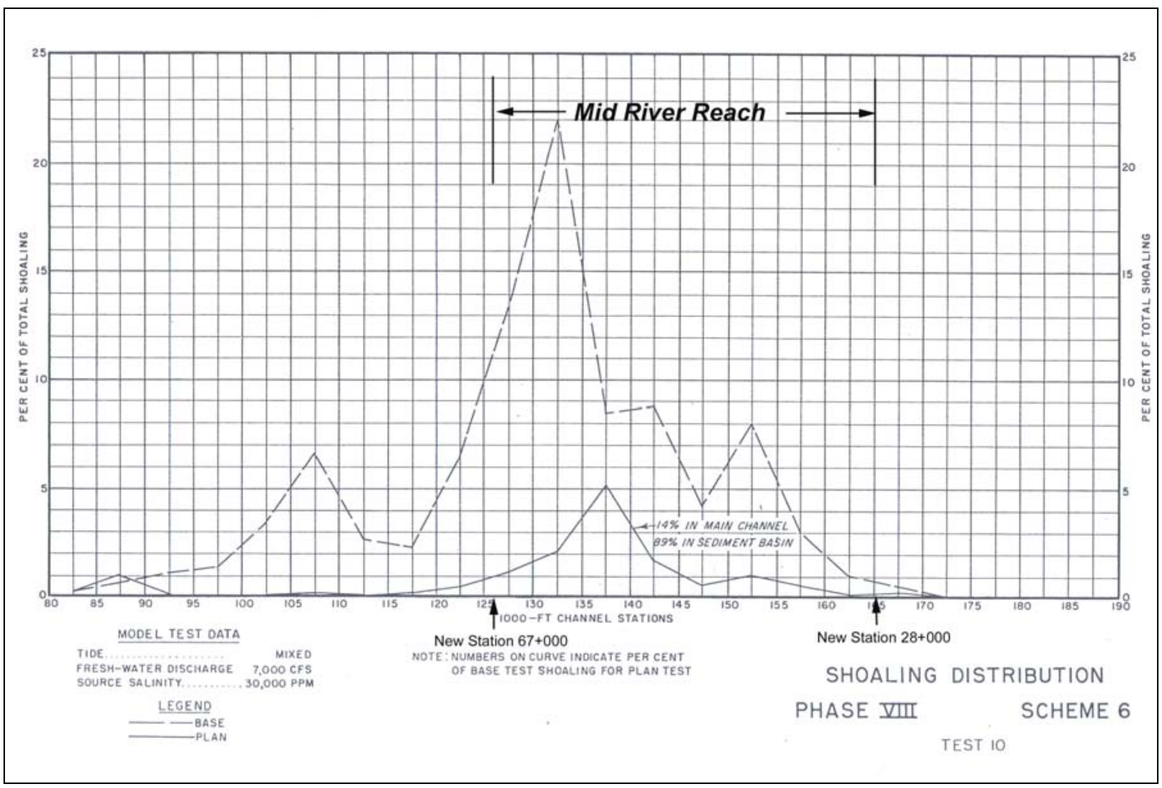

Figure 7-23 Shoaling Test Results After 119 Tidal Cycles, Reference 2.7.

The average annual volume dredged in the inner harbor channel for the period from 1970 to 1975 is 8,363,000 cubic yards. The average annual volume dredged in the inner harbor channel for the period 1981 to 1985 is 3,275,000 cubic yards. The reduction in the volume dredged in the inner harbor channel for the two periods is 5,088,000. The average annual volume dredge in the Sediment Basin for the period 1981 to 1985 was 2,792,000 cubic yards. This leaves 2,296,000 unaccounted for. Of this unaccounted for volume, 1,157,000 cubic yards can be attributed to a reduction in river discharge by the linear regression equation in Figure 7-16. The period from 1970 to 1975 had an average discharge of 13,510 cfs and the period 1981 to 1985 had an average discharge of 10,159 cfs. The river discharge reduction combined with an additional 361,000 cubic yards dredged from the SLNG turning basin reduces the unaccounted volume to 364,000 cubic yards. This remaining unaccounted for volume can either be due to the error in the regression equation that has a 0.44 R-squared value, survey accuracy or due to the nature of the shoals. The shoals in the mid and upper river have an average density of 1,144 gram per liter or 20 percent solids by weight, Reference 2.1. Since the shoal are mostly water and are composed of flocculated aggregates of clay particles, it is possible that the shoal material does not deposit in a low velocity area that allows the aggregate structures to remain intact. If the sediment is then spread over a large area, it could be undetected.

7.2.3.1.4.2 Shoaling Response to Closing New Cut, Ceasing Operation of the Tide Gate, Channel Widening, and Deepening from -38 feet to -42 feet.

The closing of New Cut, ceasing the operation of the Tide Gate, widening the upper river channel, and increasing the channel depth from -38 feet to -42 feet occurred in the time period from 1991 to 1994. The closure of New Cut and ceasing the operation of the Tide Gate reversed the changes that construction of these features created. The velocities in the upper river reach decrease 1.5 to 3.0 feet per second and the location of zero net bottom flow shifted back from the mid-river reach to the upper river reach. In response to these changes, the shoaling distribution in the upper river reach reverted to a pattern similar to the pattern to the 1970-1975 period. The shoaling volume in the upper river reach increased as shoaling shifted from the mid-river reach and the Sediment Basin to the upper river reach. The lower river reach had a slight decrease in shoaling volume. The combined shoaling of the three reaches showed a decrease in shoaling from the period 1981-1985 to 1997-2004, which was unrelated to river discharge.

To determine the shoaling changes caused by the closing of New Cut, ceasing the operation of the Tide Gate, widening the upper river channel, and increasing the channel depth from -38 feet to -42 feet, the volume dredged distributions were analyzed. The volume dredged distributions for the periods 1970-1975, 1981-1985 and 1997-2004 are plotted in Figure 7-24 and listed in Table 7-8. The volume dredged distributions for just the periods 1981-1985 and 1997-2004 are plotted in Figure 7-25 and the changes between these two periods is plotted in Figure 7-26.

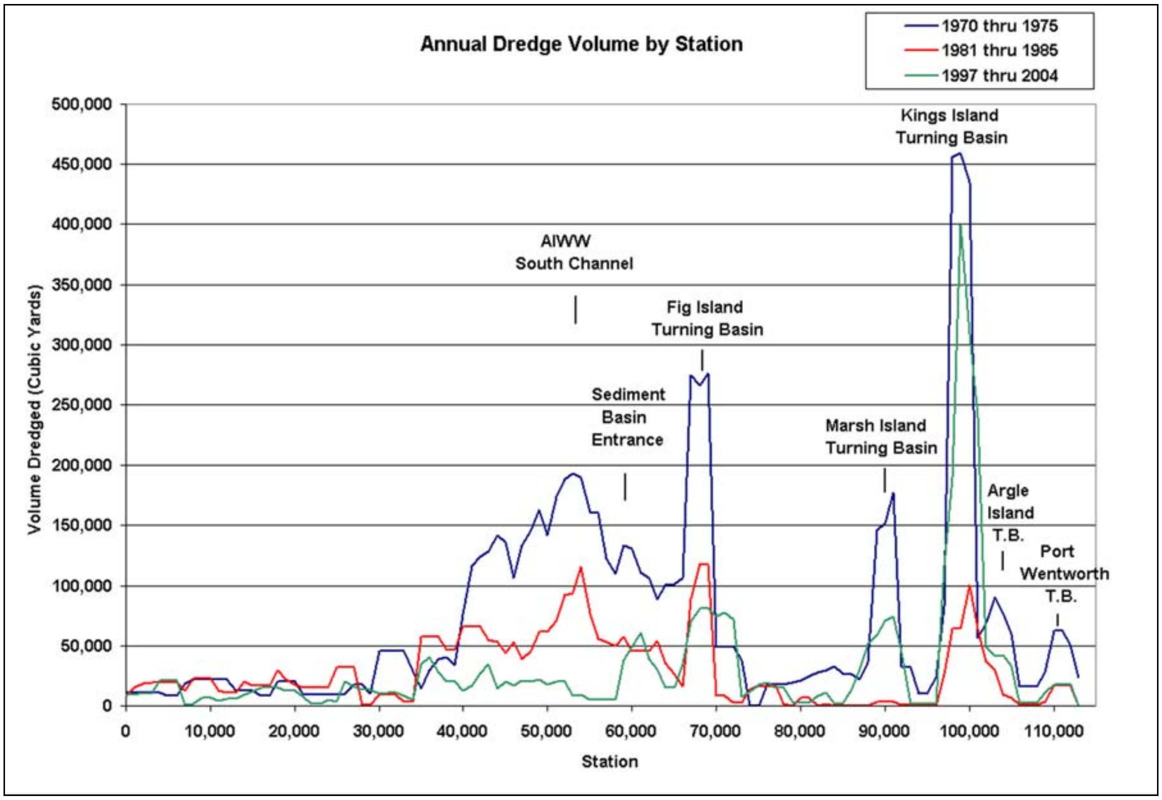

Figure 7-24 Annual Volume Dredged by Station 1970 thru 1975, 1981 thru 1985 and 1997 thru 2004.

Station	Annual Volume 1970 - 1975	Annual Volume 1981-1985	Annual Volume 1997-2004
0	11,001	8,797	9,683
1000	11,001	15,079	9,683
2000	11,001	18,823	11,380
3000	11,001	19,272	10,010
4000	11,001	19,272	21,153
5000	8,447	19,272	21,153
6000	8,447	19,272	21,367
7000	18,585	12,459	837
8000	22,019	22,587	1,995
9000	22,019	22,587	6,803
10000	22,019	22,587	6,659
11000	22,019	12,459	4,355

12000	21,611	10,694	5,533
13000	13,036	10,694	5,621
14000	13,036	19,881	9,411
15000	13,036	16,709	12,069
16000	8,497	16,709	14,940
17000	8,497	16,709	15,306
18000	20,191	29,664	15,312
19000	20,606	22,080	12,786
20000	20,606	17,662	12,392
21000	8,912	14,832	7,948
22000	8,912	14,832	2,053
23000	8,912	14,832	1,516
24000	8,912	16,425	4,915
25000	8,912	32,183	3,731
26000	10,520	32,183	19,921
27000	18,108	32,183	16,190
28000	18,108	509	13,100
29000	10,520	509	13,482
30000	45,568	9,155	10,411
31000	45,568	9,155	10,738
32000	45,568	9,155	10,738
33000	45,568	3,615	8,577
34000	28,481	3,084	5,382
35000	14,103	57,629	34,378
36000	29,818	57,629	40,242
37000	38,433	57,629	28,060
38000	40,495	46,069	19,905
39000	33,758	46,069	20,292
40000	76,149	66,182	12,368
41000	116,413	66,182	17,180
42000	124,529	66,182	26,794
43000	128,368	54,853	34,487
44000	142,068	53,224	13,999
45000	135,979	43,934	20,683
46000	106,296	53,275	16,493
47000	133,497	39,085	20,828
48000	146,264	45,191	20,529
49000	163,380	61,778	21,759
50000	141,880	61,778	18,002
51000	174,377	71,137	20,598
52000	188,639	92,452	20,598
53000	193,596	93,785	8,704
54000	190,299	115,300	9,277
55000	161,113	76,769	5,096
56000	160,300	55,987	4,693

57000	122,867	52,886	5,454
58000	109,962	49,485	4,906
59000	133,168	57,258	37,995
60000	131,148	45,450	49,241
61000	110,486	45,450	61,092
62000	106,426	45,551	39,164
63000	89,087	53,840	30,262
64000	100,260	35,414	15,444
65000	101,008	25,862	15,243
66000	106,589	16,393	34,283
67000	274,687	88,310	69,954
68000	266,254	118,417	81,214
69000	275,892	117,415	81,214
70000	48,582	8,586	74,633
71000	48,582	8,586	77,856
72000	48,582	2,414	71,549
73000	37,644	2,414	8,005
74000	0	13,229	12,072
75000	0	16,478	17,602
76000	18,037	16,120	19,442
77000	18,037	17,767	15,030
78000	18,037	1,647	15,030
79000	19,574	0	3,057
80000	20,826	6,988	2,415
81000	24,844	6,988	2,415
82000	28,076	143	8,156
83000	29,352	1,866	11,103
84000	32,851	143	1,294
85000	27,249	143	1,294
86000	25,973	143	13,693
87000	22,059	0	30,111
88000	36,358	357	51,888
89000	145,865	3,547	58,976
90000	152,442	3,414	70,584
91000	177,433	3,414	74,601
92000	32,716	534	44,419
93000	32,276	534	1,673
94000	9,929	534	1,673
95000	9,929	0	1,673
96000	23,753	0	1,381
97000	82,606	26,268	116,226
98000	455,992	63,995	189,772
99000	459,867	63,995	399,576
100000	434,603	100,592	308,948
101000	56,211	64,377	239,898

102000	68,420	37,007	49,172
103000	90,052	29,667	41,306
104000	76,625	9,392	42,106
105000	59,900	6,954	32,687
106000	16,264	776	2,191
107000	16,264	776	2,191
108000	16,264	1,256	2,191
109000	27,795	3,339	10,857
110000	62,488	17,082	17,411
111000	62,488	17,082	17,411
112000	51,033	17,082	18,226
113000	23,238	0	0

Table 7-8 Annual Volume Dredged by Station 1970 thru 1975, 1981 thru 1985 and 1997 thru 2004.

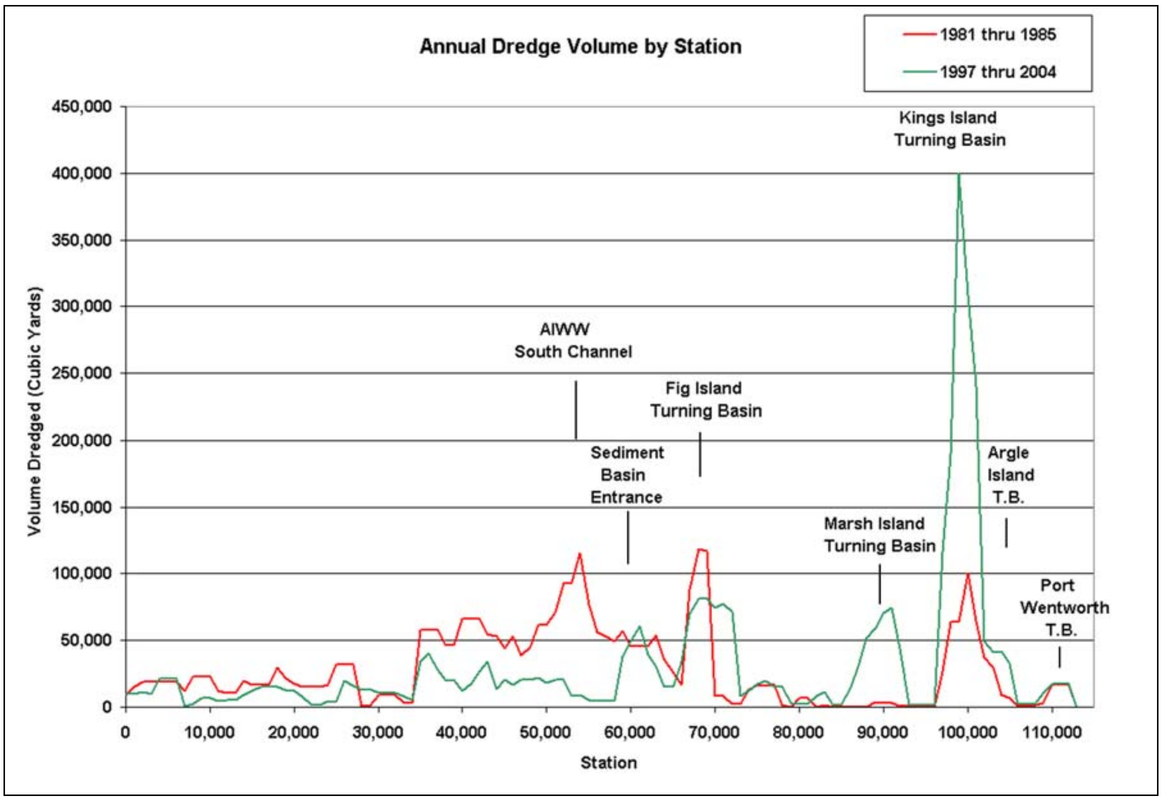

Figure 7-25 Annual Volume Dredged by Station 1981 thru 1985 and 1997 thru 2004.

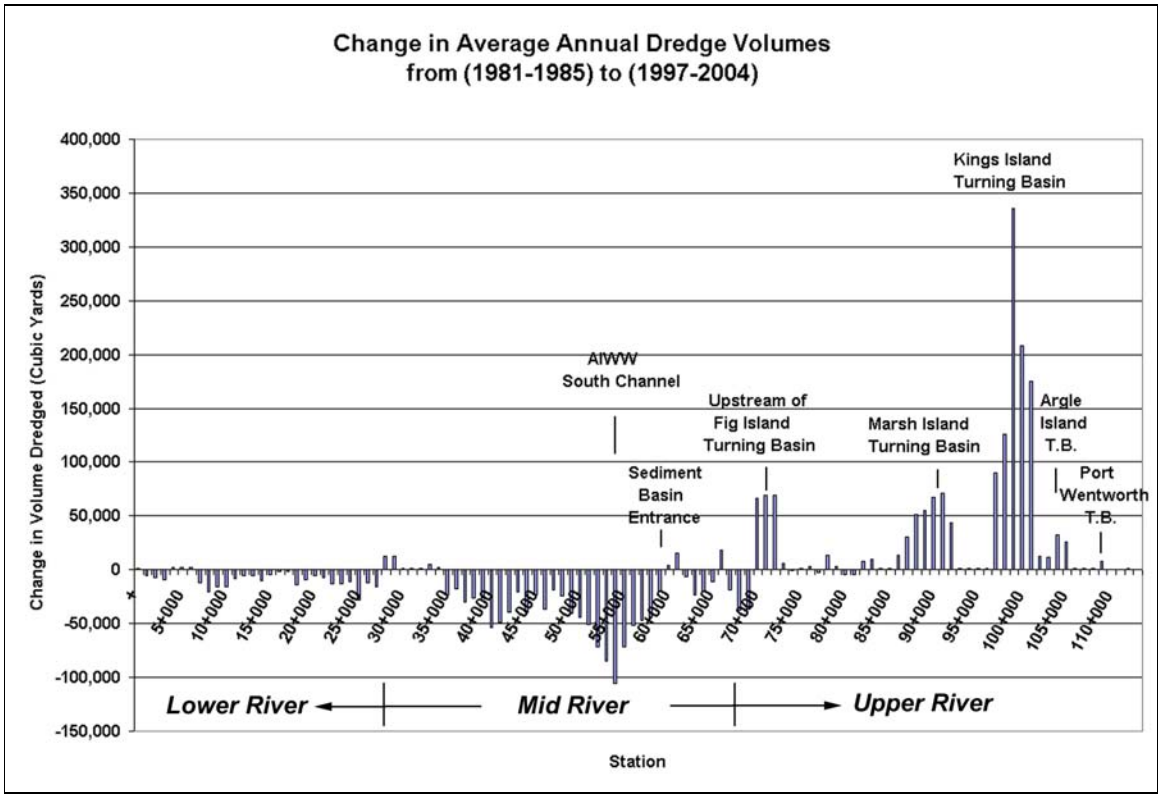

Figure 7-26 Changes in Average Annual Volume Dredged by Station from 1981-1985 to 1997-2004.

Closing New Cut and ceasing operation of the Tide Gate reversed the current changes and the shift in the zero net bottom flow location that their construction created. The changes were documented in **7.2.3.1.3.1.** The volume dredged in the upper river reach, 2,414,000 cubic yards, increased by 1,514,000 in response to the velocity reduction due to the closure of New Cut and the shift of the location of zero net bottom flow back from the mid-river reach into the upper river reach. The volume dredged increases in the upper river reach occurred primarily in the Kings Island and Marsh Island turning basins, which had been high shoaling areas prior to the construction of the Tide Gate and New Cut. The area immediately upstream of the Fig Island turning basin also showed a large increase. The cause of this increase can be determined by examining the plots of before dredging surfaces. Figures 7-27 to 7-32 are plots of before dredging surveys circa 1990. While 1990 is not in the period 1981 to 1985, it was before the changes of concern were implemented. The before dredging surveys were not available for the period 1981-1985. Figures 7-33 to 7-38 are plots of before dredging surveys circa 2003. A surface of differences between the 1990 surface and the 2003 surface are plotted in Figures 7-39 to 7-44. Figure 7-29 contains the 1990 before dredging surface above Fig Island turning basin. Two large scour areas are present. Figure 7-35 contains of plot of the 2003 before dredging surface. The two scour areas are not as prominent. Figure 7-41 contains the difference between the 1990 and 2003 surfaces and even though in 2003 the project depth was 4 feet deeper than in 1990 the scour areas had higher elevations in 2003 than in 1990. It appears from the surface plots that the strength of the flow pattern in this area oscillates from one side of the channel to the other causing the scour areas as the flow impinges on the side of the channel resulting in an increase in velocity. The reduction of the scour areas appears to be due to the channel widening, which spreads the flow out and lessens the effect of the flow impinging on the side of the channel. This change in the shoaling pattern does not appear to be related to the closure of New Cut or the removal of the Tide Gate since it also appears when comparing the shoaling distributions from 1970-1975 to 1997-2004, Figure 7-24. It is also unlikely related to agitation dredging since the volume change is an order of magnitude larger than the volume dispersed by the nearest agitation dredging permit holder East Coast Terminal.

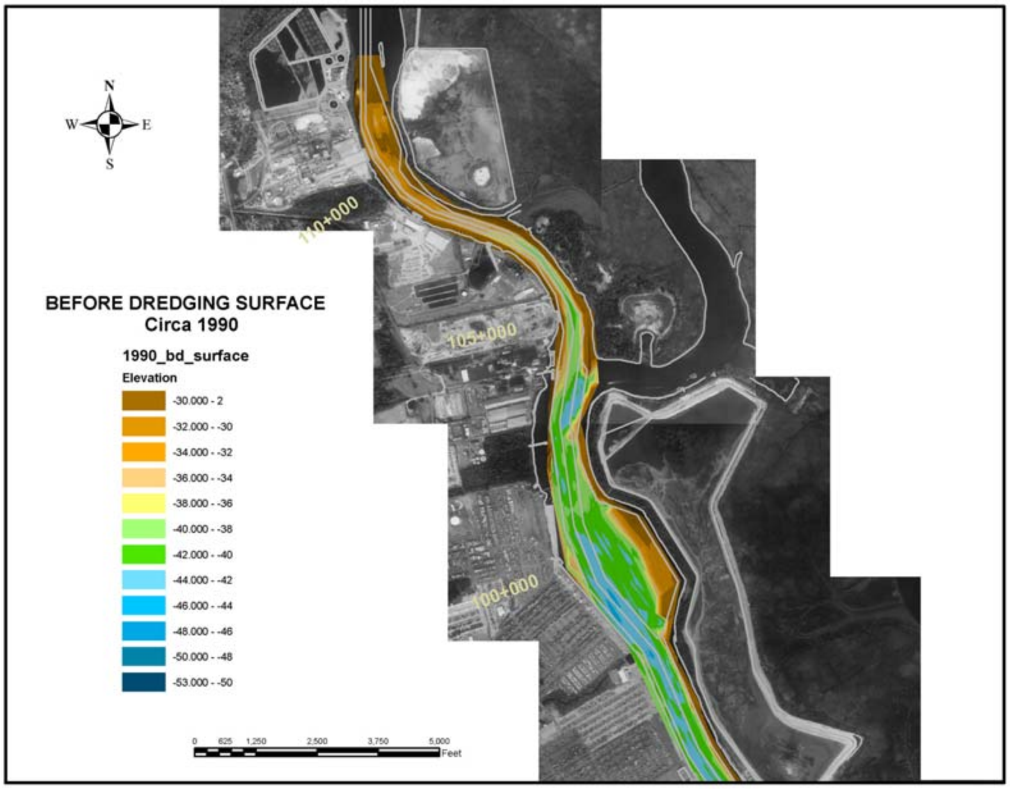

Figure 7-27 Before Dredging Surface Circa 1990 Stations 100+000 to 110+000.

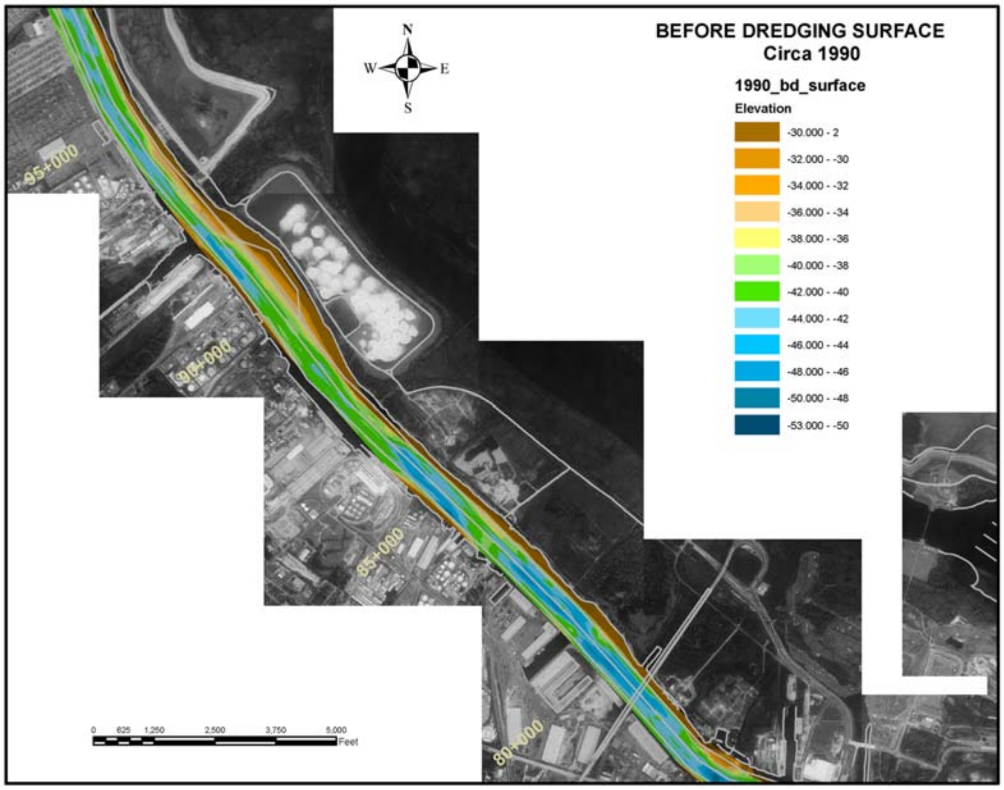

Figure 7-28 Before Dredging Surface Circa 1990 Stations 80+000 to 95+000.

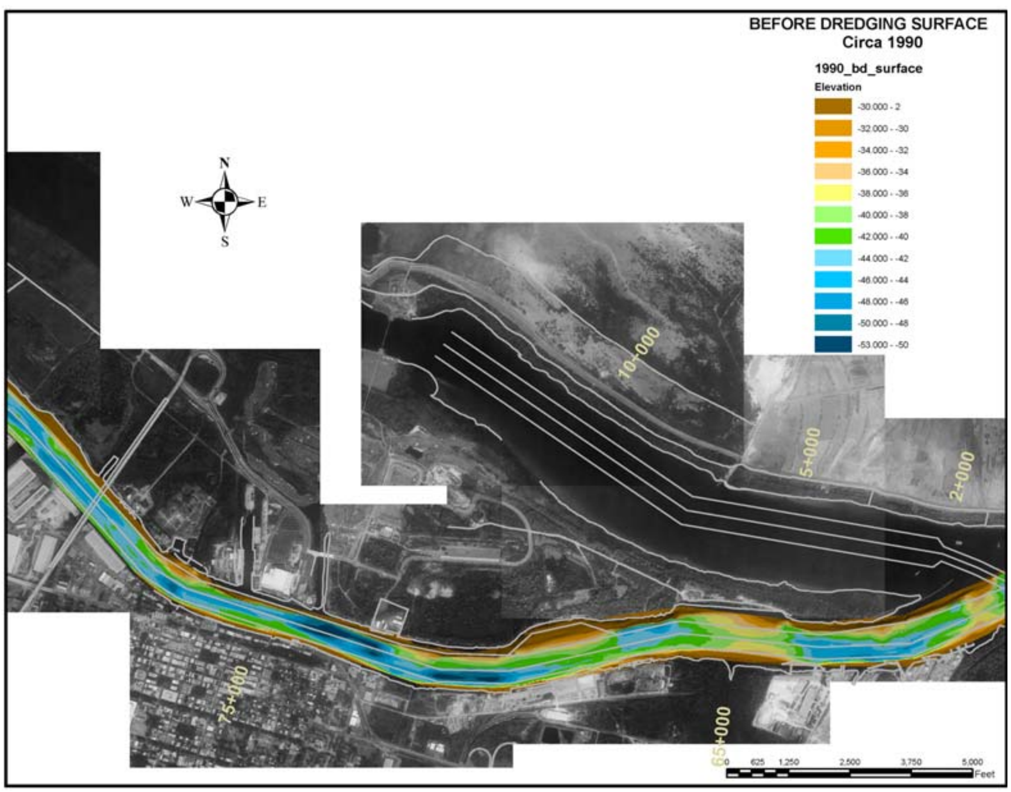

Figure 7-29 Before Dredging Surface Circa 1990 Stations 60+000 to 75+000.

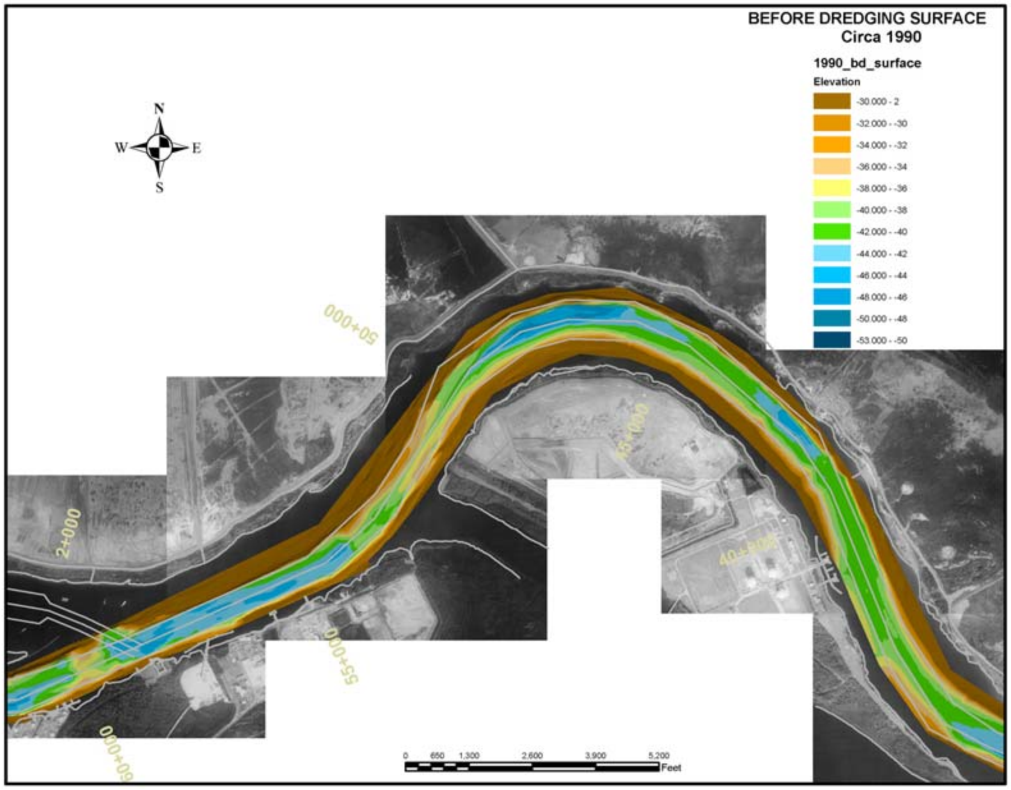

Figure 7-30 Before Dredging Surface Circa 1990 Stations 40+000 to 60+000.

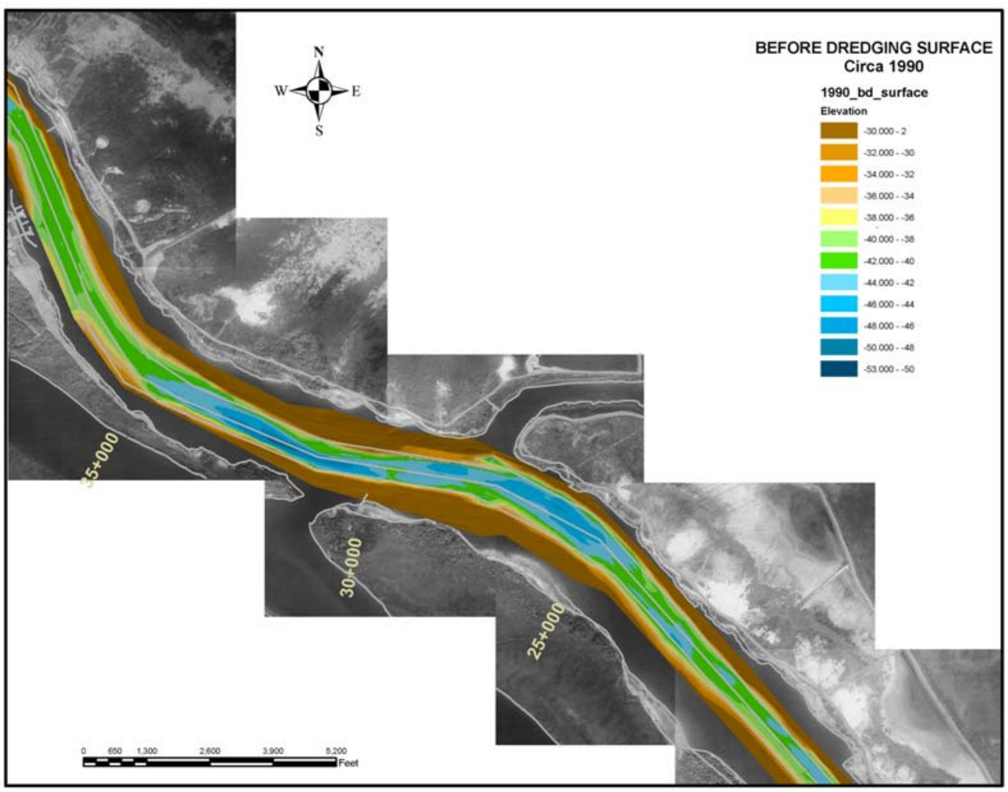

Figure 7-31 Before Dredging Surface Circa 1990 Stations 25+000 to 35+000.

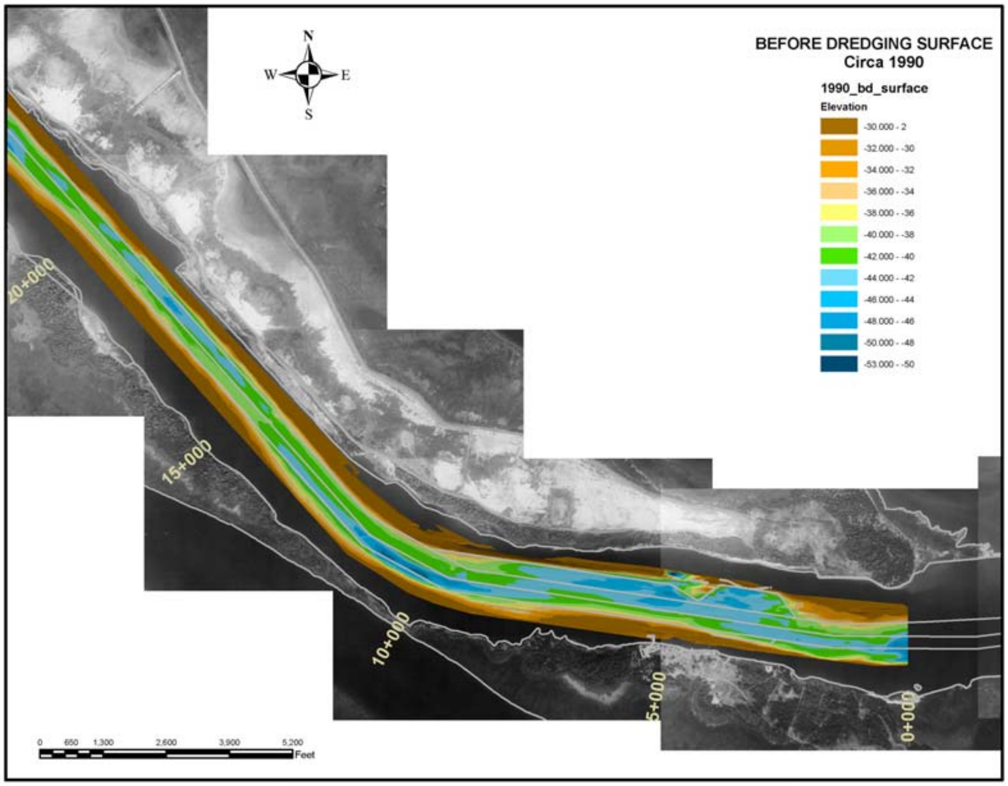

Figure 7-32 Before Dredging Surface Circa 1990 Stations 0+000 to 20+000.

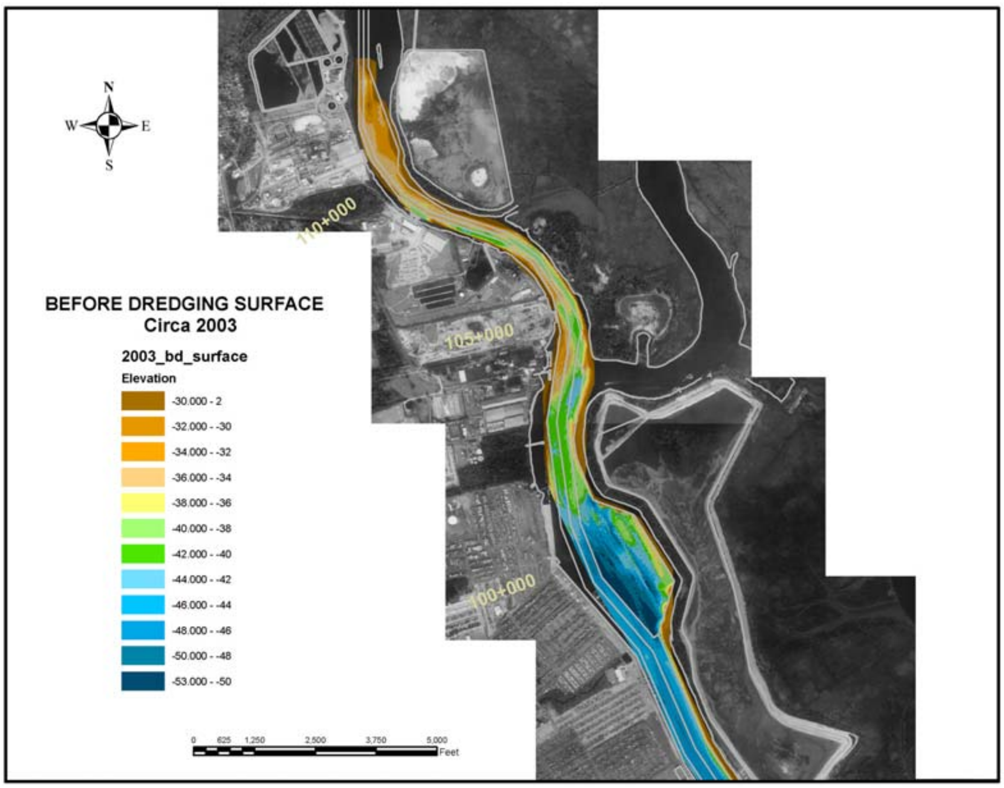

Figure 7-33 Before Dredging Surface Circa 2003 Stations 100+000 to 110+000.

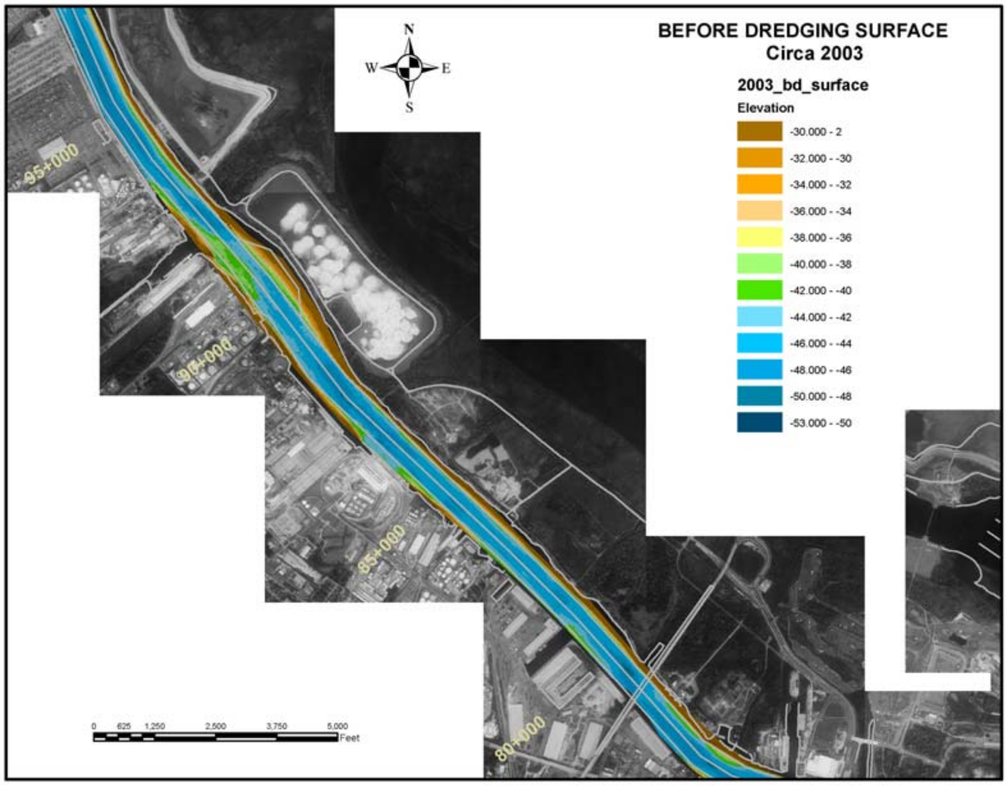

Figure 7-34 Before Dredging Surface Circa 2003 Stations 80+000 to 95+000.

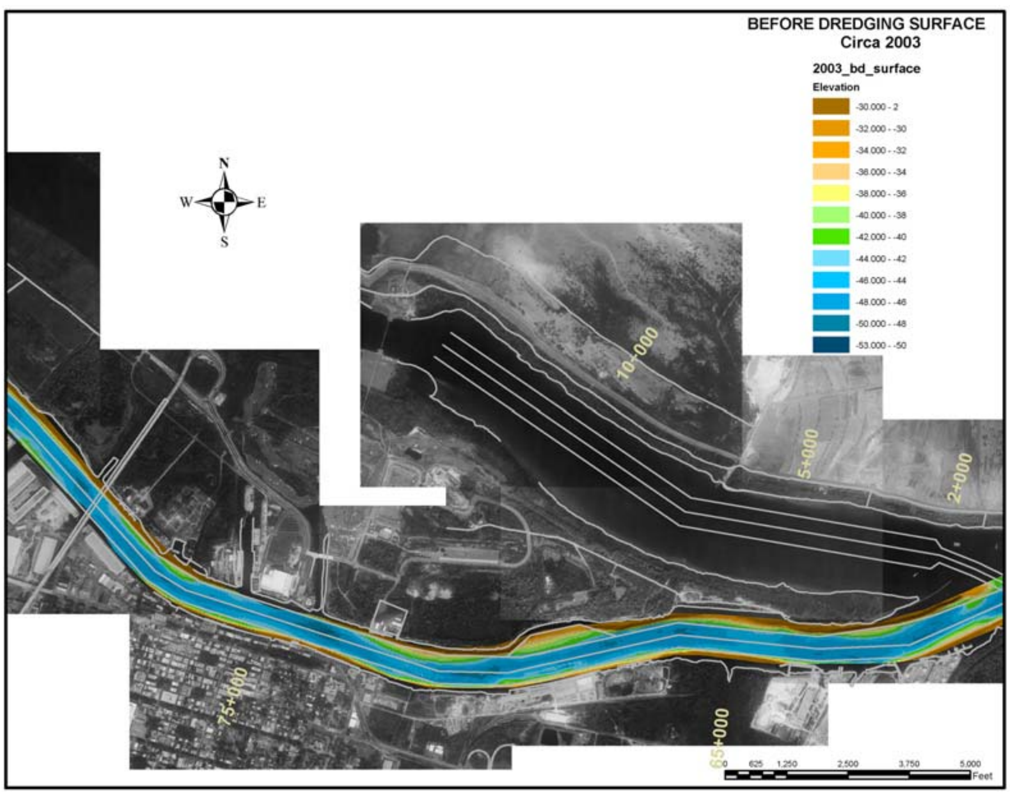

Figure 7-35 Before Dredging Surface Circa 2003 Stations 65+000 to 75+000.

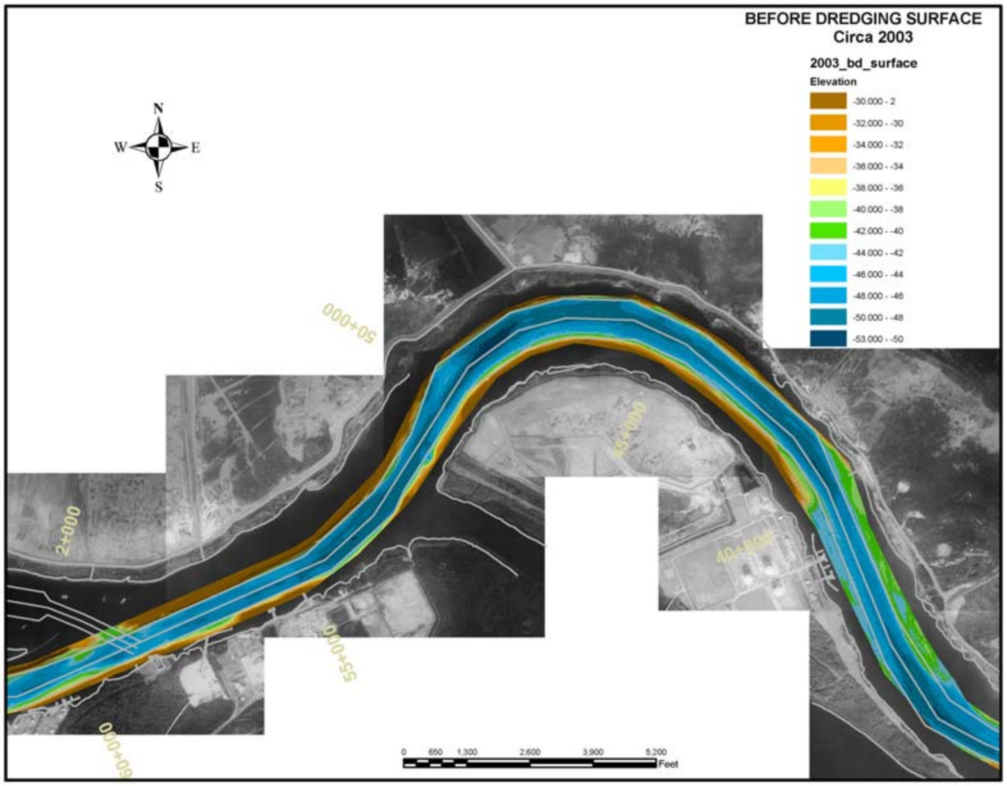

Figure 7-36 Before Dredging Surface Circa 2003 Stations 40+000 to 60+000.

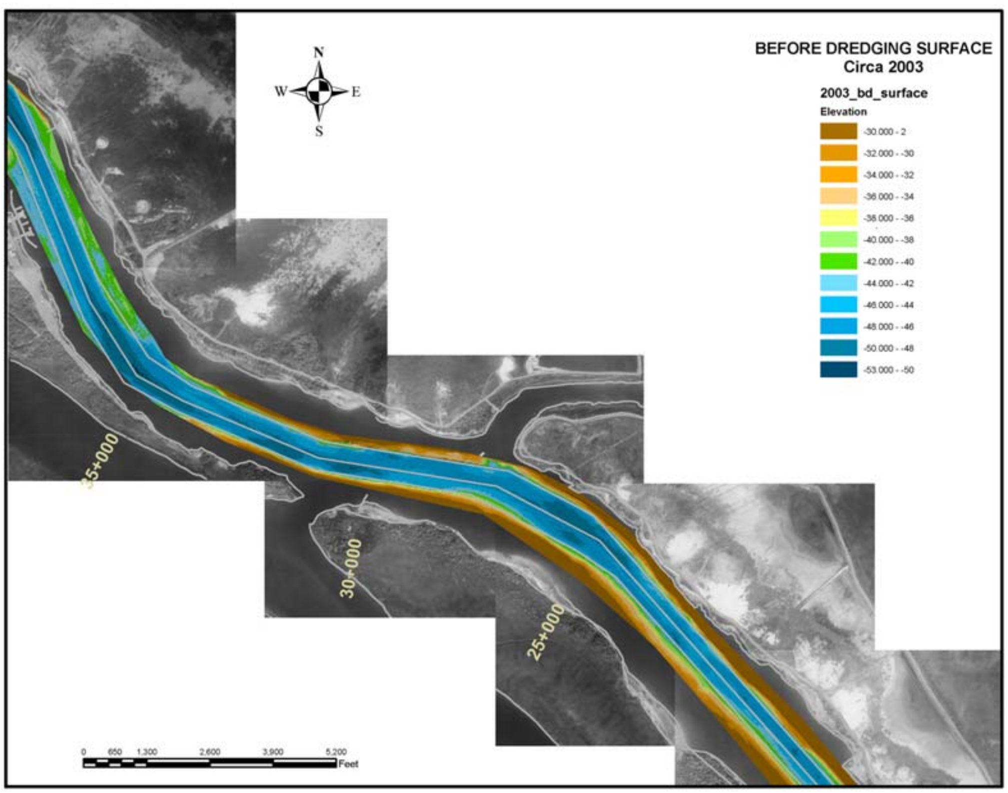

Figure 7-37 Before Dredging Surface Circa 2003 Stations 25+000 to 35+000.

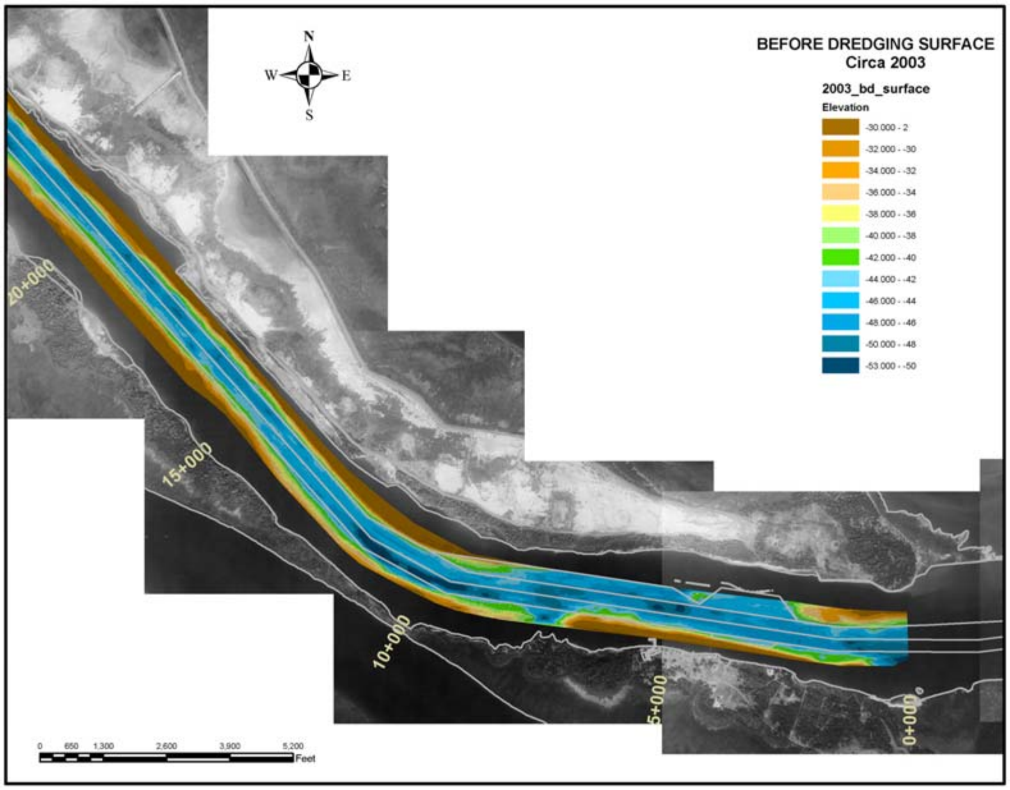

Figure 7-38 Before Dredging Surface Circa 2003 Stations 0+000 to 20+000.

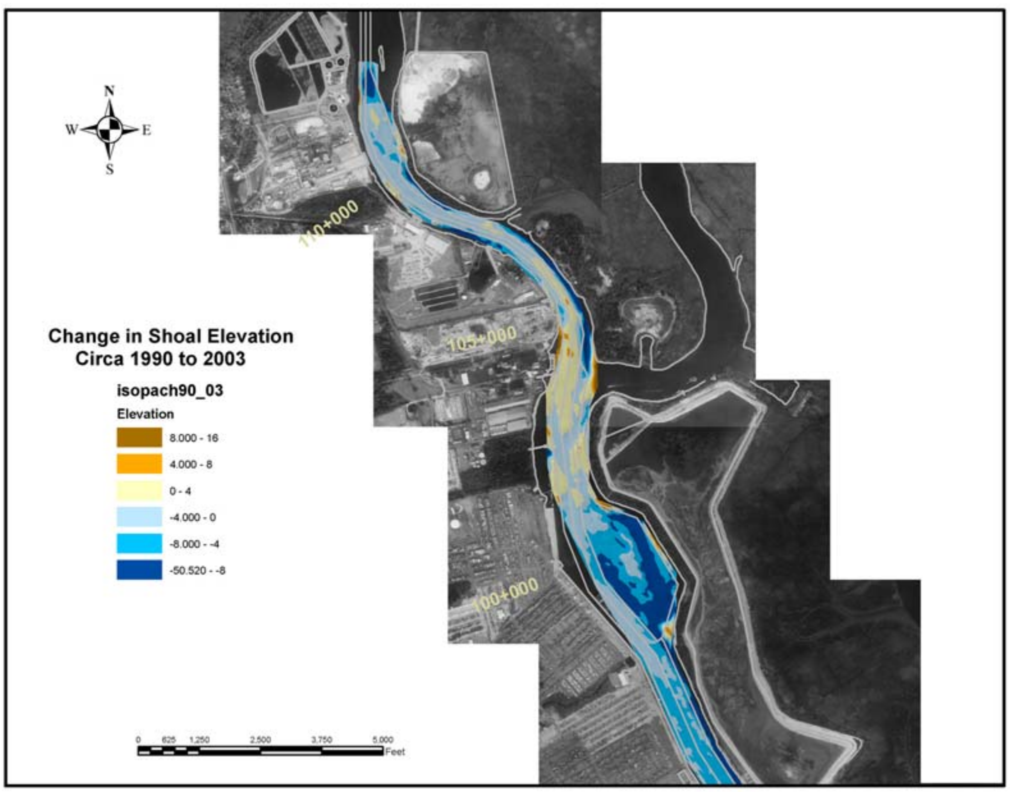

Figure 7-39 Before Dredging Surface Changes Circa 1990 to 2003 Stations 100+000 to 110+000.

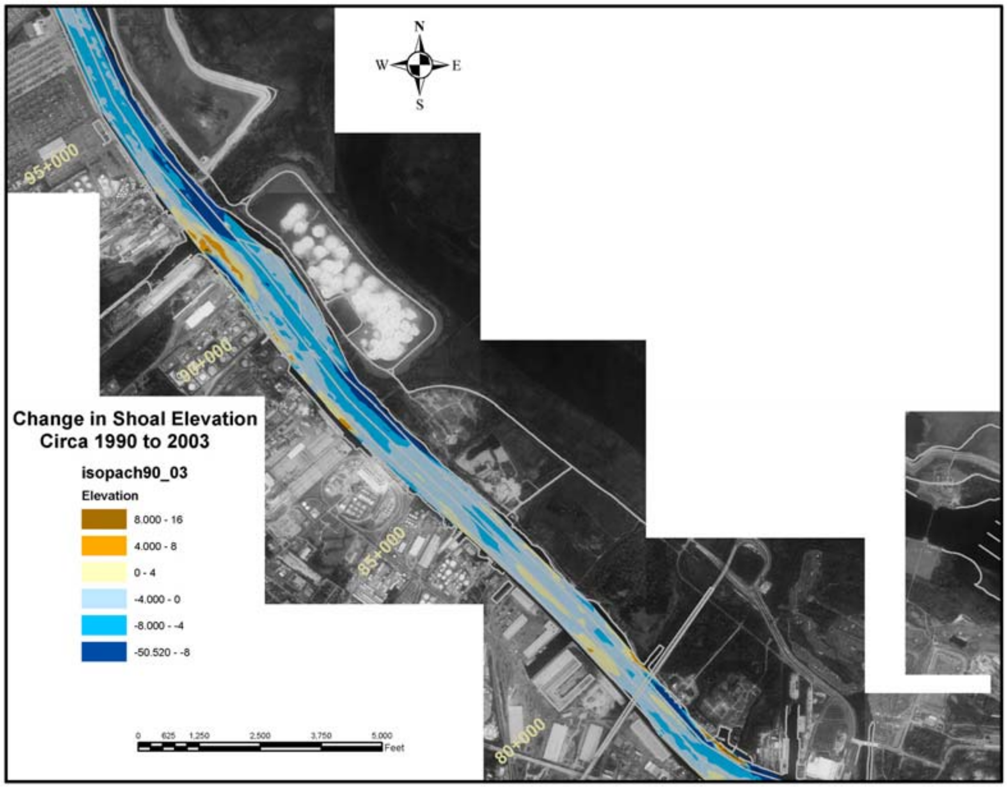

Figure 7-40 Before Dredging Surface Changes Circa 1990 to 2003 Stations 80+000 to 95+000.

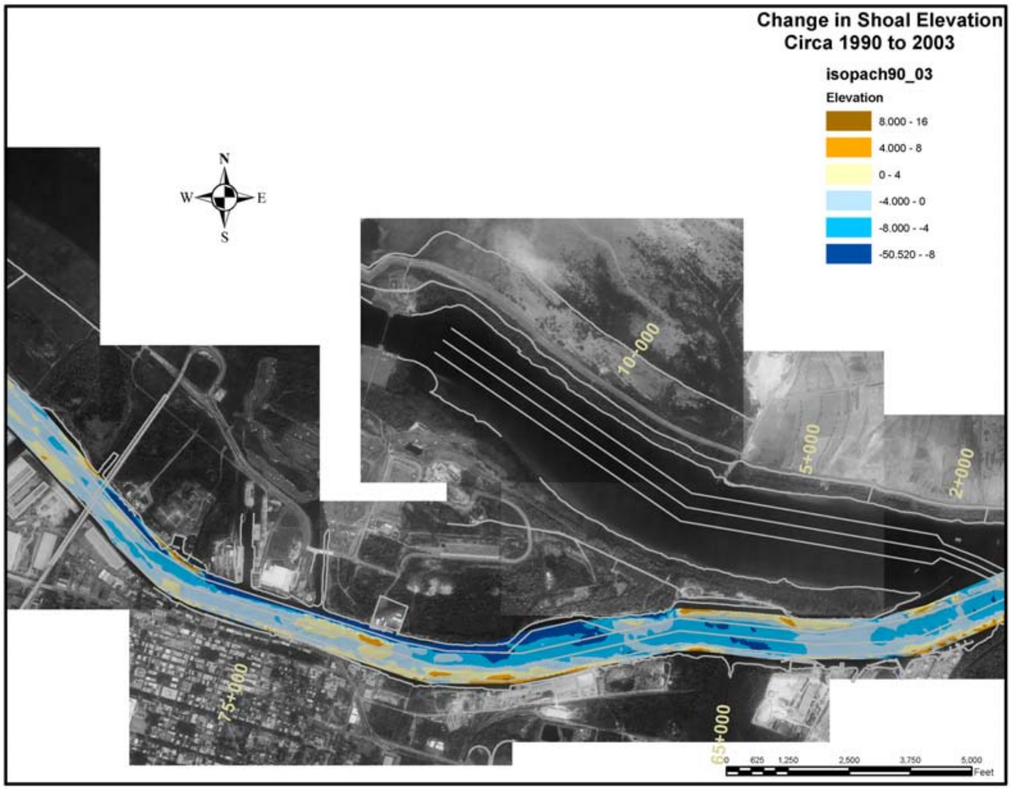

Figure 7-41 Before Dredging Surface Changes Circa 1990 to 2003 Stations 65+000 to 75+000.

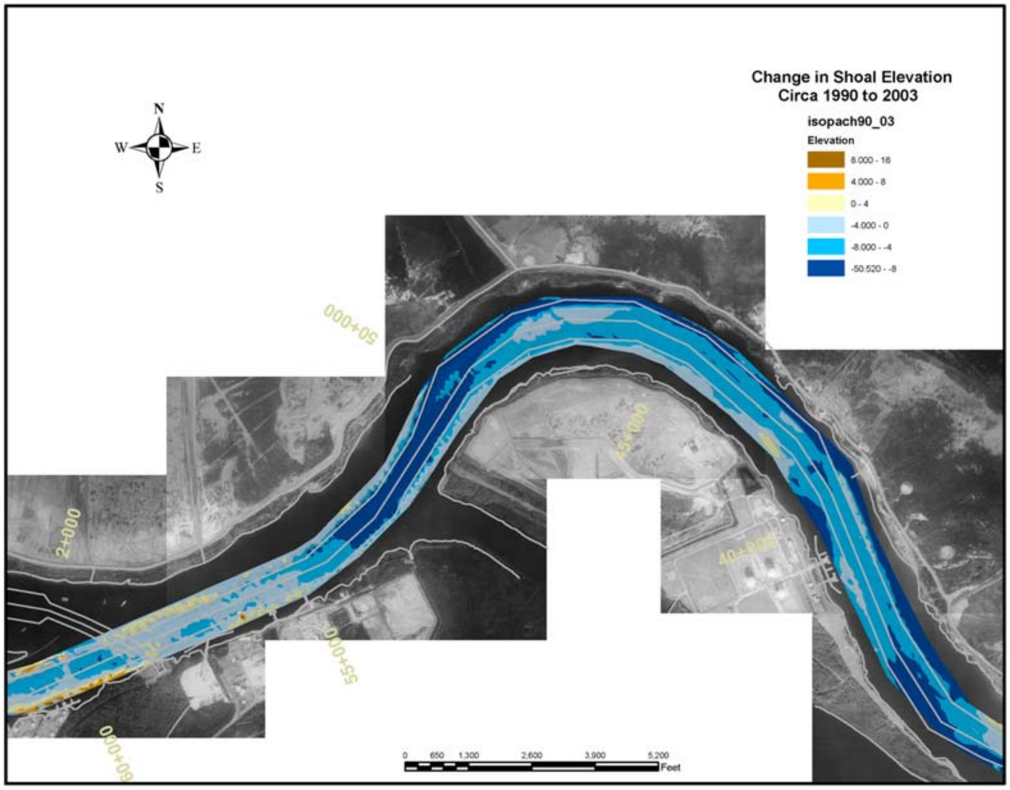

Figure 7-42 Before Dredging Surface Changes Circa 1990 to 2003 Stations 40+000 to 60+000.

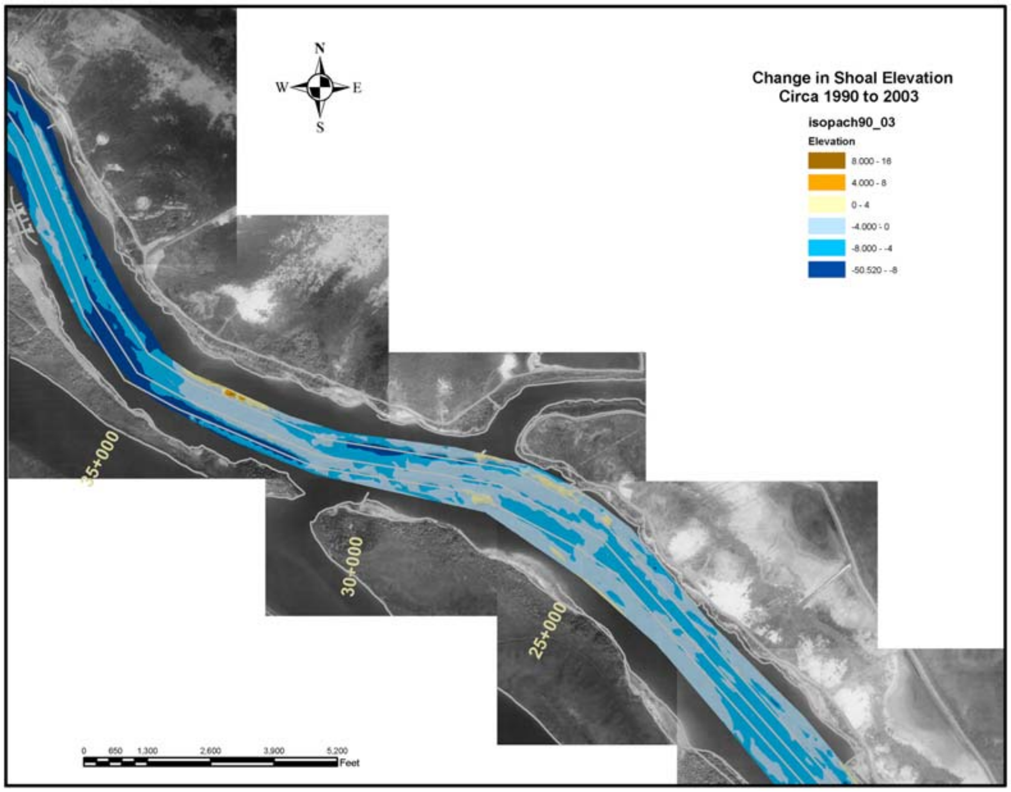

Figure 7-43 Before Dredging Surface Changes Circa 1990 to 2003 Stations 25+000 to 35+000.

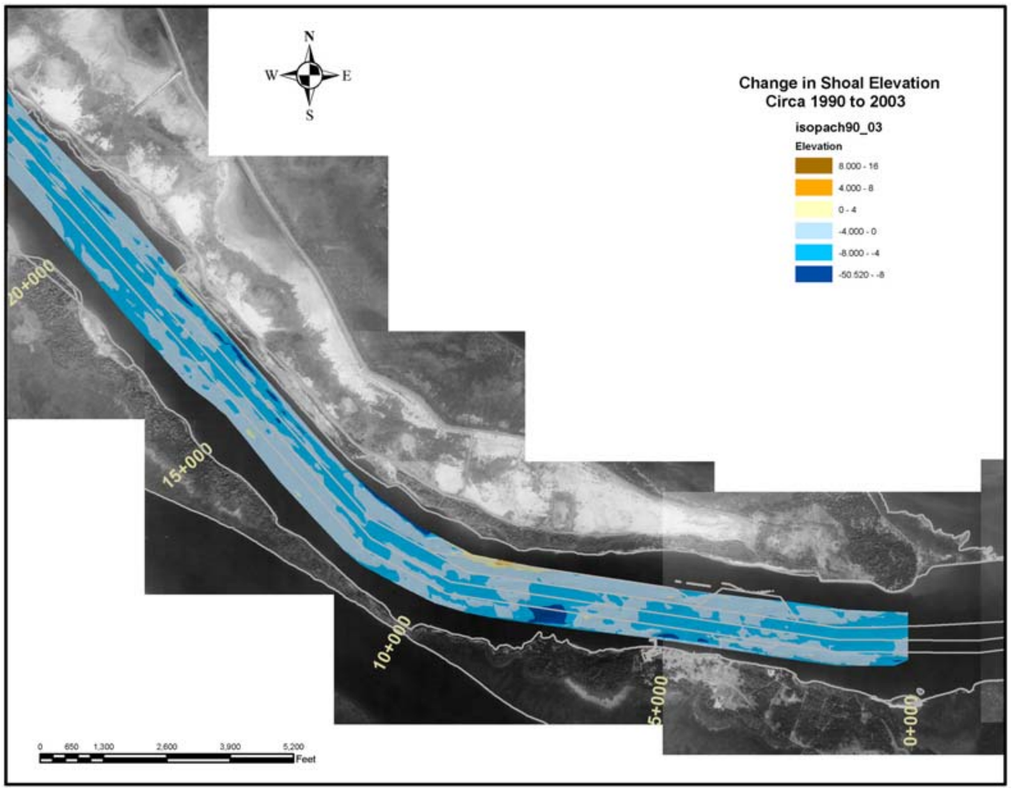

Figure 7-44 Before Dredging Surface Changes Circa 1990 to 2003 Stations 00+000 to 20+000.

The volume dredged in the in the mid-river reach, 787,000 cubic yards, decreased by 1,057,000 cubic yards from the period 1981-1985 to 1997-2004. Of this mid-river dredging decrease, 126,000 cubic yards can be attributed to an average annual dredging increase at the SLNG turning basin. The remainder of the decrease in annual volume dredged can be attributed to the location of zero net bottom flow moving from the mid-river reach to the upper river reach and the continued operation of the sediment trap. The area from station 28+000 to 34+000 was unchanged or had small increases. This area is at the confluence of the inner harbor channel with both Elba Island and Fields Cuts. The shoaling at this location is controlled by the converging flows from the side channels. The area immediately upstream was shown to respond atypically to the changes from 1970-1975 to 1981-1985 and the sediment samples taken in this area were not consistent with the along channel trend. (See Table 7-2 and Figure 7-2.)

The volume dredged in the lower river reach, 298,000 cubic yards, had a decrease of 233,000 cubic yards from the period 1981-1985 to 1997-2004.

The volume dredged in the Sediment Basin, 1,555,000 cubic yards, was a decrease of 1,242,000 cubic yards. The decrease in volume dredged is likely due to increases in the ebb flow current as a result of the removal of the tide gates and to the location of zero net bottom flow moving from the mid-river reach to the upper river reach. This change will be discussed in greater detail in the Sediment Basin section 7.2.4 Sediment Basin Efficiency.

The average annual volumes dredged by period and reaches are shown in Figure 7-45 and Table 7-9. In order to account for changes in the volume dredged due to river discharge the linear regression equation from Figure 7-16 was applied to an average discharge of 10,159 cfs for the period 1981-1985 and an average discharge 9,921 cfs for the period 1997-2004. The ratio of the calculated volume dredged for the period to the calculated volume dredged for the average river discharge was multiplied by the actual volume dredged for the period to produce normalized volumes dredged. The normalized values are presented in Table 7-10.

Using the values in Table 7-10, the shift in shoaling from the mid-river reach and Sediment Basin to the upper river reach more than accounts for the 1,738,000 cubic yard increase in the volume dredged in the upper reach. This shift in shoaling to the upper river reach is due to the shift of the location of zero net bottom flow from the mid-river reach to the upper river reach. While the zero net bottom flow was in the mid-river reach the Sediment Basin was able to filter out the re-circulating sediment. The shift of the net zero bottom flow location out of the mid-river reach would have taken with it the sediment that was shoaling in the channel and the Sediment Basin. Of the 1,344,000 cubic yard reduction in the Sediment Basin, 578,000 cubic yards shifted to the upper river reach and 126,000 cubic yards were dredged out of the SLNG turning basin. The remaining 640,000 cubic yards are unaccounted for. The volume of material that is unaccounted was either deposited outside of the navigation channel or can be attributed in small part to the uncertainty in the river discharge correction to the shoaling volume.

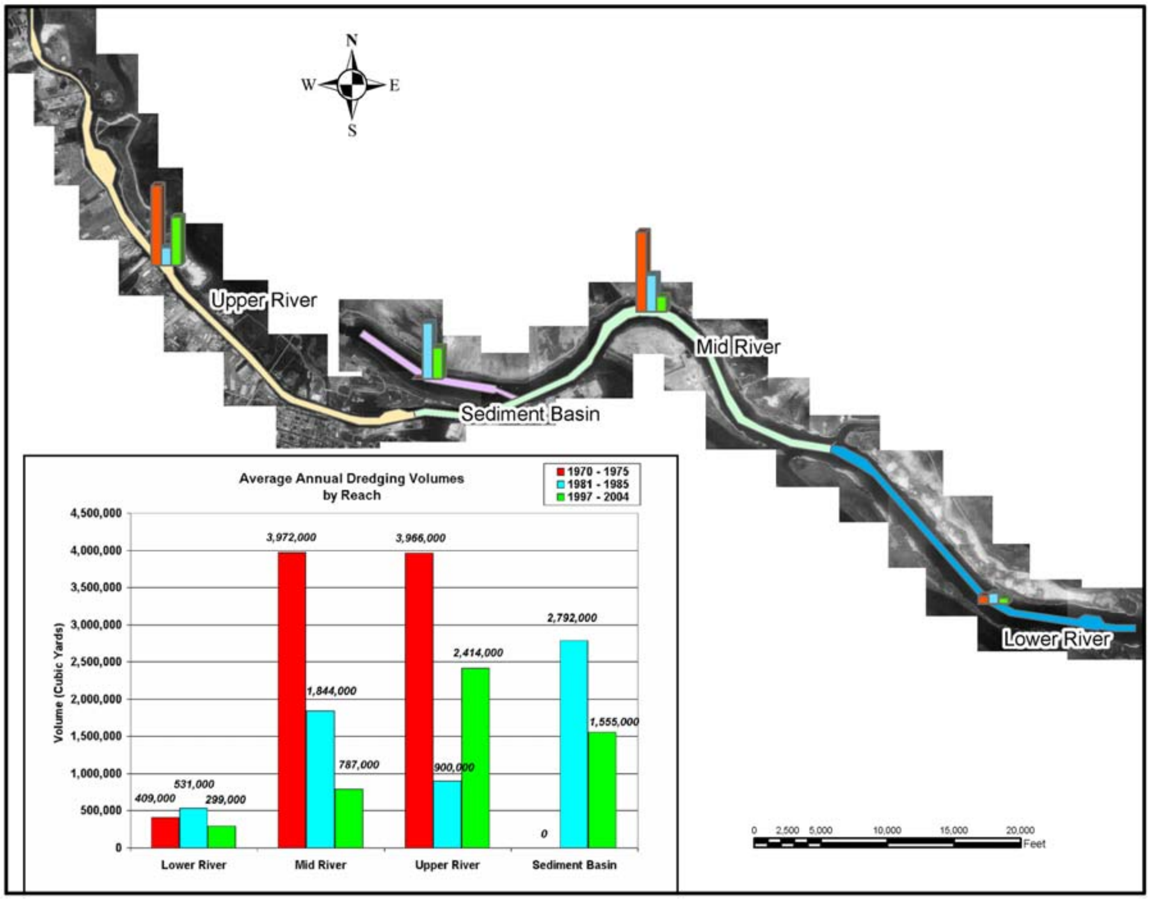

Figure 7-45 Average Annual Volume Dredged by Reach 1970 to 2004.

Reach	Average Annual Cubic Yards Dredged 1981 to 1985	Average Annual Cubic Yards Dredged 1997 to 2004	Difference
Lower River	531,000	298,000	-233,000
Mid-river	1,844,000	787,000	-1,057,000
Upper River	900,000	2,414,000	1,514,000
Sediment Basin	2,792,000	1,555,000	-1,237,000
Total	6,067,000	5,054,000	-1,013,000

Table 7-9 Average Annual Volumes Dredged From the Period 1981-1985 to the Period 1997-2004 by Reach.

Reach	Average Annual Cubic Yards Dredged 1981 to 1985	Average Annual Cubic Yards Dredged 1997 to 2004	Difference
Lower River	591,000	338,000	-253,000
Mid-river	2,053,000	893,000	-1,160,000
Upper River	1,002,000	2,740,000	1,738,000

Sediment Basin	3,109,000	1,765,000	-1,344,000
Total	6,755,000	5,736,000	-1,019,000

Table 7-10 Discharge Adjusted Average Annual Volumes Dredged From the Period 1981-1985 to the Period 1997-2004 by Reach.

7.2.3.1.5 Predicted Inner Harbor Shoaling Response to Proposed Changes.

To determine the changes to the amount and distribution of the inner harbor dredging volumes due to potential channel depth increases, the changes due to the 4-foot depth increase in 1994 were used as a predictor. In addition to the shoaling response to past changes, the velocities as predicted by the three-dimensional hydrodynamic model Environmental Fluid Dynamics Code (EFDC) were used to check for potential shifts in shoaling distribution due to potential depth increases. With the small exception of the passing lane extending into an existing shoal, no changes to the shoaling volume or distribution are predicted for the three inner harbor reaches.

The most significant statistic in examining the changes from the period 1981-1985 to 1997-2004 is that the total average annual volume dredged decreased by approximately 1,000,000 cubic yards, Tables 7-8 and 7-9.

A comparison between the inner harbor dredging volume distributions between the periods 1970-1975 and 1997-2004, Figure 7-46, does not indicate any shoaling changes that can be attributed to a depth increase. There were multiple construction related changes between the two time periods. The construction related changes reflected in the distributions are inner harbor depth increase from -38 feet to -42 feet between Stations 0+000 and 103+000, the widening of the channel from 400 feet to 500 feet from station 70+000 to station 100+000, the enlargement of the Kings Island Turning Basin from 900 x 1,000 feet to 1,500 x 1,600 feet and the operation of the Sediment Basin. The Tide Gate and New Cut were not operational during either the 1970-1975 or the 1997-2004 time periods.

Starting at the downstream end, the changes to note between the two distributions are:

1. Around station 5+000 there is an increase in dredging due to Oyster Bed Island Turning basin being incorporated into the Federal Project.

2. There is a small increase around station 35+000. This is an atypical area upstream from the confluence of the inner harbor channel with Elba and Fields Cuts. The sediments in this area have higher components of silt and clay than the sediments at stations upstream and downstream. The localized changes in this area are related to the complex converging flows and are not directly related to channel deepening.

3. There is a large reduction in the volume dredged from station 40+000 to station 66+000. The continued O&M dredging of the Sediment Basin has resulted in a reduced dredging volume in the inner harbor channel, Section **7.2.3.1.4.1**.

4. At the Fig Island Turning Basin there is a spreading out of the volume dredged due to the diminution of two scour areas upstream of the Fig Island Turning Basin. The scour areas are caused by the oscillating channel flow impinging on the side of the channel, which causes a localized increase in velocity. The channel widening caused the flow to spread out and reduce the velocity increase. A small part of the reduction from station 67+000 to 69+000 may be due to the Sediment Basin but the quantity is difficult to determine since the effects of the Sediment Basin ends in this area.

5. The last significant change is at the Kings Island Turning Basin. The increase here is due to the size of the Turning Basin being increased from 900 x 1,000 feet to 1,500 x 1,600 feet, which more than doubled its size.

There are no changes to the total volume dredged or to the shoaling distribution that can be attributed to the 1994 channel deepening and widening.

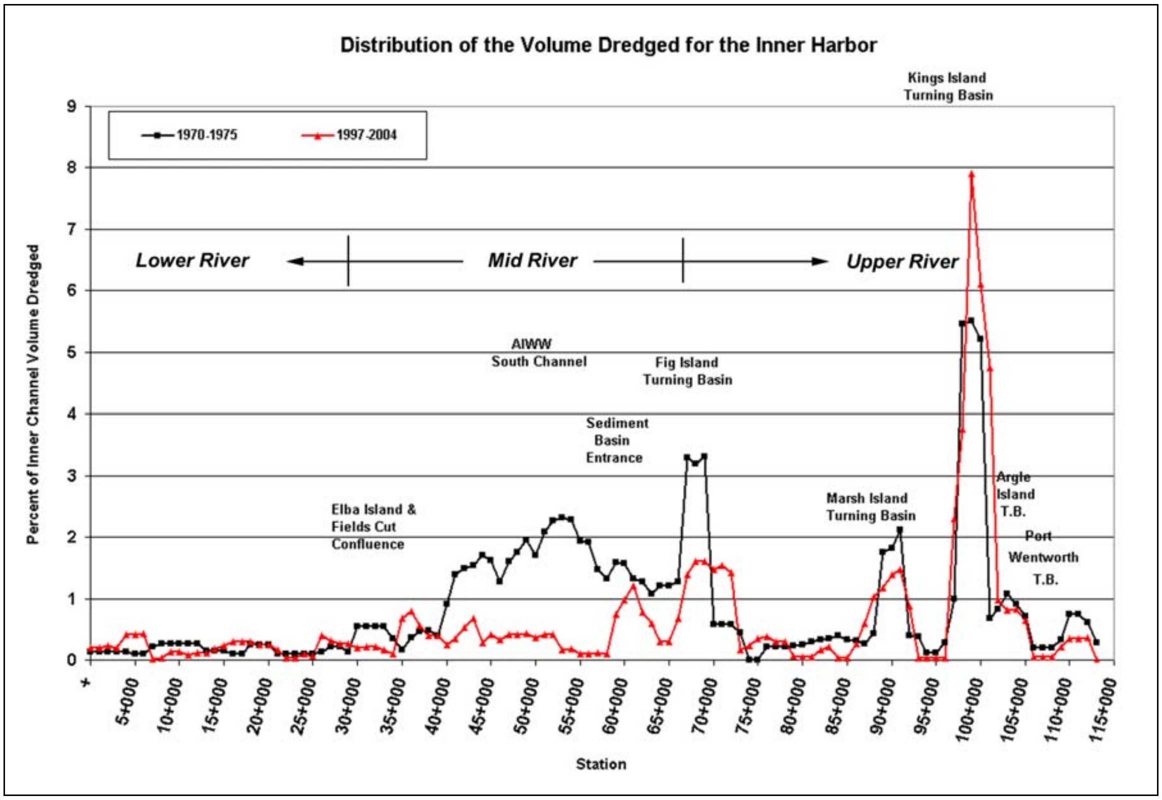

Figure 7-46 Distribution of the Volume Dredged for the Inner Harbor.

To determine if proposed depth increase would change the shoaling pattern in the river, the three-dimensional hydrodynamic model, EFDC, was run for low, average and high flow conditions with existing project depths, a 3-foot depth increase and a 6-foot depth increase. The low flow runs used historic river discharges starting on April 1, 1999 and was run for 214 days. The average flow runs used historic river discharges starting on August 1, 1997 and was run for 91 days. The high flow runs used historic river discharges starting on July 1, 1998. The EFDC cells are plotted in Figure 7-47 and the inner harbor river stations associated with the cells are listed in Table 7-11. The maximum current speeds for the existing project geometry, the plan geometry, and the difference between the maximum current speeds for the existing and plan geometry are plotted in Figures 7-48 through 7-59. There are specific locations where velocity changes occur. The velocity changes due to a 6-foot deepening with average flow conditions best represents the locations where changes occur and is plotted with the percent of volume dredged distributions for the 1970-1975 and 1997-2004 time periods in Figure 7-60. Velocity changes are predicted at locations where there is high shoaling already occurring and no shift in shoaling pattern is predicted with two possible exceptions. The first exception is a small shoal at station 35+000. Based on the predicted ebb velocity changes this shoal may shift toward station 31+000. The second exception is the spreading out of the Marsh Island Turning Basin shoal based on predicted flood velocity changes. If these exceptions did occur they may cause small changes in the shoaling distribution but the response of the volume-dredged distribution to the last deepening in 1994, Figure 7-24, indicates that this changes will not occur and the total volume-dredged would likely not change.

Another indication that there will not be major flow induced changes due to potential channel deepening is that the past depth increases have improved the conveyance of the channel to the point where a full tidal range is presently moving up the channel to the upstream end of the harbor. The mean tidal range at the entrance to Savannah Harbor, Fort Pulaski, is 6.9 feet and the mean tidal range at the upstream end of the harbor is 7.0 feet, Port Wentworth. Additional deepening would not be expected to significantly affect the tidal flow or salinity related shoaling that is associated with the location of no net bottom flow.

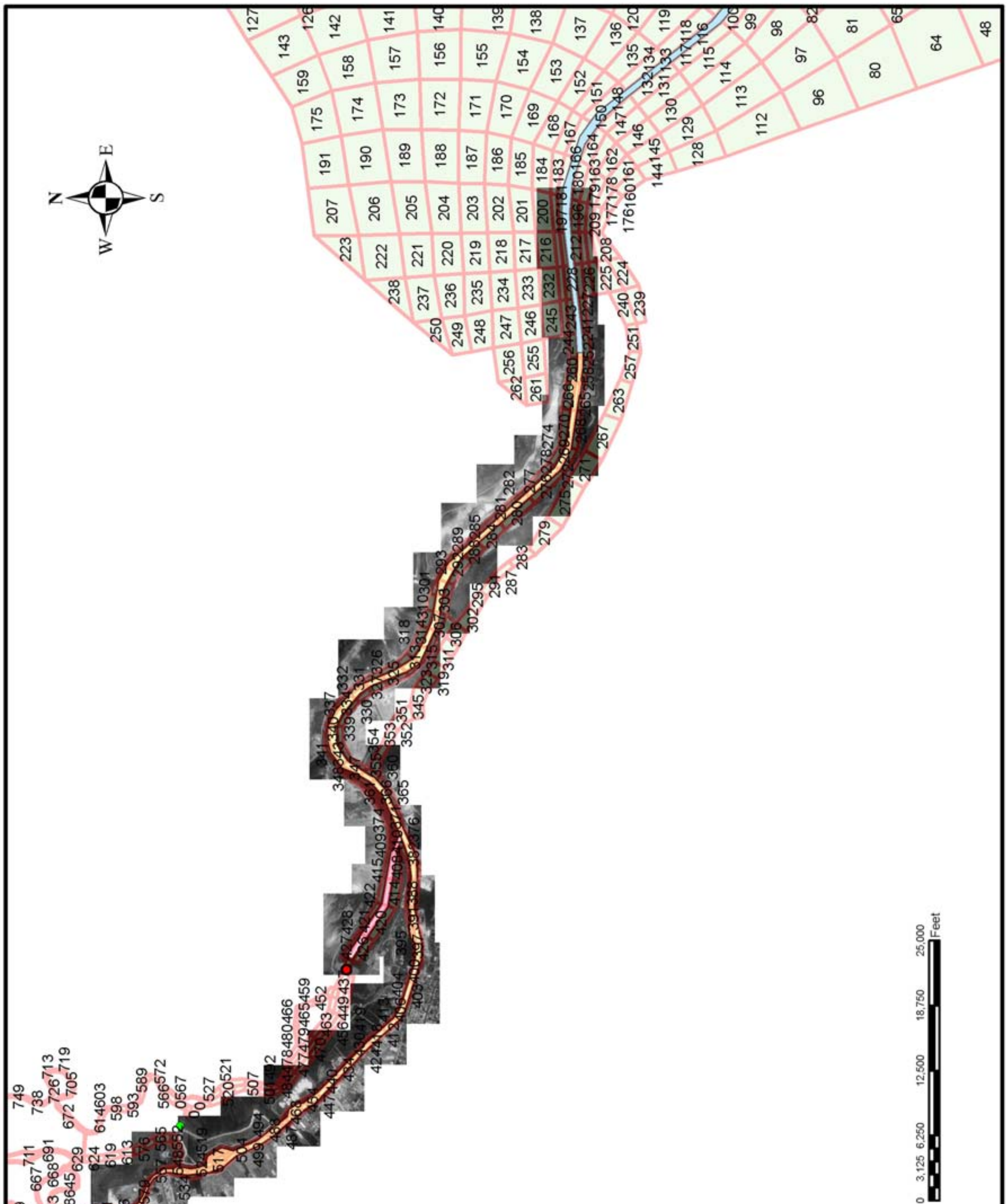

Figure 7-47 EFDC Inner Harbor Cells.

Cell #	Start Station	End Station	Cell #	Start Station	End Station	Cell #	Start Station	End Station
259	0+500	3+000	361	53+000	54+250	488	92+500	94+000
265	3+000	5+500	366	54+250	56+250	494	94+000	95+250
269	5+500	9+000	371	56+250	58+250	499	95+250	96+250
273	9+000	11+500	376	58+250	60+000	504	96+250	97+500
277	11+500	15+500	382	60+000	62+000	509	97+500	98+750
281	15+500	19+000	385	62+000	63+500	516	98+750	100+000
285	19+000	22+000	388	63+500	66+250	523	100+000	101+250
289	22+000	23+750	391	66+250	68+000	530	101+250	102+000
293	23+750	25+750	394	68+000	69+750	535	102+000	102+750
297	25+750	27+000	397	69+750	71+500	540	102+750	103+500
300	27+000	28+500	400	71+500	73+500	545	103+500	104+250
304	28+500	30+000	403	73+500	75+500	557	104+250	105+000
309	30+000	32+000	406	75+500	77+500	563	105+000	105+750
313	32+000	33+750	412	77+500	79+000	569	105+750	106+750
317	33+750	35+000	418	79+000	80+750	574	106+750	107+250
321	35+000	36+750	424	80+750	82+250	579	107+500	108+500
325	36+750	38+750	430	82+250	83+750	583	108+500	109+250
328	38+750	40+500	434	83+750	85+250	587	109+250	110+000
331	40+500	42+250	440	85+250	86+750	591	110+000	110+250
334	42+250	44+000	447	86+750	88+000	595	110+250	110+750
337	44+000	45+750	454	88+000	89+250	600	110+750	111+250
340	45+750	47+750	461	89+250	90+000	605	111+250	112+250
343	47+750	49+750	468	90+000	91+250	610	112+250	113+000
347	49+750	51+750	475	91+250	91+750	616	113+000	114+000
357	51+750	53+000	482	91+750	92+500			

Table 7-11 EFDC Cell Inner Harbor Station Numbers.

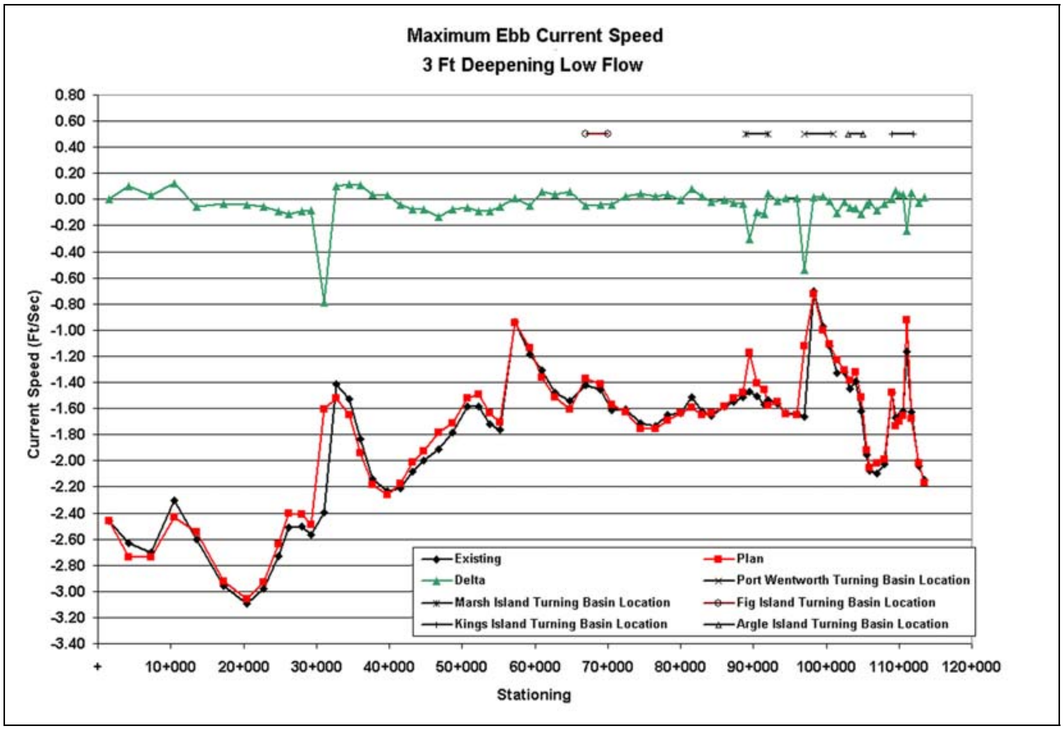

Figure 7-48 Maximum Ebb Current Speeds for a 3-Foot Depth Increase During Low Flow Conditions.

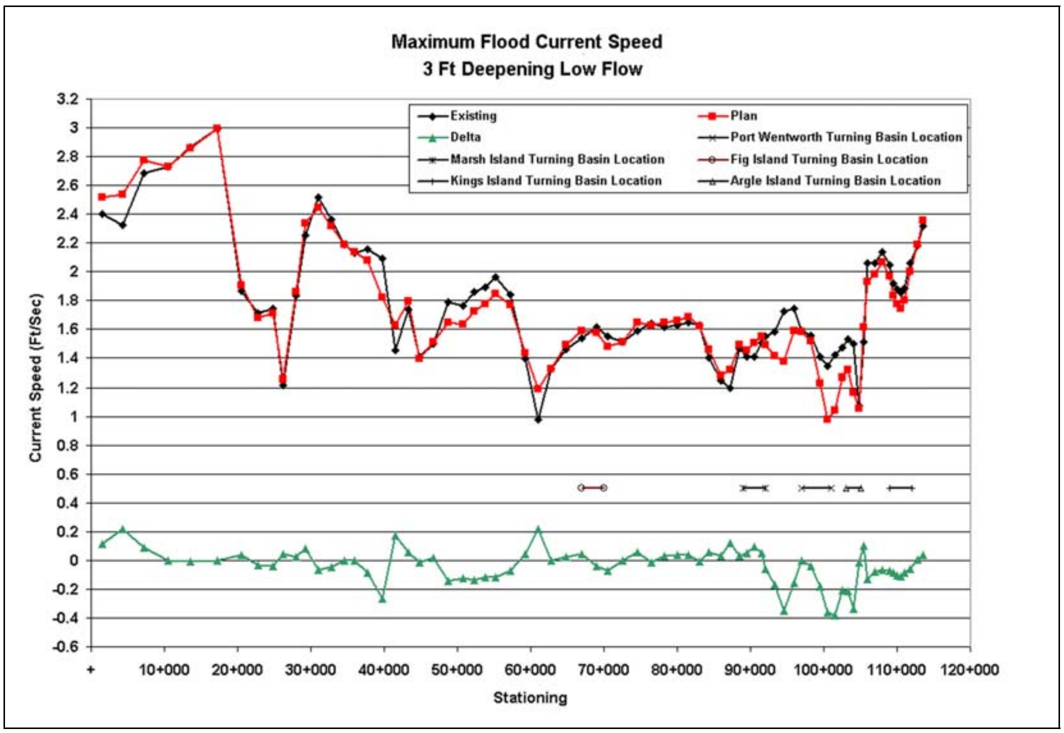

Figure 7-49 Maximum Flood Current Speeds for a 3-Foot Depth Increase During Low Flow Conditions.

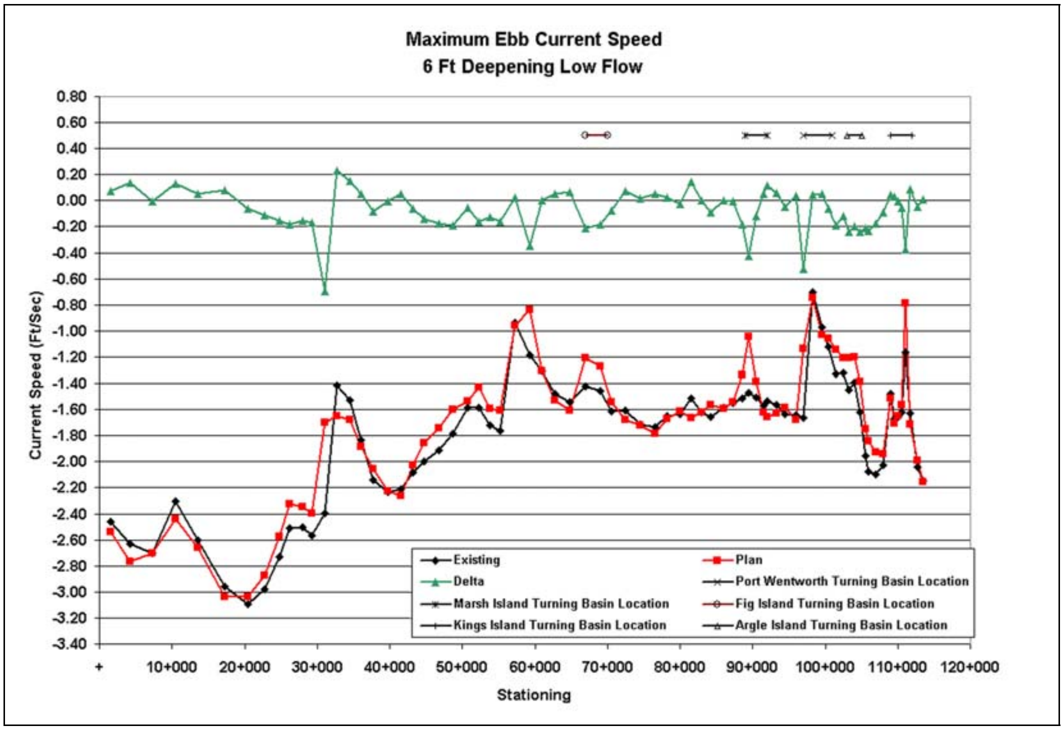

Figure 7-50 Maximum Ebb Current Speeds for a 6-Foot Depth Increase During Low Flow Conditions.

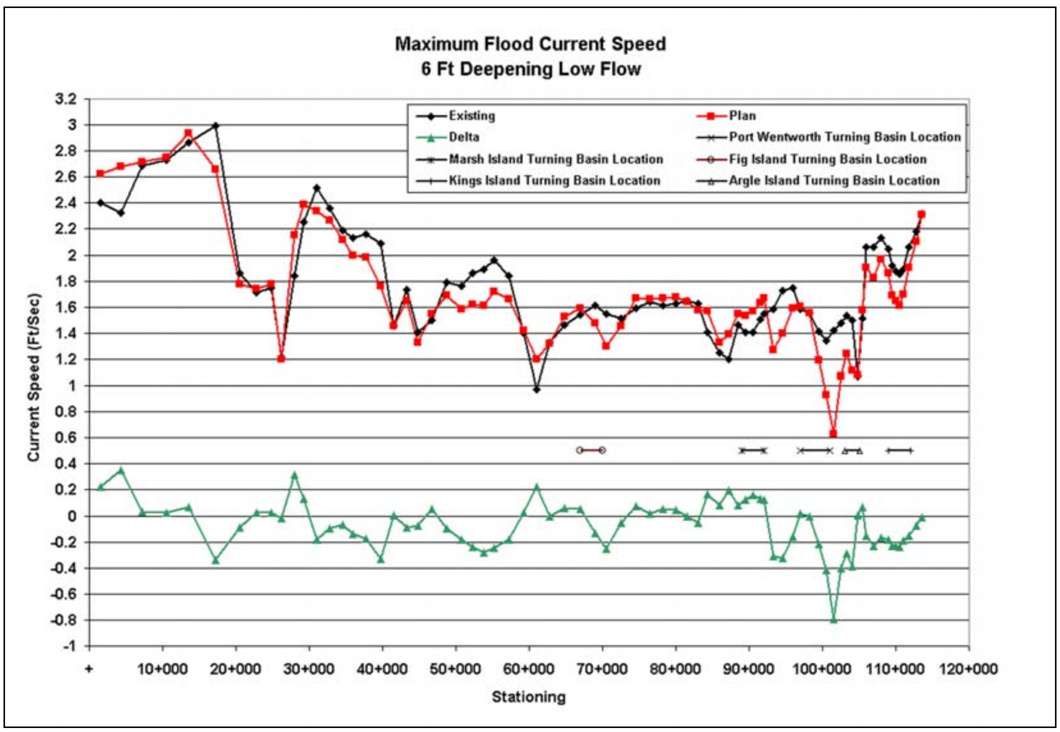

Figure 7-51 Maximum Flood Current Speeds for a 6-Foot Depth Increase During Low Flow Conditions.

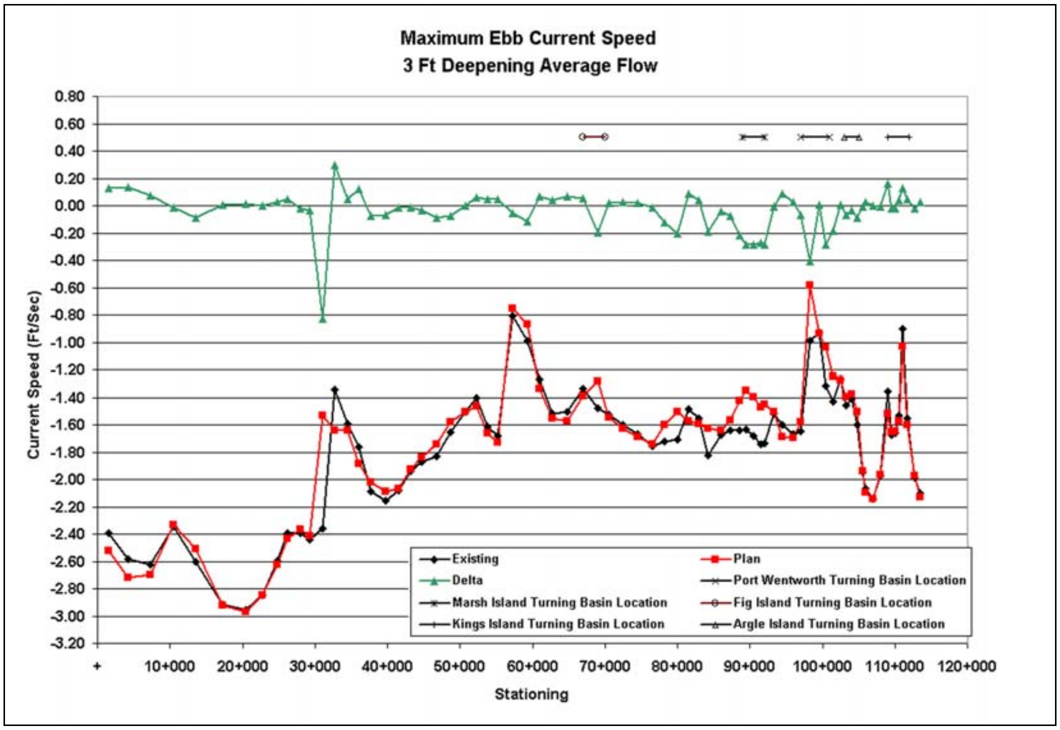

Figure 7-52 Maximum Ebb Current Speeds for a 3-Foot Depth Increase During Average Flow Conditions.

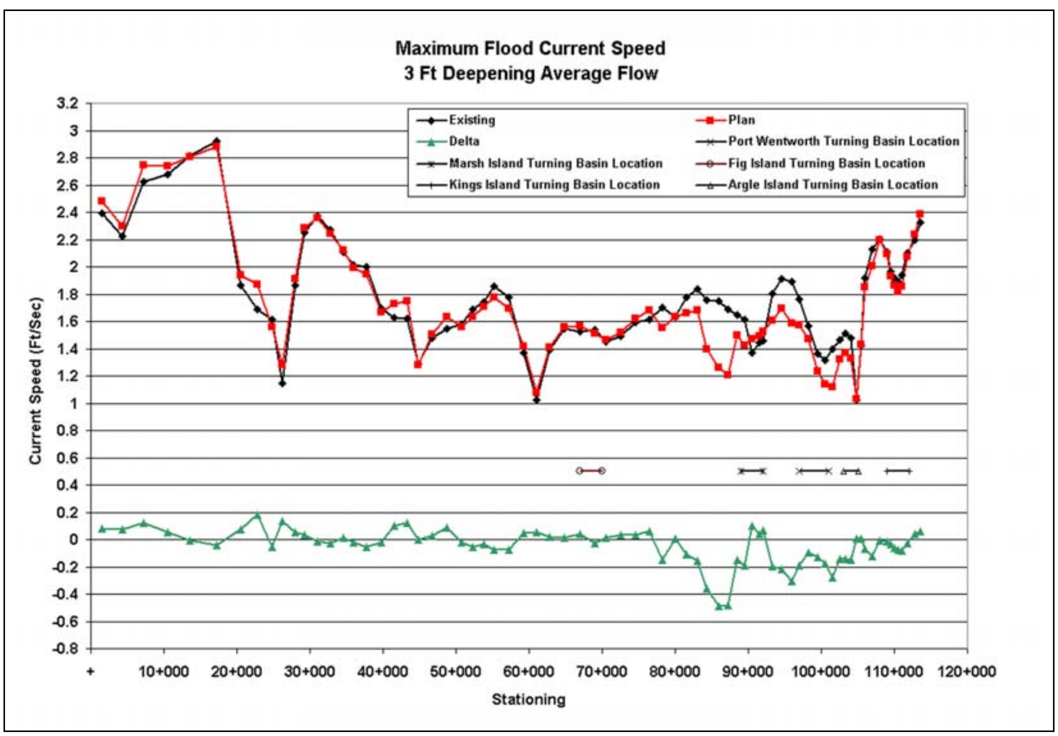

Figure 7-53 Maximum Flood Current Speeds for a 3-Foot Depth Increase During Average Flow Conditions.

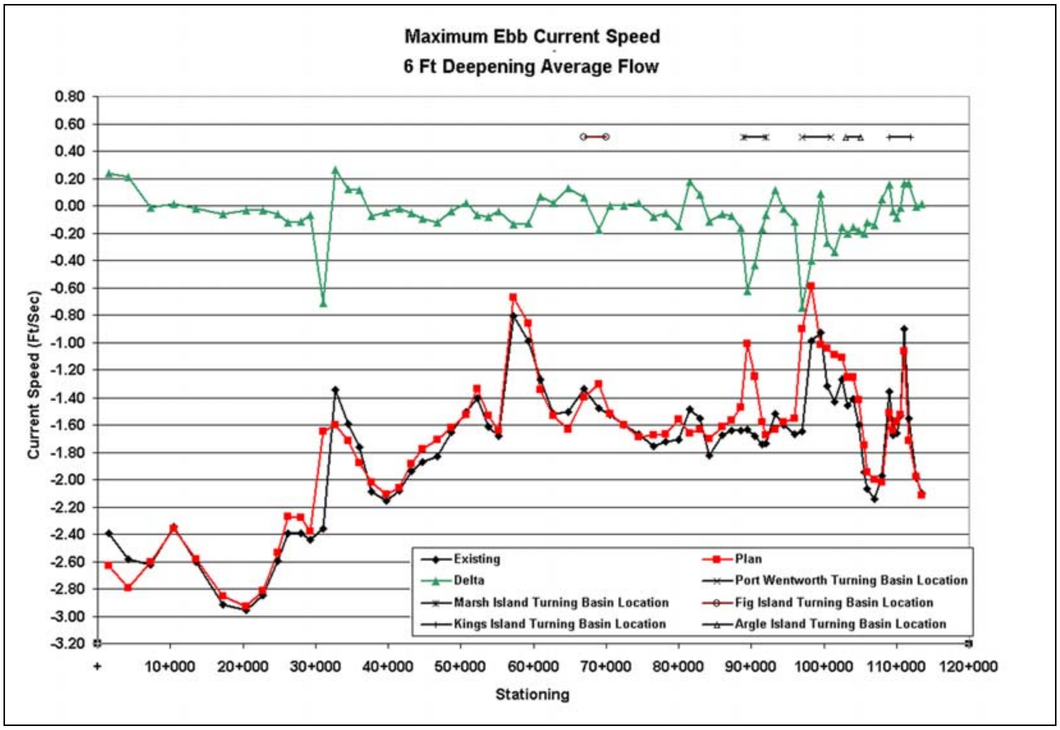

Figure 7-54 Maximum Ebb Current Speeds for a 6-Foot Depth Increase During Average Flow Conditions.

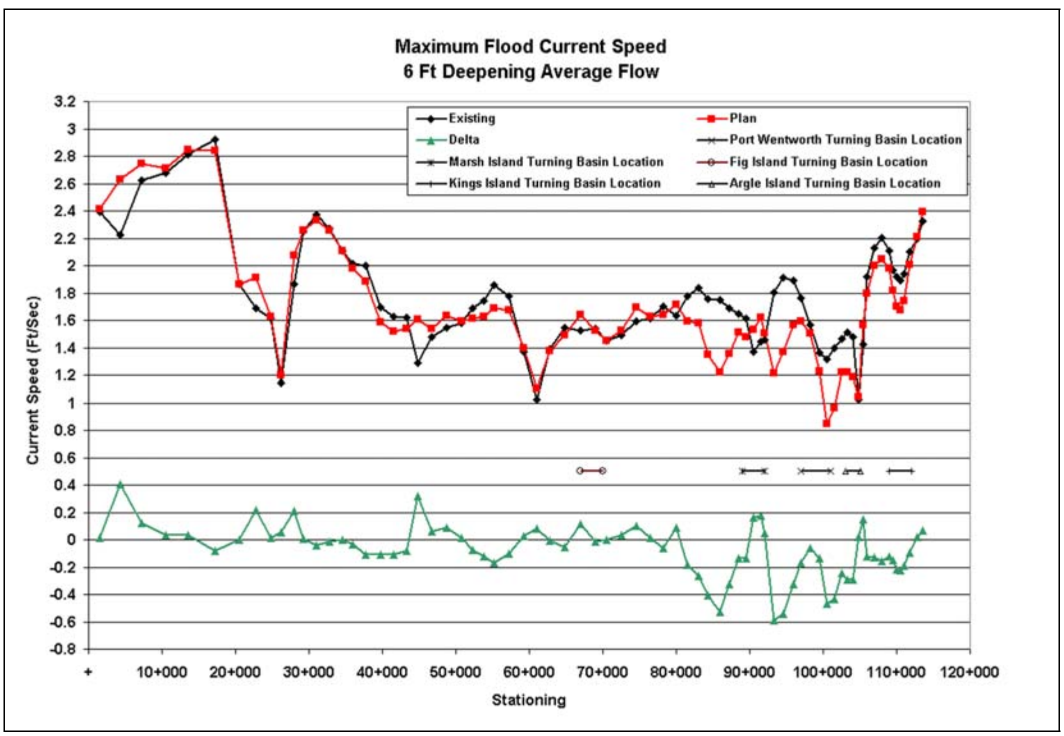

Figure 7-55 Maximum Flood Current Speeds for a 6-Foot Depth Increase During Average Flow Conditions.

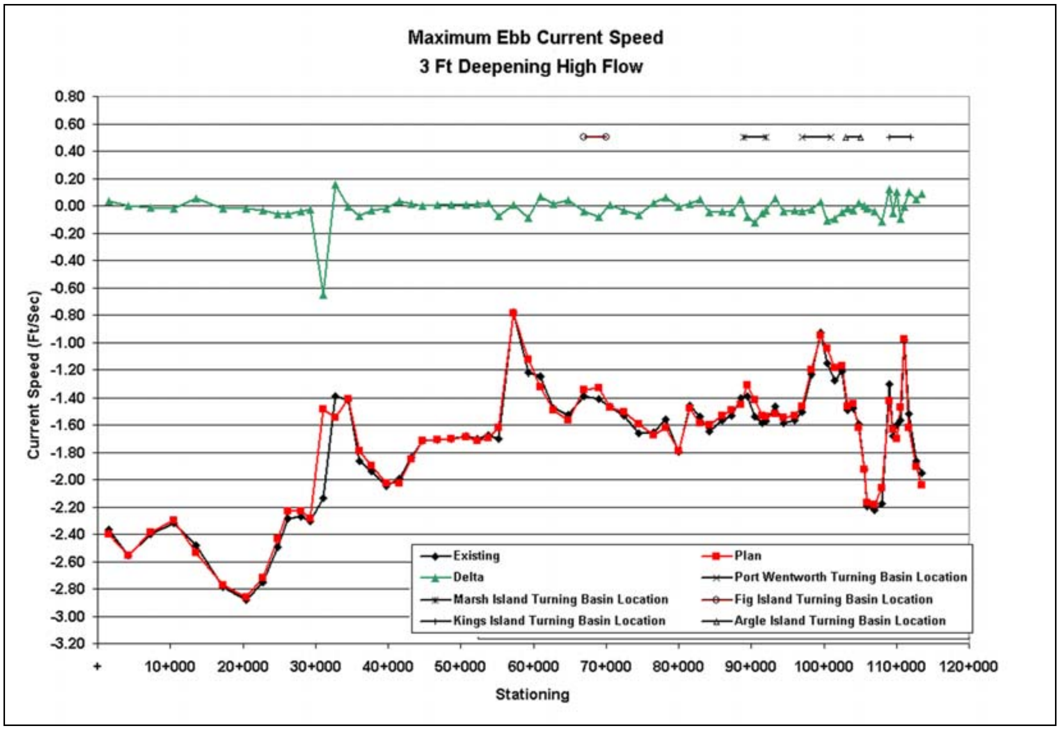

Figure 7-56 Maximum Ebb Current Speeds for a 3-Foot Depth Increase During High Flow Conditions.

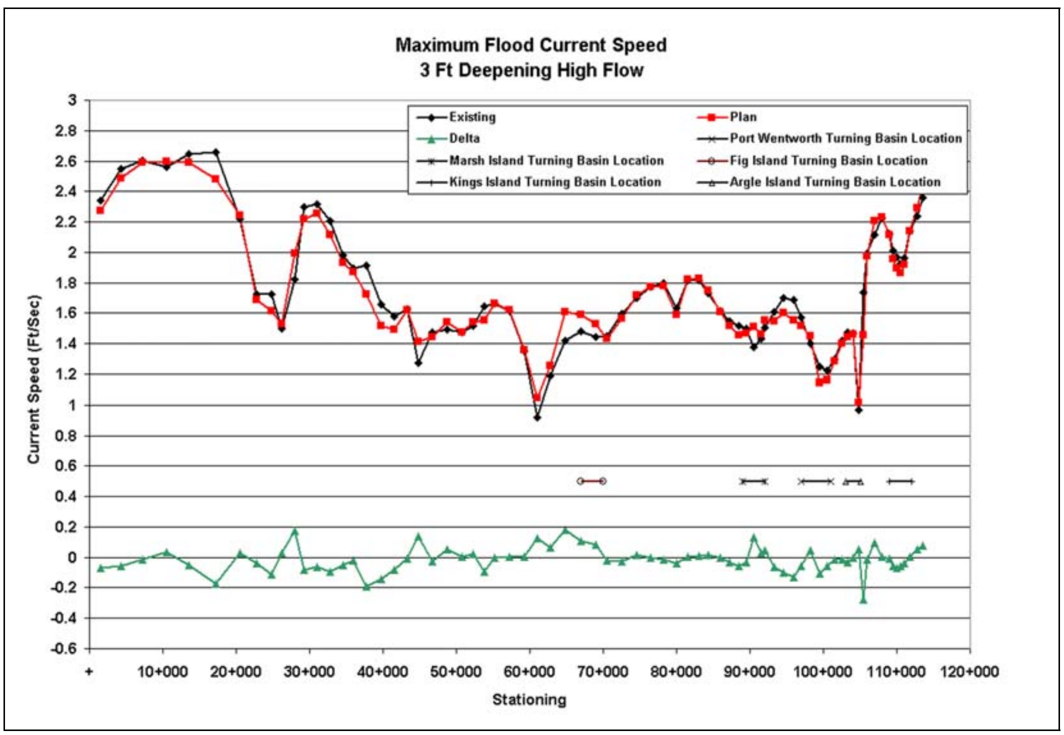

Figure 7-57 Maximum Flood Current Speeds for a 3-Foot Depth Increase During High Flow Conditions.

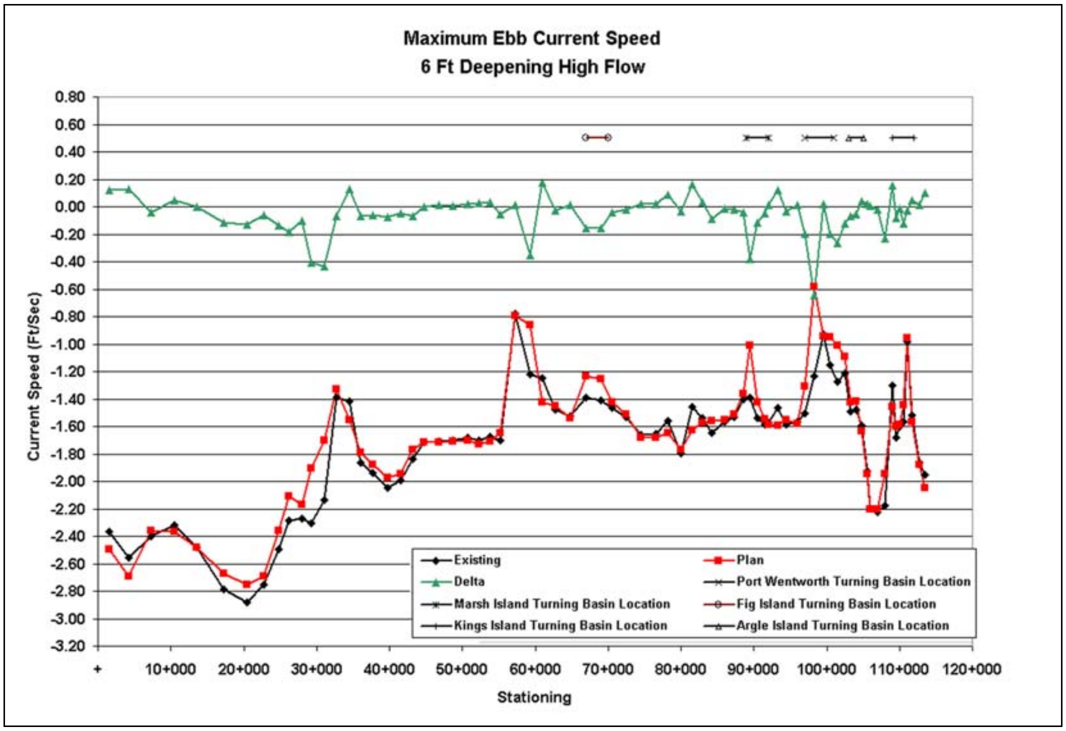

Figure 7-58 Maximum Ebb Current Speeds for a 6-Foot Depth Increase During High Flow Conditions.

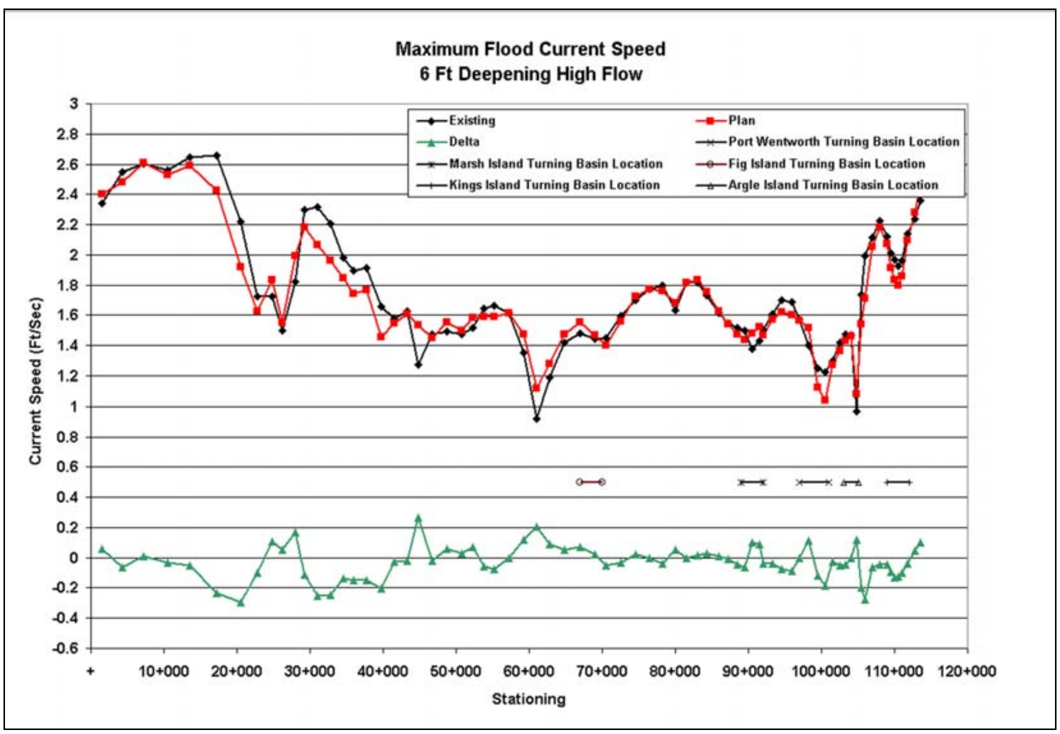

Figure 7-59 Maximum Flood Current Speeds for a 6-Foot Depth Increase During High Flow Conditions.

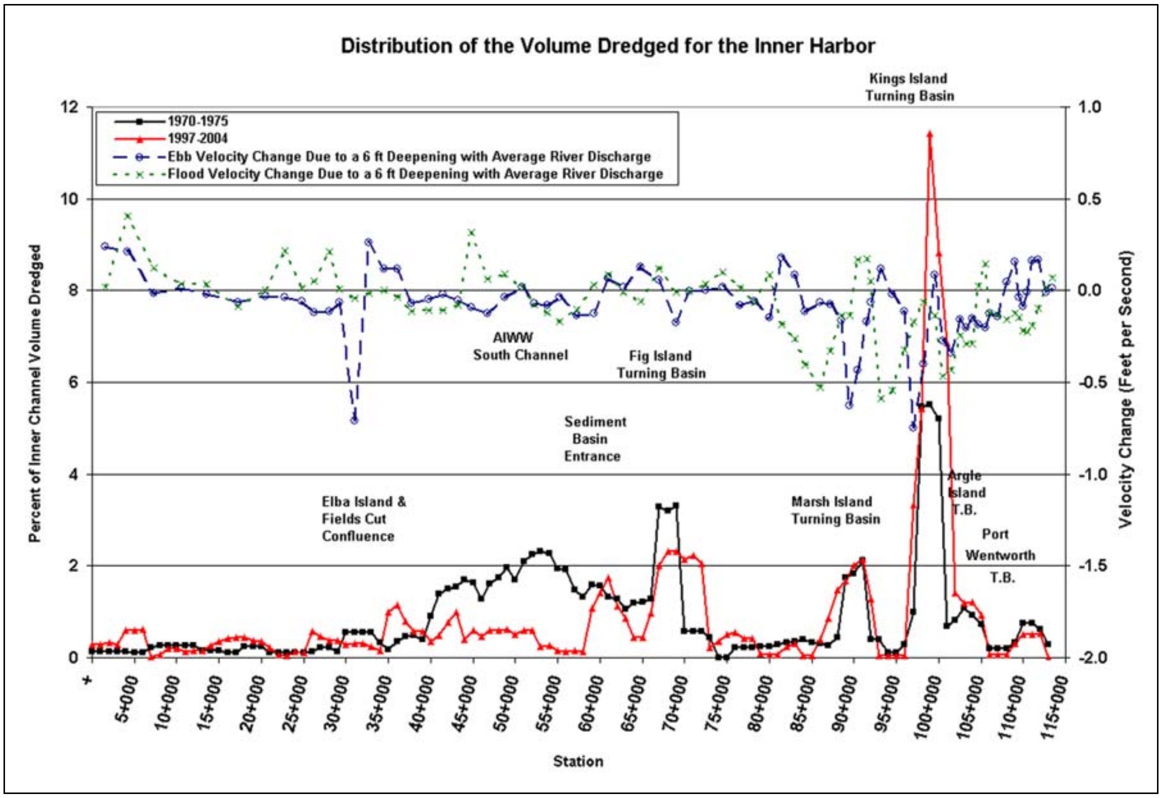

Figure 7-60 Distribution of the Volume Dredged for the Inner Harbor with Plan Velocity Changes.

Since 1) there were no changes to the shoaling volume or distribution attributed to the last channel deepening, 2) essentially all of the shoaling material from upstream sources is being trapped within the system, Section 7.2.3.1.1, and 3) the future depth increases will extend down along the existing channel side slopes which will decrease the bottom width of the channel, no major changes to shoaling volume or distribution is predicted.

The long-term average annual volume dredged from the inner harbor and the Sediment Basin from 1970 to 2004 is 6,194,000 cubic yards, Table 7-13. The average annual volume dredged for the period 1997 to 2004 is 5,054,000, Table 7-9. The ratio of long-term average to the 1997-2004 average is 1.226. This ratio was used to adjust the volume-dredged distribution for the period 1997 to 2004 from Table 7-9 to a long-term average that represents the present shoaling distribution and the result is presented in Table 7-14. To determine the shoaling volume for the various depth increases, the volumes in Table 7-12 should be multiplied by 1.226 and product distributed between stations 59+000 and 60+000 in Table 7-14. The total predicted volume for the inner harbor is 6,194,000 cubic yards plus the adjusted volume increase from Table 7-12.

The average volume dredged in the Sediment Basin during the period 1997-2004 was 1,555,000 cubic yards. The adjusted long-term average for the present shoaling distribution is 1,906,000 cubic yards.

Year	Volume	Year	Volume	Year	Volume
1970	8,922,658	1983	5,012,204	1996	-
1971	9,225,271	1984	8,115,635	1997	6,360,202
1972	7,196,706	1985	4,944,118	1998	4,366,081
1973	6,220,269	1986	4,569,268	1999	6,537,177
1974	11,754,058	1987	5,022,490	2000	8,051,883
1975	6,762,687	1988	2,083,541	2001	3,409,743
1976	9,362,727	1989	3,157,696	2002	1,508,184
1977	11,269,682	1990	3,500,328	2003	6,639,202
1978	5,130,898	1991	8,814,338	2004	3,565,498
1979	12,294,584	1992	3,529,807		
1980	6,100,646	1993	2,528,830	Average	6,194,000
1981	5,864,877	1994	-		
1982	6,397,966	1995	-		

Table 7-12 Inner Harbor and Sediment Basin Dredging Volume by Year.

Station	Long-Term Average Annual Volume Dredged	Station	Long-Term Average Annual Volume Dredged	Station	Long-Term Average Annual Volume Dredged
0	11,866	38000	24,392	76000	23,825
1000	11,866	39000	24,867	77000	18,418
2000	13,946	40000	15,157	78000	18,418
3000	12,266	41000	21,054	79000	3,746
4000	25,921	42000	32,835	80000	2,959
5000	25,921	43000	42,262	81000	2,959
6000	26,184	44000	17,155	82000	9,995
7000	1,026	45000	25,345	83000	13,606
8000	2,445	46000	20,211	84000	1,586

9000	8,337	47000	25,524	85000	1,586
10000	8,160	48000	25,158	86000	16,780
11000	5,337	49000	26,665	87000	36,899
12000	6,781	50000	22,060	88000	63,586
13000	6,888	51000	25,242	89000	72,272
14000	11,533	52000	25,242	90000	86,497
15000	14,790	53000	10,667	91000	91,420
16000	18,308	54000	11,369	92000	54,434
17000	18,756	55000	6,245	93000	2,050
18000	18,764	56000	5,751	94000	2,050
19000	15,669	57000	6,683	95000	2,050
20000	15,186	58000	6,011	96000	1,693
21000	9,740	59000	46,565	97000	142,429
22000	2,516	60000	60,347	98000	232,556
23000	1,858	61000	74,865	99000	489,662
24000	6,023	62000	47,994	100000	378,601
25000	4,572	63000	37,084	101000	293,983
26000	24,413	64000	18,925	102000	60,257
27000	19,840	65000	18,679	103000	50,618
28000	16,054	66000	42,012	104000	51,599
29000	16,521	67000	85,725	105000	40,057
30000	12,758	68000	99,524	106000	2,684
31000	13,158	69000	99,524	107000	2,684
32000	13,158	70000	91,460	108000	2,684
33000	10,511	71000	95,409	109000	13,305
34000	6,595	72000	87,680	110000	21,336
35000	42,128	73000	9,810	111000	21,336
36000	49,315	74000	14,794	112000	22,334
37000	34,386	75000	21,570	113000	0

Table 7-13 Long-Term Average Annual Volume Dredged.

7.2.3.1.6 Sediment Basin Efficiency.

The Sediment Basin is maintained to a depth of 40 feet. It was not deepened to 42 feet when the inner harbor channel was deepened in 1994 and is therefore at a higher elevation than the navigation channel. Two questions concerning the depth of the Sediment Basin have been raised. First, does the depth difference between the navigation channel and ,second, the Sediment Basin reduce its efficiency and second, at what depth should the Sediment Basin be maintained to?

To determine if the increase in channel depth decreased the shoaling capacity of the Sediment Basin, the response of the shoaling in the Sediment Basin to the channel depth increase and cessation of the Tide Gate operation was analyzed. During the period 1981-1985, an average annual volume of 2,792,000 cubic was dredged in the Sediment Basin. The average depth in the Sediment Basin in 1990 before dredging was 24.0 feet. During the 1997-2004 period, the average annual volume dredged in the Sediment Basin was 1,555,000 cubic yards and the average depth before dredging was 32.5 feet. Figures 7-63 to 7-65 contain surface plots of the Sediment Basin depths for the before dredging conditions in 1990, 2003 and the difference between the 1990 and 2003 before dredging surfaces. Figure 7-66a contains cross section plots at station 10+000 in the Sediment Basin for the before dredging conditions in 1990 and 2003. During both periods, the depth to which the Sediment Basin shoals is at least 10 feet above the channel depth. The shoaling in the Sediment Basin to an elevation 10 feet above the channel depth indicates that the sediment shoaling in the basin is suspended sediment and the depth difference between the channel and the basin is not the controlling factor for Sediment Basin shoaling. The change in shoaling conditions between the periods 1981-1985 to 1997-2004 was due to an increase in ebb flow velocities which controls the depth to which the basin shoals. Based on current measurements with and without the Tide Gate operating it was reported in Reference 2.4 that the maximum ebb tide velocities in the Sediment Basin are reduced from about 3 feet per second to less than 1 foot per second when the tide gates are operating. The depth to which the Sediment Basin shoals is not controlled by the depth difference between the basin and the inner harbor channel but by the ebb flow velocities in the basin.

To calculate the present efficiency of the Sediment Basin without the Tide Gate operating, the volume dredged distributions in Figure 7-46 were used to calculate the percent change in the volume dredged from stations 40+000 to 66+000, -73%, and this change is attributed to the operation of the Sediment Basin, Section **7.2.3.1.4.1**. The volume dredged between stations 40+000 to 66+000 during the period 1997 to 2004, 572,800 cubic yards, should be 27% of the volume that would have shoaled between stations 40+000 and 66+000 without the Sediment Basin or the SLNG turning basin, 2,121,500 cubic yards. The 73% reduction of the 2,121,500 cubic yards that would have shoaled between stations 40+000 and 66+000 is 1,548,700 cubic yards, which is 76% of the volume dredged in the Sediment Basin, 1,555,400 cubic yards, and the SLNG turning basin, 487,1000 cubic yards. The 76% is the percentage of sediment that shoals in the Sediment Basin and SLNG turning basin that would have shoaled in the navigation channel. The physical modeling tests for the Sediment Basin design predicted a reduction in channel shoaling of 86%, Figure 7-13. The 86% reduction in channel shoaling was based on ability of the Sediment Basin to filter a model shoaling material over a 119 tidal cycles. The reduction predicted by the model is used as the maximum reduction since it is based on the long term filtering capacity of the Sediment Basin and it is a very high efficiency. It would be unreasonable to assume that the Sediment Basin could eliminate all of the shoaling between stations 40+000 to 66+000. To calculate how much would have to be removed from the Sediment Basin to achieve a 86% reduction in channel shoaling, the 86% was applied to the 2,121,500 cubic yards that would shoal between stations 40+000 to 66+000 to get 1,824,500 cubic yards. The shoaling between stations 40+000 to 66+000 would have to be reduced by an additional 269,100 cubic yards. Because the Sediment Basin traps channel sediment at a 76% efficiency the capacity the Sediment Basin needs to increase in volume by 354,000 cubic yards. Using the ratio 1.23, developed in the preceding section, to adjust this increase to the present long-term average gives a volume of 425,400 cubic yards. The Sediment Basin volume increases versus 1-foot depth increases are contained in Table 7-15. Using the 425,400 cubic yard volume and Table 7-15, the Sediment Basin would need to be deepened by 2.0 feet to achieve maximum efficiency.

Increasing the depth of the Sediment Basin by 1-foot would trap an additional 244,444 cubic yards and prevent 185,800 cubic yards from settling in the navigation channel. Increasing the depth of the Sediment Basin by 2 feet would trap slightly more than the additional 425,400 cubic yards required to achieve 354,000 cubic yards reduction of shoaling in the navigation channel. Based on the results of the physical model test, additional depth increases beyond 2 feet would not trap additional sediment from that which would have settled in the navigation channel.

Sediment Basin Depth Increase (Feet)	Sediment Basin Volume Increase (Cubic Yards)
1	244,444
2	488,889
3	733,333
4	977,778
5	1,222,222

Table 7-14 Sediment Basin Depth Increase Versus Volume Increase.

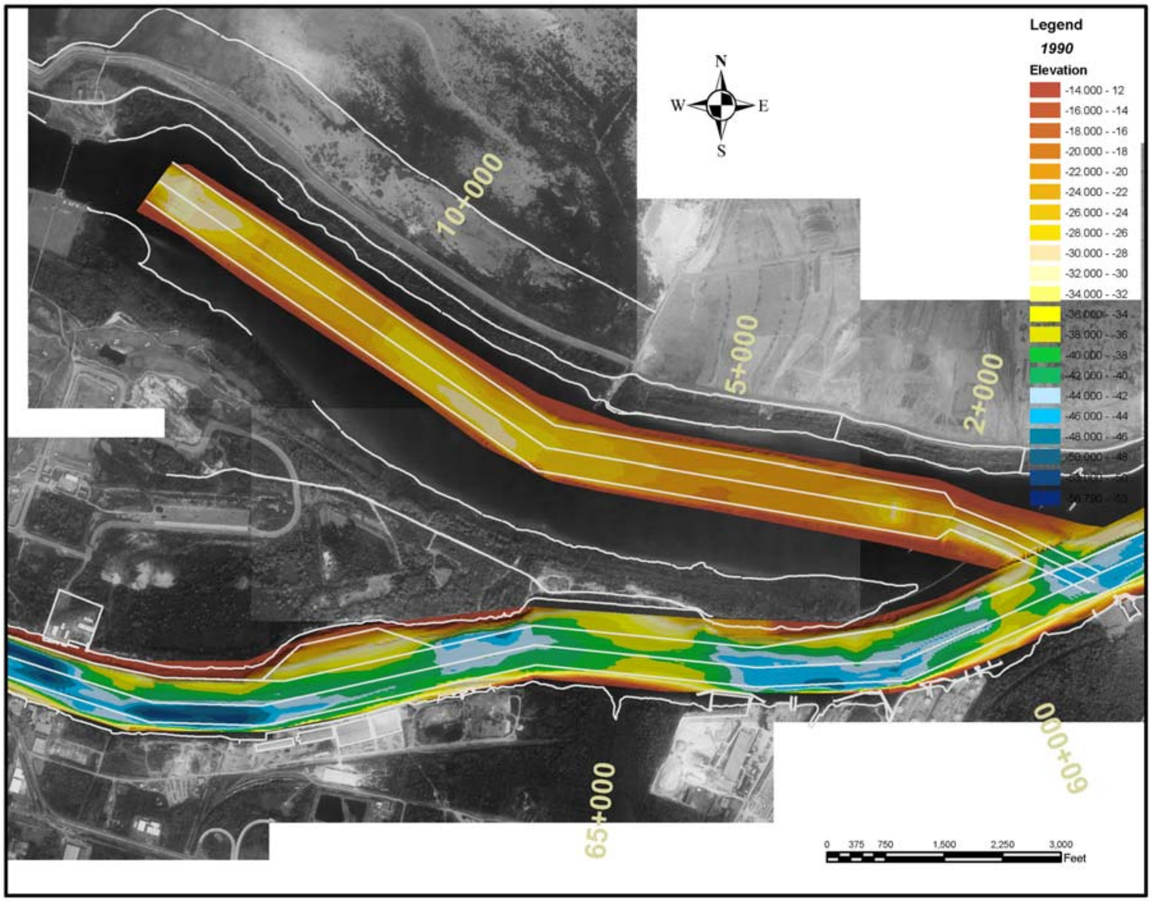

Figure 7-61 Sediment Basin 1990 Before Dredging Surface.

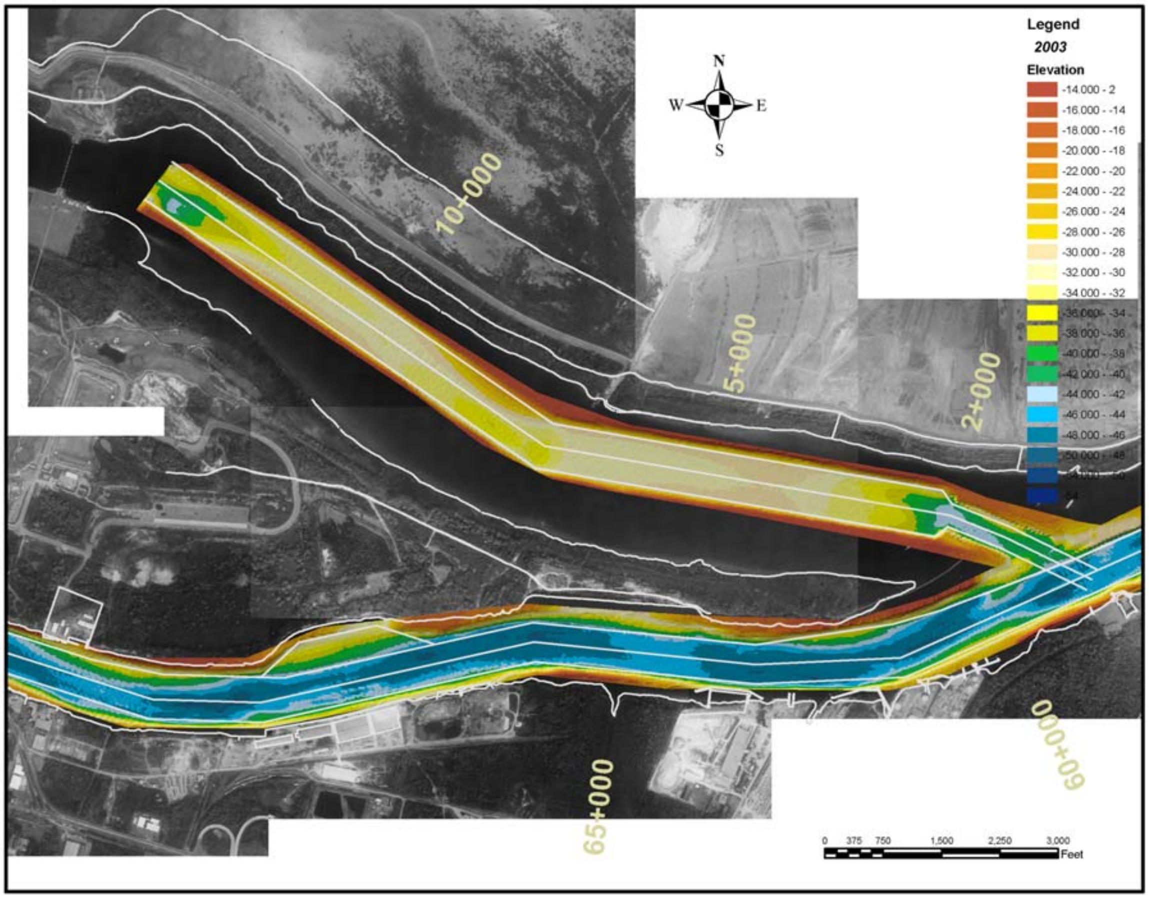

Figure 7-62 Sediment Basin 2003 Before Dredging Surface.

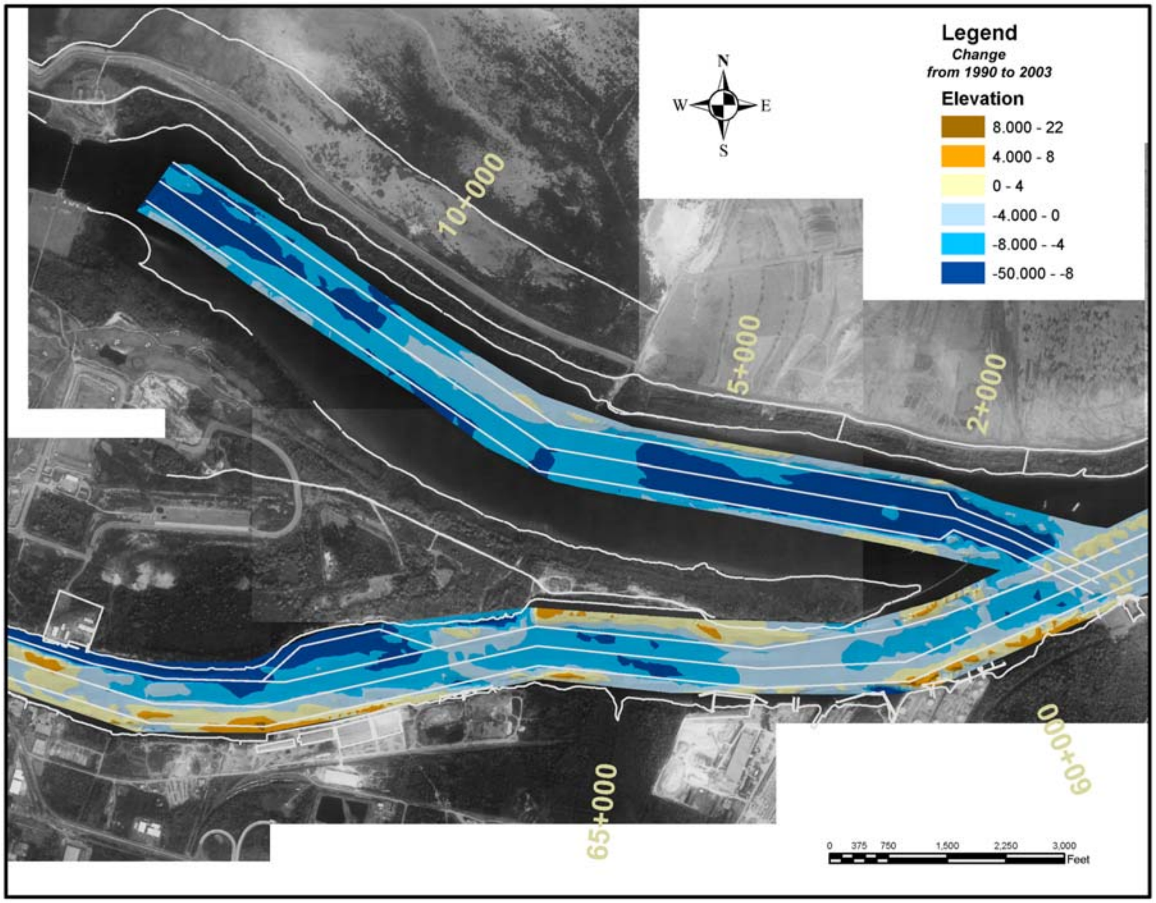

Figure 7-63 Sediment Basin Change from 1990 Before Dredging to 2003 Before Dredging Surface.

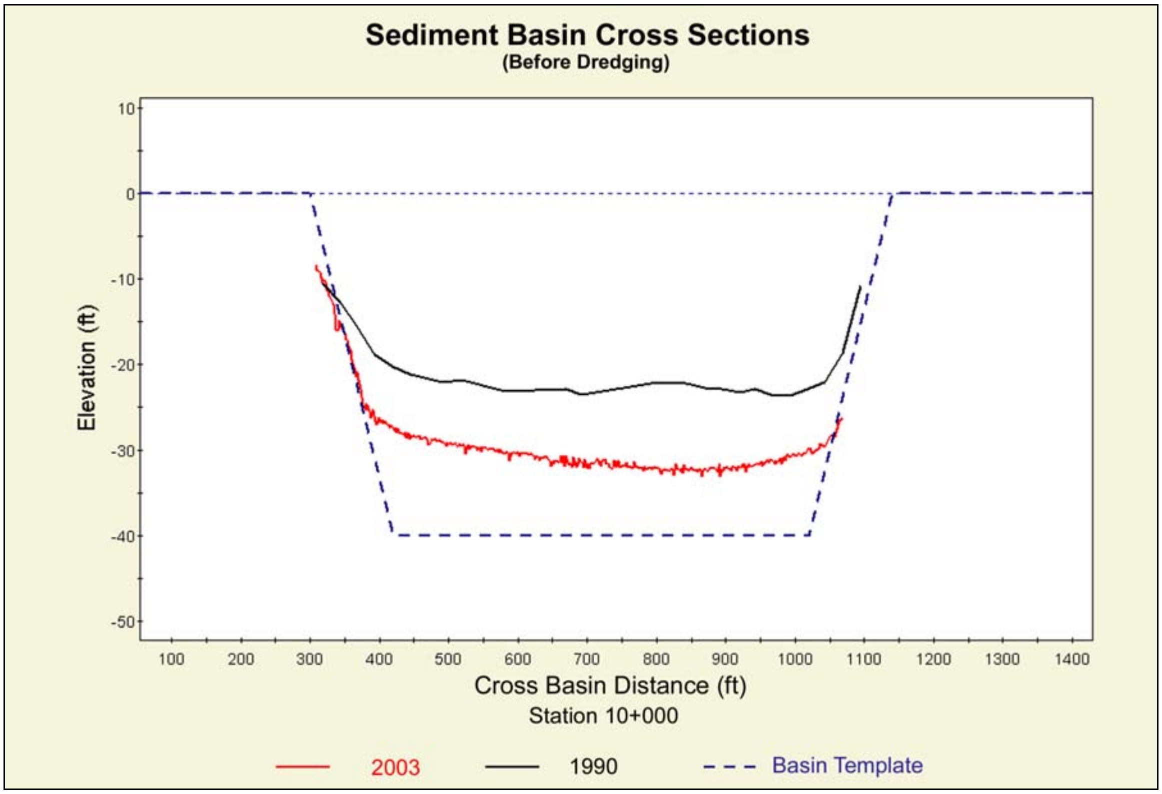

Figure 7-64a Sediment Basin Before Dredging Cross Sections.

7.2.3.1.7 Discontinued Use of the Sediment Basin

A mitigation feature under consideration is to discontinue dredging the sediment basin which will reduce the amount of salinity moving up back river. If the use of the sediment basin is discontinued, the sediment that is annually trapped in the sediment basin will begin to settle in the river channel in a pattern similar to that which occurred before the construction of the sediment basin. The river channel shoaling distributions, before and after construction of the sediment basin, are plotted in Figure 7-66b. After construction of the sediment basin, the river channel shoaling volume between stations 40+000 and 70+000 was reduced by 2,050,000 cubic yards. The 1,906,000 cubic yards that shoaled in the sediment basin, which is adjacent to the reach of river between stations 40+000 to 70+000, was responsible for the majority of the shoaling reduction in the river channel. The remainder of shoaling reduction, between stations 40+000 and 70+000, is account for in the enlarged turning basins upstream. If the sediment basin is not maintained, the sediment that would have settled in the sediment basin will now be deposited in the river channel between stations 40+000 and 70+000. The distribution would be similar to the without sediment basin distribution in Figure 7-66b. A tabular form of the predicted without and with sediment basin distributions are contained in Table 15a.

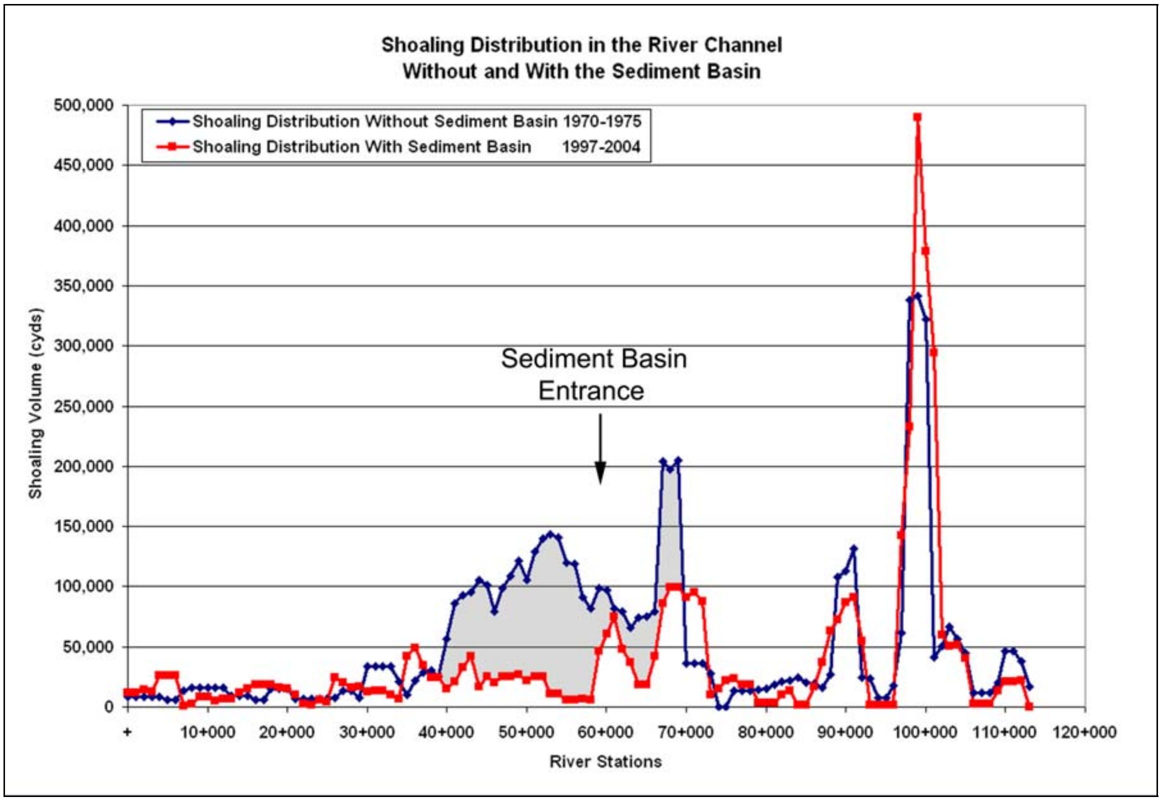

Figure 7-64b Shoaling Distribution Without and With the Sediment Basin.

Station	Long Term Shoaling Average CYDS Existing Conditions	Long Term Shoaling Average CYDS Without Sediment Basin	Station	Long Term Shoaling Average CYDS Existing Conditions	Long Term Shoaling Average CYDS Without Sediment Basin	Station	Long Term Shoaling Average CYDS Existing Conditions	Long Term Shoaling Average CYDS Without Sediment Basin
0	11,866	11,866	38+000	24,392	24,392	76+000	23,825	23,825
1+000	11,866	11,866	39+000	24,867	24,867	77+000	18,418	18,418
2+000	13,946	13,946	40+000	15,157	50,776	78+000	18,418	18,418
3+000	12,266	12,266	41+000	21,054	78,654	79+000	3,746	3,746
4+000	25,921	25,921	42+000	32,835	79,121	80+000	2,959	2,959
5+000	25,921	25,921	43+000	42,262	77,469	81+000	2,959	2,959
6+000	26,184	26,184	44+000	17,155	100,139	82+000	9,995	9,995
7+000	1,026	1,026	45+000	25,345	91,506	83+000	13,606	13,606
8+000	2,445	2,445	46+000	20,211	71,338	84+000	1,586	1,586
9+000	8,337	8,337	47+000	25,524	89,525	85+000	1,586	1,586
10+000	8,160	8,160	48+000	25,158	99,451	86+000	16,780	16,780
11+000	5,337	5,337	49+000	26,665	111,788	87+000	36,899	36,899
12+000	6,781	6,781	50+000	22,060	97,610	88+000	63,586	63,586
13+000	6,888	6,888	51+000	25,242	120,877	89+000	72,272	72,272
14+000	11,533	11,533	52+000	25,242	131,767	90+000	86,497	86,497
15+000	14,790	14,790	53+000	10,667	142,640	91+000	91,420	91,420

16+000	18,308	18,308	54+000	11,369	139,781	92+000	54,434	54,434
17+000	18,756	18,756	55+000	6,245	119,986	93+000	2,050	2,050
18+000	18,764	18,764	56+000	5,751	119,605	94+000	2,050	2,050
19+000	15,669	15,669	57+000	6,683	90,569	95+000	2,050	2,050
20+000	15,186	15,186	58+000	6,011	81,041	96+000	1,693	1,693
21+000	9,740	9,740	59+000	46,565	79,048	97+000	142,429	142,429
22+000	2,516	2,516	60+000	60,347	70,804	98+000	232,556	232,556
23+000	1,858	1,858	61+000	74,865	74,865	99+000	489,662	489,662
24+000	6,023	6,023	62+000	47,994	57,927	100+000	378,601	378,601
25+000	4,572	4,572	63+000	37,084	49,992	101+000	293,983	293,983
26+000	24,413	24,413	64+000	18,925	67,354	102+000	60,257	60,257
27+000	19,840	19,840	65+000	18,679	68,045	103+000	50,618	50,618
28+000	16,054	16,054	66+000	42,012	60,960	104+000	51,599	51,599
29+000	16,521	16,521	67+000	85,725	168,061	105+000	40,057	40,057
30+000	12,758	12,758	68+000	99,524	154,911	106+000	2,684	2,684
31+000	13,158	13,158	69+000	99,524	162,270	107+000	2,684	2,684
32+000	13,158	13,158	70+000	91,460	91,460	108+000	2,684	2,684
33+000	10,511	10,511	71+000	95,409	95,409	109+000	13,305	13,305
34+000	6,595	6,595	72+000	87,680	87,680	110+000	21,336	21,336
35+000	42,128	42,128	73+000	9,810	9,810	111+000	21,336	21,336
36+000	49,315	49,315	74+000	14,794	14,794	112+000	22,334	22,334
37+000	34,386	34,386	75+000	21,570	21,570			

Table 7-14a Tabular Shoaling Distribution Without and With the Sediment Basin.

7.2.3.1.7.1 The Effect of Mitigation Plan 6a on the Shoaling Distribution.

The features of mitigation plan 6a are described in Figure 7-66c. To predict if

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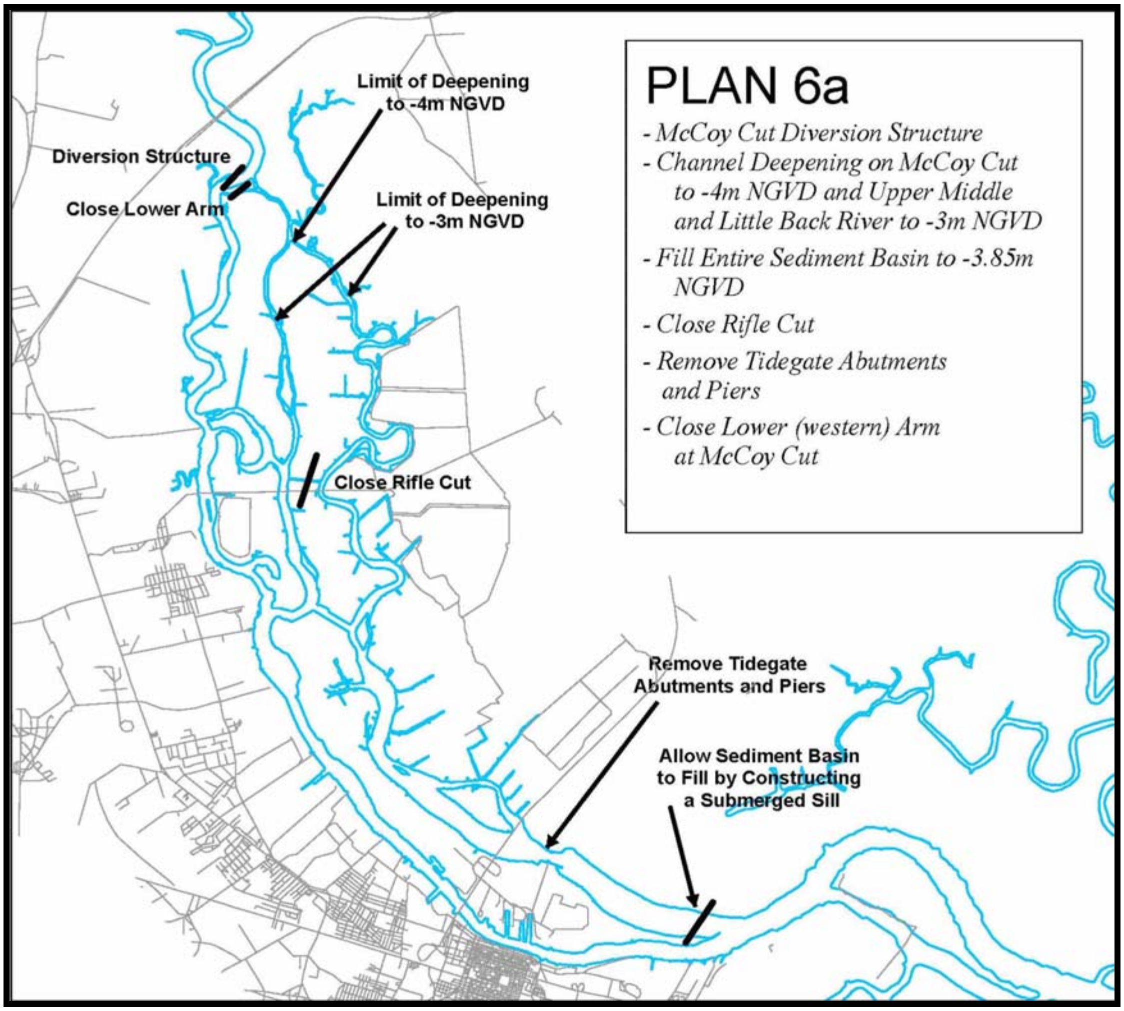

Figure 7-64c Mitigation Plan 6a.

there will be a shift of the shoaling distribution due to the implementation of plan 6a, the numerically modeled shift of the salinity distribution associated with the implementation of the mitigation plan 6a was compared to the measured shift of the salinity distribution and the corresponding shoaling shift in a physical model of a deepened Savannah River. The use of a shift in the salinity distribution as an indicator of a shift in the shoaling distribution is valid since not only is the shoaling process sensitive to salinity concentrations but the hydrodynamics that affect the shoaling distribution also affect the salinity concentration. (See Section 7.2.3.1.2)

A physical model of the Savannah River was constructed at the U. S. Army Engineer Waterways Experiment Station in 1955 to investigate the effects of increasing the navigation channel dimensions (Reference 2.5). Figure 7-66d contains the plan for Test 1 from Reference 2.5. Test 1 is a 2 foot deepening of the navigation channel. The shift in the salinity distribution for normal flow conditions is displayed in Figure 7-66e. The average of the shift at high and low slack water for location of 10,000 part per million (10 parts per thousand) is approximately 10,000 feet. For this shift in salinity distribution, the shoaling distribution did not change significantly, as shown in Figure 7-66f.

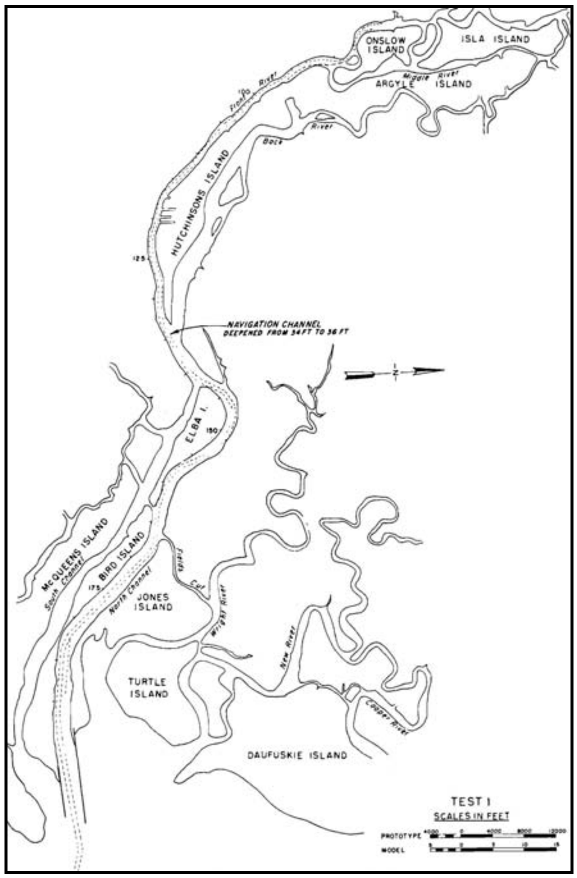

Figure 7-64d Test 1 Plan. Deepen Base Condition Channel by 2 feet.

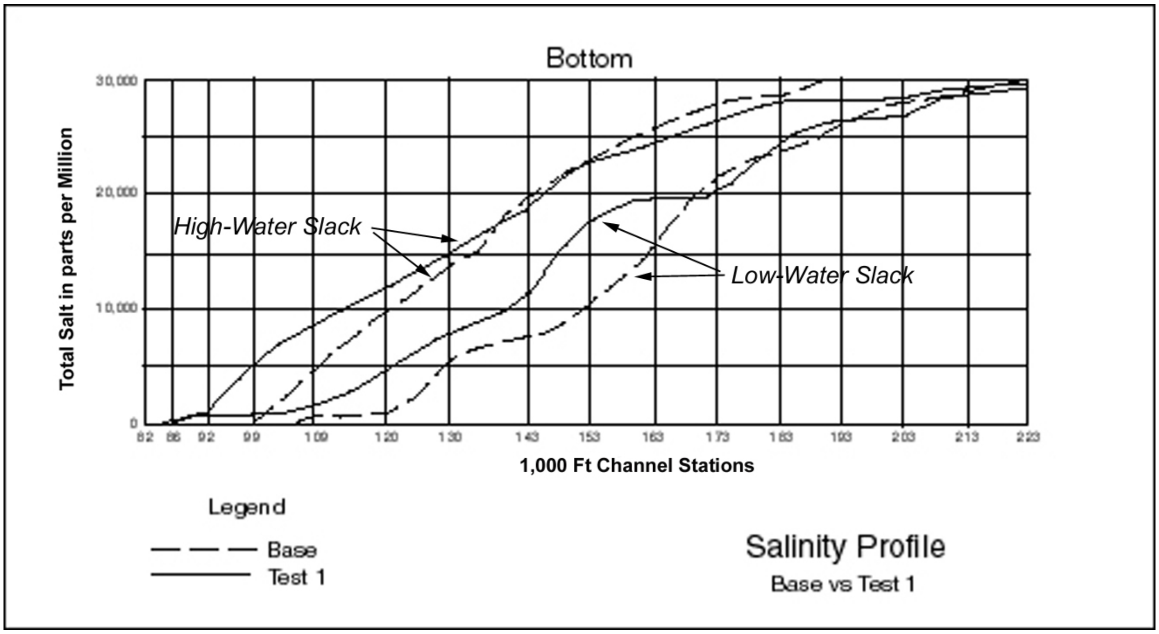

Figure 7-64e Test 1 Shift in Salinity Profile.

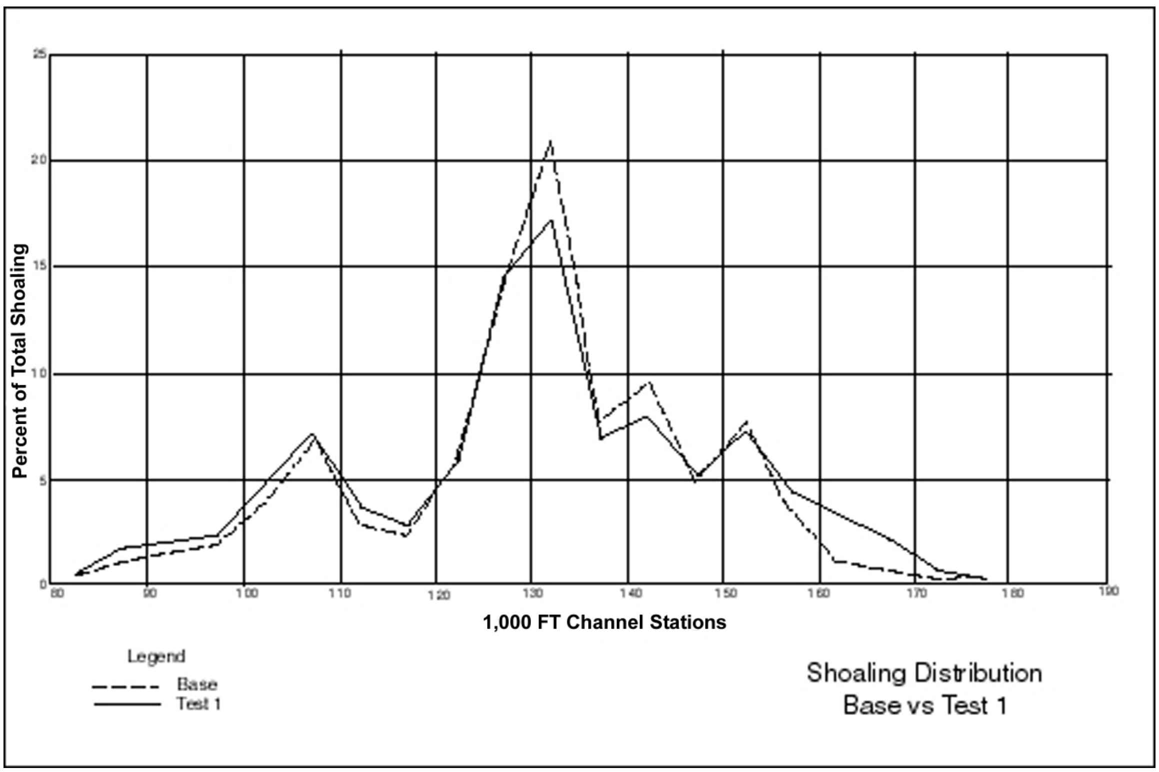

Figure 7-64f Test 1 Shoaling Distribution.

The salinity distributions as predicted by the three-dimensional hydrodynamic model Environmental Fluid Dynamics Code (EFDC) is shown in Figure 7-66g for the 6 foot deepening plan 6 and the 6 foot deepening plan with mitigation plan 6a implemented. The average shift in the 10 parts per thousand concentration is on the order of 500 ft, Figure 7-66g. The predicted salinity shift for plan 6a is much less than the modeled salinity shift for Test 1 which did not produce a significant change in the shoaling distribution. Based on the small predicted change in the salinity distribution for plan 6a, implementation of plan 6a will not change the shoaling distribution from the 6 foot deepening plan 6. The predicted salinity changes for the other deepening alternatives are less than for plan 6a and therefore they also will not affect the without mitigation shoaling distribution.

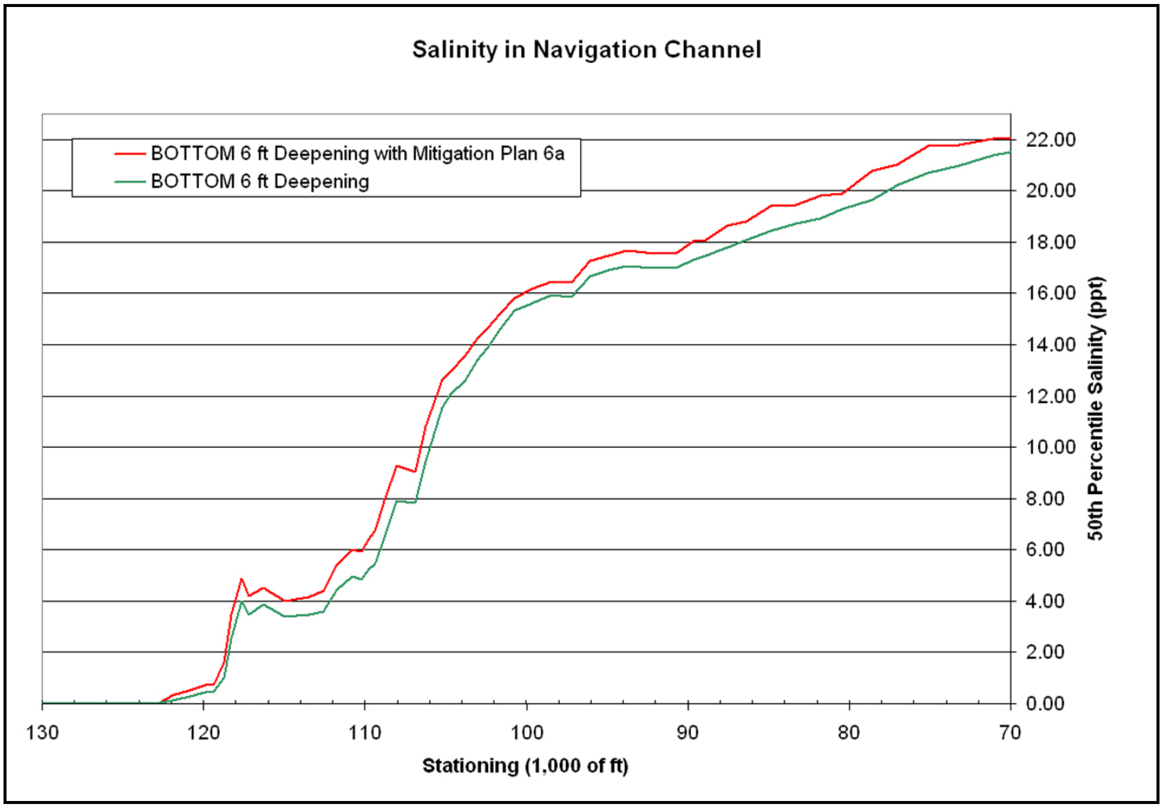

Figure 7-64g. Shift in Salinity Profile Due to Mitigation Plan 6a.

7.2.3.1.8 Berth Maintenance

The berths in Savannah Harbor are maintained by agitation dredging. Table 7-16 lists the agitation dredging permit holders and their approximate location. Records of the agitation volumes dredged go back to 1995. The total volume dredged by agitation is plotted in Figure 7-66 for the period 1995 to 2004.

Permit Holders	Approximate Channel Station
S.T. Services	60+500
Conoco Phillips	61+000
S.T. Services Dock 2	62+300
G P Gypsum	63+600
East Coast Term.	68+450
Ga. Ports Auth. O.T.	78+000-82+000
Colonial Oil (Plant 1)	83 + 424
Gobal Ship Systems	84+000
Colonial Oil (Plant 2)	85 + 594
International Paper	88+500
Citgo	90+000
Colonial Ga. Kaolin	91+000
Conbulk Mar. Term. (S. Bulk)	91+872
Ga. Ports Auth. G.C.	92+000-102+000
Savannah Sugar	104+100
G.P.A. Berth 7	109+000

Table 7-15 Agitation Dredging Permit Holders.

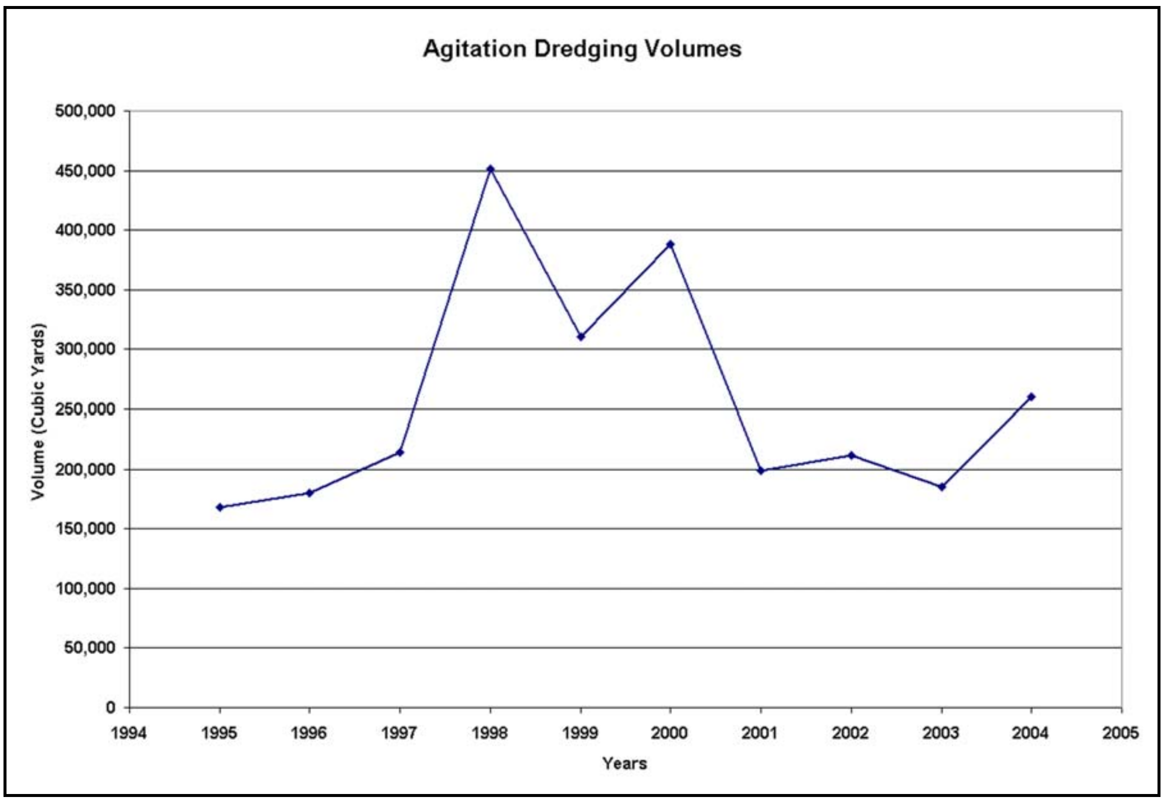

Figure 7-64 Agitation Dredging Volumes.

The existing shoaling pattern is not predicted to change with project depth increase and therefore the agitation volumes dredged are not predicted to change due to a project depth increase.

7.2.3.2 Entrance Channel

7.2.3.2.1 Entrance Channel Shoaling Response to Depth Increases

At the present project depth of 44 feet mllw, the entrance channel is a sediment sink, which is a total interdiction of the littoral transport. Increases in depth will not increase the channel ability to capture sediment. The average annual shoaling volume record did show an apparent increase in shoaling after the last deepening but this was due to the short post-deepening record not including both a high and low shoaling period as did the pre-deepening record. A small volume increase is predicted based on an increase in channel length.

The location of the entrance channel is shown in Figure 7-67. The entrance channel is 42 feet deep (mllw) and is 500 feet wide from station 0+000 to -14+000. From station -14+000 to -60+000 the channel is 44 feet deep (mllw) and 600 feet wide. The entrance channel is a trap for all of the sediment that is transported to it. To substantiate that the entrance channel is sediment sink, the depth of closure, or the depth beyond which the bottom doesn't change with storms, was calculated. Hallermeier proposed the following equation to estimate the depth of closure, Reference 2.10.

$$h_c = 2\,H + 11\,\sigma_H$$

Where

h_c is the depth of closure.
H is the annual mean significant wave height.
σ_H is the standard deviation of significant wave height.

Using, in the above equation, an annual mean significant wave height of 3.28 feet and a standard deviation of 1.64 feet from station 368 of the Wave Information Study database, http://frf.usace.army.mil/wis, produces a depth of closure of 24.6 feet. As will be shown in the following section on advance maintenance, the shoals in the entrance change rarely rise above a depth of 40 feet. Sediment that is presently transported into the entrance channel remains there until it is dredged and an increase in depth will not make the entrance channel a more effective trap. The shoaling in the entrance channel is a function of the amount of sand transported to it, which is then trapped in it.

Another indication that the entrance channel is a total interdiction of the sediment entering the inlet environment is that the entrance channel completely cuts through the inlet's ocean bar. The ocean bar is the end product of the integrated effects of tidal currents, wave action and the associated sediment transport and deposition, Reference 2.11. Channel depths deeper than the depth at which the seaward tip of the ocean bar meets the offshore sea bottom will cause the channel to be a total interdiction of the littoral drift. The color-coded depths in Figure 7-67 indicate that the bulbous shape of the ocean bar does not extend beyond the 30 to 35 foot depth band. This is in agreement with the shoaling distribution along the entrance channel, Figure 7-68, which has virtually no shoaling beyond entrance channel station 50+000.

Maintenance dredging records for the entrance channel were available for the period 1974 to 2005. Dredging volumes for the entrance channel were also available from annual reports for the period 1975 to 2002. Both sets of dredging data are shown in Figure 7-69. The data from the dredging records reflect the total volume dredged in a calendar year. The annual reports give the volume dredged that was paid for in a fiscal year. There is a general agreement between the two data sets but the dredging record data appears to be missing several years. Table 7-17 contains the average annual volumes dredged in the entrance channel for the period of record, the pre-1994 deepening period and the post 1994 deepening period. Both data sets show an increase in dredging of over 100,000 cubic yards from the pre to post 1994 deepening periods. The explanation for the apparent shoaling increase is due to the difference in length of records of the pre and post deepening periods. The pre-deepening period is 19 years long and contains a cycle of both high and low shoaling periods. The post-deepening period is 8 years and contains only a high shoaling period with shoaling magnitudes comparable to those of the pre deepening high shoaling period.

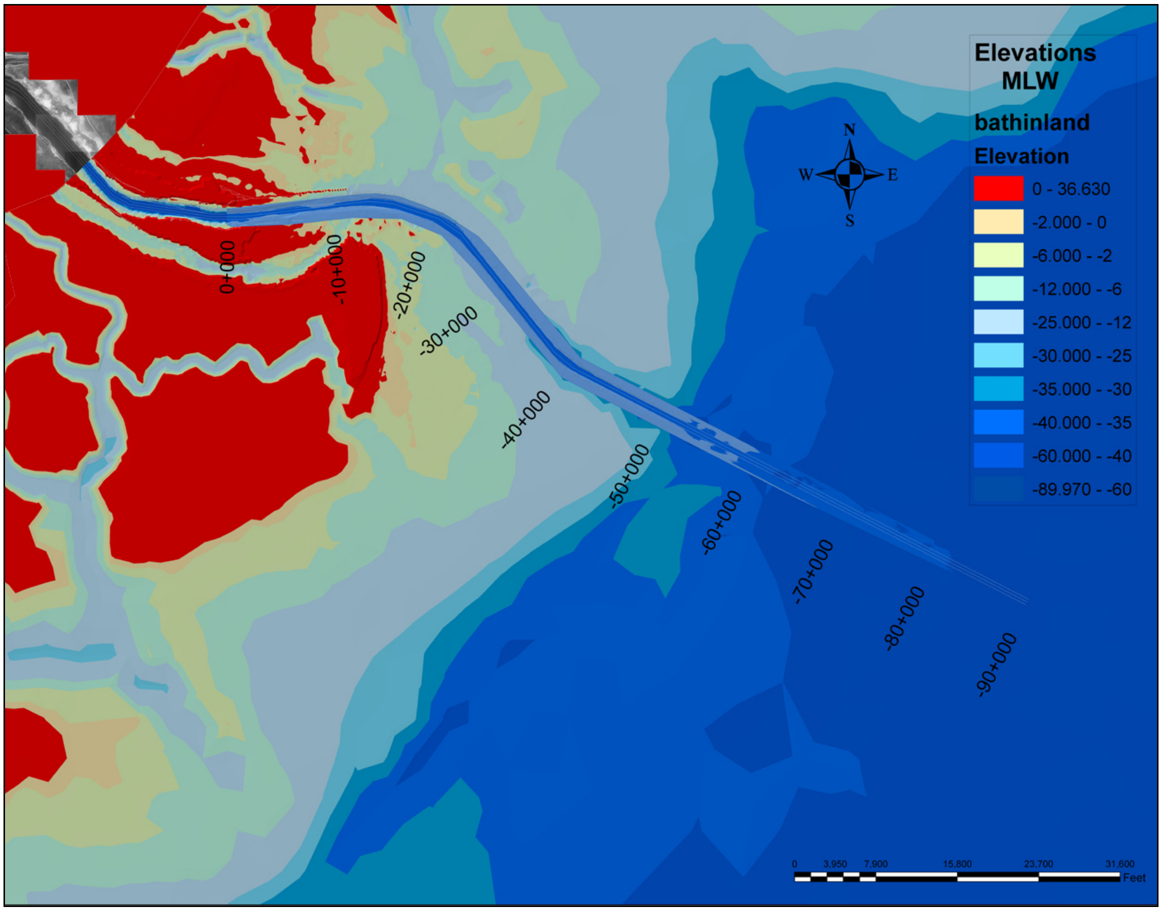

Figure 7-65 Entrance Channel.

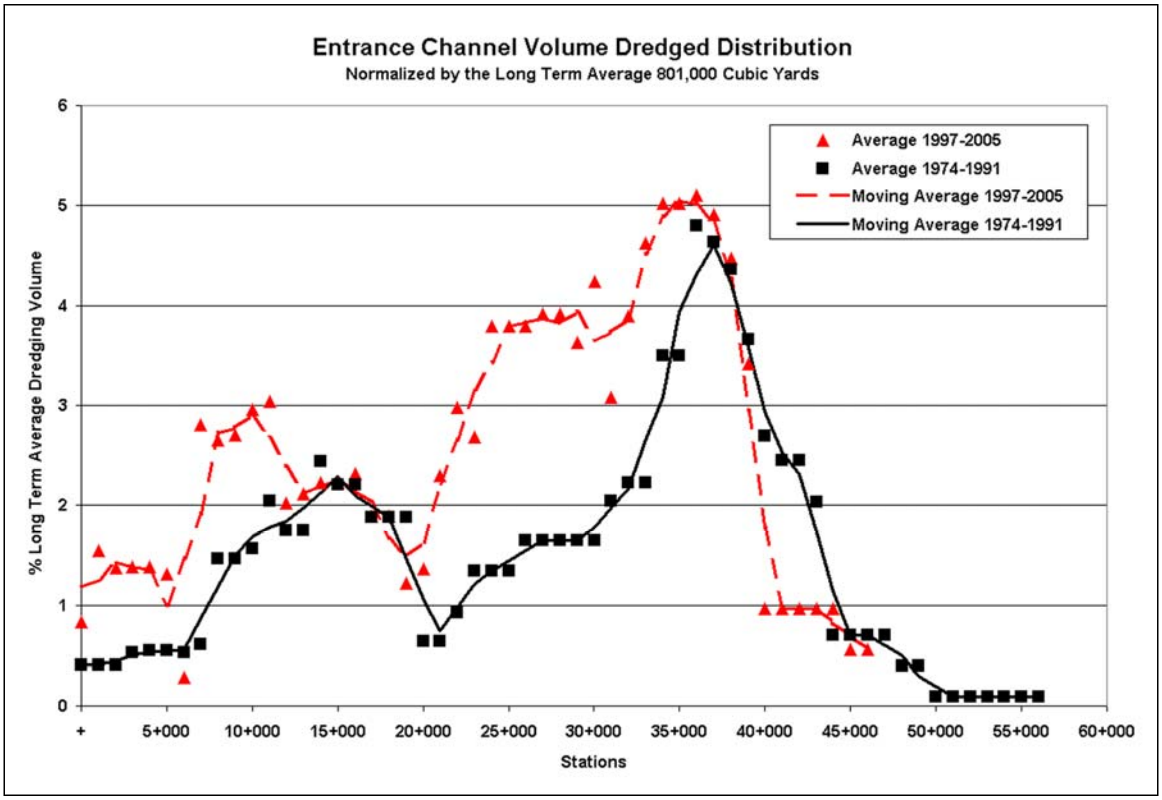

Figure 7-66 Entrance Channel Volume Dredged Distributions.

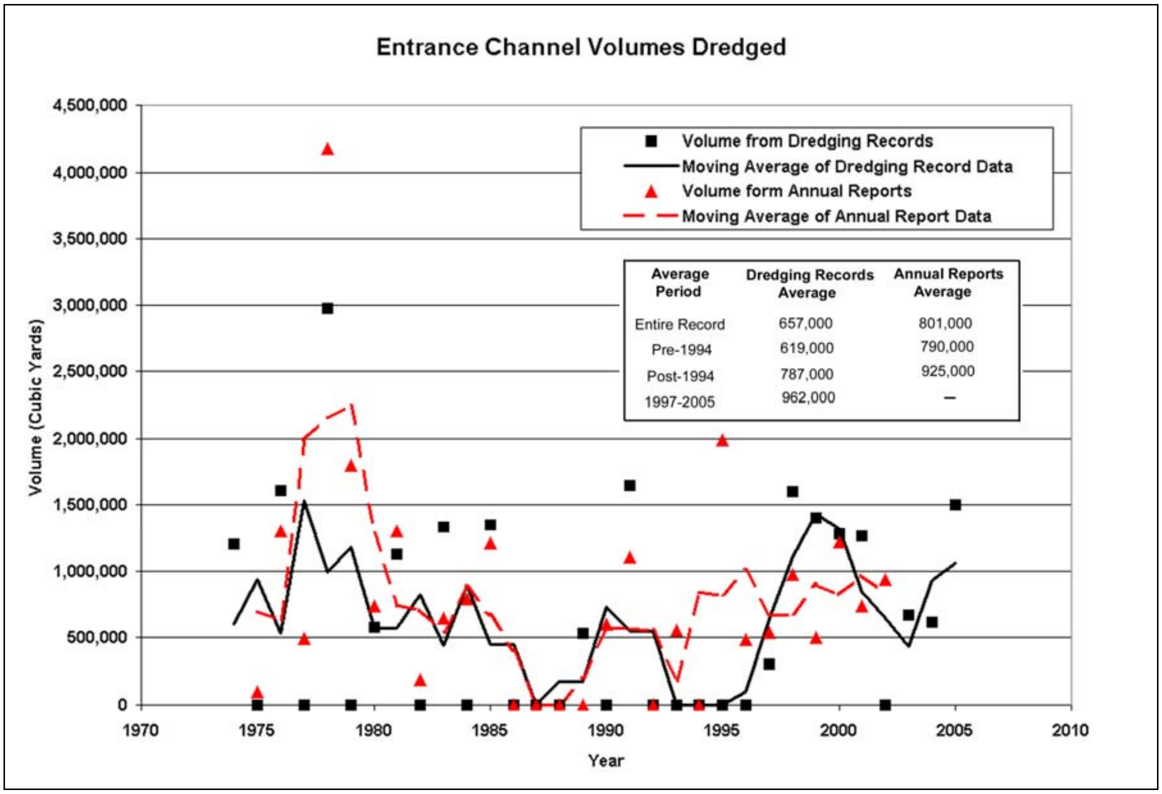

Figure 7-67 Entrance Channel Volumes Dredged.

Time	Period	Average Annual Volume	Average Annual Volume
Span		from Dredging Records	from Annual Reports
1974-2005	Period of Record	657,000	-
1975-2002	Period of Record	-	801,000
1974-1993	Pre-1994 Deepening	619,000	-
1975-1993	Pre-1994 Deepening	-	790,000
1995-2005	Post 1994 Deepening	787,000	-
1995-2002	Post 1994 Deepening	-	925,000
1997-2005	Post 1994 Deepening	962,000	-

Table 7-16 Entrance Channel Average Annual Volumes Dredged.

The first step in determining the physical cause of the short term shoaling increase was to identify where the shoaling increase occurred. The entrance channel dredging volume distributions are plotted in Figure 7-68 for the periods

1974-1991 and 1997-2005. There was an increase in the volume dredged from station 0+000 to 12+000 and another increase from station 20+000 to 36+000.

With the shoaling increase locations identified, the channel surveys were examined to further investigate the nature of the shoaling increase. Entrance channel cross sections from before dredging surveys in 1991 and 2003 are plotted in Figures 7-70 through 7-74. The shoal surface in 2003 is higher than 1991 at station 9+000, 15+000, and 25+000 even though the channel is 4 feet deeper. The reverse is true for station 37+500 and 40+000. Of special interest are the elevations outside of the channel. The elevations outside of the channel are higher in 2003 than in 1991 at stations 9+000, 15+000 and 25+000. This indicates that shoals adjacent to the channel are growing and more sediment is moving into the area and into the entrance channel. The channel stations which show increases in dredging volumes, after the 1994 deepening, line up with the shoals to the north of the entrance channel, Figure 7-75. The entrance channel reach from station 12+000 to 20+000, which didn't show an increase in shoaling, lines up with the outer end of a channel that bifurcates the shoals to the north of the entrance channel and is maintained by the flow coming out of Calibogue Sound. The entrance channel is trapping more material because of the increase in sediment transport and not because of the 4-foot depth increase in 1994. This is evidenced by the growth of the shoals in the channel exceeding the 4-foot depth increase and the growth of the shoals outside of the channel adjacent to areas where increased dredge volumes occurred.

At a project depth of 44 feet the channel is trapping all of the littoral transport and only a small increase in the volume dredged is expected for potential channel depth increases due to a corresponding increase in channel length.

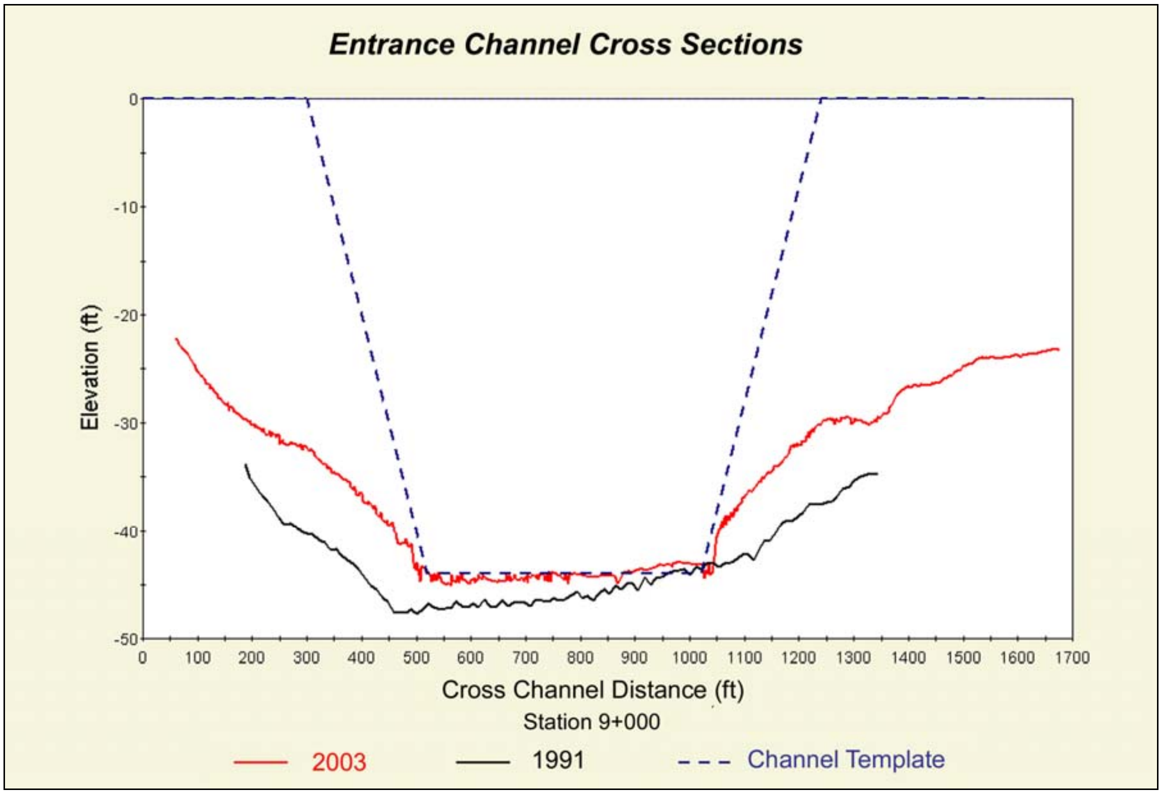

Figure 7-68 Before Dredging Cross Sections Entrance Channel Station 9+000.

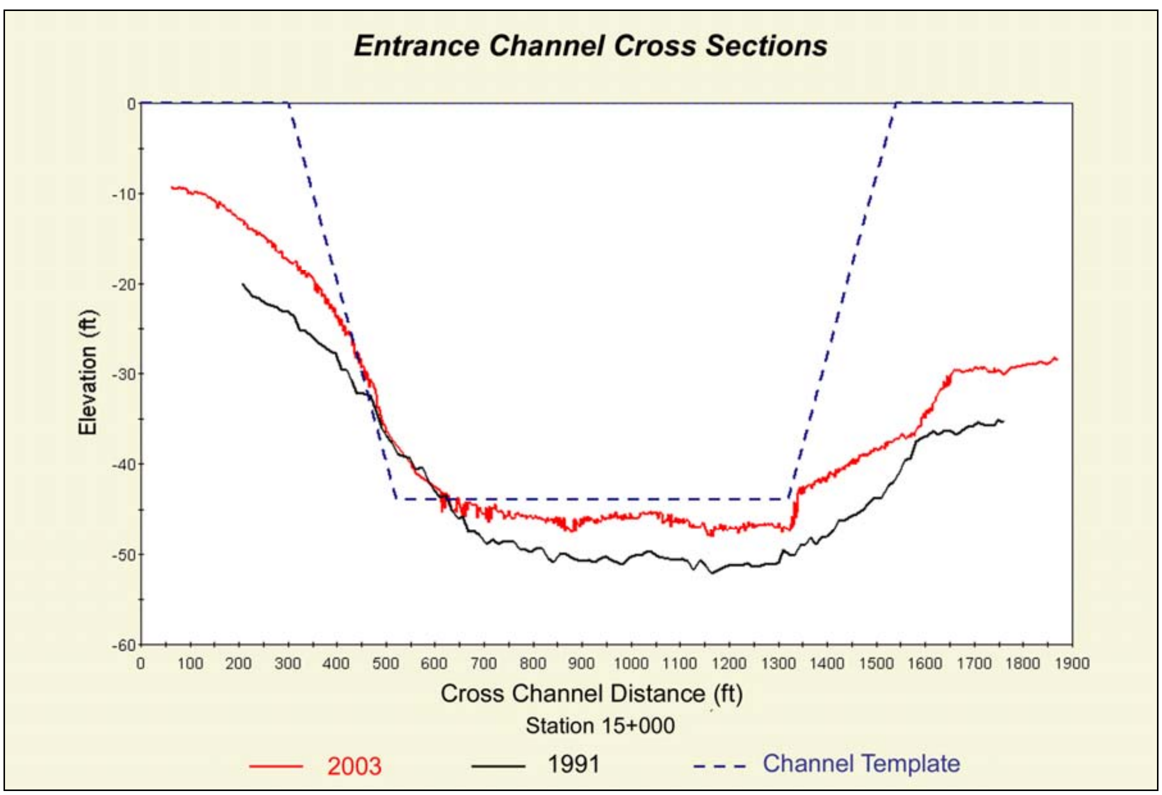

Figure 7-69 Before Dredging Cross Sections Entrance Channel Station 15+000.

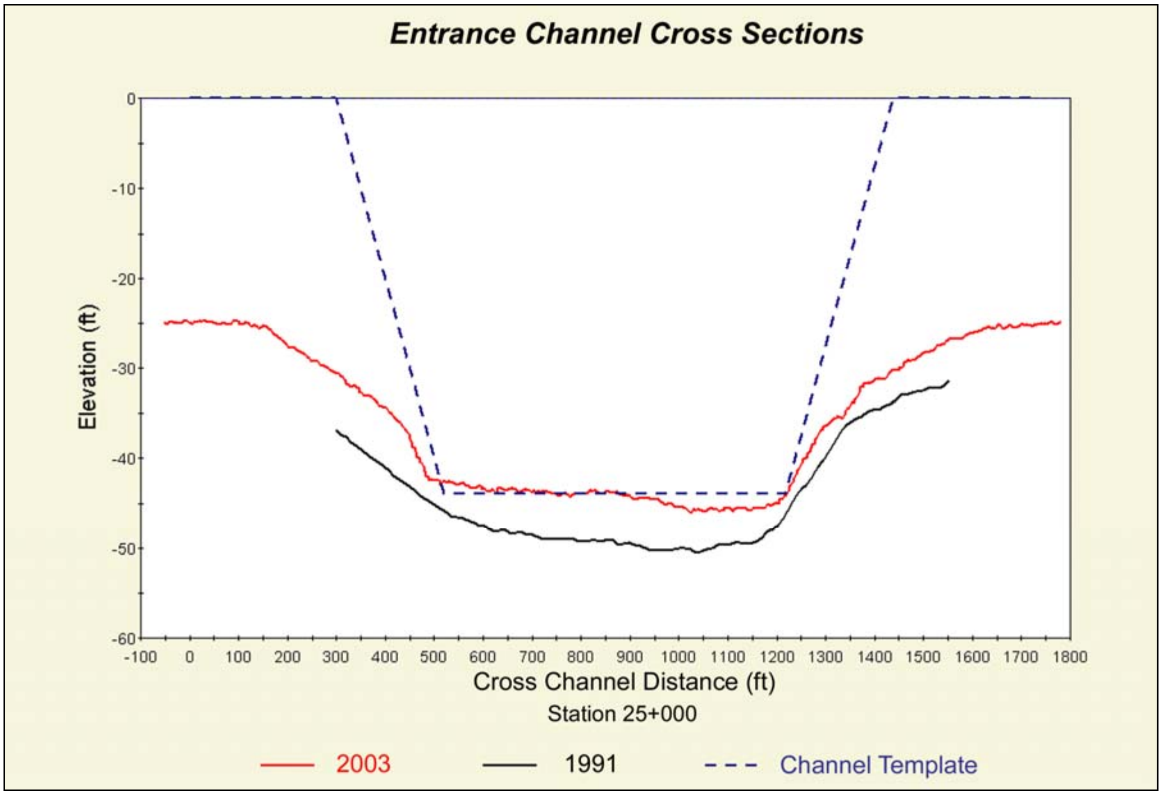

Figure 7-70 Before Dredging Cross Sections Entrance Channel Station 25+000.

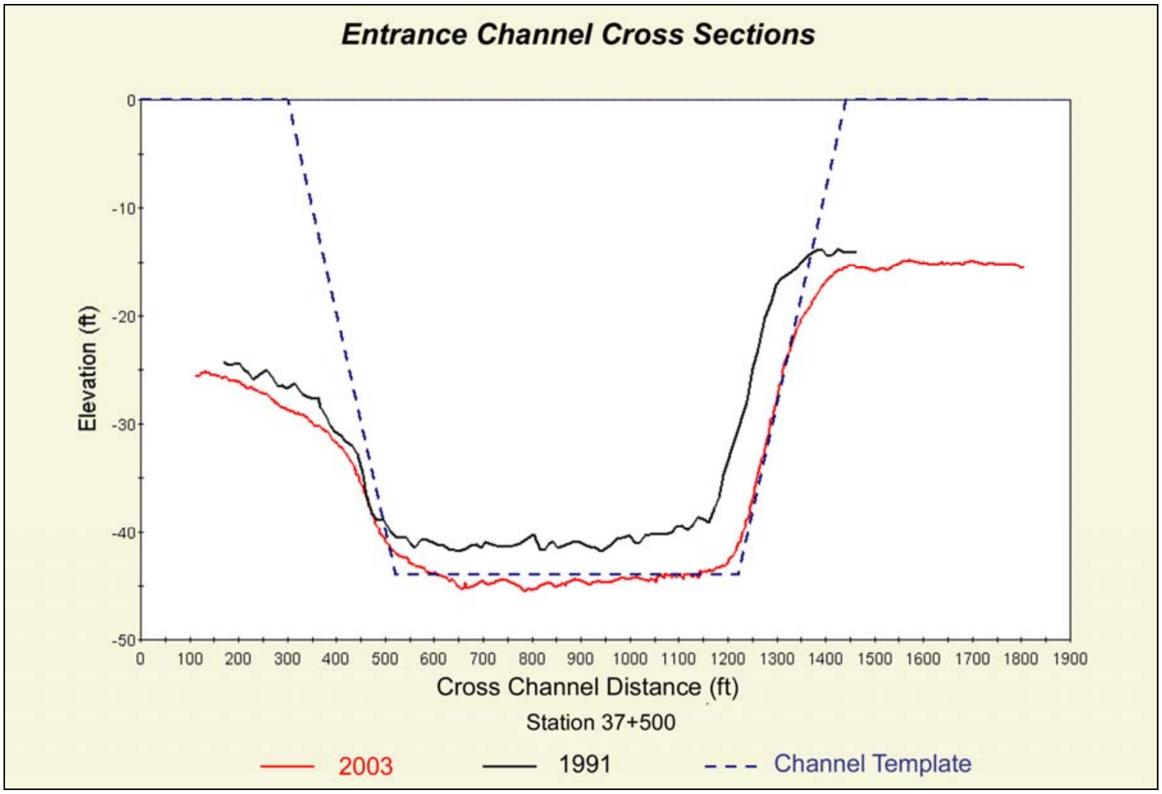

Figure 7-71 Before Dredging Cross Sections Entrance Channel Station 37+500.

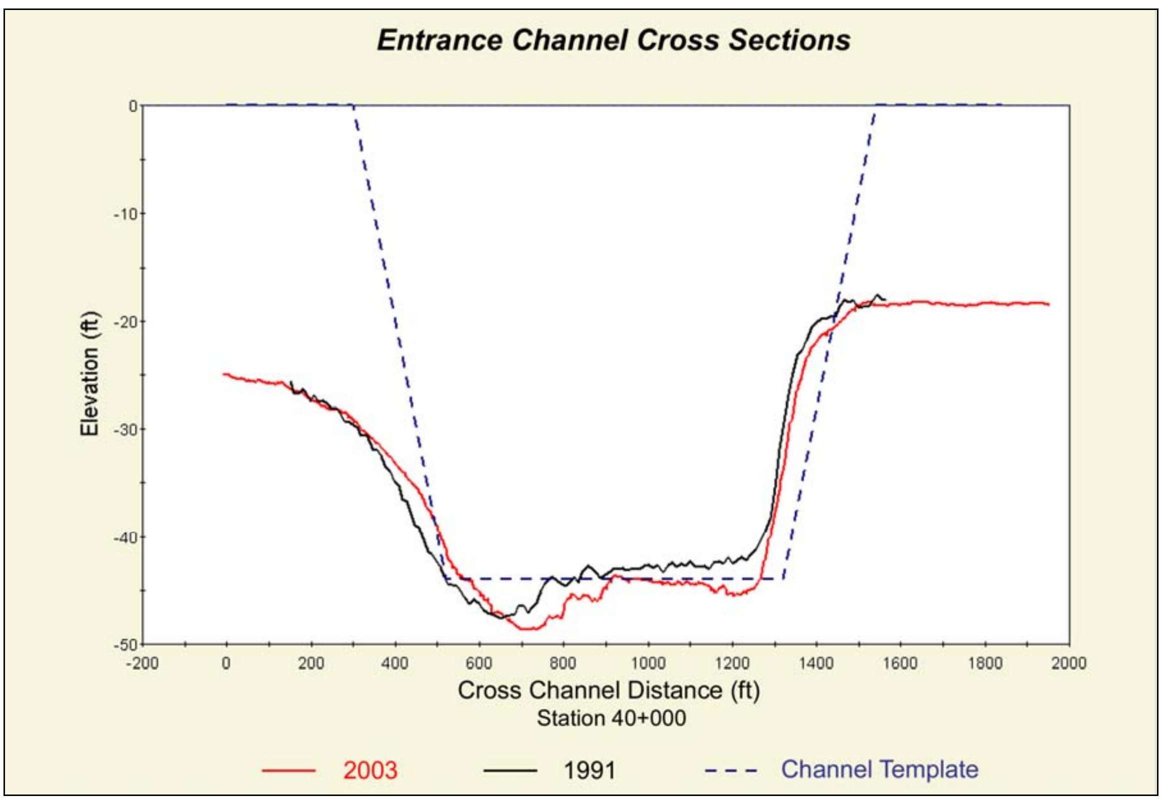

Figure 7-72 Before Dredging Cross Sections Entrance Channel Station 40+000.

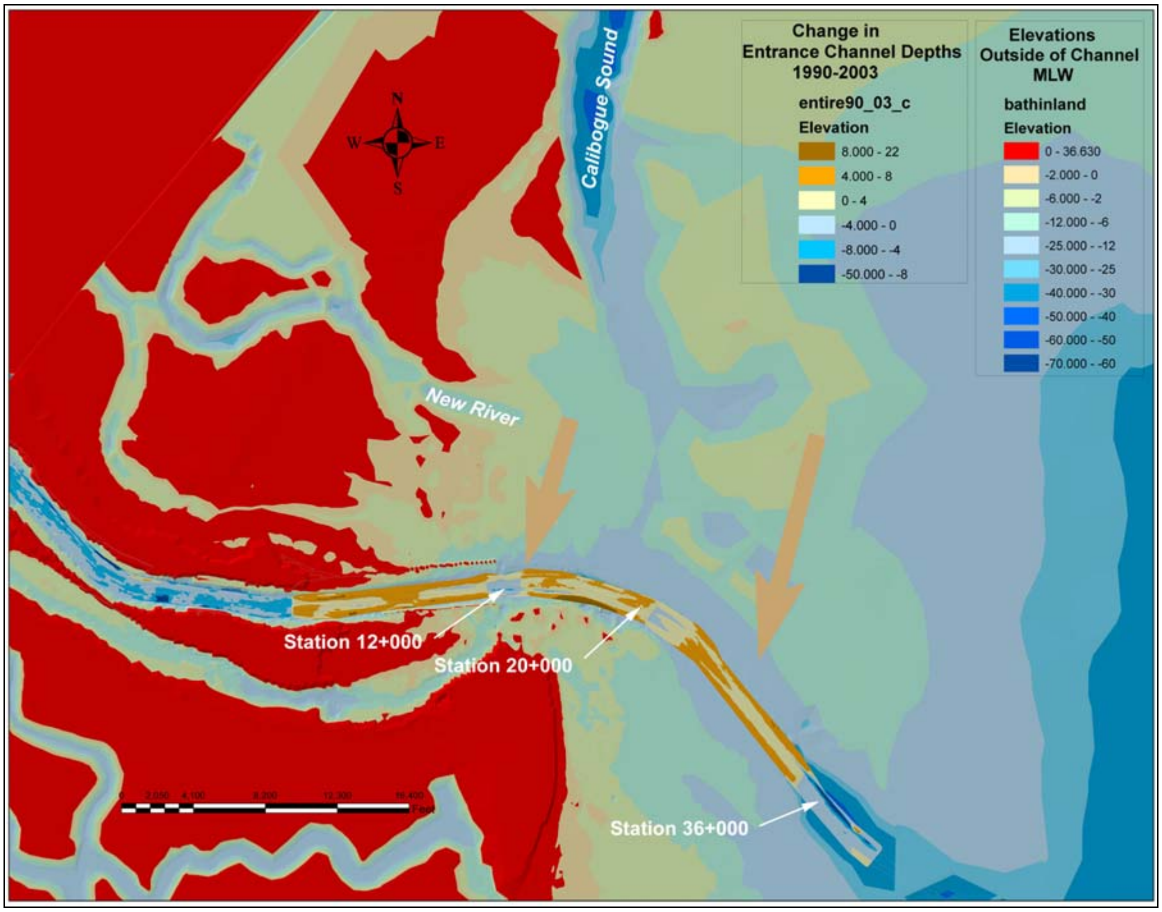

Figure 7-73 Shoals Adjacent to the Entrance Channel.

To determine channel length increases due to potential channel depth increases, the average entrance channel depths from station 0+000 to station 85+000 are shown in Figure 7-76. Based on the depths in Figure 7-76, the channel length increases beyond station 60+000 are shown in Table 7-18 for a range of channel depths.

The entrance channel between stations 50+000 and 60+000 was dredged twice between 1974 and 2005. A total of 92,000 cubic yards were removed during the two dredging operations. The average annual volume dredged from this reach was 300 cubic yards per 1,000 feet of channel. Applying this rate for the channel increases gives the volume increases, which are listed in Table 7-19 and plotted in Figure 7-77.

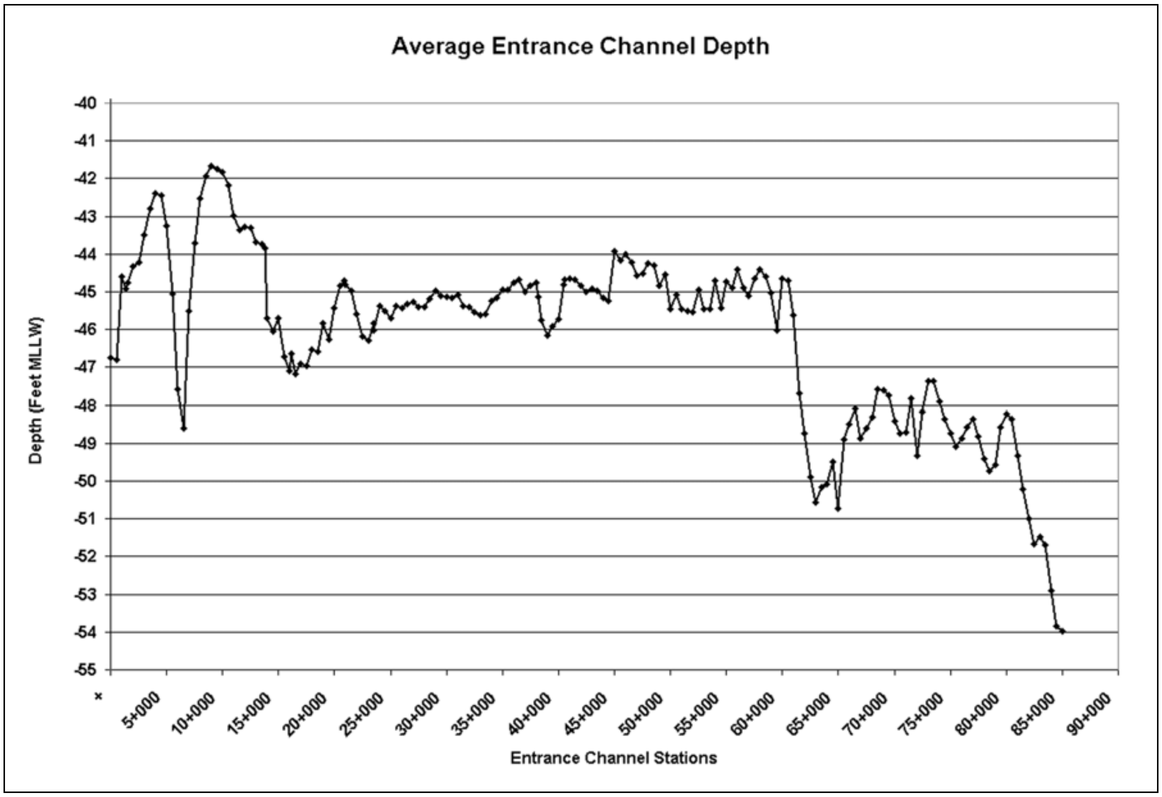

Figure 7-74 Average Entrance Channel Depths 1997.

Entrance Channel Depth	Channel Length Increase
45	1,000
46	1,250
47	1,500
48	14,000
49	21,000
50	21,500
51	22,000
52	23,500

Table 7-17 Entrance Channel Length Increases.

Entrance Channel Depth	Entrance Volume Dredged Increase
45	300
46	375
47	450
48	4,200
49	6,300
50	6,450
51	6,600
52	7,050

Table 7-18 Entrance Channel Volume Increases.

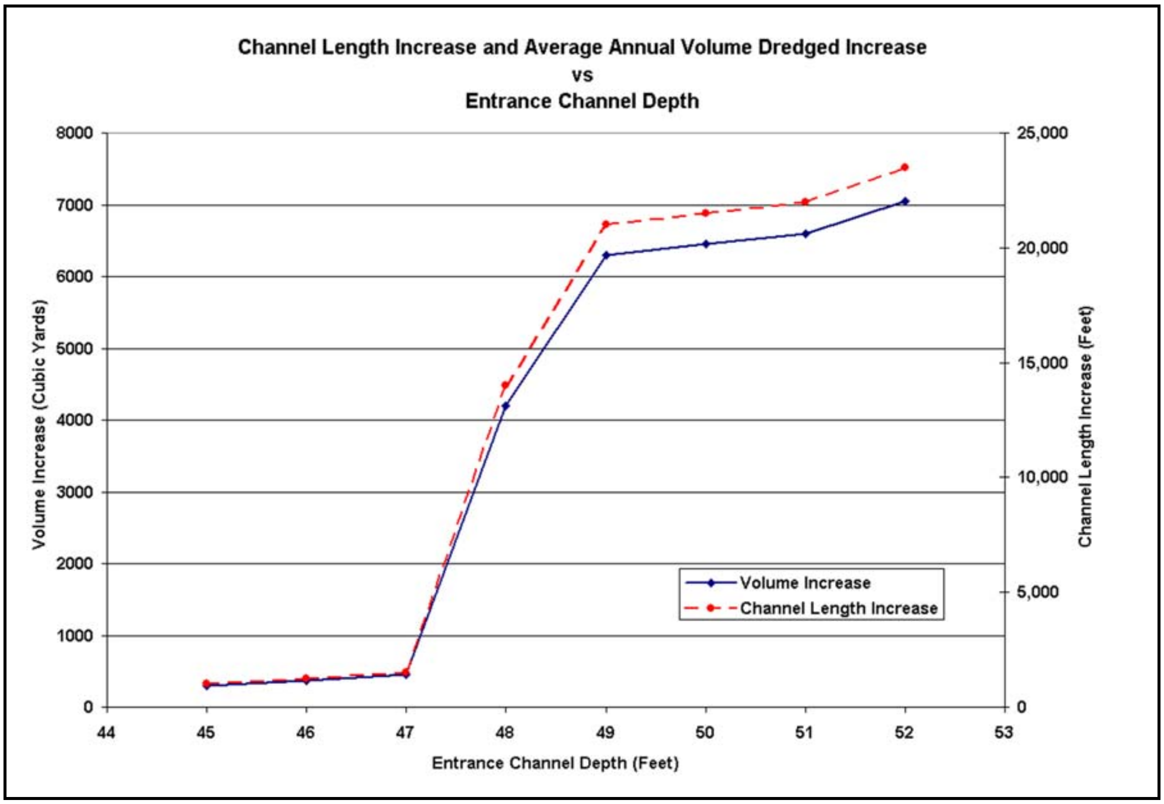

Figure 7-75 Channel Length and Volume Dredged Increases.

7.2.4 Advance Maintenance

7.2.4.1 Advance Maintenance After Deepening with Existing Operations.

Advance maintenance is authorized for Savannah Harbor to reduce the overall maintenance costs by decreasing the frequency of dredging. Dredging frequency is based on monthly project condition surveys. The condition surveys are taken along the four centerlines of the channel's quarters. When a shoal 2 feet or more above the project depth occurs at two adjacent quarters, a contractor is directed to remove the shoal. Figures 7-78 to 7-107 contain the minimum depths along channel quarters from January 1997 to January 2005. Using the preceding dredging criteria, the existing advance maintenance areas, with the exception of Kings Island range, are providing acceptable navigation depths. The shoaling pattern is not predicted to change with future depth increases and the present advance maintenance areas do not need to be shifted due to future depth increases.

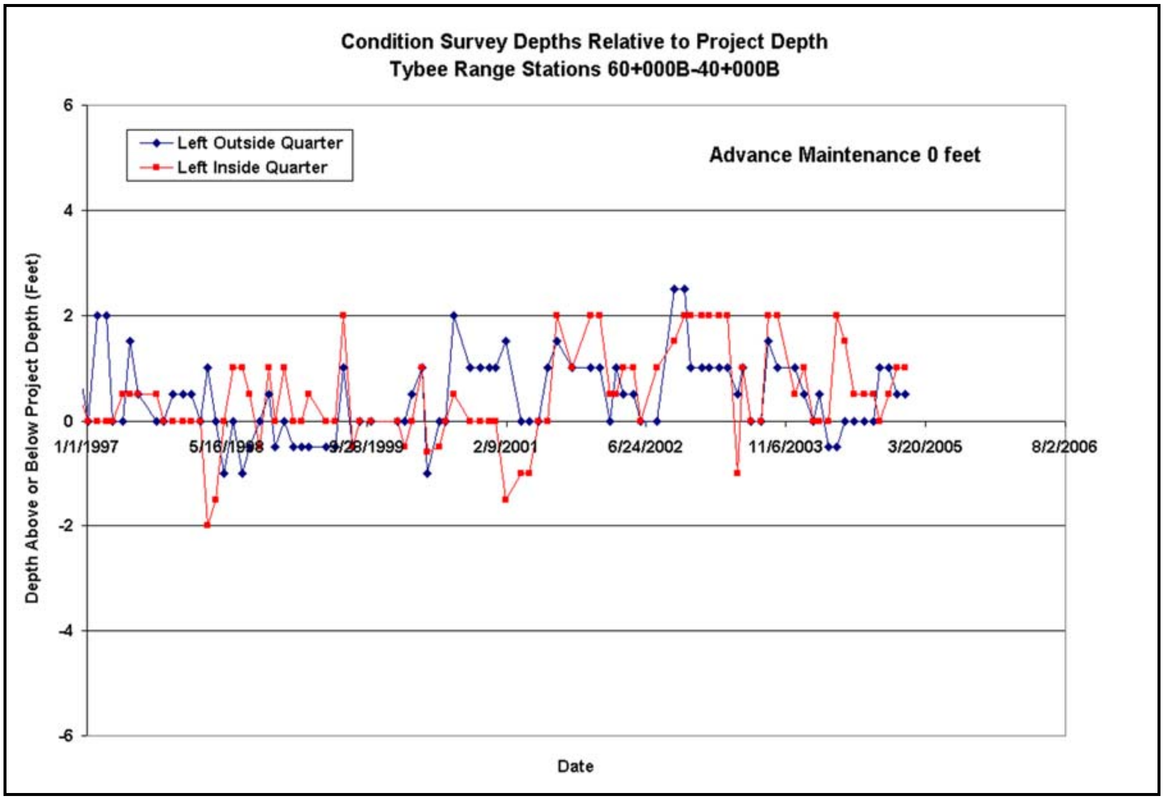

Figure 7-76 Condition Survey Left Quarter Depths, Tybee Range.

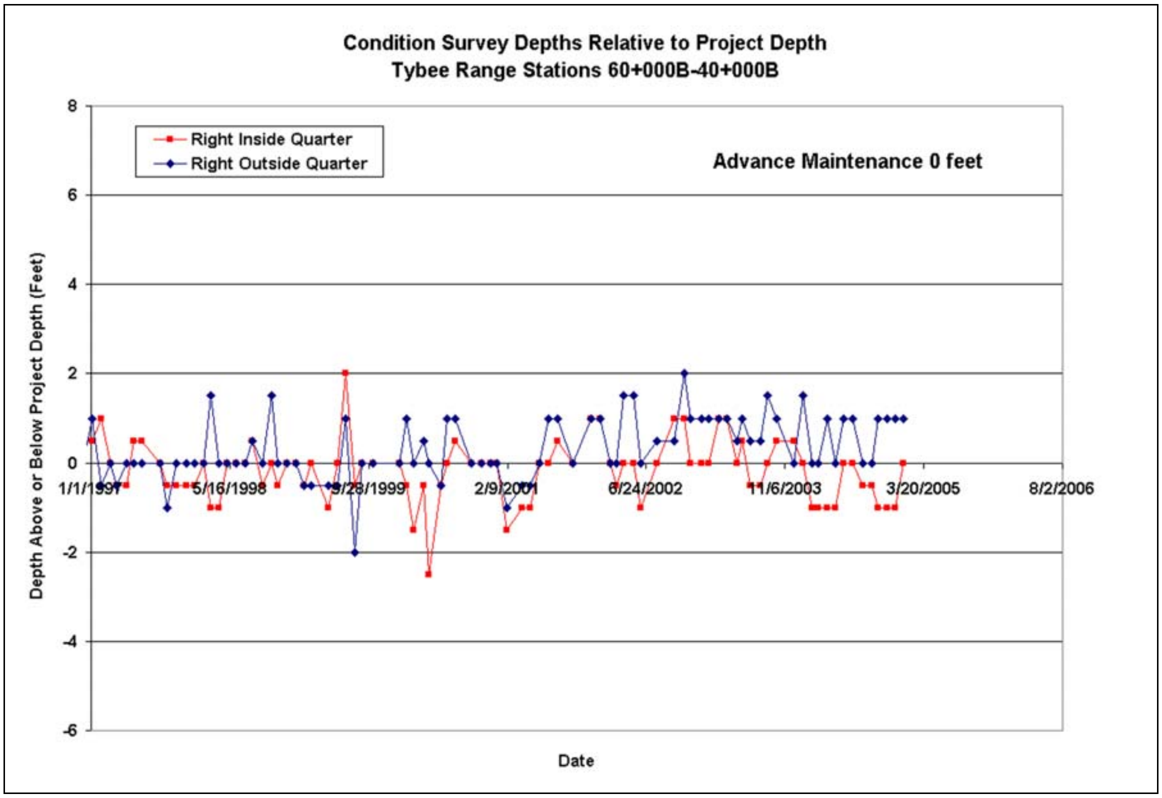

Figure 7-77 Condition Survey Right Quarter Depths, Tybee Range.

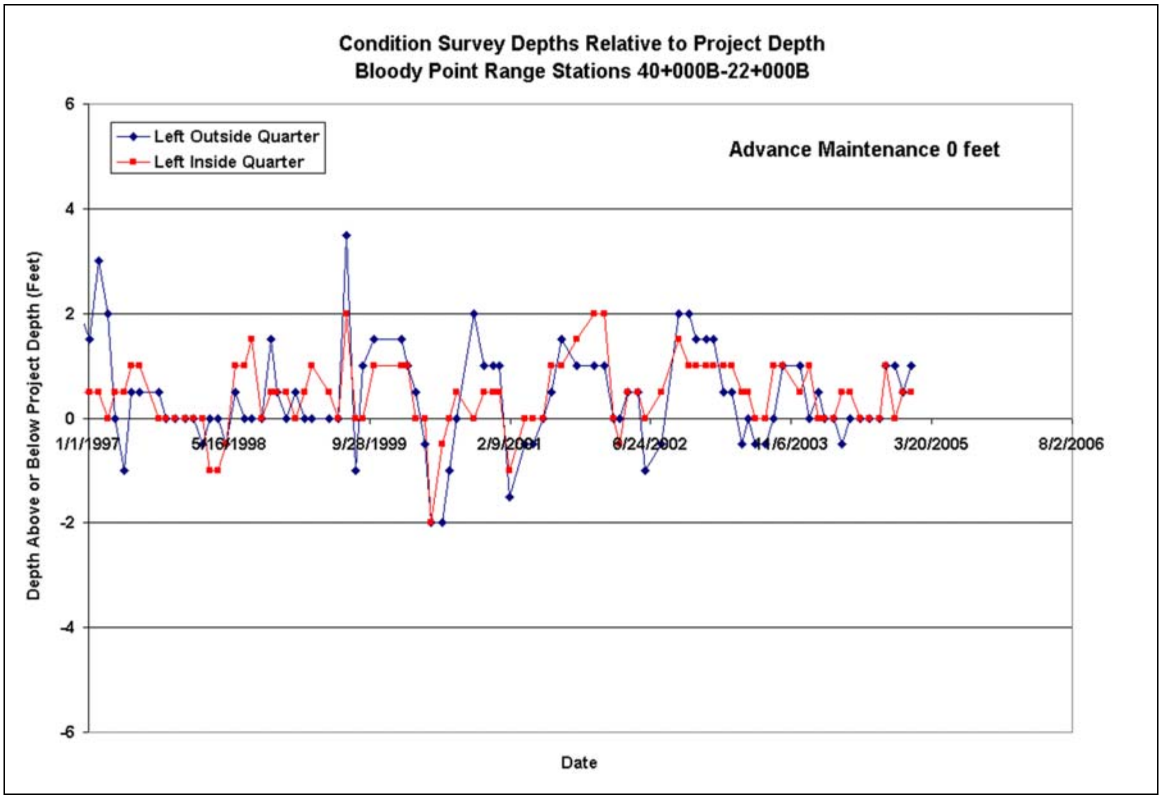

Figure 7-78 Condition Survey Left Quarter Depths, Bloody Point Range.

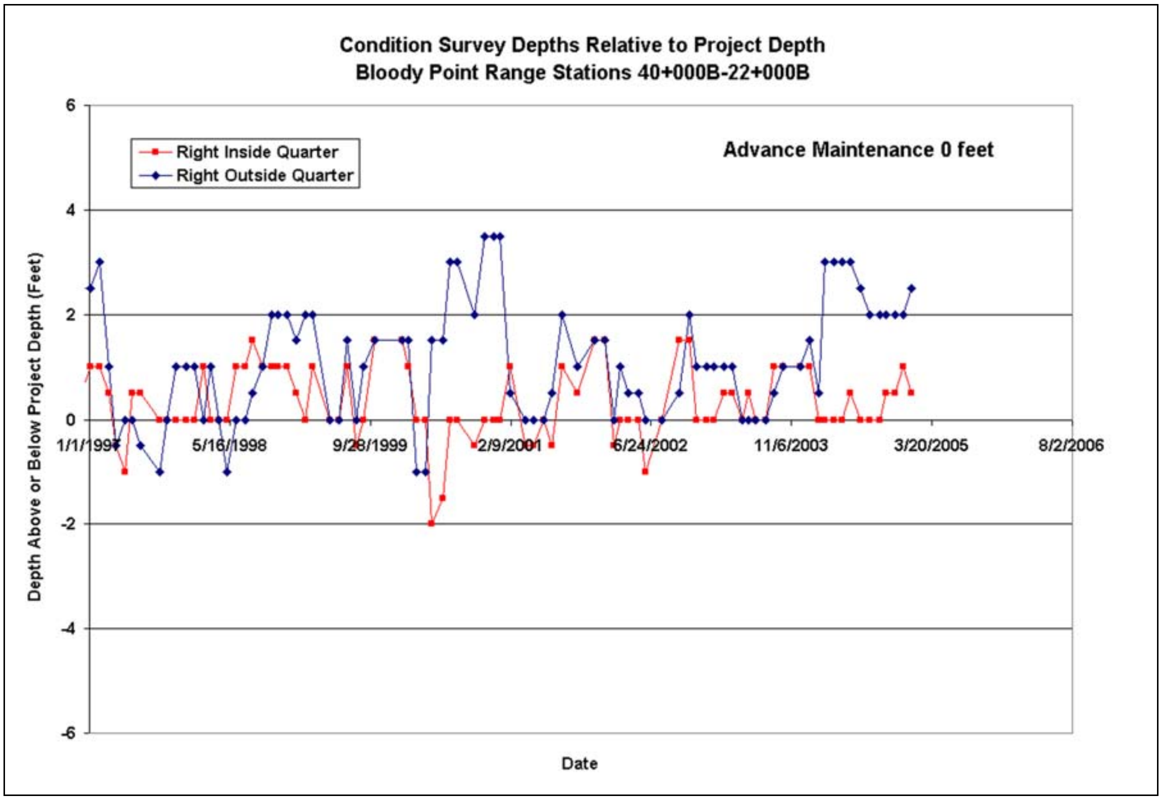

Figure 7-79 Condition Survey Right Quarter Depths, Bloody Point Range.

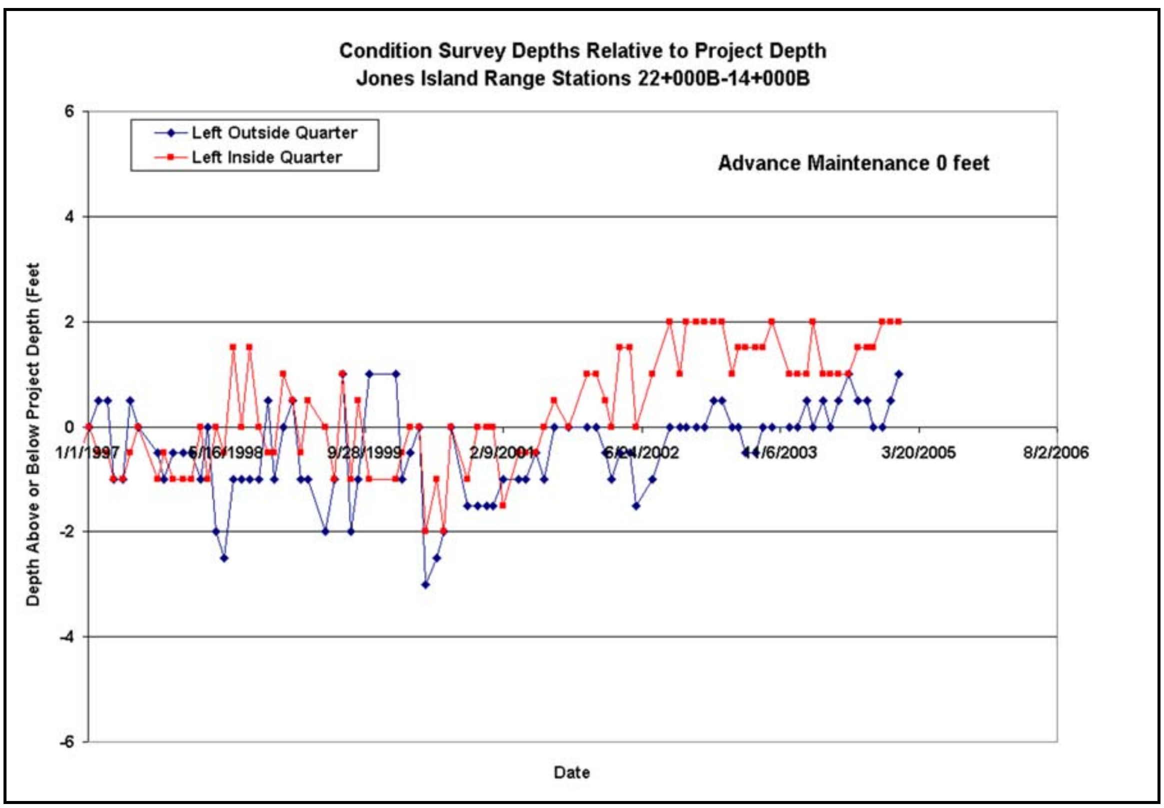

Figure 7-80 Condition Survey Left Quarter Depths, Jones Island Range.

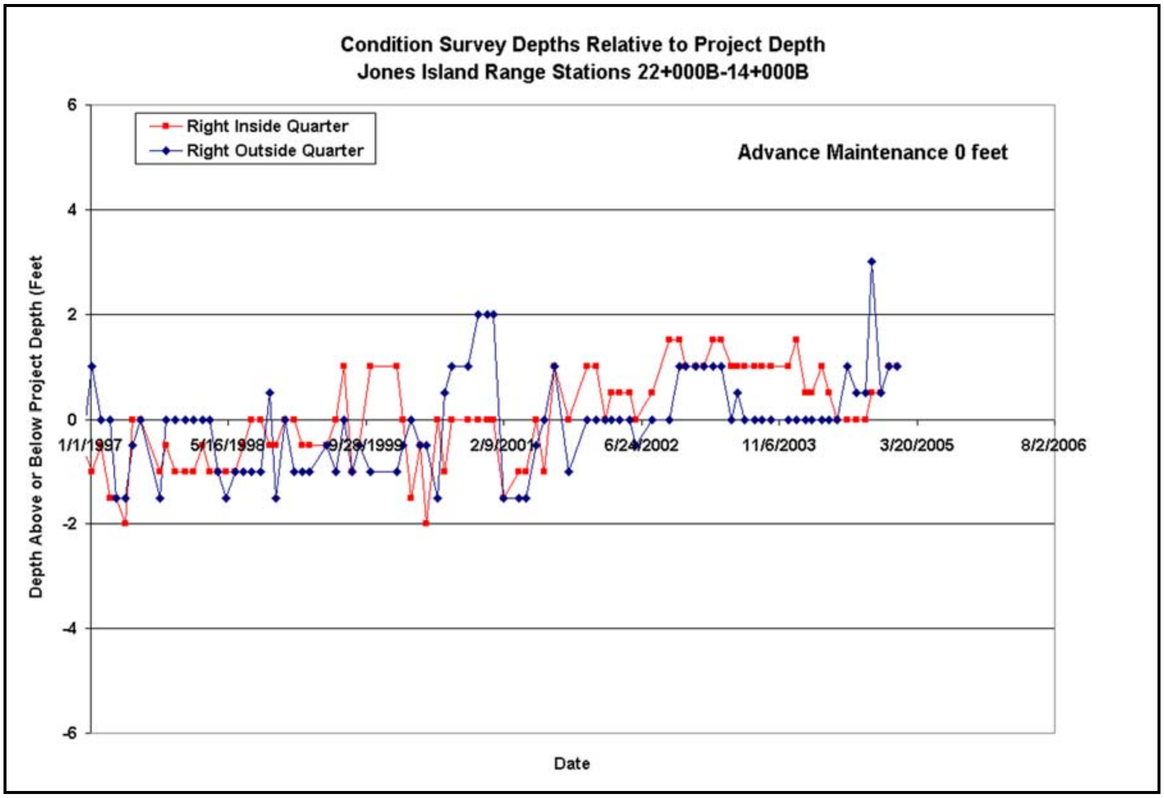

Figure 7-81 Condition Survey Right Quarter Depths, Jones Island Range.

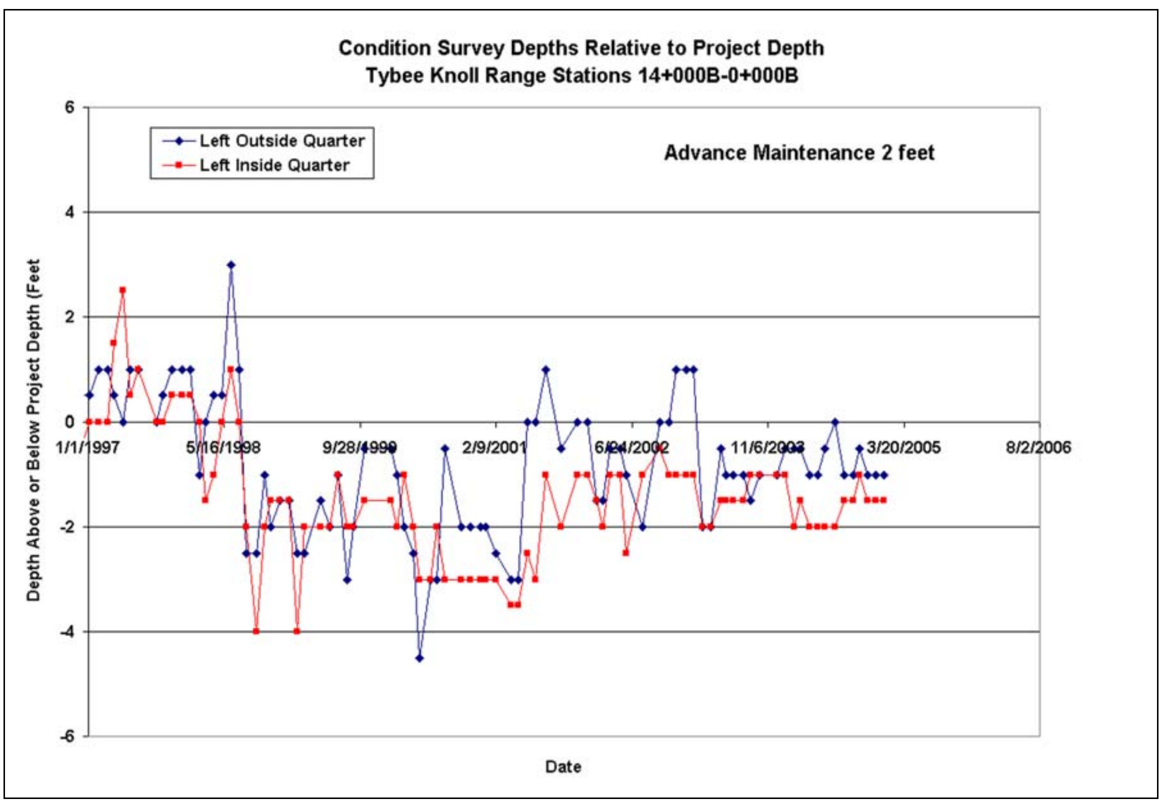

Figure 7-82 Condition Survey Left Quarter Depths, Tybee Knoll Range.

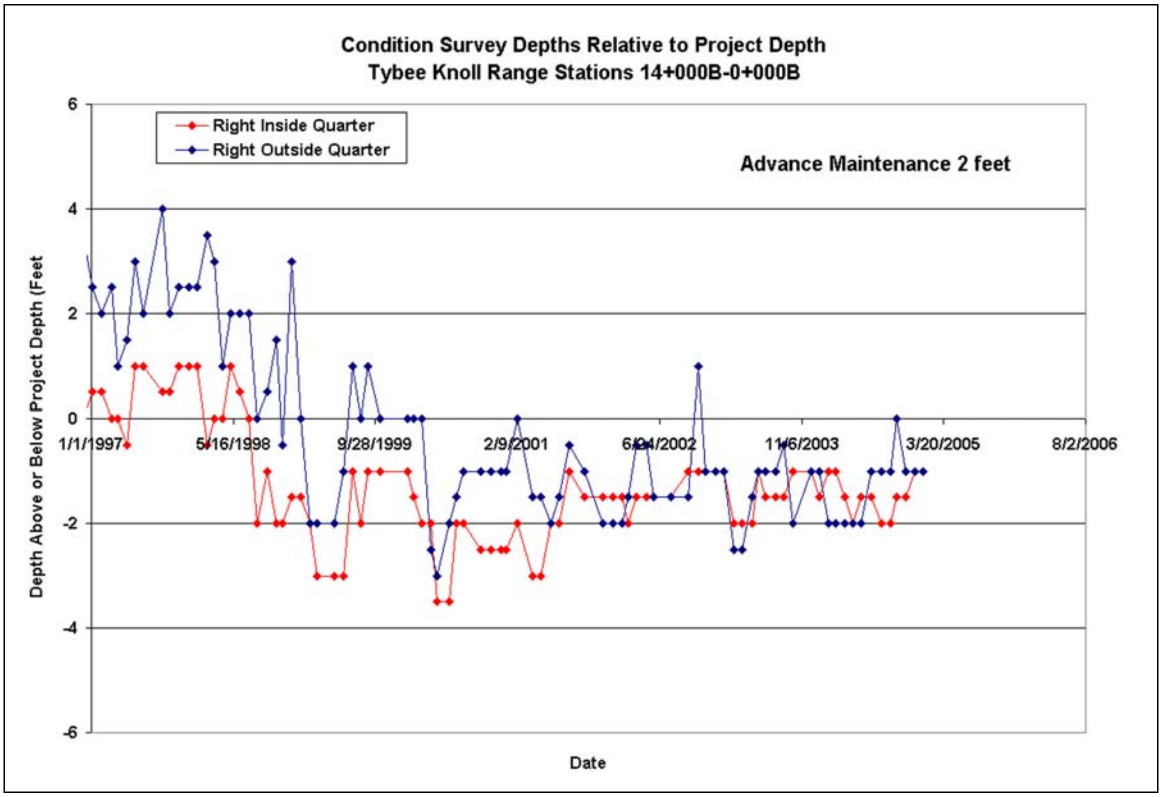

Figure 7-83 Condition Survey Right Quarter Depths, Tybee Knoll Range.

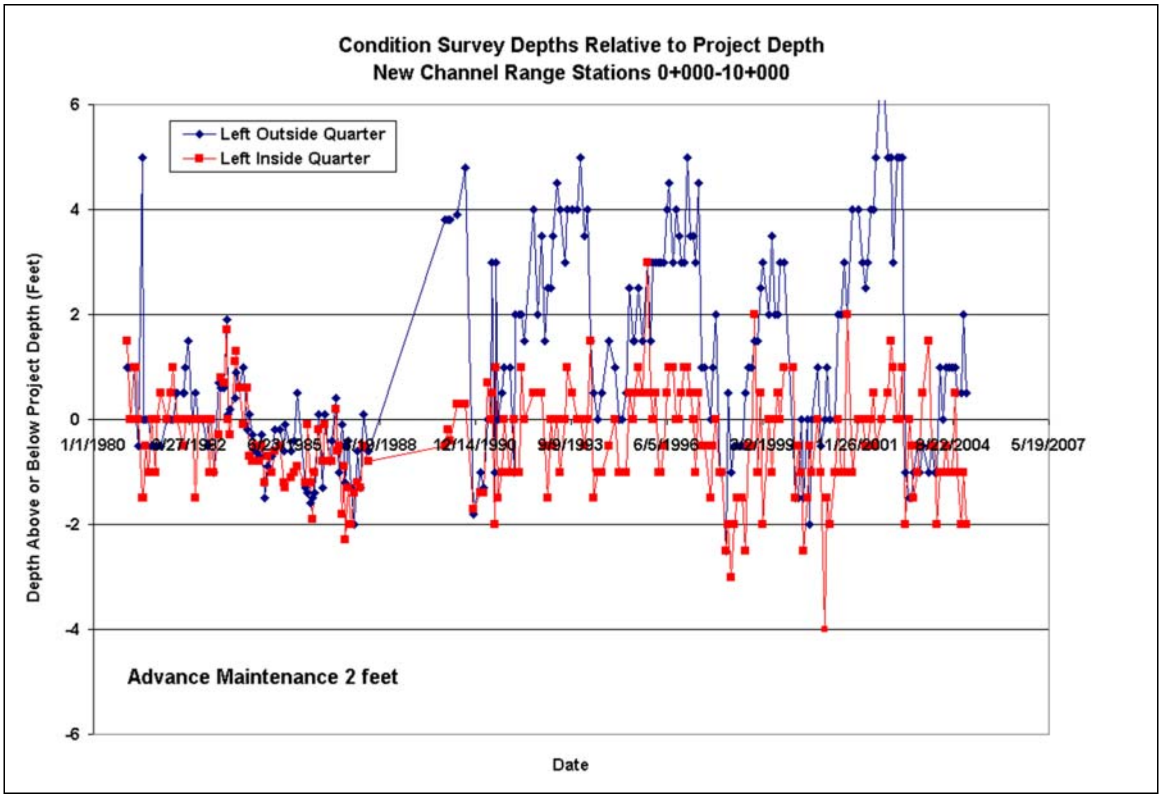

Figure 7-84 Condition Survey Left Quarter Depths, New Channel Range.

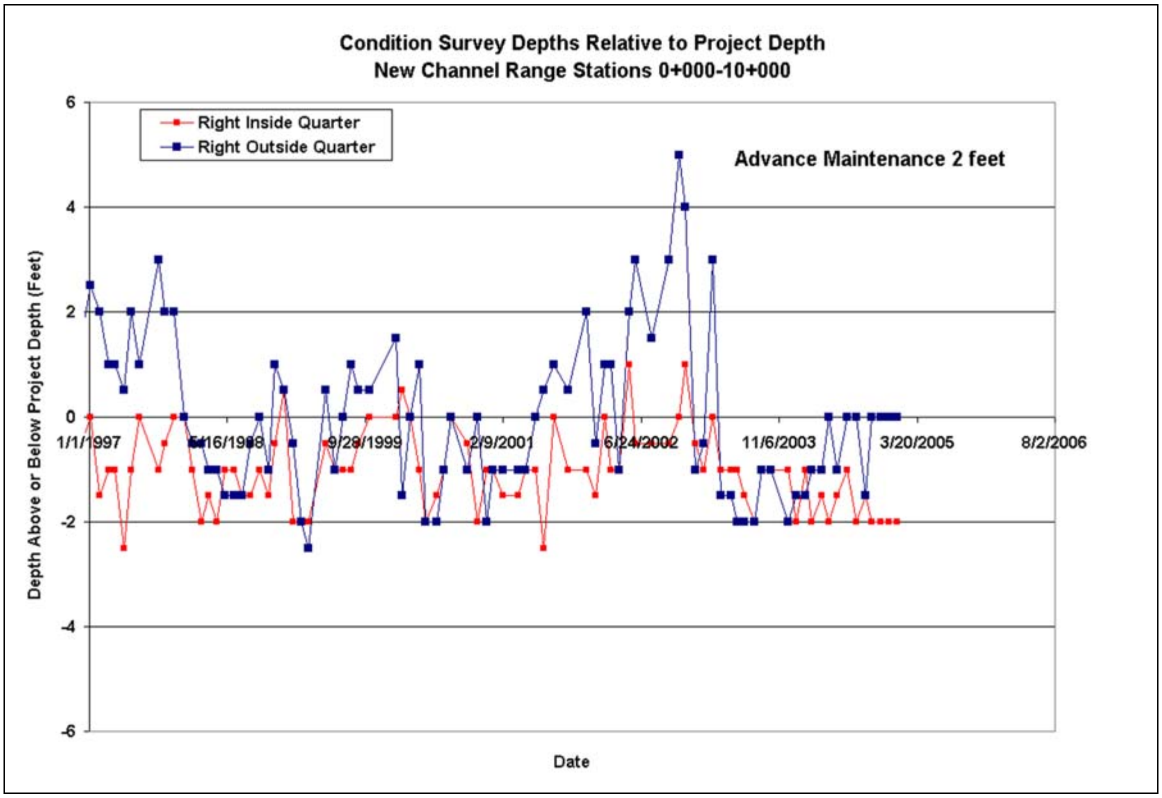

Figure 7-85 Condition Survey Right Quarter Depths, New Channel Range.

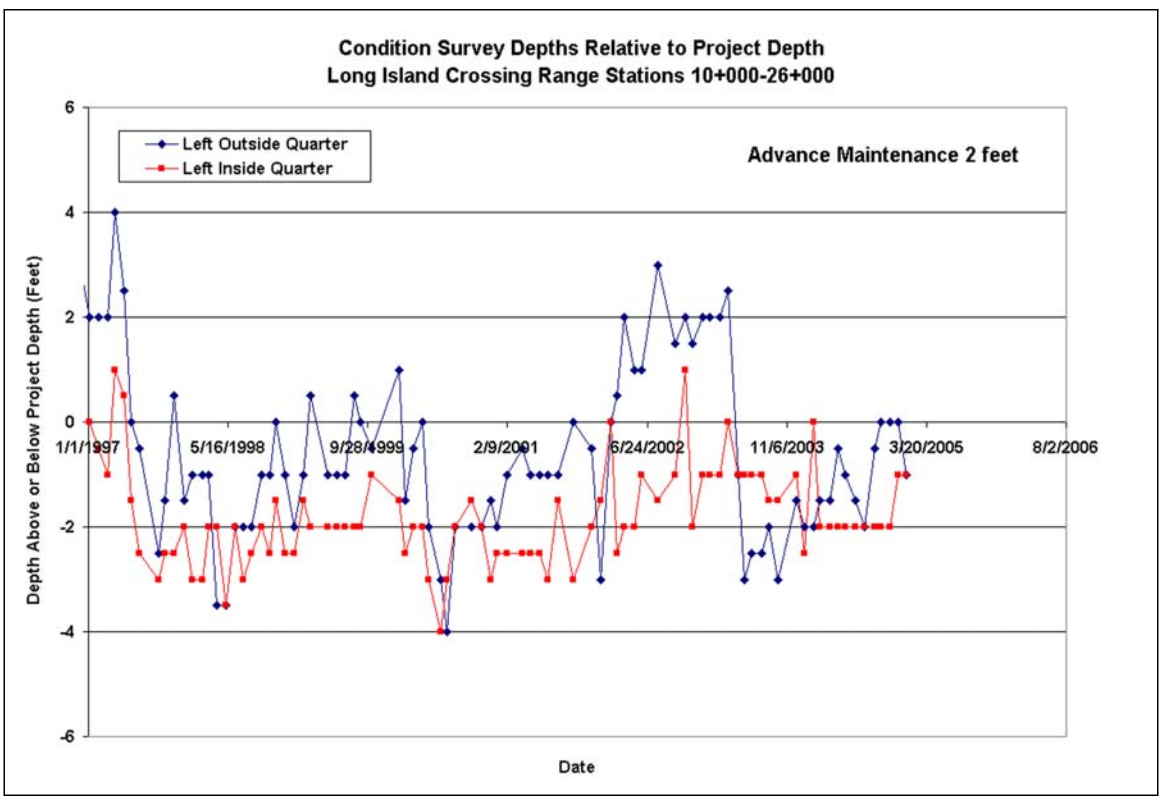

Figure 7-86 Condition Survey Left Quarter Depths, Long Island Crossing Range.

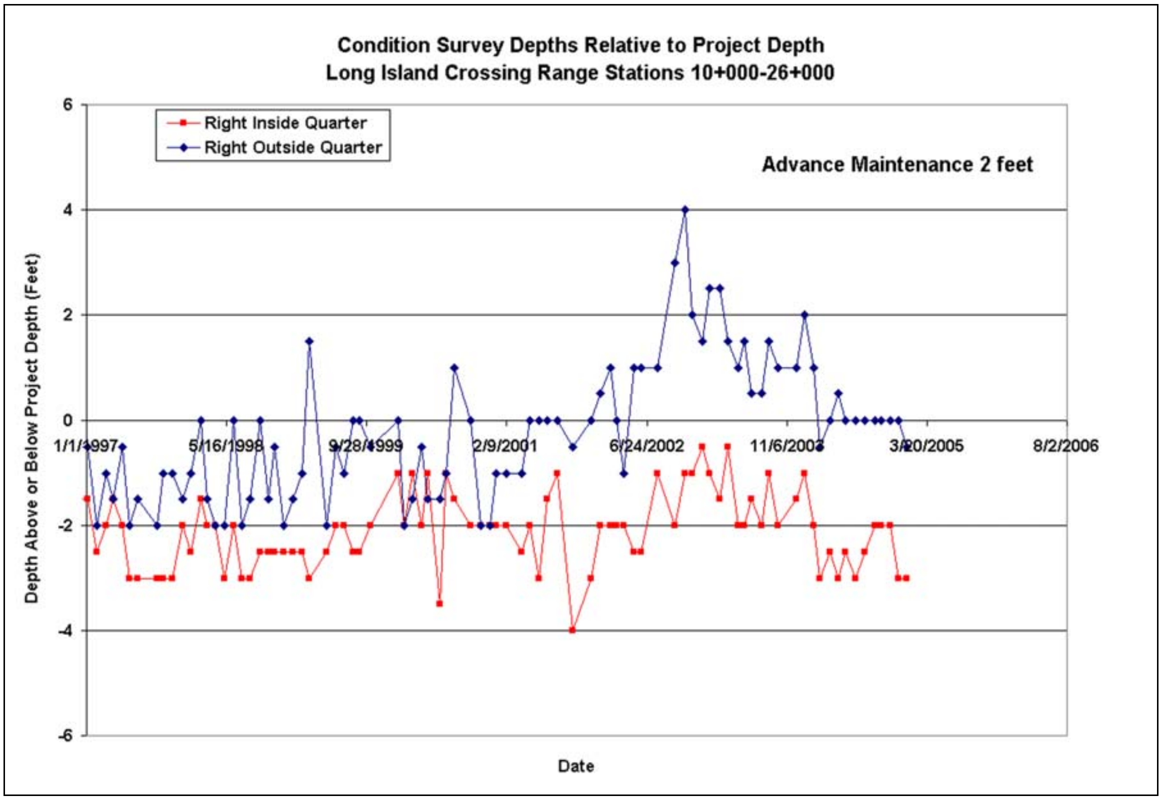

Figure 7-87 Condition Survey Right Quarter Depths, Long Island Crossing Range.

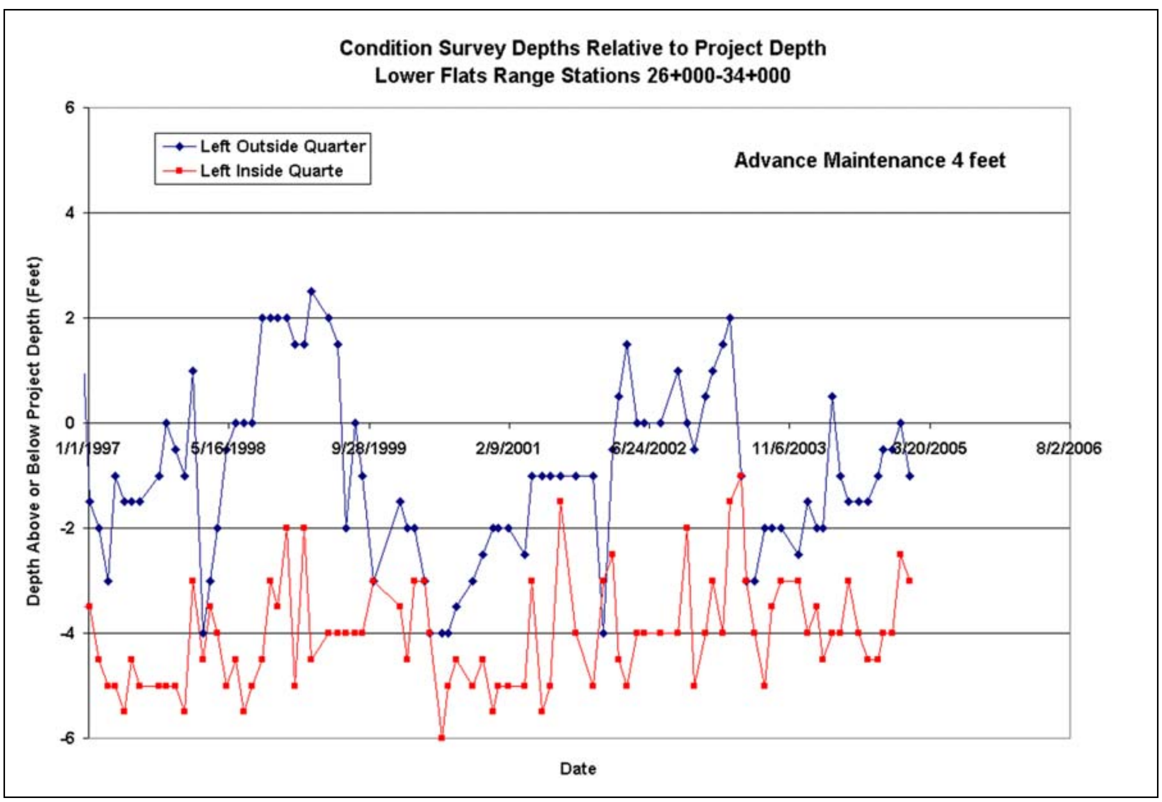

Figure 7-88 Condition Survey Left Quarter Depths, Lower Flats Range.

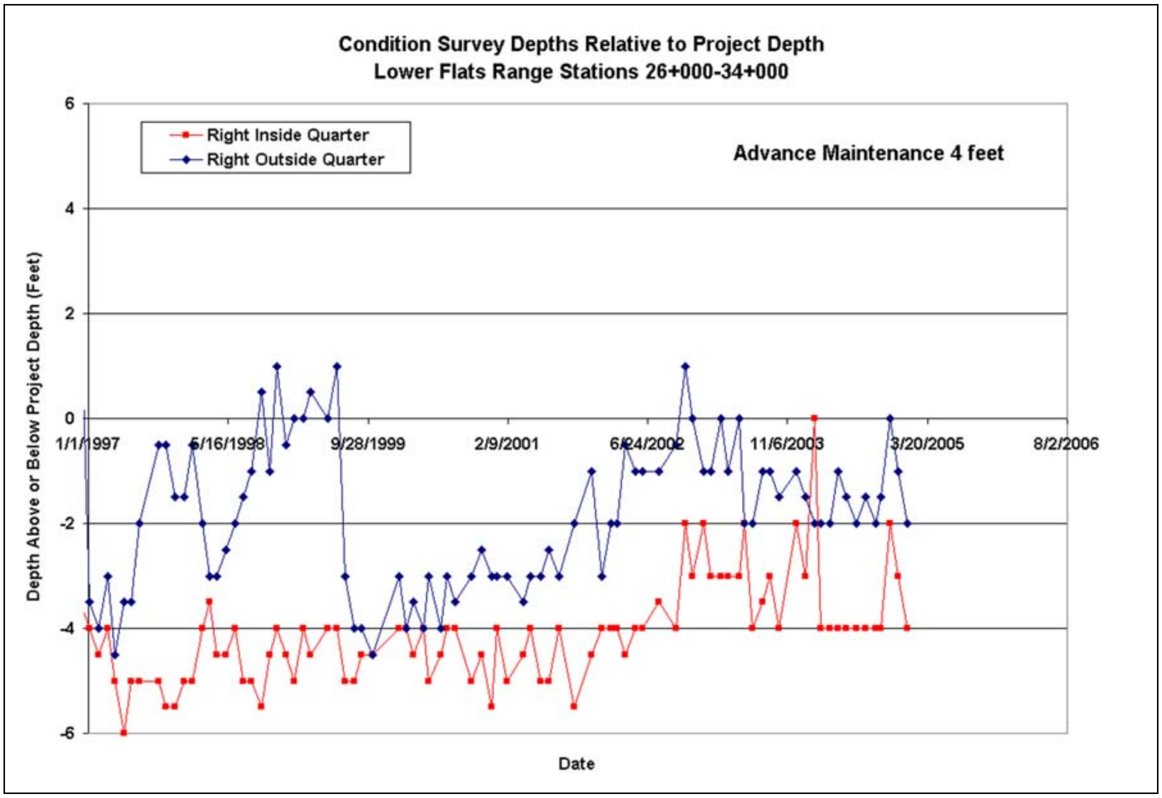

Figure 7-89 Condition Survey Right Quarter Depths, Lower Flats Range.

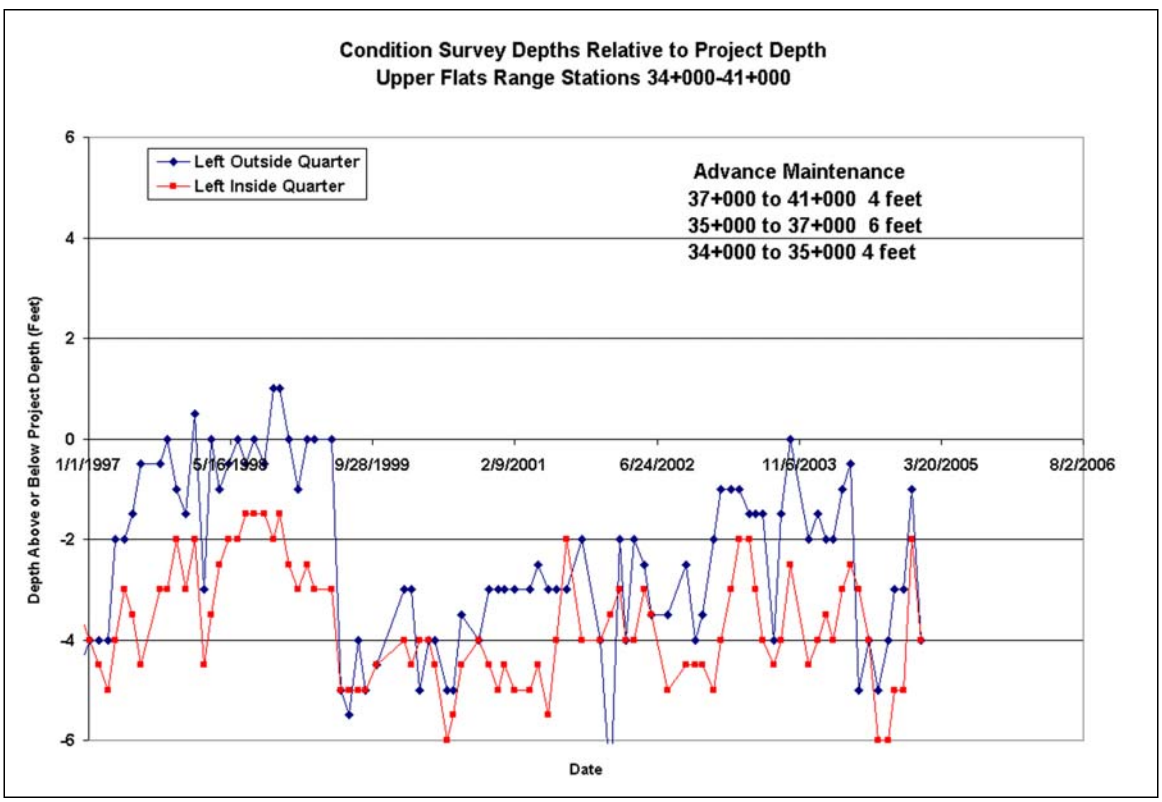

Figure 7-90 Condition Survey Left Quarter Depths, Upper Flats Range.

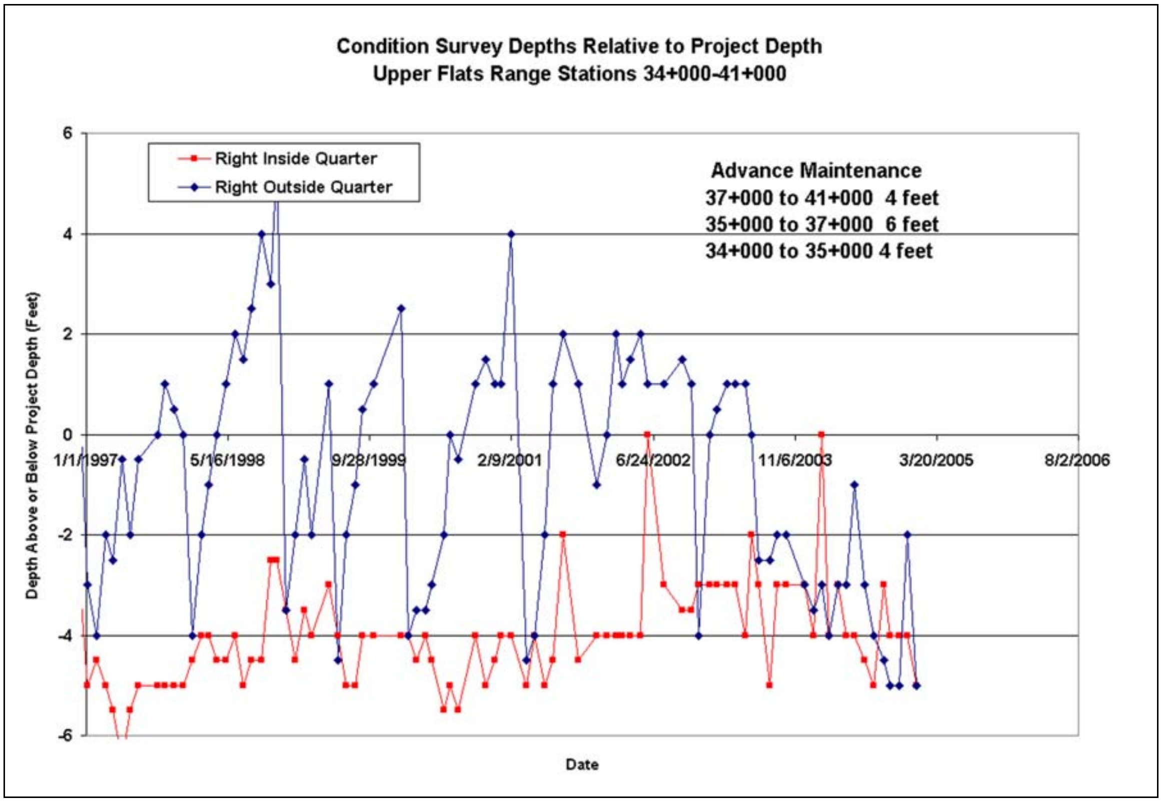

Figure 7-91 Condition Survey Right Quarter Depths, Upper Flats Range.

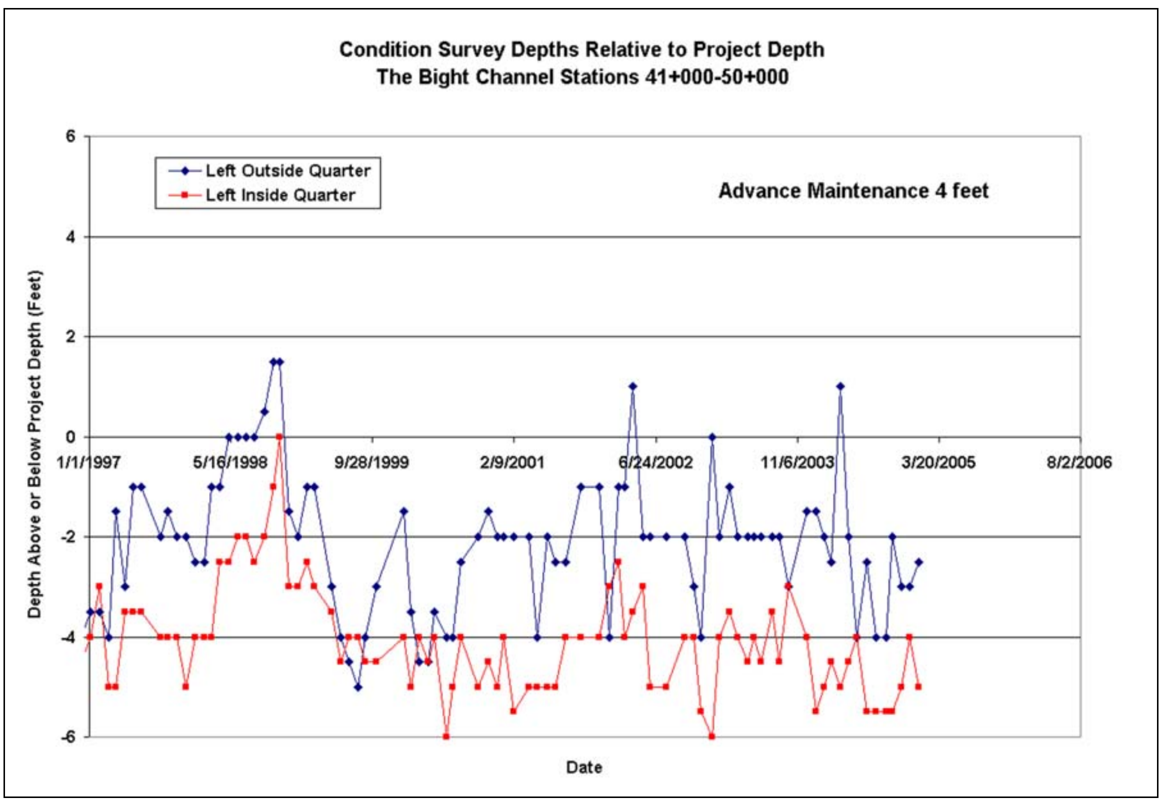

Figure 7-92 Condition Survey Left Quarter Depths, The Bight Channel.

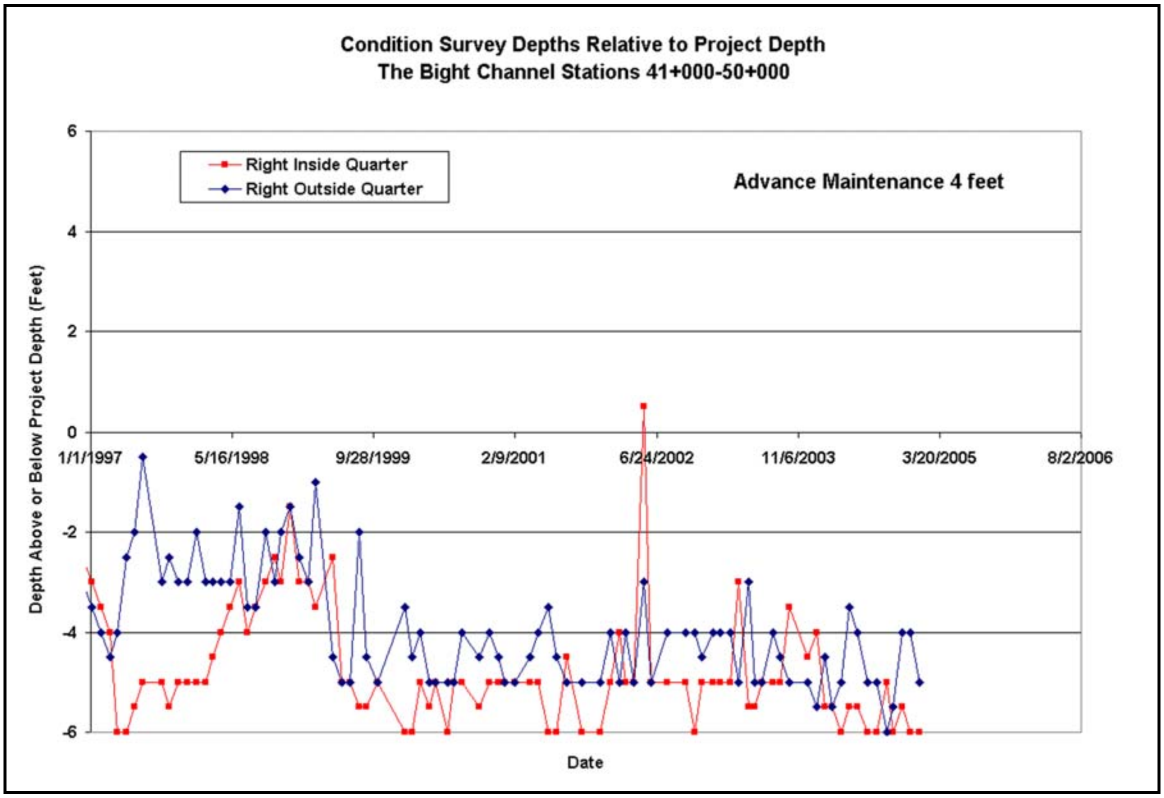

Figure 7-93 Condition Survey Right Quarter Depths, The Bight Channel.

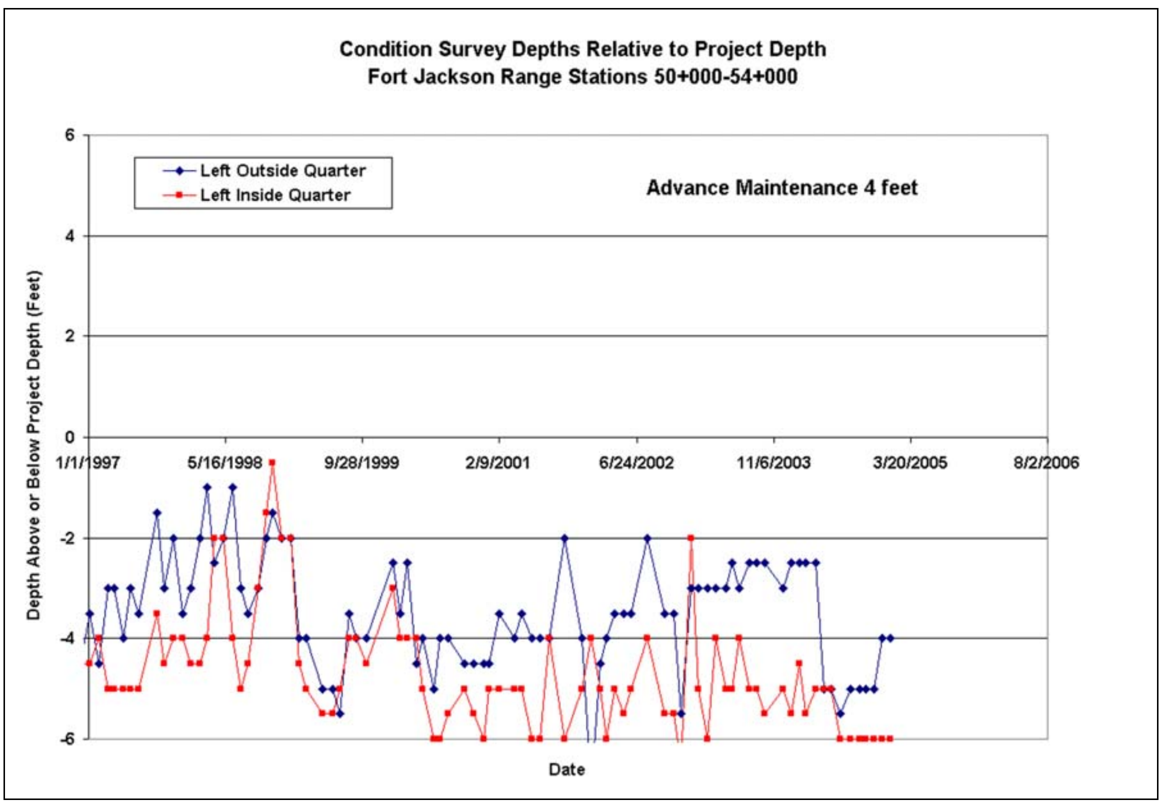

Figure 7-94 Condition Survey Left Quarter Depths, Fort Jackson Range.

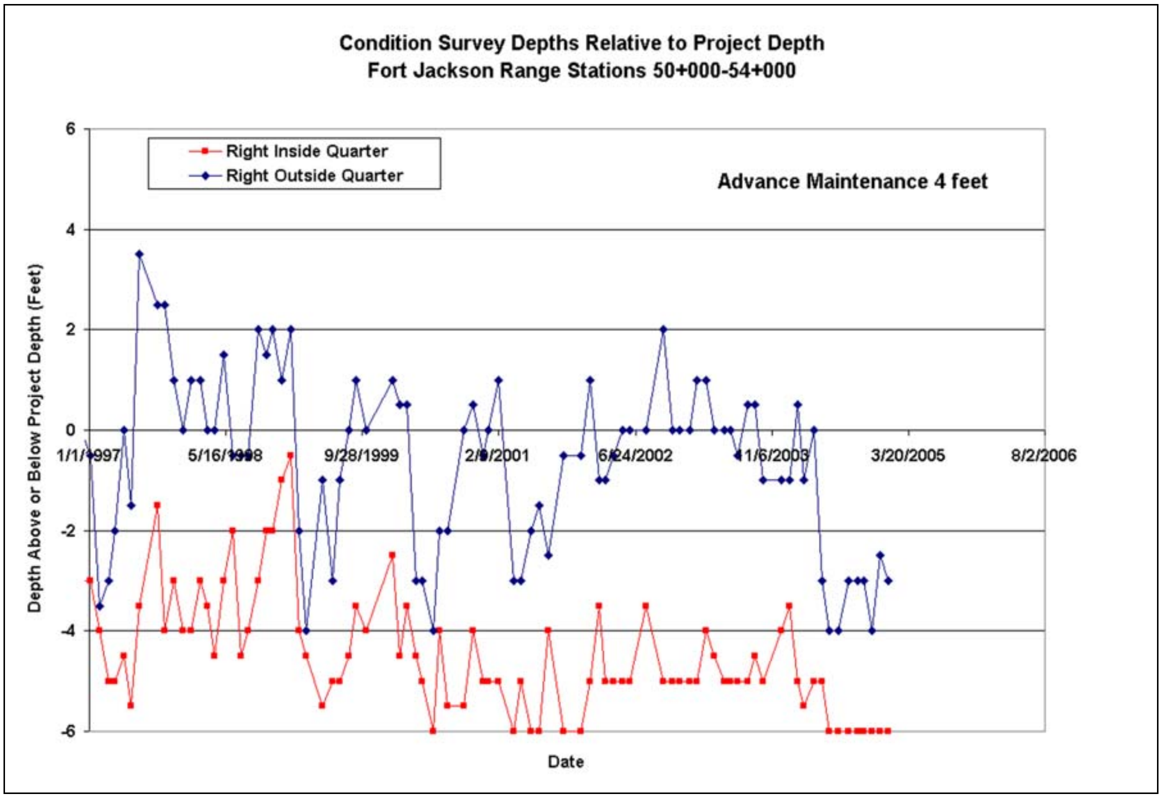

Figure 7-95 Condition Survey Right Quarter Depths, Fort Jackson Range.

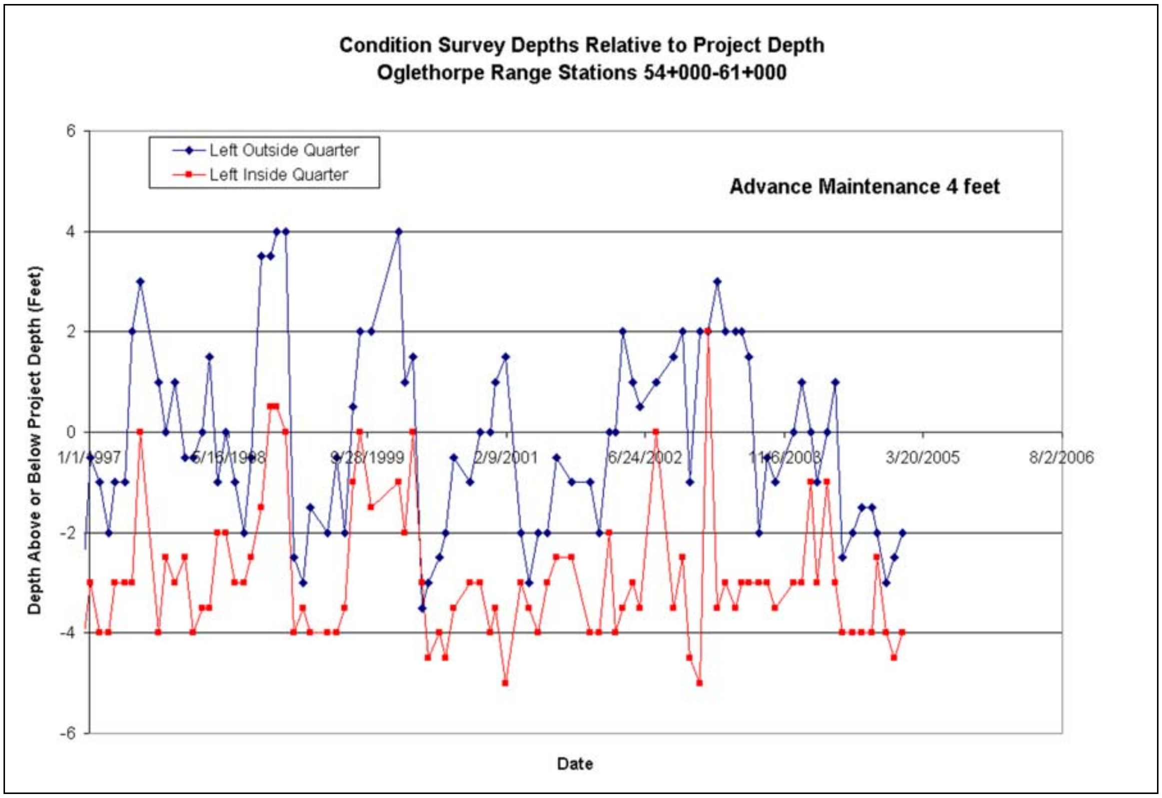

Figure 7-96 Condition Survey Left Quarter Depths, Oglethorpe Range.

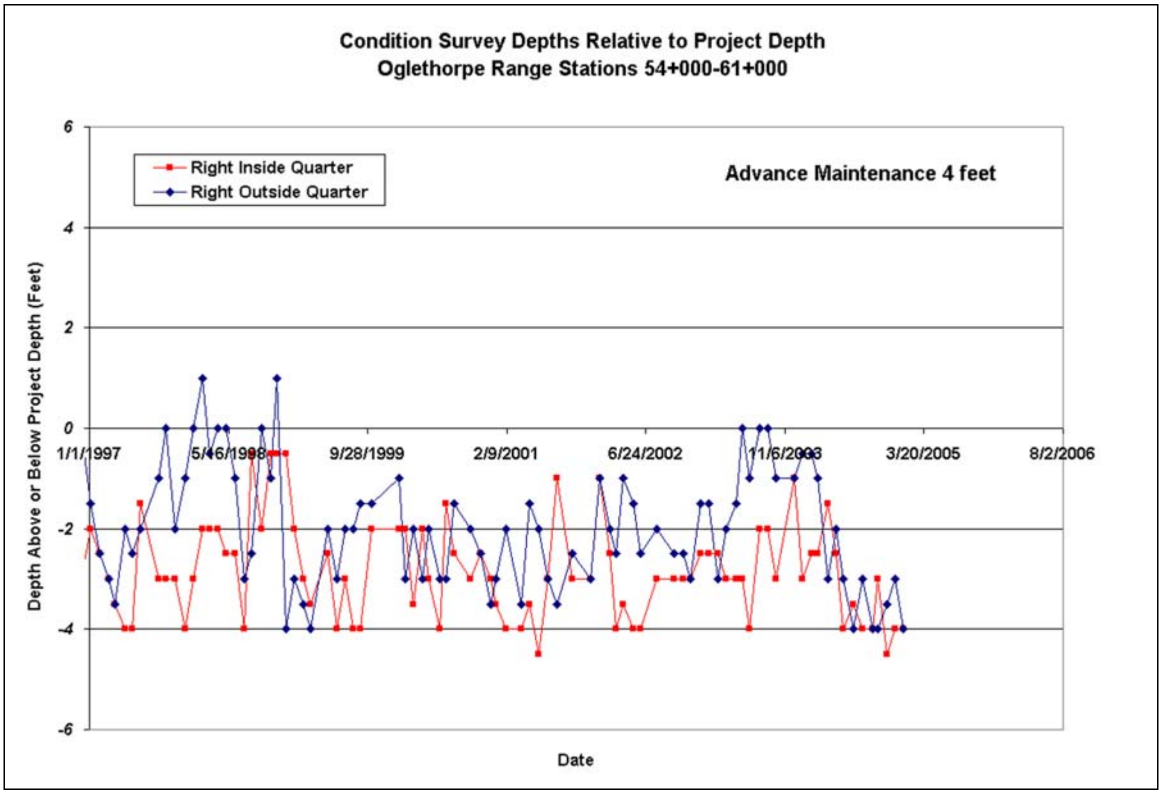

Figure 7-97 Condition Survey Right Quarter Depths, Oglethorpe Range.

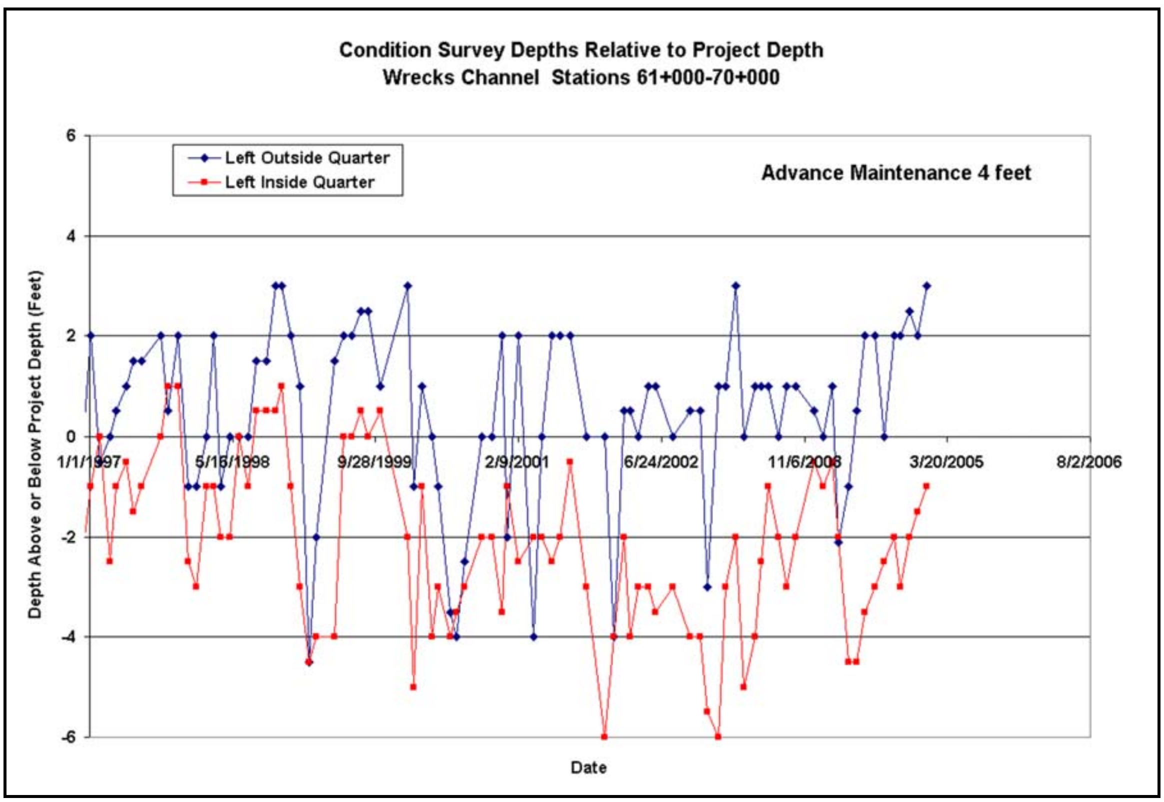

Figure 7-98 Condition Survey Left Quarter Depths, Wrecks Channel.

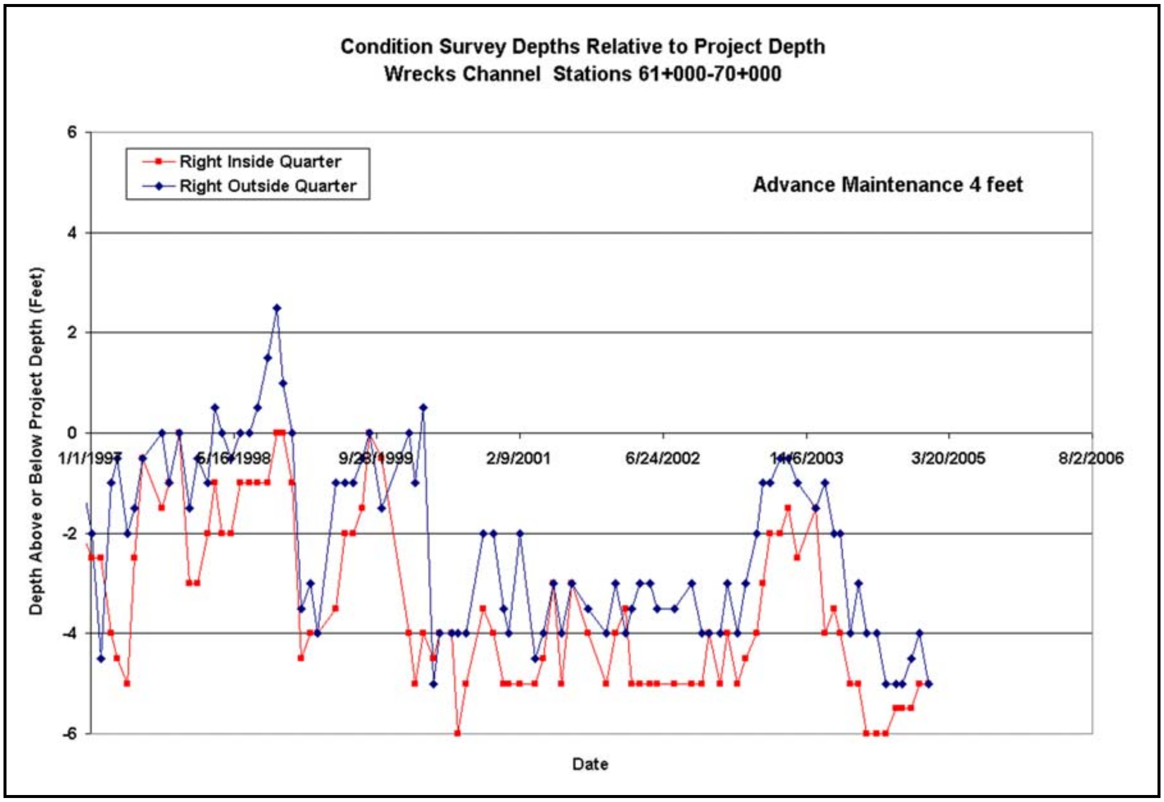

Figure 7-99 Condition Survey Right Quarter Depths, Wrecks Channel.

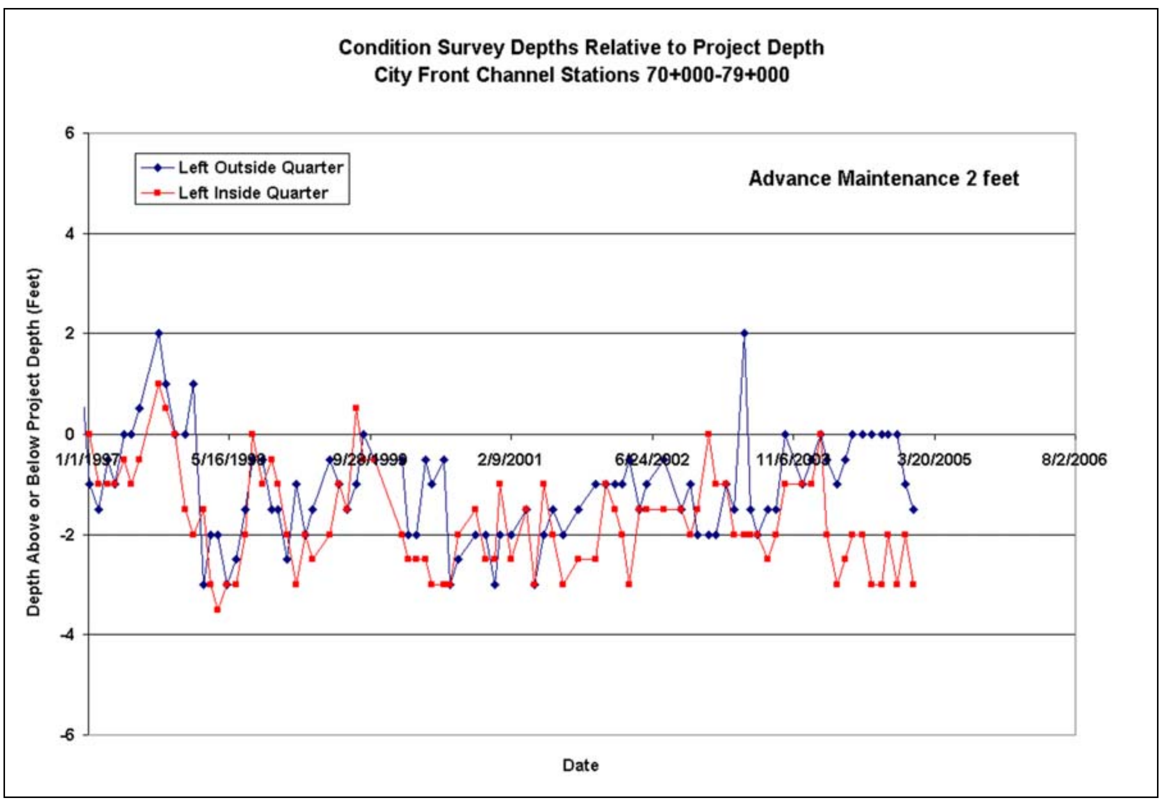

Figure 7-100 Condition Survey Left Quarter Depths, City Front Channel.

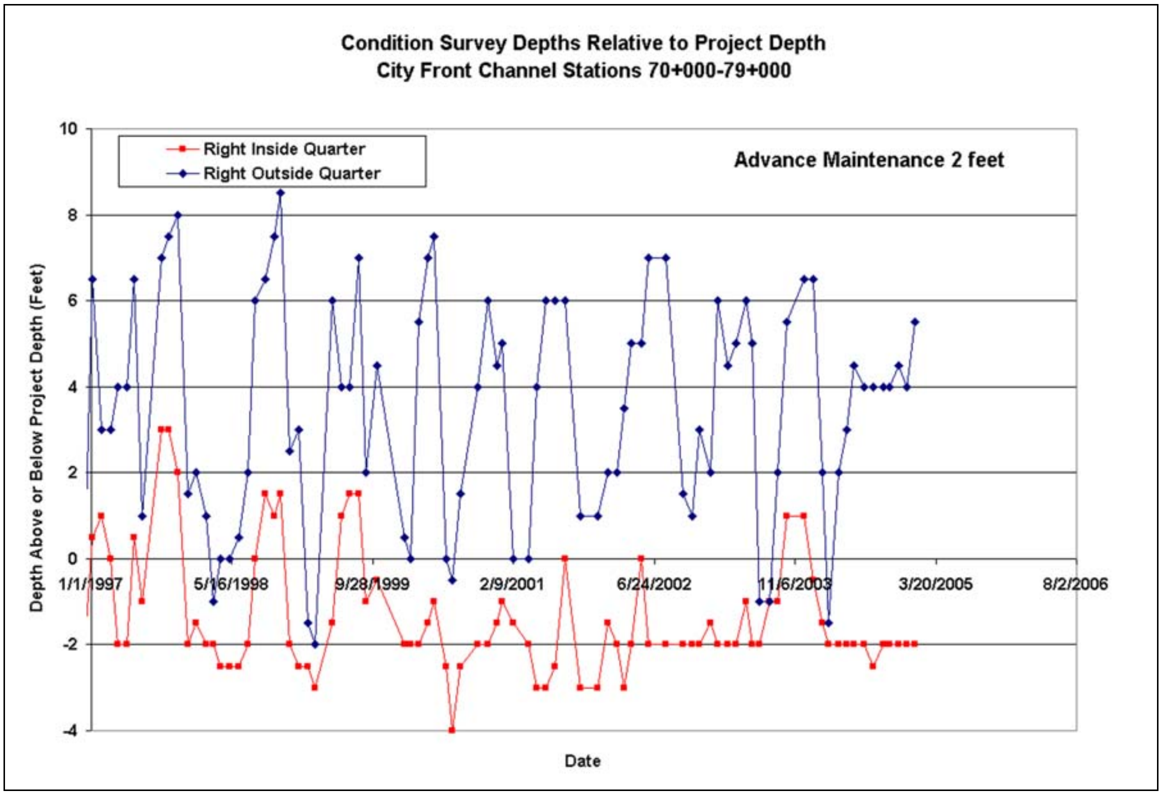

Figure 7-101 Condition Survey Right Quarter Depths, City Front Channel.

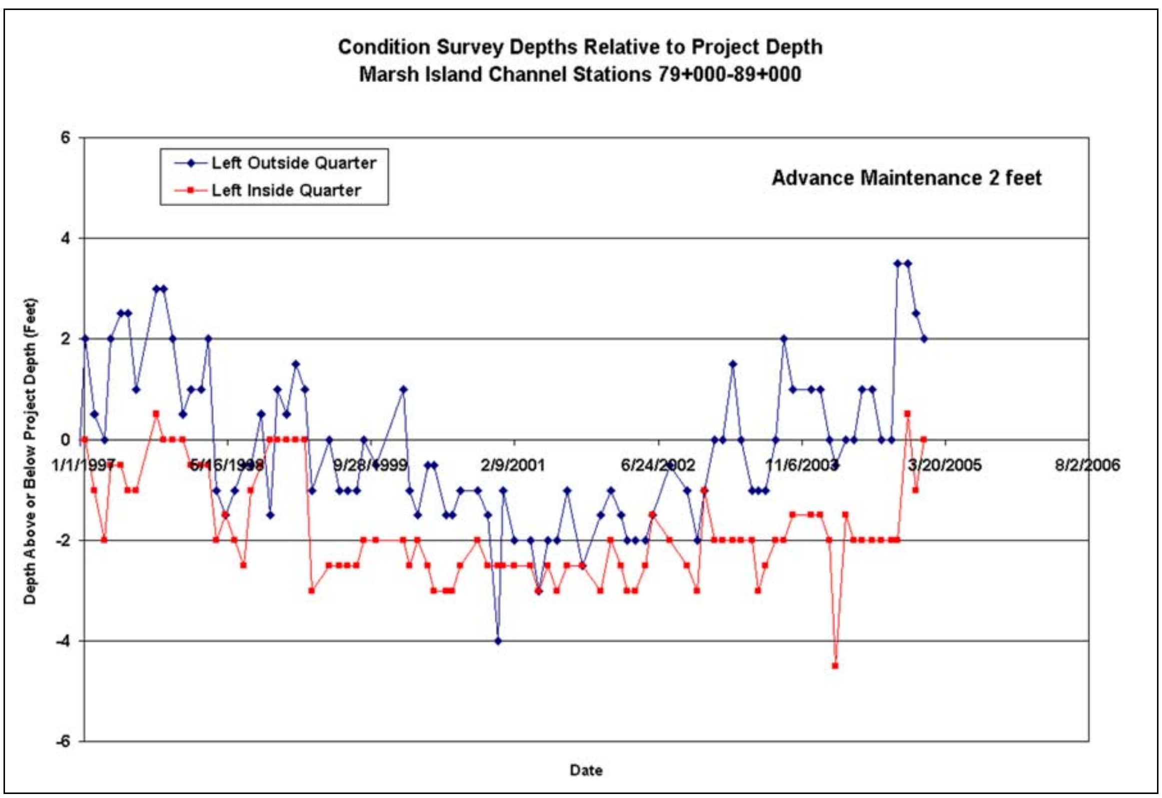

Figure 7-102 Condition Survey Left Quarter Depths, Marsh Island Channel.

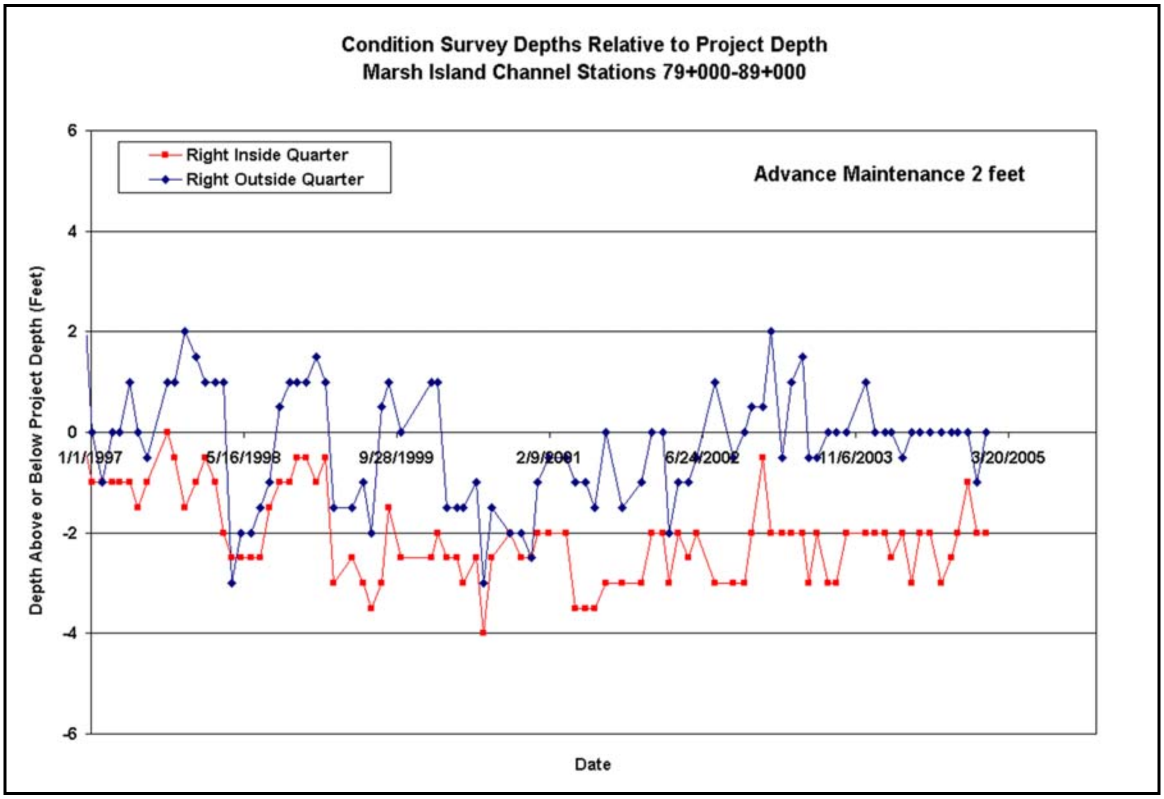

Figure 7-103 Condition Survey Right Quarter Depths, Marsh Island Channel.

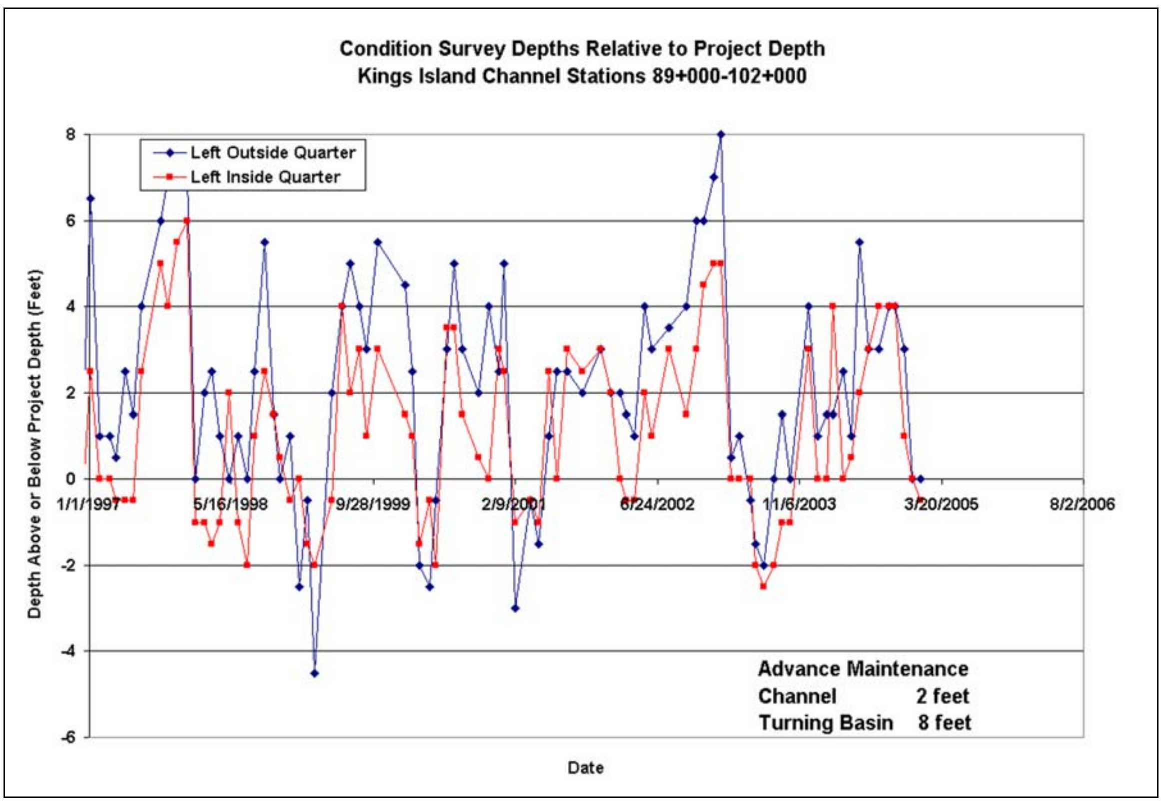

Figure 7-104 Condition Survey Left Quarter Depths, Kings Island Channel.

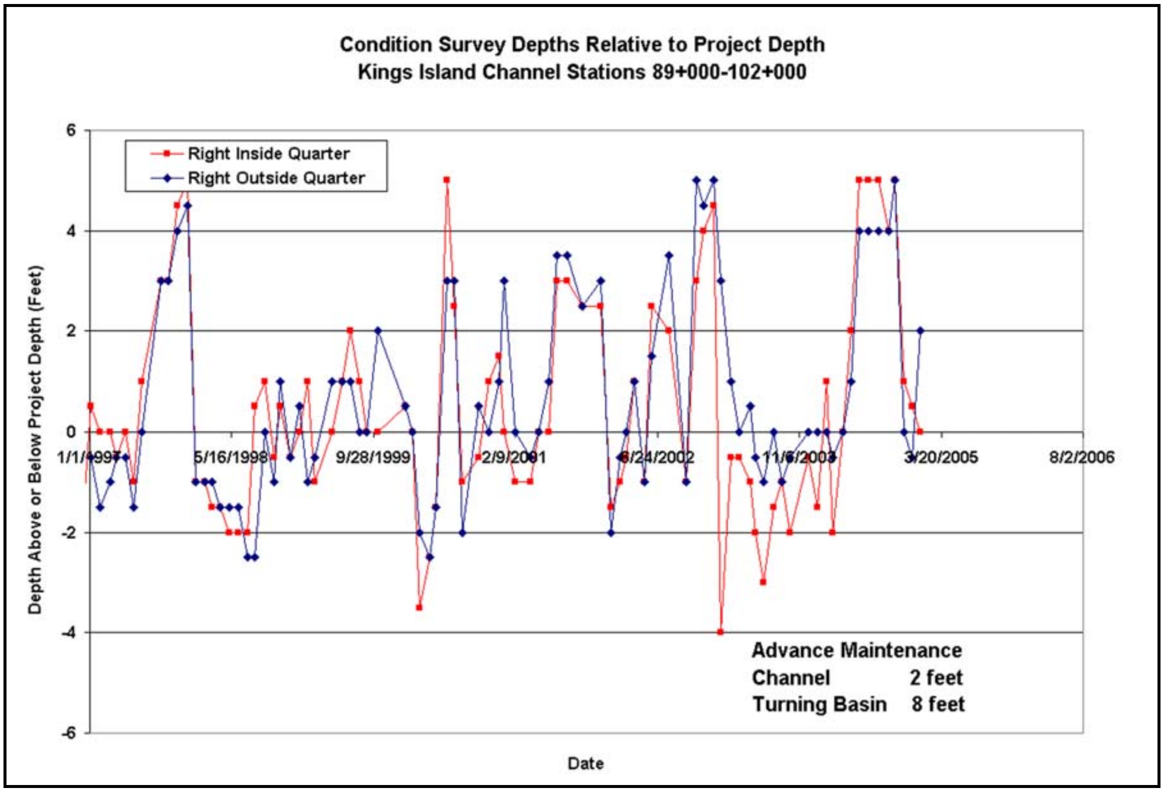

Figure 7-105 Condition Survey Right Quarter Depths, Kings Island Channel.

7.2.4.2 Advance Maintenance After Deepening Without Maintaining the Sediment Basin.

As discussed in 7.2.3.1.7 Discontinued Use of the Sediment Basin, a mitigation feature under consideration is to discontinue dredging the sediment basin which will reduce the amount of salinity moving up back river. If the use of the sediment basin is discontinued, the sediment that is annually trapped in the sediment basin will begin to settle in the river channel in a pattern similar to that which occurred before the construction of the sediment basin. The river channel shoaling distributions, before and after construction of the sediment basin, are plotted in Figure 7-66b. A tabular form of the predicted without and with sediment basin distributions, at 1,000 foot intervals, are contained in Table 15a. The shoaling increases in Table 15a are graphically displayed in Figure 7-108.

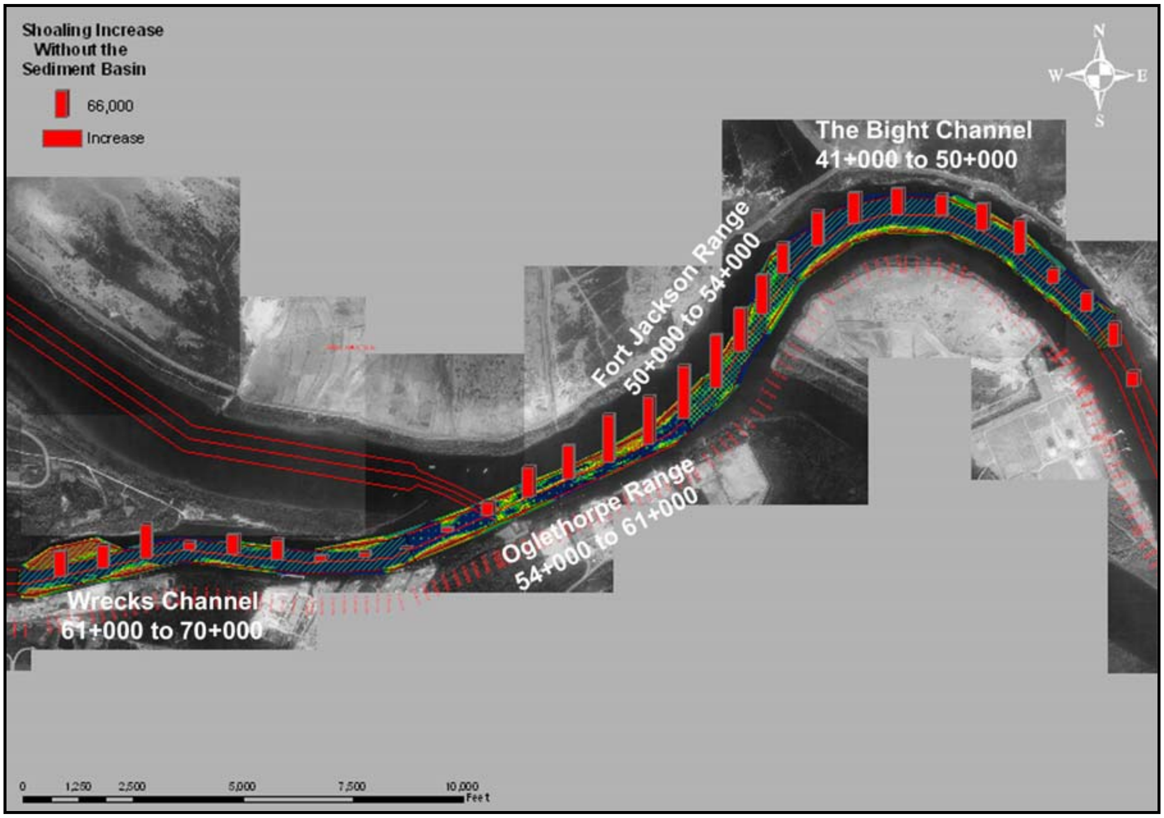

Figure 7-106 Channel Shoaling Increases Due to Discontinued Use of the Sediment Basin.

Two assumption made in this analysis are (1.) As stated in section 7.2.3.1.5, the shoaling volume and distribution is not predicted to change with the increase in channel depth. This analysis of advance maintenance requirements due to the discontinued use of the sediment basin is made relative to the project depth and applies to all the alternatives. (2.) The existing difference between advance maintenance depth and project depth will be maintained for the new project depth.

In order to evaluate the effect of the increased navigation channel shoaling on the existing advanced maintenance procedures, the shoaling volume increases need to be converted into shoal thickness. Before dredging shoal cross sections from the year 2003 were used as templates. (Examination of Figures 7-94 to 7-101 indicated that the year 2003 was not unusual.) The shoal thicknesses were non-uniformly increased. The shoal thickness increases were based on weighting factors determined by the existing shoal thickness. That is, the thicker part of the shoal was increased more than the thinner part of the shoal (Figure 7-109.) After the shoal thicknesses were increased, the volumes from the inflated cross sections were calculated. The volumes from the cross sections, which were 250 feet apart, were summed and compared to the predicted volumes for the 1,000 foot intervals from Table 7-15a. The shoal thicknesses were adjusted based on the volume comparisons. A trial and error procedure was performed until the shoaling distribution calculated from the inflated shoals matched the predicted shoaling distribution to within 0.1 %. (Table 7-109.)

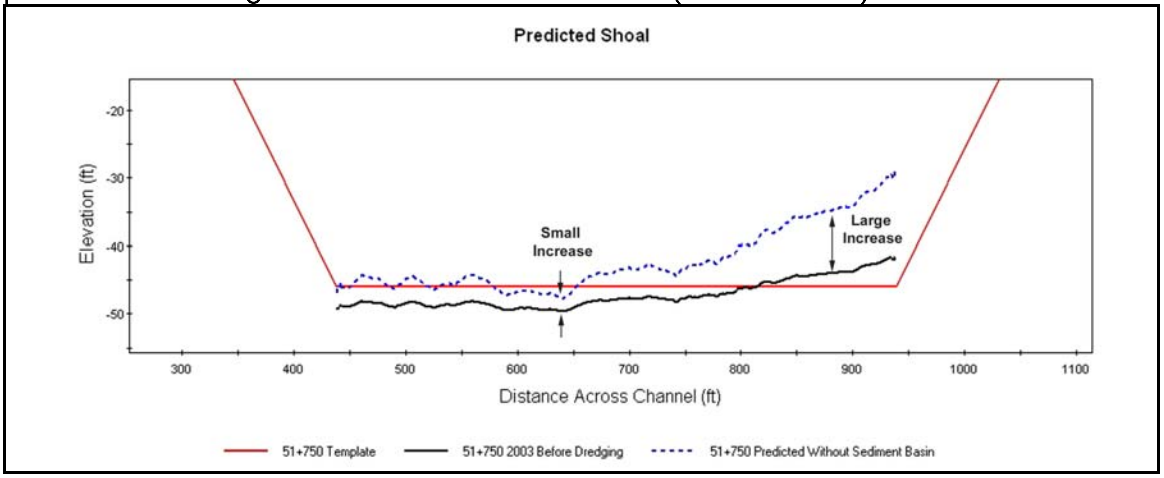

Figure 7-107 Shoal Inflation.

Station	Predicted Increase CYDs	Inflated Shoal Increase CYDs
40+000	35,619	35,619
41+000	57,600	57,600
42+000	46,286	46,286
43+000	35,207	35,173
44+000	82,984	83,026
45+000	66,161	66,147
46+000	51,127	51,127
47+000	64,001	64,001
48+000	74,293	74,293
49+000	85,123	85,123
50+000	75,550	75,550
51+000	95,635	95,635
52+000	106,525	106,525
53+000	131,973	131,973
54+000	128,412	128,412
55+000	113,741	113,741
56+000	113,854	113,854
57+000	83,886	83,886
58+000	75,030	75,030
59+000	32,483	32,483
60+000	10,457	10,457
61+000	0	1,929
62+000	9,933	9,934
63+000	12,908	12,902
64+000	48,429	48,438
65+000	49,366	49,491
66+000	18,948	18,326
67+000	82,336	80,778
68+000	55,387	56,707
69+000	62,746	62,746

Table 7-19 Inflated Shoal Volumes.

A surface of the predicted shoal increase above project depth is shown in Figures 7-110 to 7-113.

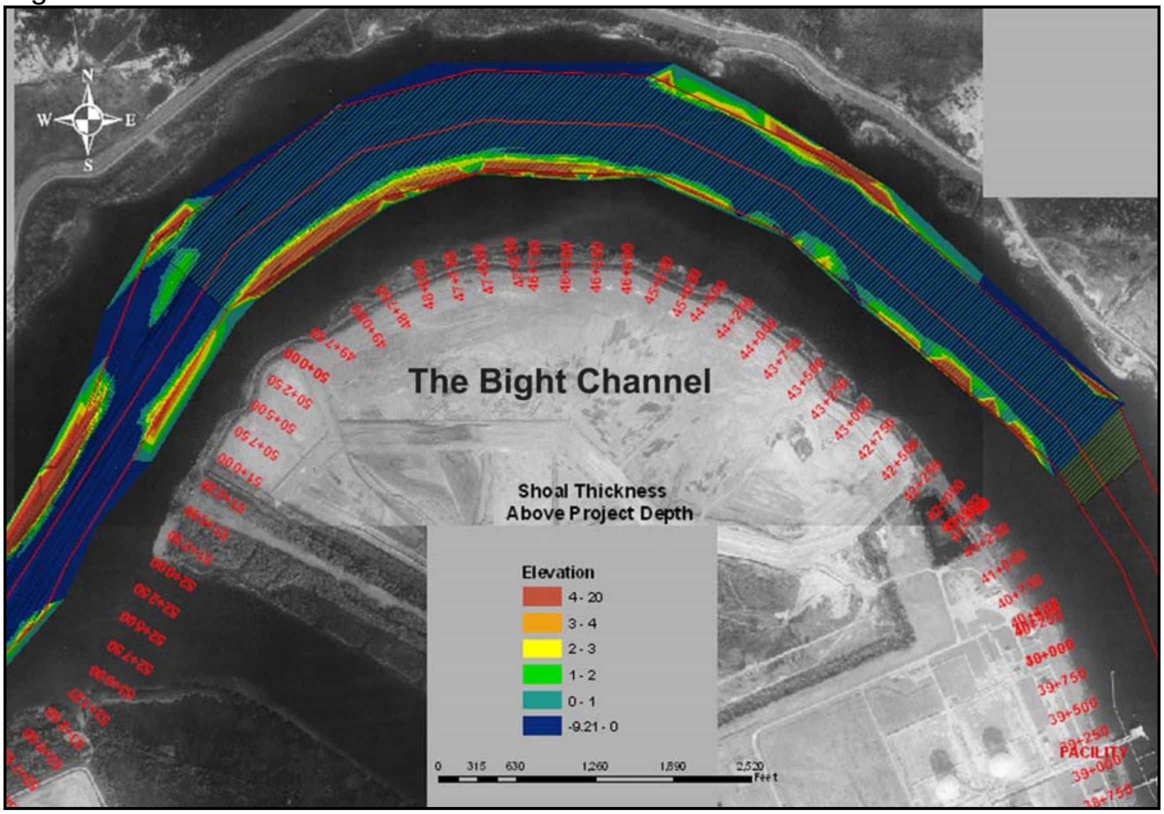

Figure 7-108 The Bight Channel Predicted Shoal Thickness Above Project Depth.

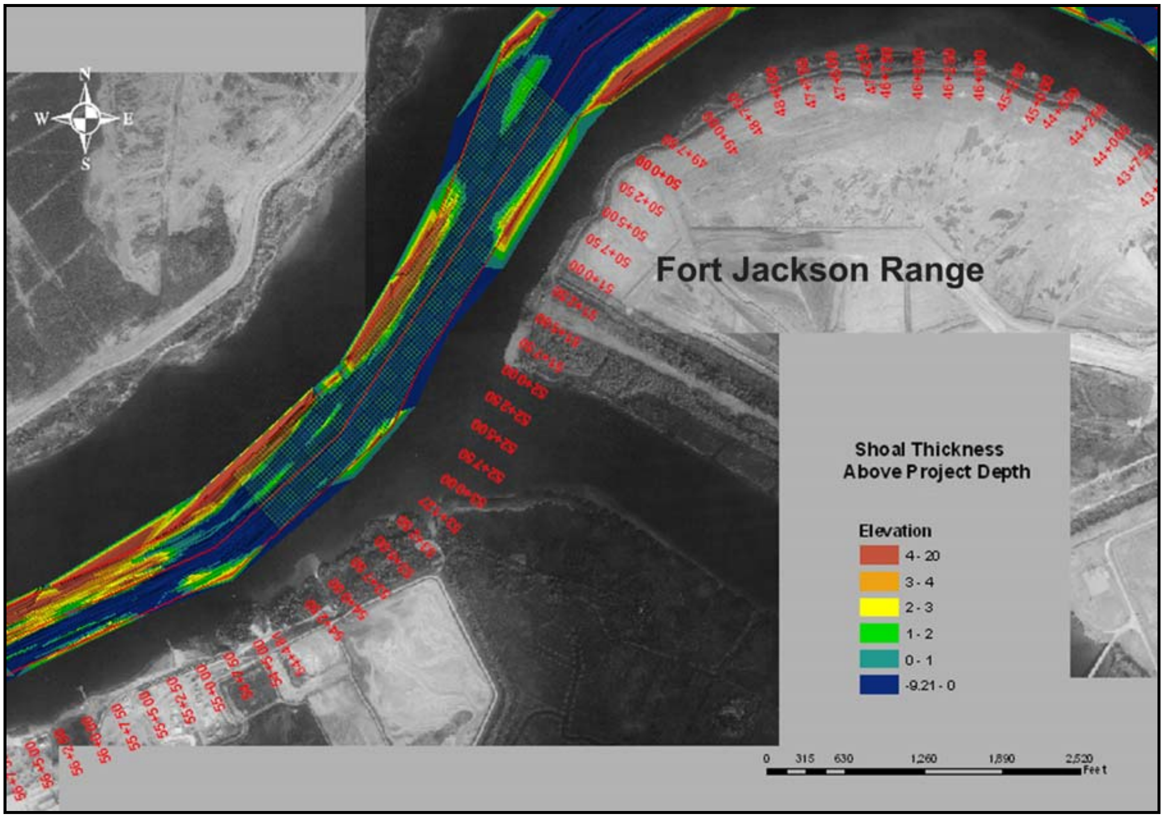

Figure 7-109 Fort Jackson Range Predicted Shoal Thickness Above Project Depth.

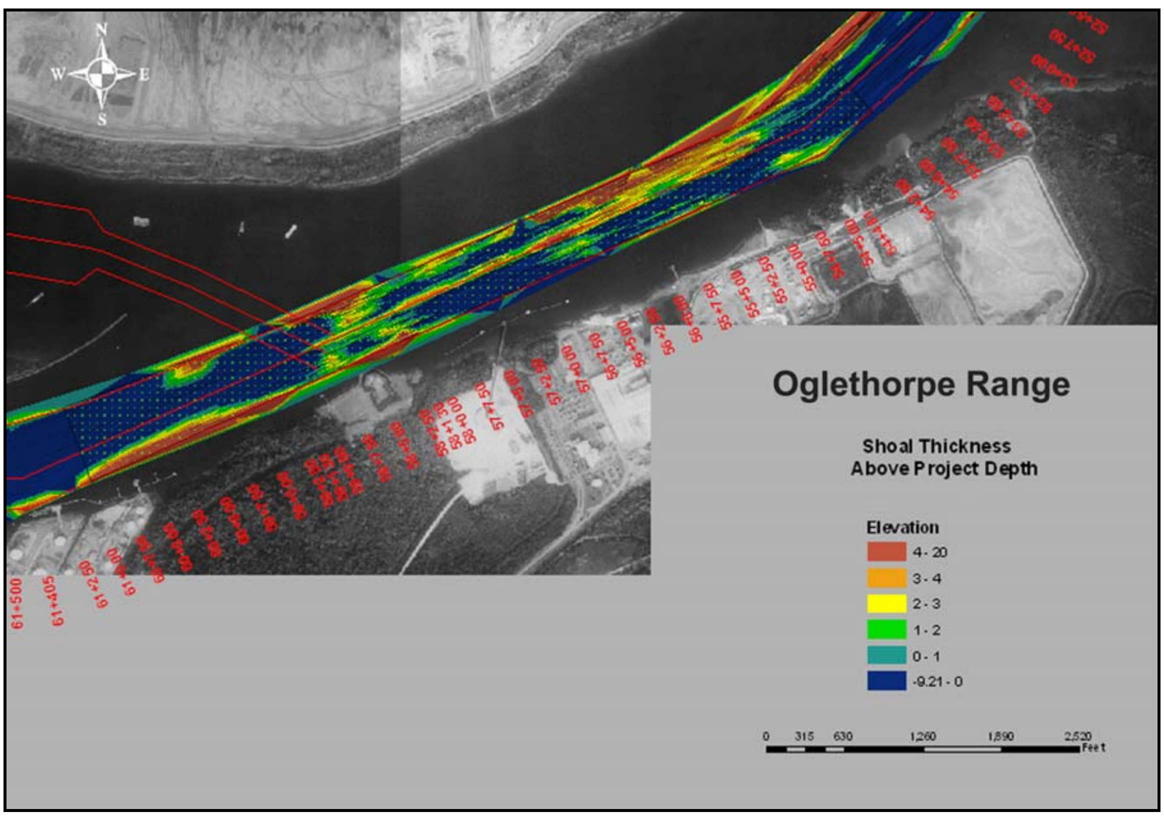

Figure 7-110 Oglethorpe Range Predicted Shoal Thickness Above Project Depth.

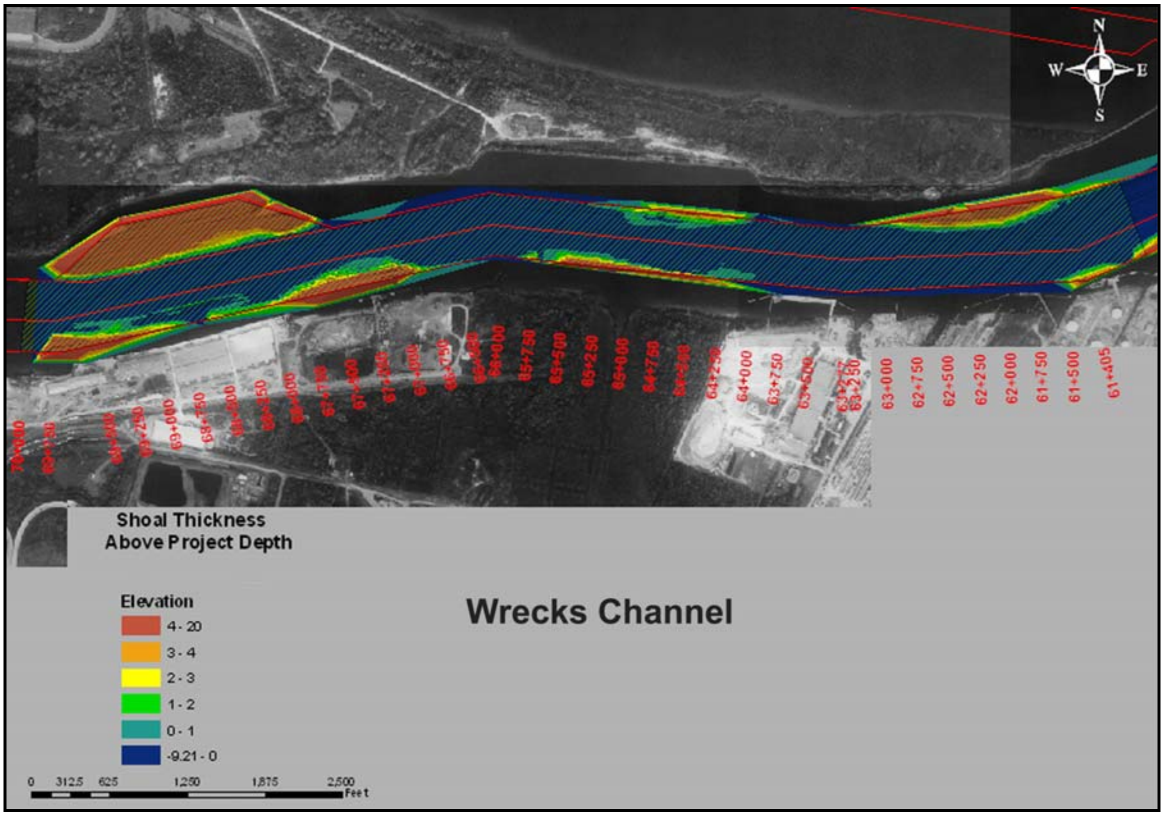

Figure 7-111 Wrecks Channel Predicted Shoal Thickness Above Project Depth.

Monthly channel condition reports identify the minimum depth along the centerline of the channel quadrants for all of the harbor's ranges. The channel condition reports were use to generate Figures 7-78 to 7-108, which express the shoal thickness above project depth for each channel quadrant. The predicted shoal increases alone the centerline of each of the channel quadrant for the stations in the ranges from the Bight Channel to Wrecks Channel was identified and listed in Table 7-21.

Station	Left Outside	Left Inside	Right Inside	Right Outside
40000	3.58	1.77	0.84	1.51
41693	3.24	1.46	1.81	2.14
41750	3.22	1.54	1.45	1.91
42000	3.49	1.24	1.29	1.62
42250	4.1	0.92	1.29	1.43
42500	3.83	0.71	1.28	1.46
42750	3.93	1.45	1.26	1.08
43000	1.55	0.72	0.42	0.53
43250	1.47	0.7	0.46	0.7
43500	1.36	0.79	0.28	0.83
43750	1.38	0.79	0.35	0.85
44000	4.61	3.07	1.27	3.28
44250	4.28	3	1.91	3.48
44500	3.29	2.72	2.16	4.23

44611	3.97	2.8	1.48	4.73
44750	3.97	2.2	1.68	4.36
45000	3.48	1.68	1.24	3.43
45250	3.96	2.21	1	1.86
45500	3.65	1.7	1.41	2.66
45750	3.41	2.5	1.41	3.55
45811	3.43	2.01	1.34	3.38
46000	2.19	1.22	0.78	1.99
46250	2.93	1.65	0.88	1.04
46500	2.98	1.58	0.99	0.94
46750	2.68	1.6	1.03	0.98
47000	3.61	1.96	0.75	1.5
47207	3.31	1.72	1.52	1.43
47250	3.37	1.73	1.54	1.4
47500	3.82	2.31	0.75	1.37
47750	4.02	2.42	0.97	1.36
48000	3.99	2.02	0.91	1.85
48222	3.78	1.46	1.13	1.84
48250	3.8	1.49	1.34	1.78
48500	4.04	2.4	1.22	1.73
48750	4.72	2.34	1.12	1.77
49000	5.41	2.6	1.12	1.91
49250	5.21	2.23	1.48	2.02
49489	4.58	1.19	2.29	2.57
49500	4.59	1.16	1.98	2.99
49750	3.2	0.97	3.63	3.41
50000	2.49	1.15	3.95	3.17
50250	3.33	1.35	4.35	2.16
50500	3.55	1.77	2.91	1.57
50750	3.91	1.64	2.26	2.37
51000	6.42	4.23	3.37	5.73
51250	4.09	4.49	3.18	8.46
51500	5.44	3.91	3.69	8.03
51750	3.53	2.28	4.46	9.12
52000	3.33	2.17	4.46	10.24
52250	3.44	2.44	5.04	9.8
52500	4.2	3.65	4.43	8.24
52750	4.86	5.06	3.17	5.79
53000	6.9	5.03	6.7	4.88
53127	5.79	3.94	7.51	6.1
53250	4.33	4.29	7.09	6.53
53500	4.78	3.56	4.27	9.89
53750	4.08	3.17	4.89	10.2
54000	3.27	3.71	6.05	9.04
54250	4.23	3.56	5.34	8.72
54481	6.92	3.63	5.94	7.67
54500	6.97	4.13	6.15	8.28
54750	7.28	3.03	6.19	6.75
55000	5.29	3.37	7.04	6.67
55250	4.84	2.98	6.6	7.21

55500	4.69	3.38	6.45	7.53
55750	4	3.09	6.01	8.45
56000	3.46	4.05	7.09	9.25
56250	4.36	4.87	7.81	8.76
56500	6.74	5.52	5.93	7.37
56750	3.22	6.09	5.96	9.36
57000	3.74	3.77	5.15	6.7
57250	3.5	3.83	5.94	5.99
57500	4.35	2.56	4.95	4.92
57750	3.77	2.64	4.47	5.54
58000	3.19	4.86	4.25	4.92
58130	5.96	3.8	3.07	4.13
58250	3.87	4.08	3.83	4.35
58500	3.48	3.35	5.05	5.72
58750	4.91	4.29	2.52	3.03
59000	2.26	1.45	2.19	1.95
59130	1.63	1.24	1.56	2.36
59250	2	1.21	1.41	2.15
59500	2.43	1.33	1.05	1.79
59750	2.47	1.29	1.25	2.73
60000	0.97	0.33	0.34	0.74
60250	1.15	0.46	0.57	0.24
60500	1.22	0.41	0.27	0.29
60750	1.24	0.3	0.36	0.42
61000	0	0	0	0
61250	0	0	0	0
61405	0	0	0	0
61500	0	0	0	0
61750	0	0	0	0
62000	0.22	0.15	0.42	1.03
62250	0.29	0.18	0.43	0.98
62500	0.2	0.23	0.39	1.07
62750	0.24	0.31	0.37	0.92
63000	0.26	0.22	0.38	0.55
63250	0.29	0.29	0.38	0.44
63277	0.29	0.29	0.38	0.45
63500	0.26	0.25	0.36	0.48
63750	0.35	0.3	0.29	0.36
64000	3.31	2.59	1.65	2.2
64250	2.85	2.04	1.35	2.97
64500	2.1	1.87	2.04	3.58
64750	2.57	1.9	1.93	2.43
65000	3.13	2.08	2.72	3.55
65250	4.52	2.46	2.76	2.38
65500	5.02	1.98	2.37	3.08
65750	4.59	2.99	2.34	2.23
66000	0.44	0.35	0.16	0.3
66136	0.36	0.32	0.17	0.33
66250	0.33	0.3	0.25	0.34
66500	0.46	0.28	0.23	0.19

66750	0.58	0.29	0.23	0.25
67000	7.23	3.79	3.53	2.09
67250	7.45	4.61	3.63	2.67
67500	8.41	3.99	2.47	2.72
67750	5.34	3	2.06	1.43
68000	1.17	0.49	0.62	0.72
68250	1.24	0.52	0.44	0.55
68500	1.41	0.45	0.79	1.02
68750	0.96	0.84	0.6	0.73
69000	1.62	1.28	0.81	1.34
69250	2.1	1.79	0.66	1.58
69500	3.45	2.25	0.8	1.87
69734	5.25	2.14	0.69	1.78
69750	5.4	2.23	0.68	1.79

Table 7-20 Predicted Shoaling Increase in Feet Along the Channel Quadrants.

The maximum shoal increases along the centerline of each quadrant for each reach was identified and are listed in Table 7-22.

	Left Outside Quadrant	Left Inside Quadrant	Right Inside Quadrant	Right Outside Quadrant
The Bight Channel 41+000 to 50+000	5.41	3.08	3.63	4.74
Ft Jackson Range 50+00 to 54+000	6.9	5.06	7.51	10.24
Oglethorpe Range 54+000 to 61+000	7.28	6.09	7.81	9.36
Wrecks Channel 61+000 to 70+000	8.41	4.61	3.63	3.58

Table7-21 Maximum Shoal Increases in Feet along the Centerline of Each Channel Quadrant.

The historic monthly channel condition report data was increased by the maximum shoal increases in Table 7-22 and the results are contained in Figures 7-114 to 7-121.

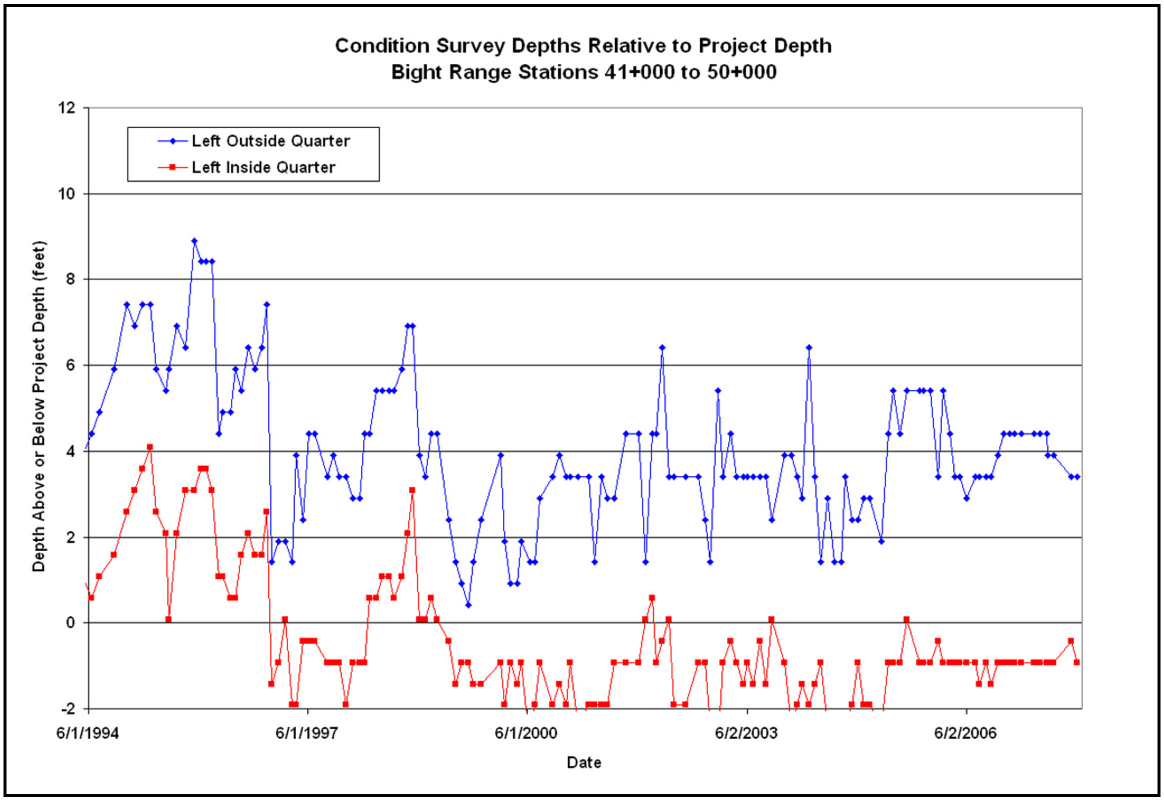

Figure 7-112 Predicted Channel Condition Depths for the Left Bight Range.

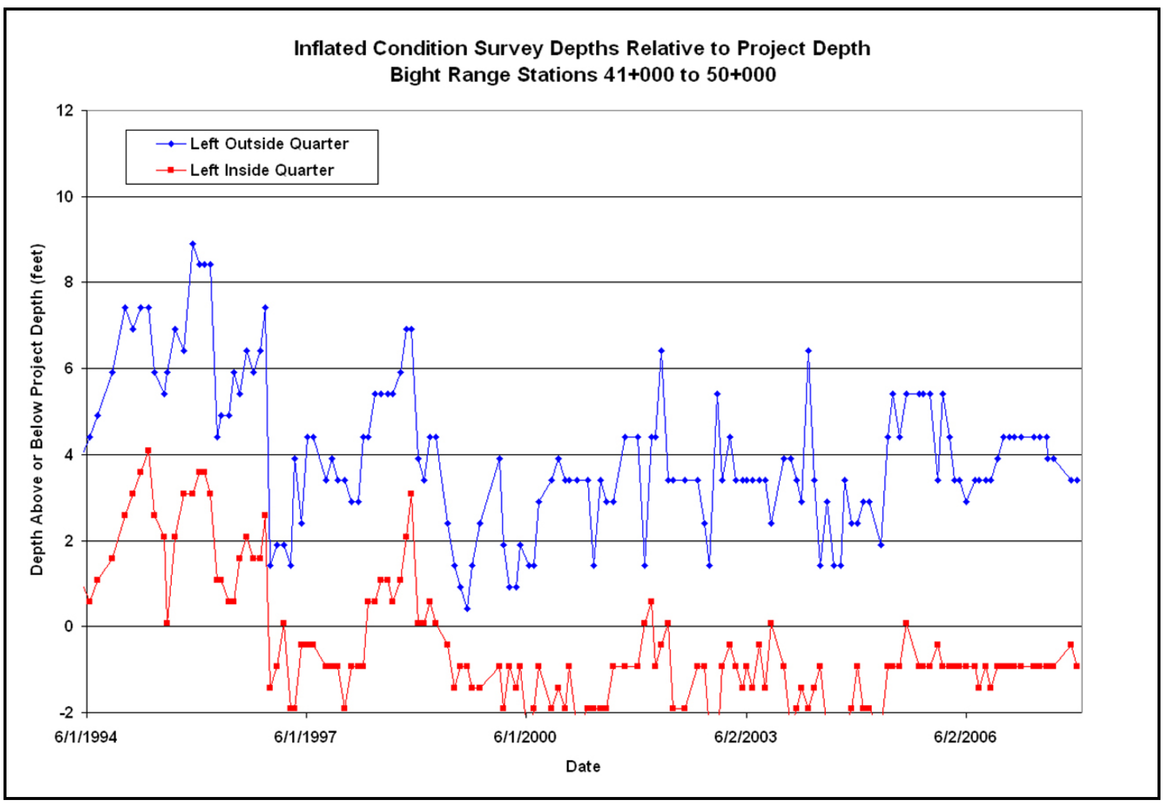

Figure 7-113 Predicted Channel Condition Depths for the Right Bight Range.

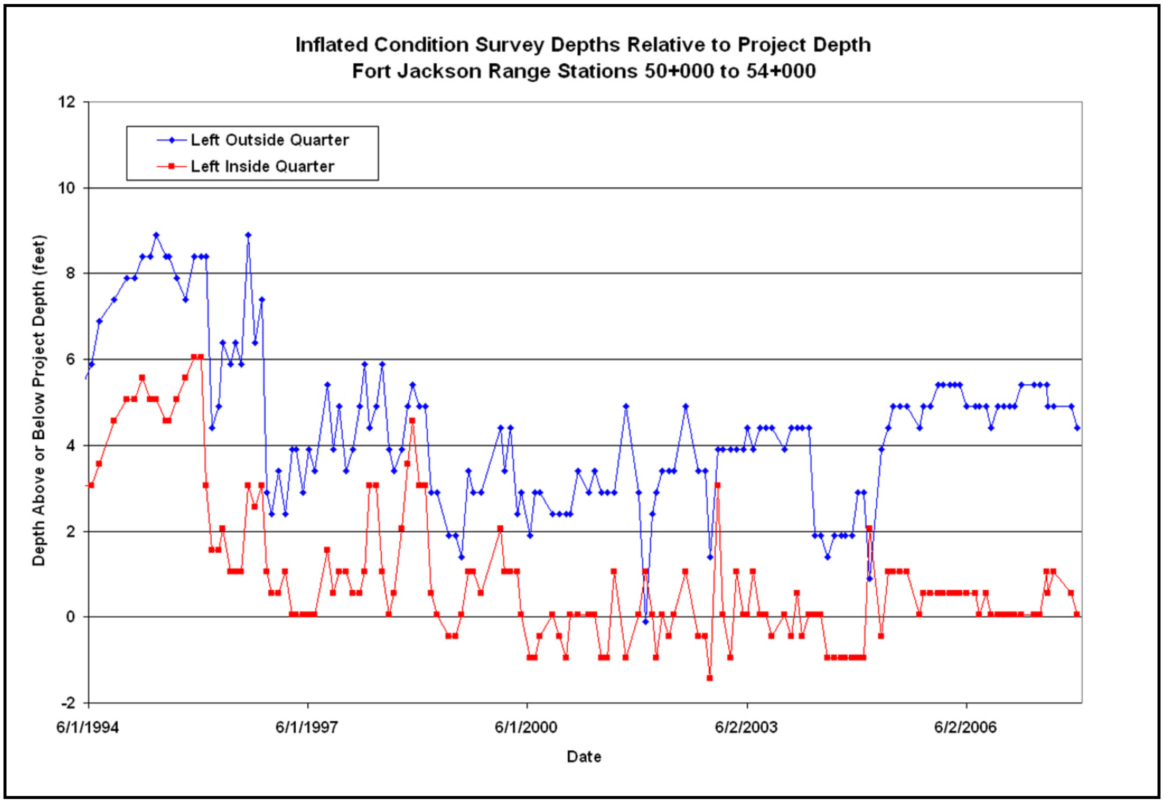

Figure 7-114 Predicted Channel Condition Depths for the Left Ft Jackson Range.

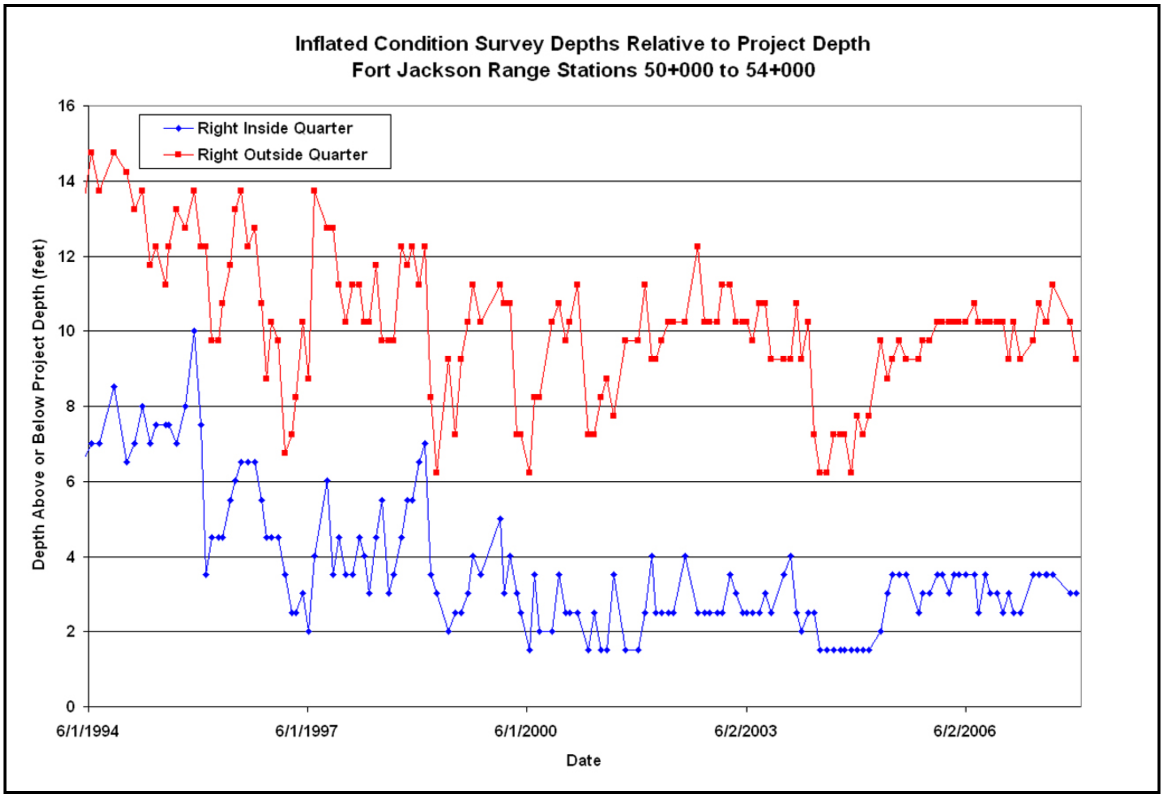

Figure 7-115 Predicted Channel Condition Depths for the Right Ft Jackson Range.

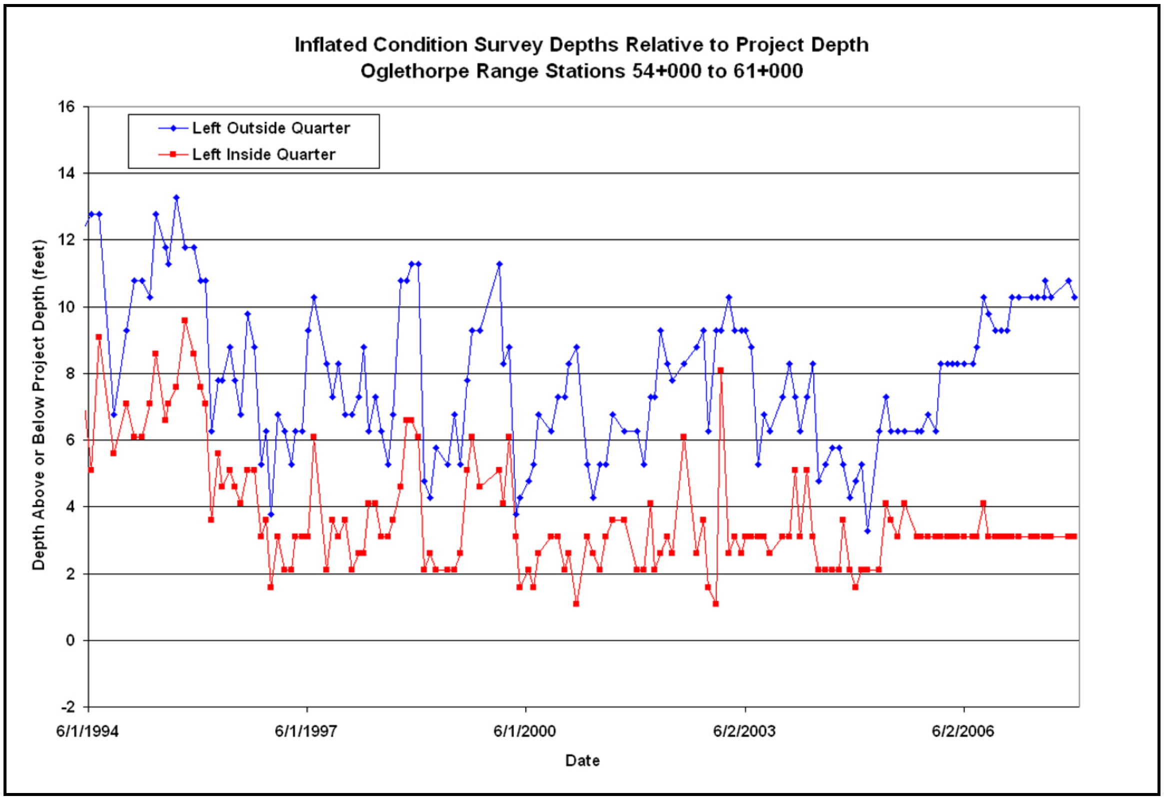

Figure 7-116 Predicted Channel Condition Depths for the Left Oglethorpe Range.

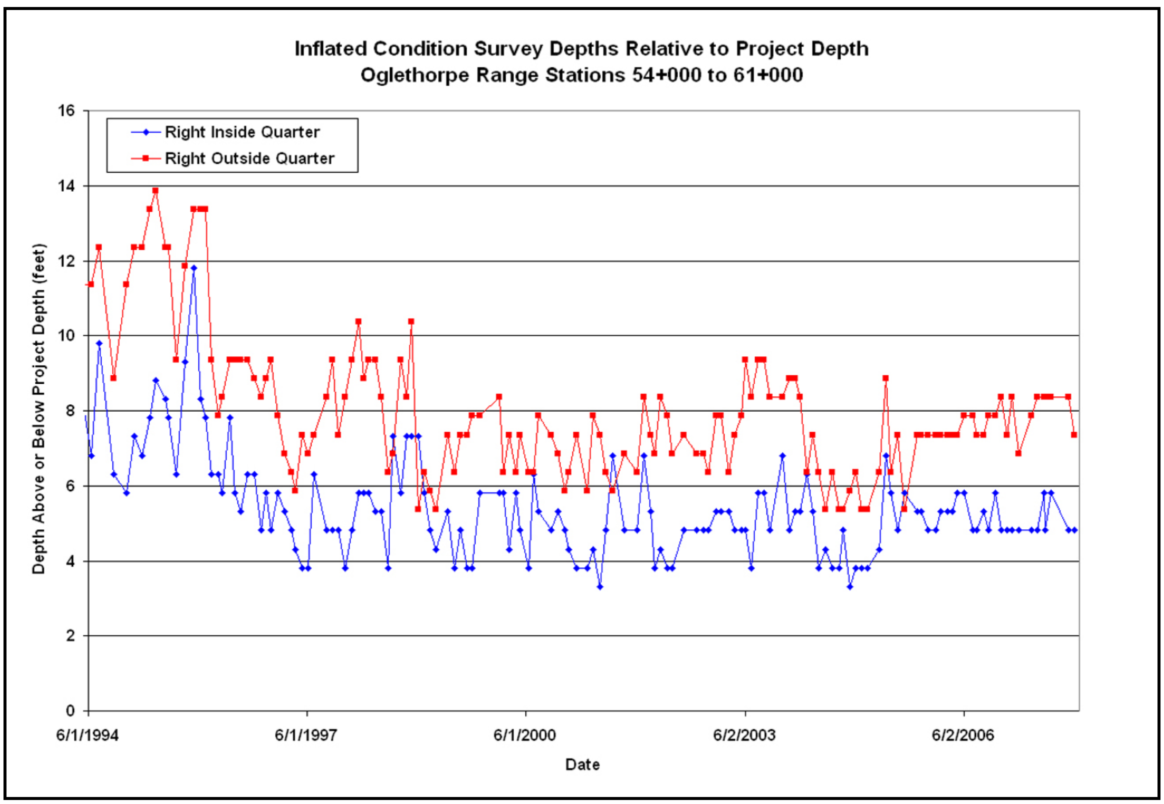

Figure 7-117 Predicted Channel Condition Depths for the Right Oglethorpe Range.

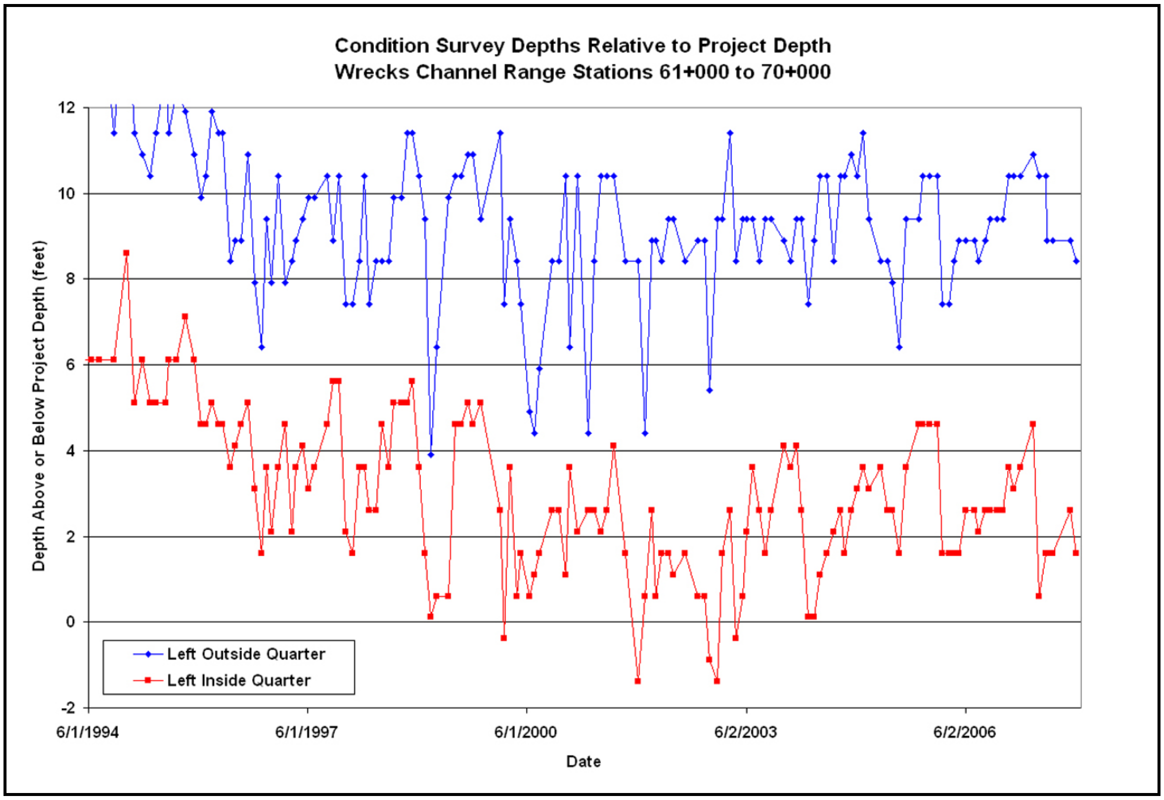

Figure 7-118 Predicted Channel Condition Depths for the Left Wrecks Range.

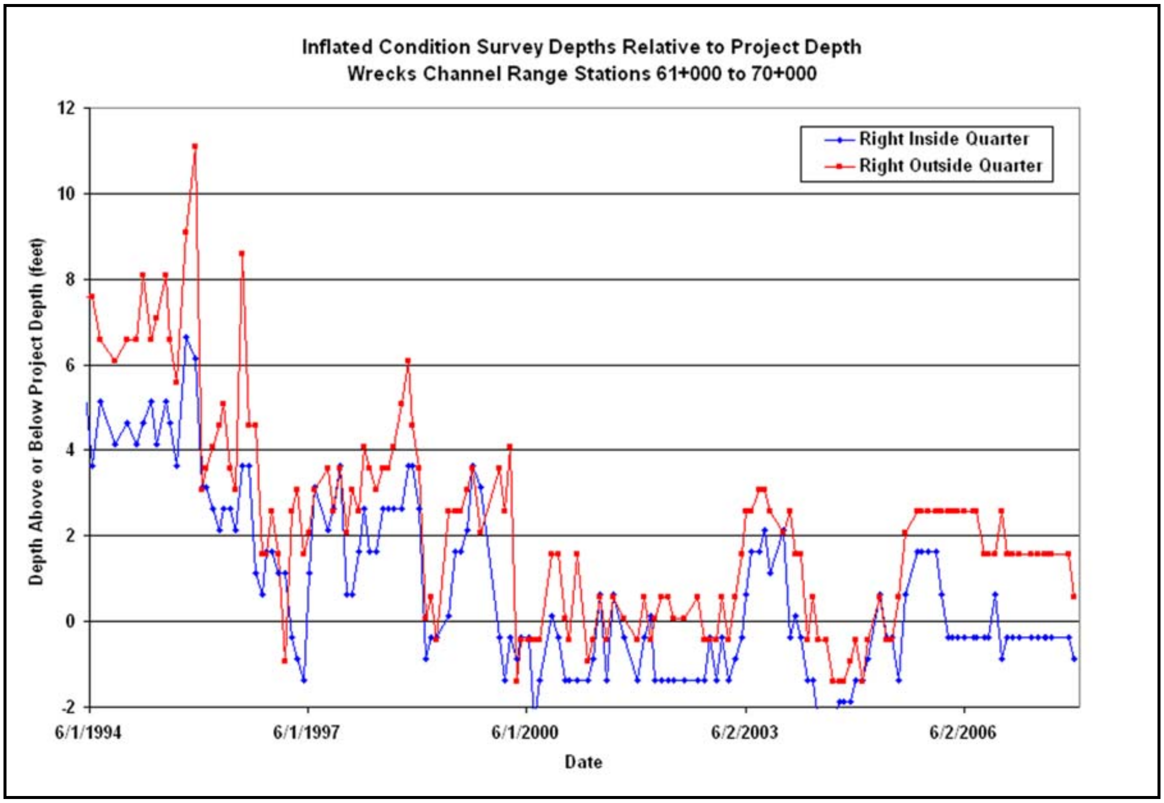

Figure 7-119 Predicted Channel Condition Depths for the Right Wrecks Range.

From the predicted channel condition plots, the adequacy or the need to increase the existing advance maintenance design can be determined. Using the criterion that when a shoal 2 feet or more above the project depth occurs at two adjacent quarters, a contractor is directed to remove the shoal, the following conclusions were reached. The existing advanced maintenance relative to project depth in the Bight Channel Range will be adequate without the operation of the sediment basin. A portion of existing advanced maintenance design in the Ft. Jackson Range will need to be increase by 2 feet. The Oglethorpe Range will need a portion of its advanced maintenance increased by 4 feet. A section of the Wrecks Channel Range advanced maintenance design will need to be increased by 2 feet.

While using the data from the channel condition surveys gives the required increase in the advance maintenance depths, it does not delineate the area within the range which needs to deepen. Surface plots of the shoal thickness above the project depth with the values of the predicted shoal increase at the centerline of the inside quadrants displayed were used to delineate the channel areas that are predicted to violate the dredging criterion. The shoal values at the inside quadrants are shown since the shoals start growing in the outside quadrants and grow inward. When the inside quadrants values are two feet higher the project depth, the dredging criterion is violated.

Figures 7-122 to 7-124 display the predicted shoal thickness above -42 feet MLLW and the amount of shoal increase at the centerline of the inner channel quadrants. The area where the advanced maintenance should be increased is shaded in the figures. Table 7-23 contains the stationing and the amount of increase in advance maintenance for each range.

There are some isolated shoals that appear near the center of the channel at Stations 50+000 and 53+000. These areas did not have a significant shoal to inflate and the uneven post dredging bottom was raised. Historic surveys do not indicate these areas to have shoals and are not anticipated to be a problem.

In portion of the Fig Island Turning Basin that extends beyond the navigation channel shoal in excess of 10 feet occur under existing conditions. With out the operation of the sediment basin, the shoal thickness along a line midway between the edge of the navigation channel and the outer edge of the turning basin will increase by an average of 2.5 feet. The turning basin is in the area recommended for a 2.0 foot increase in the advance maintenance depth.

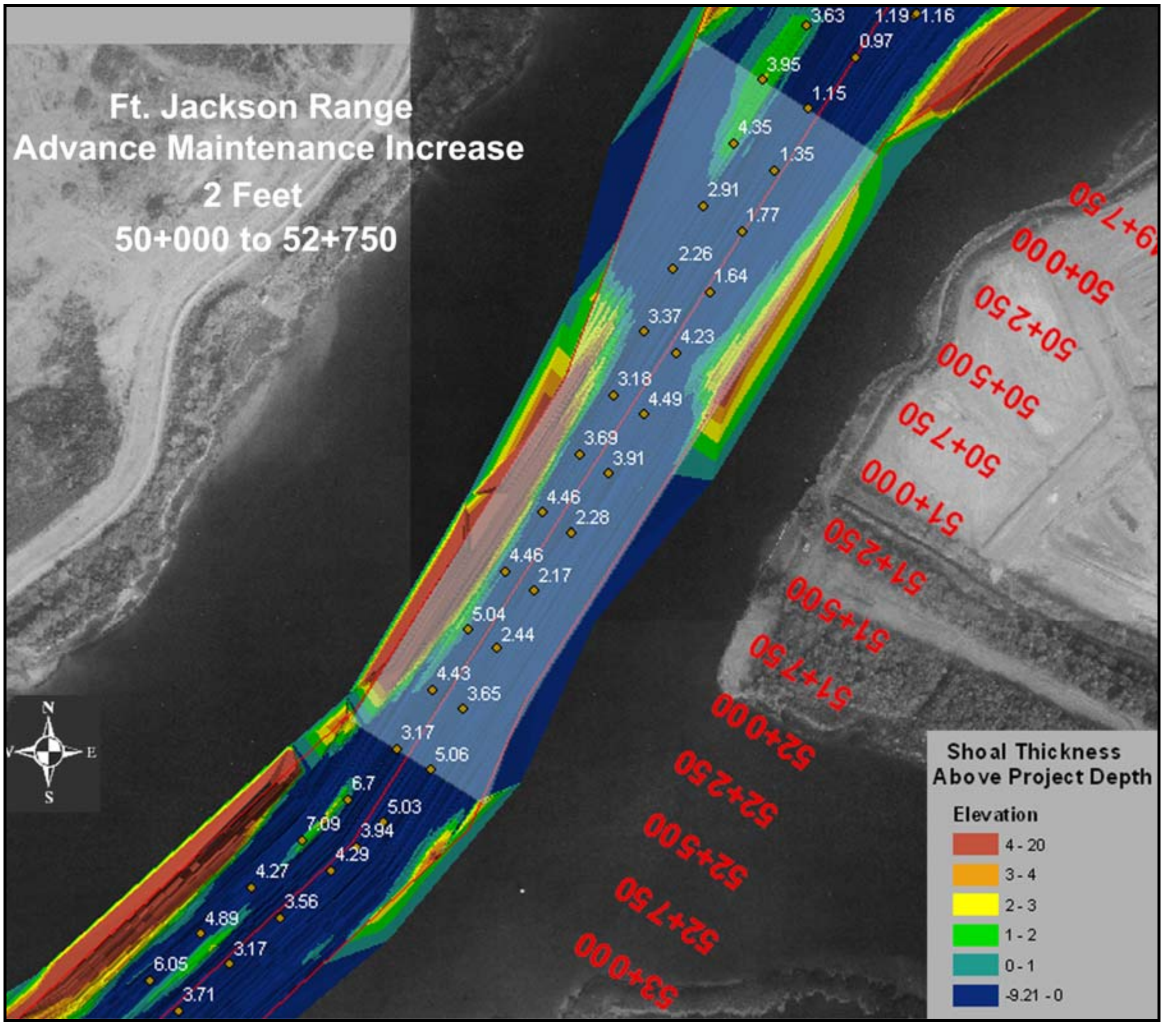

Figure 7-120 Fort Jackson Advance Maintenance Increase.

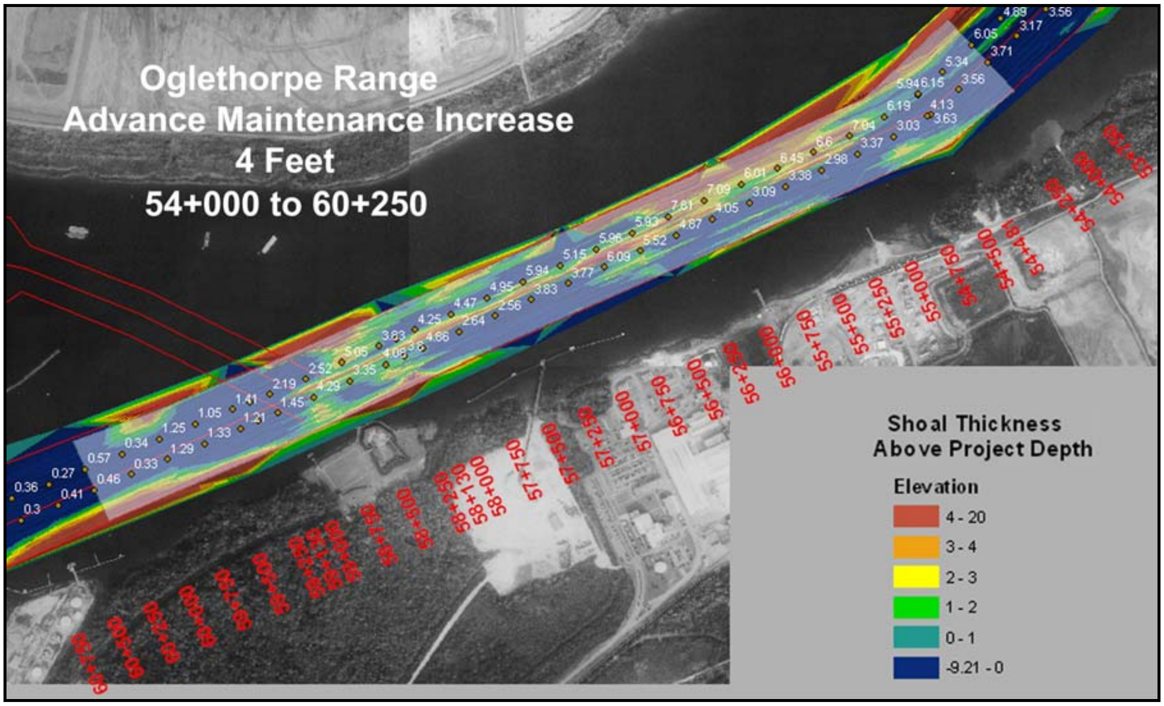

Figure 7-121 Oglethorpe Range Advance Maintenance Increase.

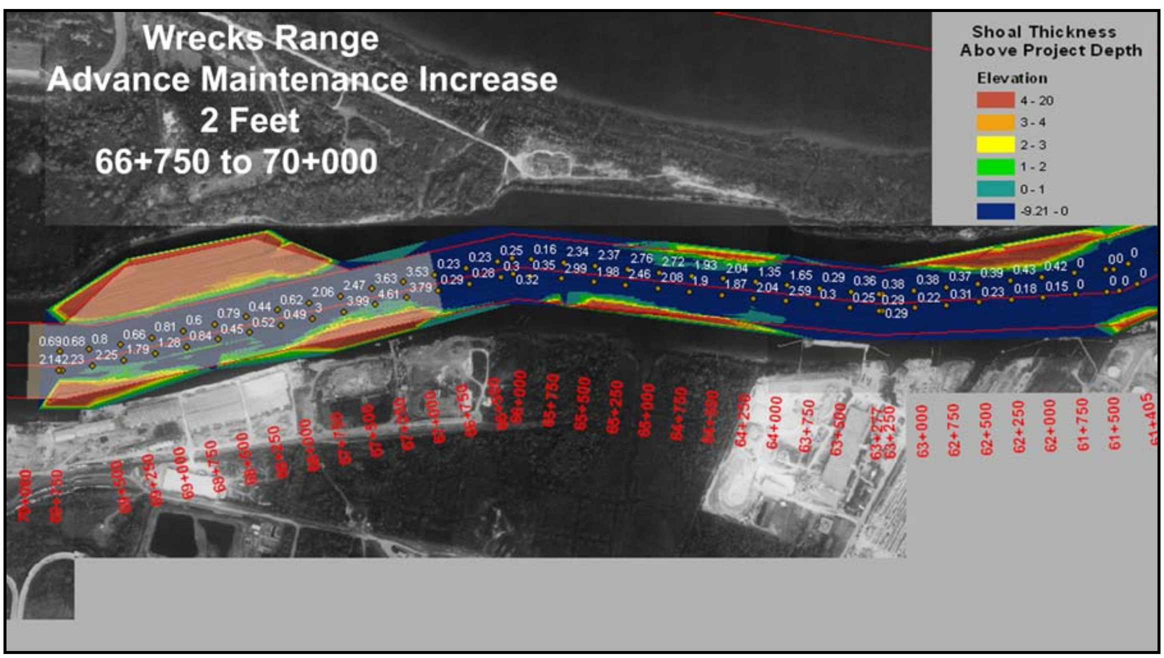

Figure 7-122 Wrecks Channel Range Advance Maintenance Increase.

Range	Stations	Advance Maintenance Depth Increase (feet)
The Bight Channel	None	None
Fort Jackson	50+500 to 52+750	2
Oglethorpe	54+000 to 60+250	4
Wrecks Channel	66+750 and 70+000	2

Table 7-22 Advance Maintenance Increases.

Conclusions

The Savannah Harbor Project captures all of the sediment that enters the harbor. The last channel deepening did not change the inner harbor shoaling volume and future depth increases are predicted not to increase the shoaling volume.

The entrance channel is a sediment sink that is a total interdiction of the littoral transport. Increases in depth will not increase the channel's ability to capture sediment.

Based on the results of physical model test, the Sediment Basin would need to be deepened by 2.0 feet to achieve maximum efficiency.

Based on the small predicted change in the salinity distribution for plan 6a, implementation of plan 6a will not change the shoaling distribution from the 6 foot deepening plan 6.

The existing advance maintenance areas, with the exception of the Kings Island range, are generally allowing an annual maintenance cycle without unacceptably encroaching above the authorized channel depth.

If the operation of the sediment basin is discontinued, the advanced maintenance depth in sections of the Fort Jackson Range, the Oglethorpe Range, and the Wrecks Channel Range will need to be deeper by 2 to 4 feet.