CHAPTER 34

BY-PASSING SAND AT SOUTH LAKE WORTH INLET, FLORIDA

Joseph M. Caldwell
Chief, Research Section, Beach Erosion Board
Corps of Engineers, Department of the Army
Washington, D. C.

INTRODUCTION

This paper describes the installation of and results obtained with the sand pumping plant located on the north jetty of South Lake Worth Inlet, Florida. This pumping plant was installed in order to pump drifting beach sand past the littoral drift barrier formed by the creation of South Lake Worth Inlet with its protecting jetties. It was anticipated that the pumping of the sand would relieve the erosion of the shore south of the inlet and cut down on the rate of shoaling in Lake Worth at the inner end of the inlet channel. A discussion of the results obtained with the installation is also included in the paper.

LOCAL CONDITIONS PRIOR TO BY-PASS PUMPING

Prior to 1918, Lake Worth had no direct access to the Atlantic Ocean and communication with the ocean was through a somewhat tortuous system of tidal channels running north and south from the lake. In 1918, local authorities began the work of dredging through the barrier to create Lake Worth Inlet near the north end of Lake Worth as a navigation channel for both pleasure and commercial craft (Fig. 1). The inlet has from its inception been protected by two jetties constructed for that purpose. The resultant littoral drift of beach sand is from north to south along this section of the coast, and, as could be expected, sand was impounded by the north jetty and erosion set in along the coast to the south of the inlet. The principal interest of this inlet to this paper is the fact that the measurements of the sand impounded north of the north jetty at Lake Worth Inlet enabled a fairly reliable computation of the average rate of littoral drift at this point to be made; such a computation shows the average drift to be about 225,000 cubic yards per year. The navigation channel, now a Federal project, has a depth of 25 ft.

In 1927, the South Lake Worth Inlet District was created by local authorities and South Lake Worth Inlet was dredged through the barrier near the south end of Lake Worth (Fig. 1). This inlet was dredged primarily to create a circulation of water in the southerly end of Lake Worth to relieve the stagnant condition of these waters; although pleasure craft drawing up to 6 or 8 ft. find it possible to use the inlet. Two stabilizing jetties were constructed as the inlet was being dredged; these jetties are much shorter than the jetties at Lake Worth Inlet, extending seaward only to about the 6- or 8-ft. contour and being only about 250 ft. in length. The mean tide range in the Atlantic Ocean at Palm Beach is 3.3 ft. and flow velocities in the inlet (as measured in February 1949) at strength of flood and ebb are in the order of 5 ft. per sec.

As stated previously, the littoral drift along this section of the coast is from north to south; this drift quickly filled the impounding area of the north jetty and worked its way around the seaward end of this jetty and into the inlet. The tidal velocities in the inlet were sufficient to sweep this sand through the inlet and into Lake Worth where the sand accumulated as a large shoal area (Fig. 2). The unrestricted growth of this shoal probably would bring about the eventual closure of the inlet, or at least an almost complete loss of its effectiveness. Measurements of the shoal area showed that it gained approximately 1,000,000 cubic yards between 1931 and 1937, an average growth of 165,000 cubic yards per year.

Concurrently with the filling of the impounding area behind the north jetty at South Lake Worth Inlet and the creation of the Lake Worth shoal, erosion of the beach south of the inlet was becoming noticeable. This was of concern to the property owners along the eroding area and some took steps to prevent or decrease the rate of erosion. One property owner who owned a considerable length of shore

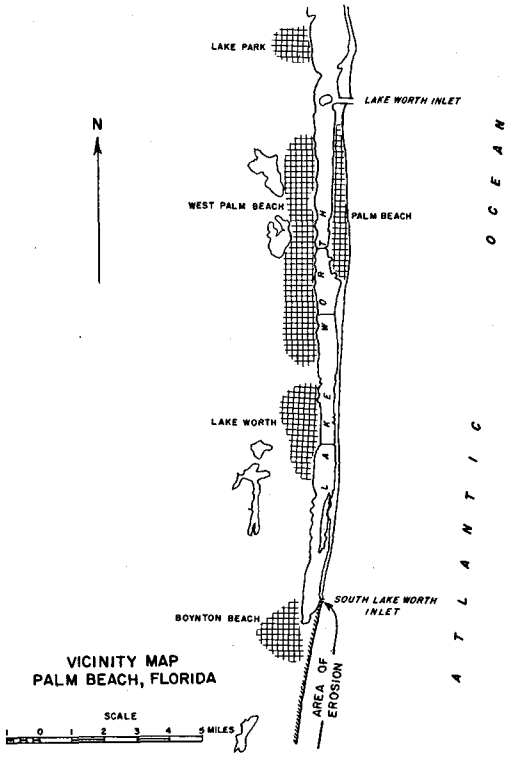

Fig. 1

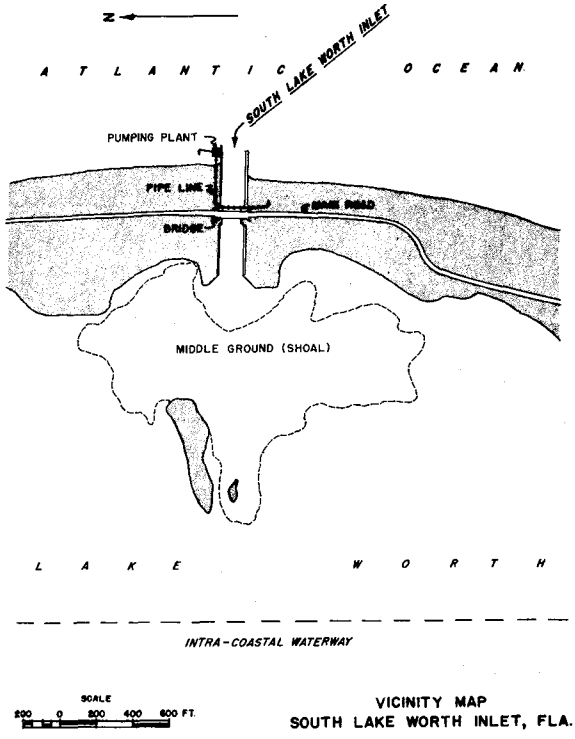

Fig. 2

property about 1/2 mile south of the inlet recognized the danger to his property within 4 years after the completion of the inlet in 1928. Starting in 1932 this particular property owner spent $160,000 to construct 2,000 ft. of seawall along the ocean frontage of his property and by 1936 found it necessary to spend an additional $40,000 to construct seven groins to support and protect the seawall from undermining. The owner had hoped that the groins would trap whatever sand was moving along the beach and thereby create a protective beach for the seawall; it was also hoped that the protective beach would also serve as a recreation beach. The quantity of drift was so small during this time (1932-37) that no effective beach was formed and the undermining of the seawall appeared probable even after the groins had been installed.

The concern of the South Lake Worth Inlet District over the shoaling of Lake Worth adjacent to the inlet and the concern of the downdrift property owners over the erosion resulting from the creating of the inlet, led to the decision to establish a sand pumping plant at the inlet as a means of pumping the sand from the north beach onto the south beach; it was hoped that both the Inlet District and the aggrieved property owners would benefit by such action. The operation was a joint undertaking on the part of the Inlet District and the property owner who had spent $200,000 on protection.

The basis of design of the pump and pumping plant as initially installed was not related to the rate of littoral drift along the shore, in fact the rate of littoral drift did not enter the initial computation. The design was based entirely on the anticipated needs of the groin field in front of the $160,000 seawall. The designing engineers had calculated the amount of sand they thought was needed to give adequate protection to the seawall and to fill the groins, and the pumping plant was designed to transport this quantity of sand in a period of about 2 years. The pumping was started in 1937 and was continued until about 1942. At this time the beach in front of the seawall had been built up to the desired level, and as the fuel oil shortage due to the war was becoming acute, it was decided to discontinue the pumping for the time being.

The pumping plant as installed in 1937 was placed on the north jetty about 50 ft. from the end. The pumping plant consisted basically of an 8-in. suction line, a 6-in., 65 hp. Diesel-driven centrifugal pump and about 1,200 ft. of 6-in. discharge line. The discharge line was carried across the inlet on the nearby highway bridge. An A-frame derrick on the roof of the pump house enabled the operator to swing the intake in a horizontal arc and to raise and lower it as required to reach the sand. The cost of the plant as installed was reported to be $15,000.

During the first year of operation (1937) the pump operated about 1100 hours, and moved about 60,000 cubic yards of beach material. This represents an average pumping rate of about 55 cubic yards per hour and an average operation time of 21 hours per week. The cost of moving the sand, including operation, maintenance, and depreciation, was in the order of 9 cents per cubic yard of beach material moved across the inlet. During the four years 1938-41, beach material was pumped past the inlet at the rate of about 48,000 cubic yards per year, or a total of about 250,000 cubic yards to 1942 at which time the pumping was discontinued due to the war.

RESULTS OF INITIAL PUMPING

The effects of the pumping operation was felt almost immediately along the shoreline south of the inlet. A noticeable accretion was said to be in evidence after 1 month's operation and within six months the 2,000-ft. length of seawall referred to previously was found to have a protective beach 120 ft. wide at high tide, whereas it had been almost devoid of beach material before pumping was started. Information is available which indicates that the rate of shoaling in Lake Worth decreased during the period the pumping plant was in operation, though this information is not sufficiently precise to enable quantitative statements to be made.

At the end of 5 years (1942) it was found that the beach had been completely restored for a distance of at least a mile south of the inlet as was evidenced by the fact that the groin field in front of the 2,000-ft. seawall had been filled with sand and the beach sand reached almost to the top of the seawall which was at an elevation of about 12 ft. above mean sea level. Unfortunately, no definite information is available on the comparative condition of the beaches for more than one or two miles south of the inlet.

RESULTS OF DISCONTINUING PUMPING

As noted previously, the pumping plant was shut down in 1942 due to war conditions. During the interval 1942-45, severe erosion of the beaches south of the inlet again set in and the Lake Worth shoal began to build rapidly threatening to nullify the effectiveness of the inlet channel. As a result of these conditions, the South Lake Worth Inlet District and Palm Beach County decided to resume pumping operations. Accordingly, in 1945 the Inlet District re-installed the 6-in. pump and 6-in. pipe line and resumed operation, the cost of the operation being borne by Palm Beach County. By 1948 it was evident that the 6-in. pump was not removing the material fast enough to prevent rather rapid shoaling of the inlet and in June 1948 an 8-in. pump and pipe line were installed in the hopes that this would meet the demands at this locality. Observations up to the present time indicate that an even larger pump is needed if the pumping rate is to equal the rate of littoral drift reaching the pump intake during northeast storms, and the installation of a 12-in. pump and line is under consideration.

PRESENT INSTALLATION

The present installation consists of a 10-in. intake mounted on a swinging boom of 30-ft. radius with a flexible rubber sleeve at the center of the turning radius (Fig. 3). A jet for agitating the sand is placed along the side of the intake. The pumping plant consists of an 8-in. centrifugal pump driven by a 275 hp. Diesel motor. The pump operates at about 600 rpm. The pump discharges into an 8-in. line about 1200 ft. in length which transports the sand across the inlet and discharges it on the beach to the south. The discharge end of the line is about 16 ft. above mean sea level while the high point in the line, where it crosses the

inlet on the bridge, is about 24 ft. above mean sea level. The line appears to flow full at the outfall during normal pumping rates (Fig. 4). The pump is rated to have a 135-ft. total dynamic head for normal operation, and pumps at a velocity of about 12 ft. per sec. with from 10 to 20 percent solids (by volume). The beach material is about 60 percent shell and about 40 percent medium to coarse sand. The consensus is that the pump places about 100 cubic yards of beach material per hour of normal operation.

Fig. 3. Pumping plant near outer end of north jetty.

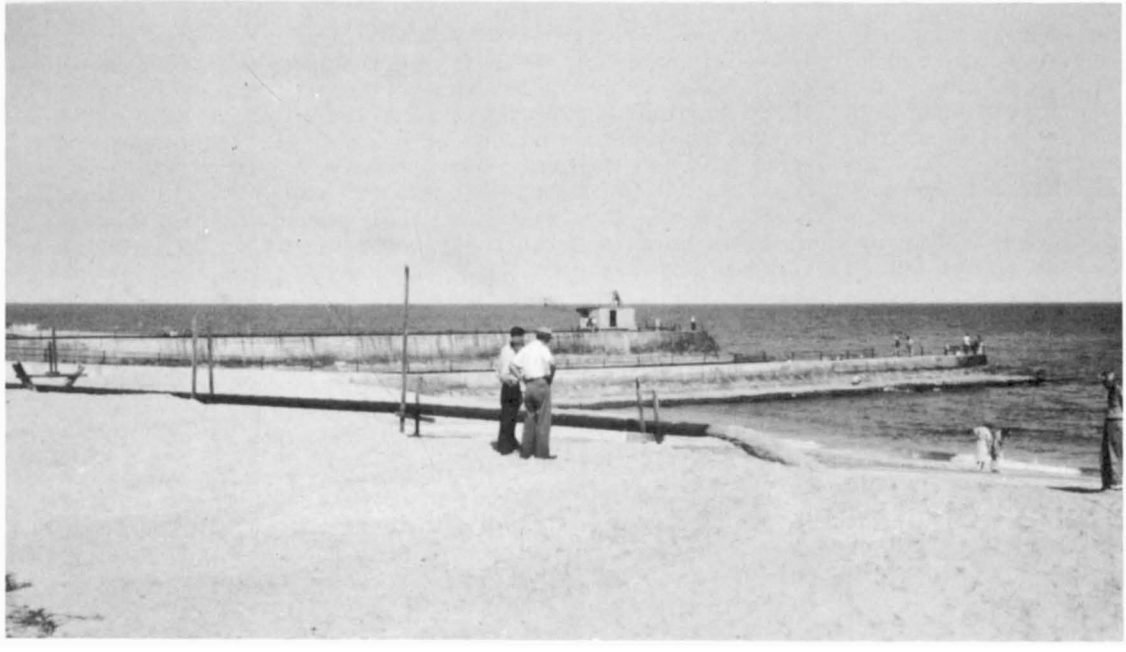

Fig. 4. Discharge line south of south jetty.

The operating schedule of the pump is flexible. Two full-time operators are assigned to the pumping plant for maintenance and operation. During periods of relatively calm weather, two or three hours pumping each day is found to remove all the material in reach of the 30-ft. boom. The boom has provisions for vertical movement of about 12 ft. and for horizontal movement of about 30 ft. around the arc of the boom radius. In effect it is capable of digging a circular trench some 30 ft. long and 8 or 10 ft. deep. The depth to which it digs is limited by bed rock or hard pan, and the amount it pumps is limited by the quantity available in the pumping area from day to day. During periods of northeast weather it is found that pumping on a 18-hour-per-day basis is hardly sufficient to remove the sand at the rate it accumulates in the impounding area, and it is believed that under these conditions much material moves around the outer end of the north jetty and into the inlet channel.

The eye of the pump is some 6 ft. above mean sea level and the priming of the pump is accomplished by a check valve in the suction head and a small auxiliary priming pump. No difficulty was reported in starting the equipment. As the 8-in. pump had been in operation less than a year at the time of last contact, the engineers concerned were not prepared to give an estimate of the yearly amount of material moved with the larger pump. However, they stated that over the period 1945-48 it was estimated that 70,000 cubic yards per year had been moved by the 6-in. pump previously installed, though it should be recognized that even the 6-in. pump was not operated on an average of more than about 25 or 30 hours a week. The annual operating costs of the present 8-in. installation, including depreciation, is in the order of $15,000 to $20,000 based on 1950 prices.

DISCUSSION

The results of the operation of the pumping plant at South Lake Worth Inlet present several aspects which are of interest to engineers concerned with shoreline processes. The fact that a pumping plant has been in operation for a number of years and has successfully replenished the downdrift beaches by pumping a portion of the littoral drift past the inlet is itself significant. Of corallary interest is an evaluation of the by-passing operation to determine what light this particular operation might throw on the general picture of shoreline erosion; this discussion will be concerned chiefly with this latter point.

It is to be recognized that the drift reaching the inlet from the north is split three ways at the inlet, part going within reach of the pump and being pumped past the inlet, part going into the inlet and shoaling the middle ground in Lake Worth, and part by-passing the inlet entirely and reaching the shore to the south. In practice, a measurement on the first two portions of the drift is feasible; however, the third portion -- that by-passing the inlet in deep water -- cannot be assessed by present means unless it can be assumed that the normal rate of drift at South Lake Worth Inlet is 225,000 cubic yards per year as it is at Lake Worth Inlet about 15 miles to the north. The 225,000 cubic yards per year figure obtains some support from the fact that the shoal ground in Lake Worth gained 1,000,000 cubic yards or so during the no-by-passing period, 1931-37, or an average of 165,000 cubic yards per year.

In event the 225,000, or even 200,000 cubic yards per year could be accepted as the normal rate of drift at South Lake Worth Inlet, it would then be possible to assess the magnitude of the three portions of drift described in the preceding paragraph. An assumption of 200,000 cubic yards per year might be considered to carry with it the assumption that the deepwater drift is in the order of 35,000 cubic yards per year; deepwater in this case is taken to be anything outside about the 6-ft. depth contour.

In view of the above statements, it becomes significant that the beaches for a mile or two south of the inlet have been restored and maintained by the 50,000 to 70,000 cubic yards per year which has been pumped past the inlet. The fact that this beach eroded when this 50,000 cubic yards per year or so of material was denied to it by the construction of the jetty indicates that the material traveling in the shallow water inside the 5- or 6-ft. contour is the key to successful beach maintenance downdrift from South Lake Worth Inlet. The other portions of the

drift, the deepwater drift which by-passes the inlet and the material which moves into the inlet even during pumping operations apparently play little part in the determination of the foreshore beach profiles downdrift from the inlet. This is shown by the facts: (1) that the beaches eroded severely when the inshore drift was stopped even though the deepwater drift presumably continued to move past to the south, (2) the beaches have been reestablished without recovering the material swept into the inlet and caught in the shoal in Lake Worth over the past twenty years.

The reasoning in the preceding paragraph would lead to the tentative conclusion that, so far as beach maintenance downdrift from the Lake Worth Inlet is concerned, the transfer of the material normally traveling inside the 4- or 5-ft. contour is all that is necessary. This is admittedly a rather tenuous conclusion and should be considered more as a hypothesis to be examined in the light of any additional studies made at South Lake Worth Inlet.

If the tentative conclusion set forth in the preceding paragraph were found to be valid and could be expanded to apply to other inlets as well as to South Lake Worth Inlet, the problem of restoring downdrift beaches would be greatly simplified. This simplification would be evident from the fact that only about 1/3 or 1/4 of the total drift had to be pumped past the littoral barrier and that a stationary pumping plant was found to be capable of reaching the requisite amounts of material, i.e., the littoral forces brought the required material within reach of the 30-ft. swinging boom intake of the pumping plant. Estimates of the cost of pumping sand past inlets in other localities have indicated almost prohibitive costs in many cases; these prohibitive costs were generally the result of anticipating the moving of the entire quantity of drift by the pumping plant, which resulted in large pumping rates and also necessitated the design of some form of mobile pumping plant. For example, annual cost of 5 to 25 times the annual South Lake Worth Inlet costs have been estimated for by-passing at six other inlets for which careful estimates have been made.

Some of the excessive cost at other inlets is due to the fact that a submerged or floating pipe line would have to be provided as there is no bridge to carry the pipe line across the inlet. However, the principal cause of the higher estimates was the assumption of the necessity to pump practically all the drift and to have a movable pumping plant.

Possibly the favorable results at South Lake Worth Inlet may be in a measure due to the existence of a layer of resistant material which crops out at frequent intervals along this section of coast and may be delaying or preventing any noticeable erosion of the offshore zone seaward of about the 6-ft. contour. Unfortunately no precise hydrographic surveys are available which would enable the offshore zone change over the past 20 years to be studied with any exactitude.

CONCLUDING REMARKS

The problem of protecting or restoring beaches downdrift from littoral barriers is a recognized problem in coastal engineering. The sand by-passing plant at South Lake Worth Inlet has apparently been successful in that it has restored and maintained the beaches downdrift of the inlet without excessive installation or operation costs. Since it is the first installation of this nature, the results obtained therefrom should be of interest. Even though the basic hydrographic data which describe the results of the pumping are rather limited, the tentative conclusions which may be drawn from these data appear to stand against some of the previous thinking on the subject. These tentative conclusions should serve to provoke additional consideration of the practicability of by-passing sand at littoral barriers by means of fixed pumping plants.