BREACH/INLET INTERACTION AT MORICHES INLET

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ABSTRACT

Moriches Inlet is located on the south shore of Long Island, New York, approximately 45 miles (72 kilometers) west of Montauk Point and 80 miles (130 kilometers) east of New York City. The inlet forms the primary outlet through the barrier island between Moriches Bay and the Atlantic Ocean. The inlet is protected and stabilized by two stone jetties approximately 800 feet (245 meters) apart .

During January, 1980, a severe northeast storm resulted in the breaching of the barrier island immediately to the east of the existing Moriches Inlet. By the fall of 1980, the breach had expanded to nominally 2900 feet (885 meters) in width with a maximum depth of around 10 feet (3 meters) and the U.S. Army Corps of Engineers was requested to affect its closure. The method adopted by the Corps consisted of the placement of beach fill in the opening to develop a cross-section with a centerline elevation of +13.25 feet (4 meters) MLW and side slopes of 1V:25H. Initiated in October 1980, the closure operation was succesfully completed in February, 1981.

The formation of a significant breach immediately adjacent to the existing inlet and the artificial closure of the opening afforded a unique opportunity to study the dynamics of a tidal inlet under the influence of relatively rapid changes in tidal prism and cross sectional area. The purpose of this paper is to present the results of a field measurement program and subsequent analyses of the dynamics of the inlet/breach system. The analyses were based on data obtained before, during and after closure of the breach.

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DESCRIPTION OF THE STUDY AREA

The eastern 33 miles (53 kilometers) of the south shore of Long Island has eroding headlands that contribute sediment to the net littoral drift to the west along most of the south shore. Generally narrow beaches cut by six inlets (from east to west: Shinnecock, Moriches, Fire Island, Jones, East Rockaway and Rockaway) occupy the remaining 87 miles (140 kilometers) of the south shore. A vicinity map is shown in Figure 1.

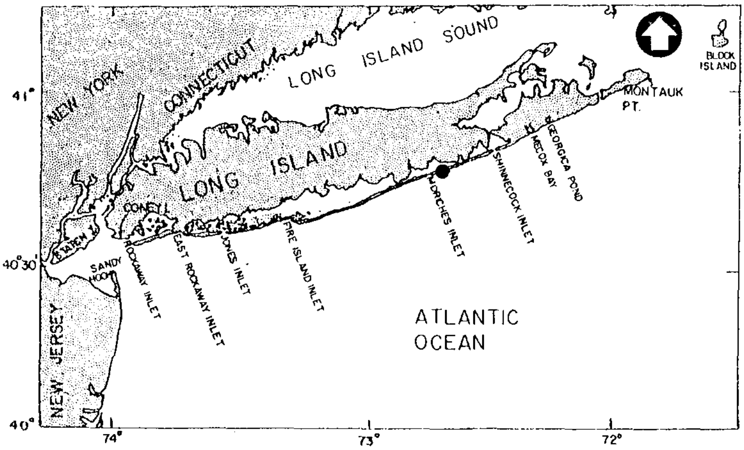

Figure 1 - Vicinity Map

Moriches Inlet, located about 80 miles (130 kilometers) from the western end of the island, connects Moriches Bay to the Atlantic Ocean. Moriches Bay extends about 13 miles (20 kilometers) along the coast and has a width of one to two miles in the vicinity of the inlet (Figure 2). The Bay, which is generally less than six feet (1.8 meters) deep, is open via narrow connections to Shinnecock Bay on the east and Great South Bay on the west. There is a small net flow through these connections into Moriches Bay which augments the ebb flow through Moriches Inlet. This system is crossed by the intercoastal waterway (ICWW) which is dredged to a depth of six feet (1.8 meters).

Inlet migration and offset patterns, sediment entrapment at groins and inlet structures, wave hindcasts, and grain size and trace mineral variations all indicate a strong net longshore transport to the west (Reference 1). Taney (Reference 2) estimated this drift in the vicinity of Moriches Inlet to be 300,000 cubic yards (230,000 m^3) per year; Panuzio (Reference 1) presents an estimated net rate of 350,000 cubic yards (269,000 m^3) per year. The longshore transport is consistently to the west except for the summer months when short term reversals can occur (Reference 3).

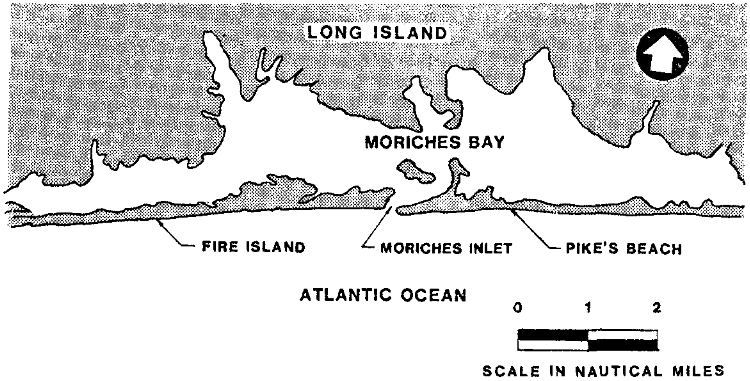

Figure 2 - Bay System (Local) Map

The history of Moriches Inlet has been treated by a number of investigators (Reference 4, 5, 6) and is summarized here only briefly. In 1828, there were two inlets to Moriches Bay, but both closed by 1838. The Bay remained landlocked for nearly a century until March, 1931, when a storm cut a new opening to the Atlantic Ocean. By 1949, this inlet had migrated 4000 feet (1220 meters) to the west and by May, 1951 it was again closed. In 1952-53, a pair of jetties was constructed in the dry at the location of the old inlet. Dredging was then initiated to cut a channel between the new jetties when a minor storm in September, 1953 completed the opening. Figure 3 shows the layout of the jetties and the pattern of adjacent channels in 1967. The jetties are spaced about 800 feet (245 meters) apart.

Further dredging was undertaken at Moriches Inlet in 1958, when a 10-foot (3 meter) deep, 200-foot (60 meter) wide channel,the Bay Channel, was cut from a point just inside the inlet to the northeast and then back to the ICCW (see Figure 3). This channel was widened to 300 feet (90 meters) in 1963. A second channel, the Northwest Channel, was dredged in the northwest direction back to the ICCW in 1966.

In 1956, just after the inlet was opened, the throat cross-sectional area was 6,500 square feet (600 m^2). The area increased to over 12,000 square feet (1,115 m^2) by 1975 as channel erosion assisted by the dredging caused the entrance cross sectional area to grow toward the estimated (Reference 4) stable value of about 18,000 square feet (1,675 m^2). The mean tide range in the bay increased from just under 0.5 feet (0.15 meters) in 1956 to about 2.0 feet (0.6 meters) in 1975. In the ocean, the mean range is 2.9 feet (0.9 meters) and the average spring tide range is 3.5 feet (1.06 meters). A photograph of Moriches Inlet as it appeared in 1973 is shown in Figure 4.

The ebb tidal flow through the Northwest Channel from the ICCW to the inlet is directed at Pikes Beach (see Figure 3). With increased flow, owing to increased inlet throat area, channel dredging and the ebb flow pattern in the main channel, the bay side of Pikes Beach adjacent to the east jetty underwent significant erosion from 1955 on. Czerniak (Reference 4) in a study of the inlet conducted for the U.S. Army Engineers, New York District identified the possibility of the formation of a breach in that area on the basis of existing flow patterns.

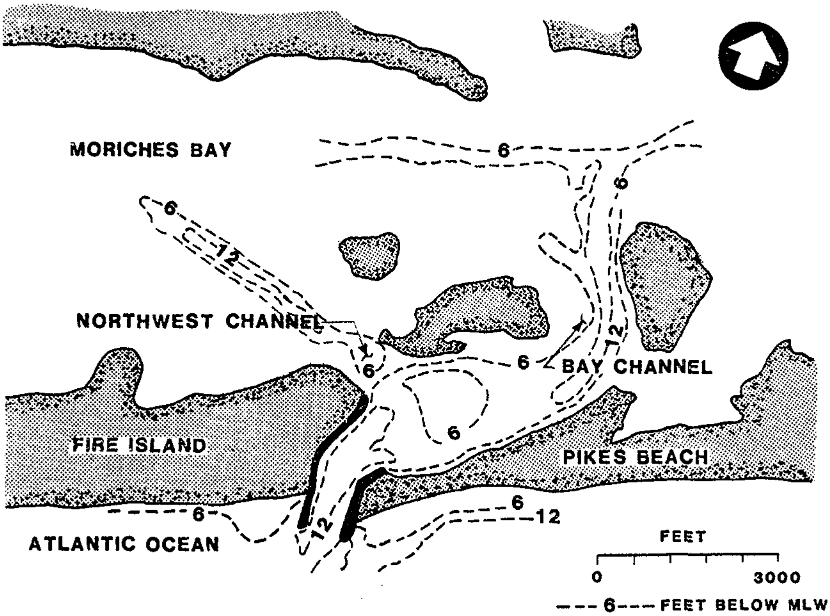

Figure 3 - Plan of Inlet and Adjacent Channels

The main (Bay) channel from the inlet to the ICCW developed a deep section adjacent to Pikes Beach (see Figure 3). Ebb flow concentrates in this section as it is deflected from a southerly to southwesterly direction. This, possibly assisted by the ebb flow from the Northwest Channel, was the likely cause of the severe erosion of the bay side of Pikes Beach adjacent to the inlet. The resulting necking of Pikes Beach is demonstrated by a photograph taken in January 1978, shown in Figure 5. Suffolk County had dredged sand from the bay to build up Pikes Beach to resist the necking of the beach but, as the photograph demonstrates, the reduction in beach width adjacent to the inlet was still quite significant.

Figure 4 - Moriches Inlet Viewed From the South (September 1973)

DEVELOPMENT OF THE BREACH

A severe Northeast storm on January 14-16, 1980 caused the formation of a breach through Pikes Beach, at the narrowest section about 1000 feet (305 meters) east of the east jetty. Figure 6 is a photograph taken soon after the breach occurred. Apparently, wave action and stronger ebb tidal currents in the bay resulting from the stronger winds and higher water levels during the storm caused excessive erosion on the bayside and washover of the barrier island from the ocean side.

The initial width of the breach when first observed on January 16 was estimated to be on the order of 300 feet (90 Meters) and the depth was estimated at about 2 feet (0.6 meters). A hydrographic survey on January 20 indicated the breach to be 700 feet (215 meters) wide and an average of 3.3 feet (1 meter) deep below Mean Low Water (Reference 7). By May 1980 the fillet between the breach and East Jetty was entirely removed and by October 1980 the breach was nominally 2900 feet (885 meters) wide. Figures 7 through 9 provide a photographic history of the development of the breach. Comparative shorelines indicating the necking of Pikes Beach and the subsequent breach development are shown on Figure 10.

Figure 5 - Pikes Beach Looking East(January 1978)

Figure 6 - Moriches Inlet and Breach Looking West (January 18, 1980)

FIGURE 7
Breach Development
April 1, 1980

FIGURE 8
Breach Development
July 12, 1980

Figure 9 - Breach Development - September 21, 1980

As a result of concerns expressed by local interests regarding increased exposure to storm induced flooding in the backbay areas and the impact of possible changes in bay salinity on the shellfish industry, the U.S. Army Corps of Engineers was requested to effect closure of the breach. It was intended that construction be completed prior to the winter storm season of 1980 - 1981 which essentially allowed for a six month construction period.

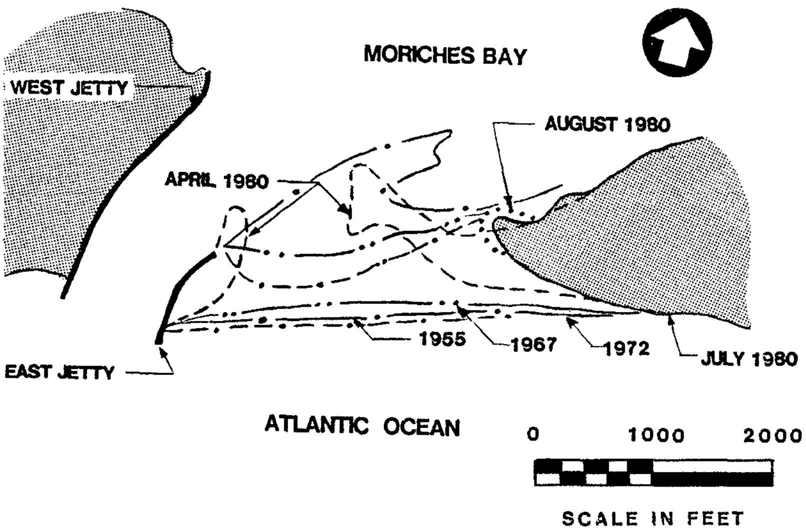

Figure 10 - Comparative Shorelines East of Moriches Inlet

The construction of the closure works and development of the methodology are treated by McCarthy, Schmeltz and Lehan (Reference 8). Briefly the design developed by the Corps of Engineers called for the placement of 1.2 million yds^3 (980,000 m^3) of beach fill in the opening to develop a cross-section with a centerline elevation of +13.25 feet (+4 meters) MLW and side slopes of 1V:25H.

For the construction, temporary steel sheetpiling was driven on the bayside of the breach essentially parallel to the original water line. The sheeting served to provide access for land based construction equipment and to "pinch off" flow in the newly formed channel. Construction proceeded from the easternmost point of the breach to the East Jetty of Moriches Inlet. Following placement of the fill the sheeting was removed and the material graded to the desired section.

Construction activities began in October 1980 and closure of the breach with the sheeting was effected in December 1980. The filling operation was completed to the final desired cross-section in February 1981. It is worthy of note that erosion of the bay side of Pikes Beach recurred after the closure. In order to stabilize this area 1600 feet (490 meters) of stone revetment was placed by Suffolk County (Reference 9) in April, 1982.

FIELD MEASUREMENTS

Prior to the startup of construction activities, a field measurement program was initiated in order to obtain data on the inlet/breach system. It was intended to collect information before, during and after closure of the breach. The program included the following measurements:

- Breach and Inlet cross-sections
- Velocity measurements as a function of breach closure and tides
- Tidal readings inside and offshore of the inlet

Data was obtained over a six month period. Systematic aerial photographs were also initiated by the Corps of Engineers in order to document the development of the breach from initial formation and continuing 15 months after closure.A chronology of activities related to the breach, closure operations and measurement program is presented in Table 1.

TABLE 1
MORICHES INLET/BREACH CHRONOLOGY

• Mid January, 1980	- Breach Opens Initially 300 Feet (90 meters)
• October 1, 1980	- Closure Operations Begun Breach 2900 Feet (885 meters)
• October 3, 1980	- Bay Tide Gauge Installed
• October 4, 1980	- 1st Current Profiling
• October 20, 1980	- Ocean Tide Gauge Installed
• October 21, 1980	- 2nd Current Profiling
• December 15, 1980(Apprrox.)	- Breach Closed
• December 19, 1980	- 3rd Current Profiling(Partial)
• January 19/20, 1981	- 4th Current Profiling
• January 31, 1981(Approx.)	- Construction Completed
• March 24/25, 1981	- 5th Current Profiling Removal of Tide Gauges
• April, 1982	- Stone Rip-Rap Protection Placed on Bay Shoreline

Cross sections of both Moriches Inlet and the breach were obtained at the locations shown on Figure 11 for each period of measurement. Depth measurements were made with a Raytheon DE 719 precision depth recorder. Profiles were obtained by piloting the vessel along a predetermined track at constant speed utilizing existing rangemarks and fixed objects to maintain alignment.

Results of the depth profiling were utilized at each measurement period to delineate segments of the inlet and breach for velocity profiling. The intent of the current measurements was to allow a volumetric analysis of flow through the respective channels. A representative sample of the segments utilized for one survey is shown in Figure 12.

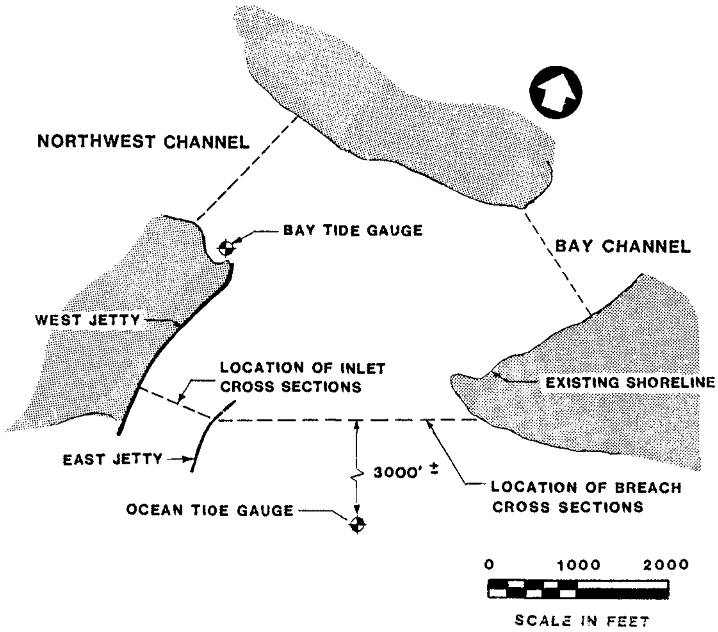

Figure 11 - Inlet Cross-Section and Tide Gauge Locations

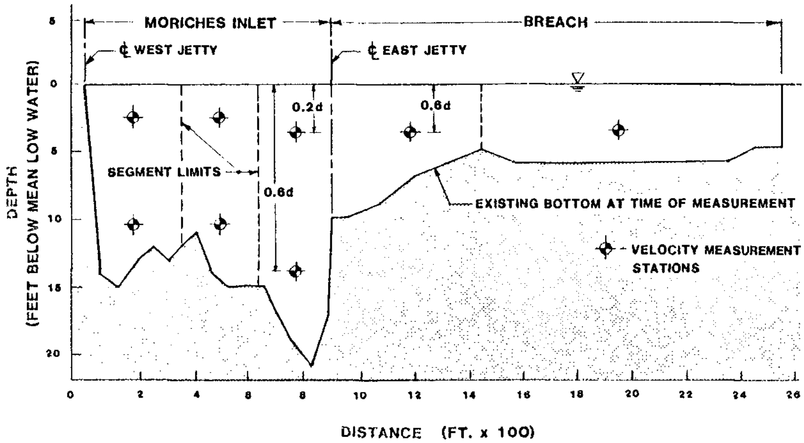

Figure 12 - Current Profiling Station Locations

Current measurements were obtained at each station at 0.2 and 0.8 of the average depth in the segment at the time of measurement. In cases where the depth was not sufficient to permit dual measurements, a single reading at 0.6 of the depth was obtained to reflect the average current in the segment. Measurements were made utilizing over the side current meters with directionality inferred from the surface currents. Readings were obtained atapproximately 1 hour intervals at each point of interest. Each monitoring period covered a minimum of 13 hours, sufficient to fully define a tidal cycle.

Cross-section data and velocity profiles were obtained on four occasions at approximately the following stages of construction of the breach closure:

- Profiling A - October 4, 1980 Prior to initiation of construction
- Profiling B - October 21, 1980 Breach half closed
- Profiling C - January 19 and 20, 1981 Closure complete
- Profiling D - March 25,1981 One month after completion of construction

Two recording tide gauges were installed on site, one inside and one outside of the inlet as shown on Figure 11. The inside or "bay" gauge was installed on October 3, 1980. This gauge was located at the base of a tide staff on the north end of the West Jetty. Initially it was intended that the "ocean" wave gauge be installed on a crib at the southern end of the West Jetty. However, due to hazardous conditions at this location the gauge was finally installed slightly east and offshore of the inlet as shown on Figure 11. This location was chosen in order to avoid the shoals offshore of the inlet and breach and to reduce the possibility of the gauge being buried by sediment transported away from the fill operations. The ocean gauge was installed on October 20, 1980.

Both of the tide gauges were bottom mounted pressure recording units set to record water levels at 10 minute intervals. Essentially concurrent readings were obtained both in the bay and in the ocean. During periods of current monitoring, tidal measurements were also obtained from tide staffs located adjacent to the north end of the inlet. Visual readings were obtained during on-site operations at 30 minute intervals.

DISCUSSION OF RESULTS

Breach and inlet cross sections obtained at various times prior to, during and after construction are shown in Figure 13 along with the relative locations of the temporary sheetpile closure structures. Cross section data is presented in tabular form in Table 2 for the breach, inlet and system total.

Initially, the inlet profile consisted of a relatively shallow channel on the west bank and a deep channel near the East Jetty. The breach was relatively flat and shallow until just east of the jetty where a small channel is apparent. As can be seen in the figure, both the inlet and breach began to deepen as closure was carried out. Examination of aerial photos also indicate significant shoaling in the ebb and flood tidal deltas. Overall the pinching off of the breach by the sheet pile retaining structure, however, resulted in a shift in tidal flow from the breach to the inlet with a commensurate increase in cross sectional area of the original channel.

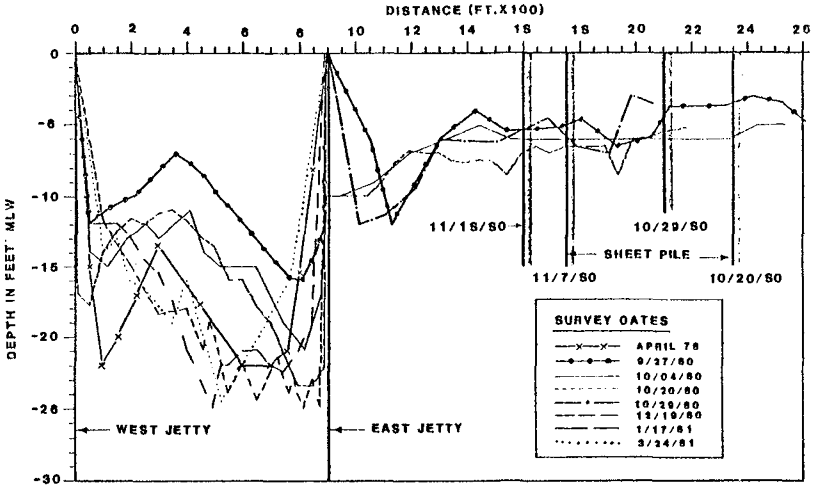

Figure 13 - Comparison of Cross-Sectional Areas

TABLE 2
TIDAL PRISMS AND CROSS-SECTIONS DURING BREACH CLOSURE

Date	Inlet			Breach			Total			A_{cs}
	Flood T.P. ($x10^8 ft.^3$)	Ebb T.P. ($x10^8 ft.^3$)	CS ($ft.^2$)	Flood T.P. ($x10^8 ft.^3$)	Ebb T.P. ($ft.^2$)	C.S. ($x10^8 ft.^3$)	Flood T.P. ($x10^8 ft.^3$)	Ebb T.P. ($ft.^2$)	C.S. ($ft.^2$)	Per O'Brien ($ft.^2$)
7/80	N.A.	N.A.	11,900	N.A.	N.A.	11,925	N.A.	N.A.	22,825	--
9/29/80	6.14	N.A.	9,975	N.A. (Breakers)	N.A. (Breakers)	N.A.	N.A.	N.A.	N.A.	-
10/4/80	3.95	4.3	12,975	2.83	3.02	10,570	6.8	7.32	23,475	14,075
10/20/80	3.3	3.3	13,797	2.1	2.2	9,584	5.4	5.4	23,381	10,800
12/19/80	N.A.	N.A.	16,273	←	Closed	→	N.A.	N.A.	16,273	-
1/20/81	11.5	10.9	15,663	←	Closed	→	11.5	10.9	15,663	22,800
3/25/81	5.9	5.7	14,765	←	Closed	→	5.9	5.7	14,765	11,620

NOTES:

1. Construction initiated approximately 10/9/80, sheet pile closure effected 12/80.
2. Breach approximately 1/2 closed as of 10/20/80.
3. N.A. Indicates data not available.

Measurements obtained in July and September 1980, both prior to construction indicate that the cross sectional area of the inlet was decreasing, implying a possible instability towards closure of the inlet. It is, however, interesting to note that the gross cross-sectional area of the inlet and breach from the first available data in July 1980 through late October, 1980 (shortly after construction began) remained relatively constant near 23,000 ft^2 (2100 m^2). From the July measurements the gross area was divided roughly equally between the breach and inlet. As a result of the apparent consistancy of the gross cross-sectional area of the inlet/breach during this period, the cross-sectional areas of the Bay and Northwest channels were evaluated from the July 1980 data. The location of the lines is shown on Figure 11. These computations indicate a combined cross-section in these channels of approximately 22,500 ft^2 (2040 m^2). The inference, than, is that a secondary control may have existed in the form of these channels.

As closure progressed, the channel in the breach adjacent to the East Jetty initially deepened in response to the decrease in width, but eventually closed. Concurrently, the inlet cross section enlarged. After closure, the inlet became deeper and began to change to a single channel more centrally located between the jetties.

The cross-section of the inlet decreased from July to late October. Subsequently the inlet cross-sectional area shows a persistant increase reaching a maximum in December shortly after closure was completed with the sheet pile walls. Subsequent measurements indicate a slight decrease in the inlet cross section which may correspond to an increase in hydraulic efficiency as the inlet moved towards its more stable, prebreach condition. Data on variations in inlet and breach cross section as a function of time are plotted in Figure 14. Data prior to the breach were obtained from reference 4.

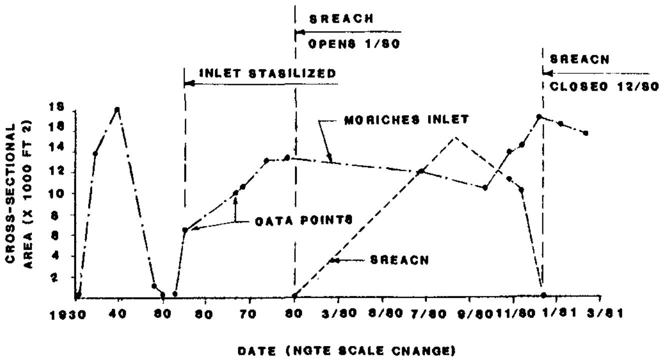

Figure 14 - Inlet/Breach Cross-Sectional Area Changes

It is interesting to note that earlier estimates by other investigators (References 4, 5) indicate a stable cross section of the inlet ranging from 16,000 ft^2 (1500 m^2) to 20000 ft^2 (2100 m^2). The latest available measurements of the cross section of Moriches Inlet prior to the breach, obtained in April, 1978, indicated an area of approximately 12500 ft^2 (1860 m^2). It appears, then, that the inlet was probably moving towards its prebreach condition at the time of the final measurements in this program.

Velocity measurements in the inlet and breach were utilized to assess variations in tidal prism at the time of measurements. Peak measured velocities, provided as an indication of the relative flow, during each measurement period are presented in Table 3. Tide ranges based on measured data from the "ocean" and "bay" as well as predicted tides in the ocean at the time of measurement (Reference 10) are also provided .Tidal prisms computed on the basis of field measurements are shown in Table 2.

TABLE 3
TIDE RANGES AND CURRENT VELOCITIES

DATE	TIDE TABLES (ft)	MEASURED TIDES (ft)		MAX. CURRENTS (ft/sec)	
		OCEAN	BAY	BREACH	INLET
10/4/80	3.3	n.a.	2.2	2.0	3.5
10/20/80	3.7	3.7	2.8	1.5	2.5
1/20/81	4.0	4.4	3.3	CLOSED	6.8
3/25/81	3.0	3.3	1.8	CLOSED	4.2

As shown in Table 3, measured ocean tide ranges varied during the measurements from 4.4 feet (1.3 meters) to a low of 3.3 feet (1 meter) and compare favorably with the predicted tide ranges. Tidal differentials and maximum current velocities in the inlet, show a marked increase as the closure was effected.

Considering the variations in the ocean tides experienced during the measurement periods, it appears that the tidal prism decreased slightly after closure was completed. However, considering that the cross section with the breach was nearly twice as large as the pre and post breach inlet sections, the change in flow quantity is relatively minor varying from a maximum of 7.3 x 10^8 ft^3 (2.07 x 10^7 m^3) with the breach open to 5.9 x 10^8 ft^3 (1.67 x 10^7 m^3) after closure. The maximum values are also substantially below the "potential" tidal prism determined by Mehta and Hou (Reference 5) of 1.5 x 10^9 ft^3. Note that both measurements sets were obtained with an ocean tide range of 3.3 feet (1 meter). Bay tide ranges, also decreased from 2.2 feet (0.67 meters) to 1.8 feet (0.55 meters) on the bay side of the inlet. These results should, however, be viewed with caution due to the limited nature of the available data and the effect of secondary controls of the Bay and Northwest Channels on tide readings obtained immediately adjacent to the northern limit of the inlet.

In any case, the level of change in the tidal prisms with and without the breach seems to provide further substantiation of the secondary control of the Bay and Northwest Channels while the breach was open.

As a gross indicator of the overall stability of the system, O'Brien's Area/Tidal Prism relationship (Reference 11) was utilized with the measured tidal prisms to determine "stable" areas. The values determined in this evaluation are provided in Table 2. As seen in the table the values vary, as a function of the measured prism, from 10,800 ft^2 (1000m^2) to a high of 22,800 ft^2 (2120 m^2). Based on the measured prisms after construction, O'Brien's method yields a stable cross-sectional area of the inlet of nominally 12,000 ft^2 (1115 m^2), close to the measured values in April 1978.

Overall the comparisons indicate that measured cross sections prior to closure were larger than could be sustained given the available tidal prism. Measurements after closure, in March 1981, show a closer agreement with computed values although it appears that a further reduction in area of the inlet is possible.

CONCLUSIONS

Prior to closure of the breach, the tidal prism determined from velocity measurements appears to have been inadequate to maintain the cross sectional area of the inlet/breach system, i.e. the system was probably unstable towards closure. However, the inlet was undergoing migration beyond its control structures which may have resulted in closure of the original inlet replaced by an uncontrolled, migratory channel. Based on previous experience with inlets at this location, the ultimate result may have been complete closure of the connection between Moriches Bay and the Atlantic Ocean.

The gross cross sectional area of the inlet/breach system, prior to the beginning of the closure operations, was on the order of 23,000 ft^2 (2140 m^2) divided roughly equally between the original inlet and the breach. During construction the cross-sectional area of the original inlet increased by nominally 25% relative to the pre construction condition to approximately 15,000 ft^2 (1390 m^2). The post construction cross section of nominally 12,000 ft^2 (1115 m^2) correlates well with measurements obtained before the breach. This seems to indicate that the channel was returning to its prebreach configuration as of the conclusion of the measurement program.

Both observations and measurements indicate that as the breach was "pinched off" by the temporary sheet pile structures, flow was shifted from the breach to Moriches Inlet. Both currents and tidal differentials showed a marked increase as construction progressed. Although the data are limited, tidal prisms appear to have decreased slightly after the closure was completed.

The magnitude of change in tidal prism, however, appears somewhat smaller than might have been expected. The Bay and Northwest channels which exist behind the inlet may have exerted a secondary control on the system. The result of the influence of these channels could have been to minimize, at least temporarily, further increases in both the cross sectional area and flow through the inlet/breach system.

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