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Dredging Research Technical Notes

Fixed Sand Bypassing Plant — an Update

Purpose

This technical note updates the status of the three most recently constructed jet pump sand bypassing plants. The bypassing system at the Nerang River Entrance, Queensland, Australia, is the largest fixed plant bypassing system in the world and has been in operation since 1986. A Corps bypassing plant at Oceanside, California, began operation in June 1989 and will add fluidizers to increase production in the fall of 1990. At Indian River Inlet, Delaware, a new bypassing plant started operation in February 1990. This facility, cost shared with the State of Delaware, has bypassed over 70,000 cu yd to date, at an average rate 40 percent above the design rate.

Background

Fixed bypassing plants have been used for over 50 years as an alternative to conventional dredging for reducing channel shoaling and for bypassing sand to reduce beach erosion. Jet pumps, hydraulic pumps with no moving parts, are becoming more popular as the active dredging element in fixed bypassing plants. Since sand bypassing continues to be a topic of interest to the Corps, this technical note provides an update of the performance of these three jet pump bypassing systems. Two of the three bypassing plants discussed in this technical note have been the subject of two prior DRP articles; the Nerang River Entrance System was discussed in DRP Technical Note 3-01 (Clausner 1989) and the Indian River Inlet Bypass System was described in *Dredging Research* (Rambo and Clausner 1989). The Oceanside Bypassing Plant is generally known throughout the Corps and has been the subject of several articles, the most recent for the Coastal Engineering Research Board meeting in June 1990.

Additional Information

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Nerang River Entrance, Queensland, Australia, Bypassing System

The Nerang River Entrance is located on the mid-east coast of Australia. Before improvements were made, the entrance was hazardous due to inlet shoals resulting from the large amount of longshore transport. To control the hazardous river entrance, local interests decided to stabilize the channel with jetties. Plans for sand bypassing were included from the start, making the Nerang System perhaps the only fixed bypassing system in the world designed and constructed as an integral part of a major inlet stabilization project. Construction of the jetties and dredging of the new channel were completed in November 1985. Sand bypassing system trials were completed and the system started operations in June 1986. A more complete description of the project as a whole is provided by Coughlan and Robinson (1990).

The primary goal of the bypassing system at Nerang is to prevent shoaling of the entrance channel. It is designed to intercept most of the northerly longshore sediment transport. Some storage in the south jetty fillet is needed during large storms. To intercept and bypass this large amount of sediment transport, the project uses a shore normal trestle over 1,600 ft long with 10 jet pumps spaced every 100 ft over the outer end (Figure 1). Hydraulic design details can be found in Clausner (1988, 1989).

System Performance

During the first three and one-half years of operations, the system has met most design standards, including the most important one of preventing inlet shoaling. Bypassing performance is summarized in Table 1. Maximum measured output from a single jet pump has been 140 cu yd per hr.

The higher monthly rate over 1986 was due to an abundant supply of relatively debris-free sand (1,300,000 cu yd) that accreted against the south jetty prior to the start of the bypassing system. During 1987 and 1988, debris problems kept the bypassing rate just slightly below the design value of 650,000 cu yd per year. During 1989, heavy rain in the area caused the creeks and rivers south of the Nerang to discharge larger than normal amounts of debris, particularly timber. This debris migrated into the jet pump craters (Coughlan and Robinson 1990), as shown by

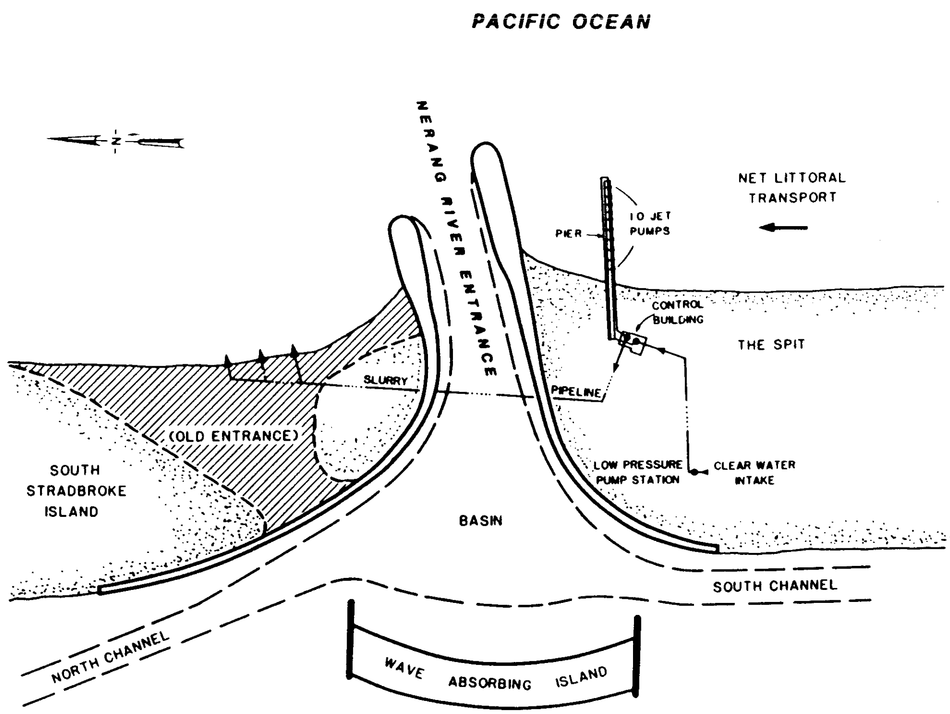

Figure 1. Nerang River Entrance Bypassing System

Table 1
Summary of Bypassing Performance

Time Period	Average per Week cu yd	Average per Month cu yd	Yearly Total cu yd
1986 (Jun to Dec)	22,000	95,000	570,000
1987	12,000	53,000	640,000
1988	11,000	49,000	590,000
1989	8,400	36,000	440,000
Total			2,240,000

Figure 2. Wave activity during the year also eroded dune grasses and allowed them to move to the jet pump craters where they formed large masses that effectively prevented sand from reaching the jet pumps. The overall result was a lower bypassing rate during 1989.

As might be expected, the nearshore jet pumps have bypassed considerably more sand than the offshore jet pumps. On the average, the nearshore pumps have over 100 percent more operating hours than pumps farther offshore.

Figure 2. Debris from a single jet pump crater

The amount of energy required to date has been significantly higher than predicted due to the debris reducing jet pump performance. The system was designed to require only 2.4 kwhr of electricity per cu yd of sand bypassed. In fact, electricity used has been: 3.0, 3.4, 3.7, and 4.7 kwhr per cu yd, respectively, for 1986, 1987, 1988, and 1989. Annual operating costs are shown in Table 2.

Table 2
Nerang Annual Operating Costs
($Australian)

Item	1987	1988	1989
Electricity	$198,603	$161,092	$ 82,782
Salaries, wages and associated costs	53,031	57,492	76,856
Repairs and maintenance	37,632	88,267	103,485
Total	$289,266	$306,851	$363,133
Cost per cubic yard bypassed	$0.45	$0.52	$0.83

The operating costs are in Australian dollars, which are roughly comparable to US dollars. These costs do not include amortization of the $7.2 million plant over the life of the project or replacement of the major components. Assuming a 9 percent discount rate and a 30-year plant life, an additional $730,000 would be needed per year and assuming bypassing of 650,000 cu yd per year, overall costs would increase by $1.12 to $1.95 per cu yd. The Gold Coast Waterways Authority (GCWA), which operates the plant, has also recently added $1,000,000 for major component replacement, amortized over 30 years at 9 percent; this adds another $0.15 per cu yd, bringing the total cost per cubic yard to $2.10 for 1989.

Problems and Solutions

By far the biggest problem has been debris in the jet pump craters reducing performance. Virtually any item entering the littoral system (rocks, bricks, wood, and trash) tends to find its way to the bottom of the craters. Eventually, this debris restricts the flow of sand enough to reduce bypassing ability from the system average of 400 cu yd per hr to less than 250 cu yd per hr.

Actual clogging of the jet pump is caused primarily by timber pieces from nearby rivers. This, along with nozzle replacement, requires periodic hiring of a 20-ton crane to lift jet pumps from their installed positions for servicing. The GCWA has tried several solutions to the debris problem. The most successful has been a clean-out jet pump, with a mixing chamber opening of 10 in. as opposed to the 3.5-in. opening on the normal jet pumps. The clean-out jet pump was able to bypass a significant amount of larger debris. Increased wave activity during 1988 and early 1989 has increased the debris problem to such an extent that the GCWA is now planning to install 10-in. jet pumps in place of the 3.5-in. pumps at each of the 10 locations along the pier. Since these larger pumps require the entire output from the supply pump, they are to be operated individually.

Oceanside Experimental Sand Bypassing System

Oceanside is located on the Southern California coast approximately 35 miles north of San Diego. In 1942, the Marine Corps constructed the Del Mar boat basin small-craft harbor with a set of entrance jetties to reduce shoaling. This site experienced large amounts of longshore sediment transport, estimated to be about 1,200,000 cu yd per year of total transport with a net southerly transport of 200,000 cu yd per year. This transport rate quickly shoaled the harbor entrance, forcing regular maintenance dredging. As sediment impounded along the north fillet, Oceanside beaches south of the harbor began to erode. The jetties were periodically lengthened to keep the harbor open. A large expansion occurred in 1963 with the construction of the Oceanside Small Boat harbor (Figure 3). Since 1963 all dredged material from the harbor, over 9,000,000 cu yd, has been placed on Oceanside beaches; however, this has not been enough to maintain the beaches. In response to public pressure, Congress mandated construction of an experimental sand bypassing facility in 1982.

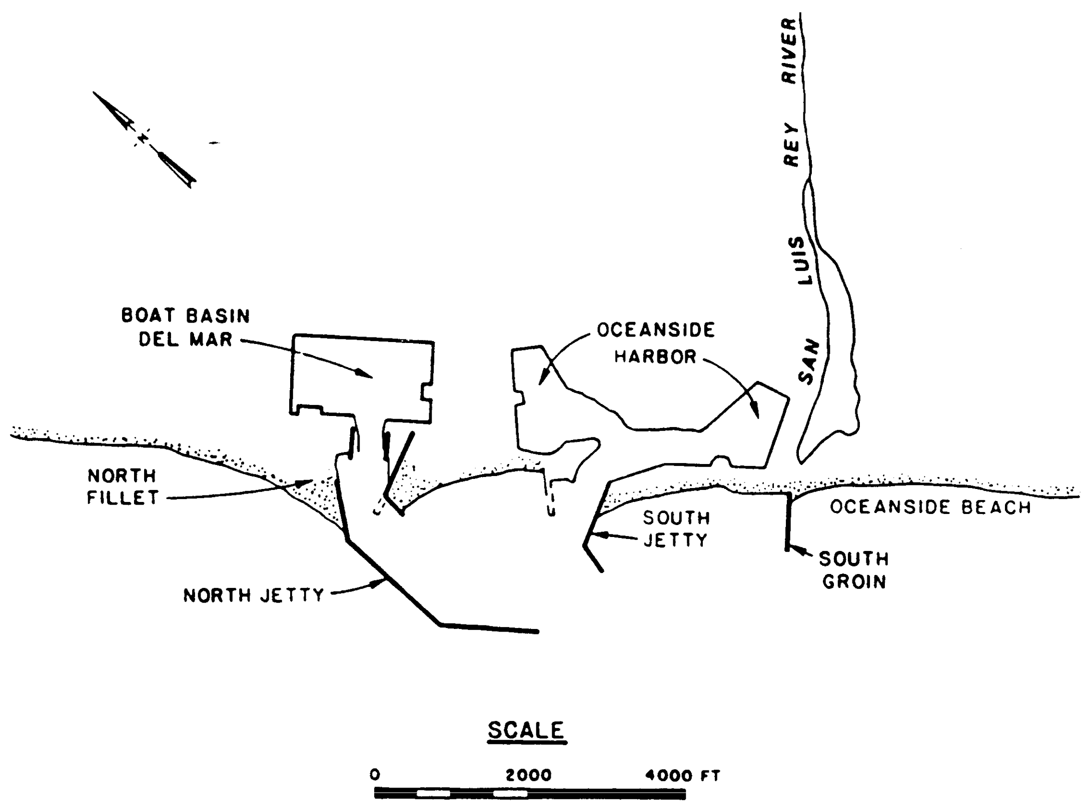

Figure 3. Oceanside Harbor and vicinity

Background

The Oceanside Sand Bypassing system was originally conceived in 1980 to reduce maintenance dredging of the harbor and to offset erosion of Oceanside's beach with a constant supply of sand. The volumes of material to be transported combined with the severe wave climate and complicated littoral processes led to the establishment of an experimental system. The system concept calls for a series of fixed jet pumps, placed in the harbor entrance, which intercept the longshore transport as it enters the harbor. This material can then be pumped downcoast on a continual basis to maintain the beaches. A single, moveable jet pump is also deployed with a crane from the north breakwater to capture sand prior to moving around the breakwater and into the entrance channel.

Design and Construction

The system is being constructed in phases, to allow testing and evaluation of each phase prior to implementing the succeeding phase. The designers kept the first phase flexible to allow for modification after the system is installed and operated for a period of time. The first phase of construction has concentrated on the basics of the bypassing system--placing the jet pumps, constructing the mobile pumping platform, configuring the discharge piping network, and constructing the shore booster station (Figure 4). The pumping platform is situated

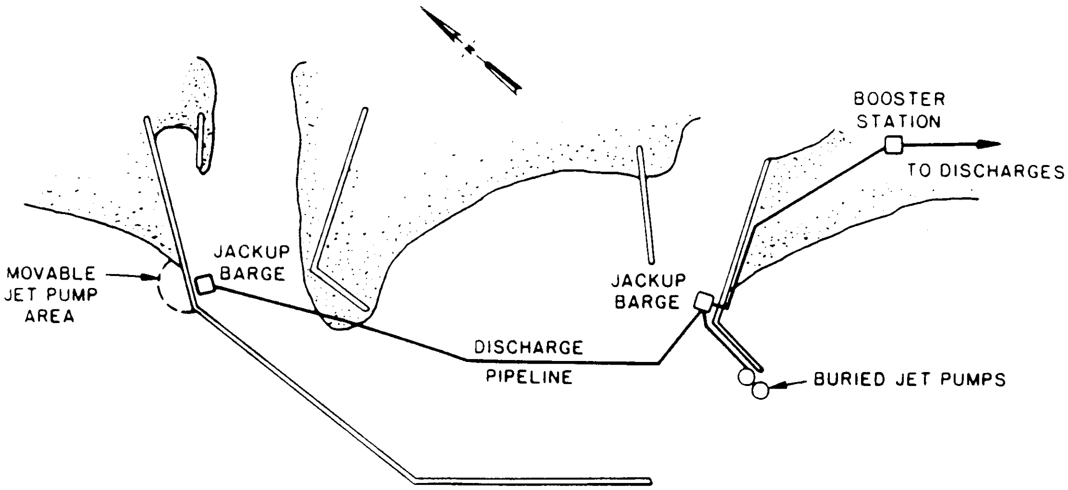

Figure 4. Oceanside Experimental Bypassing System

on a floating barge to allow sand transfer from two locations. Details of the bypassing system hydraulics are shown in Table 3.

Table 3
Hydraulic Design Data for the Oceanside Bypass System

Supply pump	750 hp (4,700 gpm at 270 ft)
Main booster pump	1,050 hp (5,750 gpm at 325 ft)
Shore booster pump	1,050 hp (5,750 gpm at 325 ft)
Discharge line	14 inch ID, HDPE, 11,000 ft
North fillet jet pump	Pekor 6" × 6" × 8" (330 cu yd per hr)
Ent channel jet pumps	Pekor 4" × 4" × 6" (230 cu yd per hr)
Sand size (D50)	
North fillet	0.21 mm
Entrance channel	0.18 mm

During the summer months (April-September), the entrance channel jet pumps are used; during the winter months (October-March), the single jet pump located at the base of the North Breakwater is used. Ultimately the system is expected to bypass 200,000 cu yd per year from the entrance channel and 150,000 cu yd per year from the north fillet.

Operation

The system is operated 5 days per week, running up to 10 hr per day with a crew of four. The crew consists of a main operator who controls the system using the Supervisory Control and Data Acquisition (SCADA) system, a mechanic observing component operations and manually operating the pumps in case of the SCADA failure, a shore booster pump operator, and an observer for the discharge point. The computer-based SCADA system monitors and regulates all facets of the bypassing operation including pump and engine speeds, pressures, valve operations, and outputs of both the mobile pumping platform and shore booster station. Over 160 sensor values are sampled every 8 sec, recorded, and displayed. An additional 88 variables are calculated and over 200 variables are archived.

As with most experimental facilities, there is a considerable amount of trial and error in determining the optimum operating conditions. Bypassing began cautiously, with concern for the burial rate of the jet pumps and the potentially catastrophic clogging of the discharge pipeline. As operational experience increased, various problems arose that required either component redesign or modifications to the mode of operation. With experience, however, a smooth routine has been developed with only minor complications.

Performance

Initial operations in June 1989 were at the north fillet, where the single jet pump was deployed from a mobile crane. Over several weeks, effective operation of the jet pump and the remainder of the system components were verified while bypassing material nearly 2 miles to the Oceanside beaches.

In July 1989, the pumping platform moved to the entrance channel. Since then operations in the entrance channel have been encouraging. One jet pump, the most seaward of the two, is functioning well. It has developed and maintained a crater approximately 80 ft in diameter and 15 ft deep. The other pump seems to be partially clogged with kelp which presumably settled around the pump during deployment. Efforts to clear the obstruction have resulted in the pump assembly settling deeper below the sand's surface. A substantial overburden of sand now exists above this jet pump.

Production records have indicated that even with only one jet pump fully operational, a transfer rate averaging 100 cu yd per hr and with a peak output of up to 150 cu yd per hr has been achieved. This equates to a daily production of up to 1,000 cu yd of sand being placed on the downcoast beach. Obviously, this production rate varies according to the amount of new sand moving into the harbor since the position of the jet pumps is fixed.

Future Phases of Construction

Subsequent phases of construction for this experiment depend upon the successful performance of the preceding construction phases. Evaluation of production rates, plant efficiency, assessment of difficulties occurring in operations and maintenance procedures, as well as advances in bypassing technology are considered in subsequent designs of the Oceanside system. Presently, the next development step involves including sand trap fluidizers. These fluidizers are long, inclined pipes with horizontal holes along the side. As water is pumped through the pipes, the water jets fluidize the overlying sand (Weisman, Lennon, and Roberts 1988), allowing it to flow to the fixed jet pumps. Two such fluidizer lines, 150 and 250 ft long, are being designed for placement in the entrance channel during the fall and winter of 1990. It is envisioned that these fluidizer lines will substantially increase the amount of material available to the jet pumps, thereby increasing the overall production rate of the bypassing system.

Indian River Inlet, Delaware

Indian River Inlet, Delaware, is located on the Atlantic Coast of Delaware approximately 10 miles north of Ocean City, Maryland. The 500-ft-wide inlet is stabilized by two parallel, rubble-mound jetties. To mitigate beach erosion which threatens a state highway north of the inlet, a fixed plant sand bypassing system using jet pumps was constructed adjacent to the south jetty, starting operations in February 1990 (Figure 5). The cost of the system is being shared with the state of

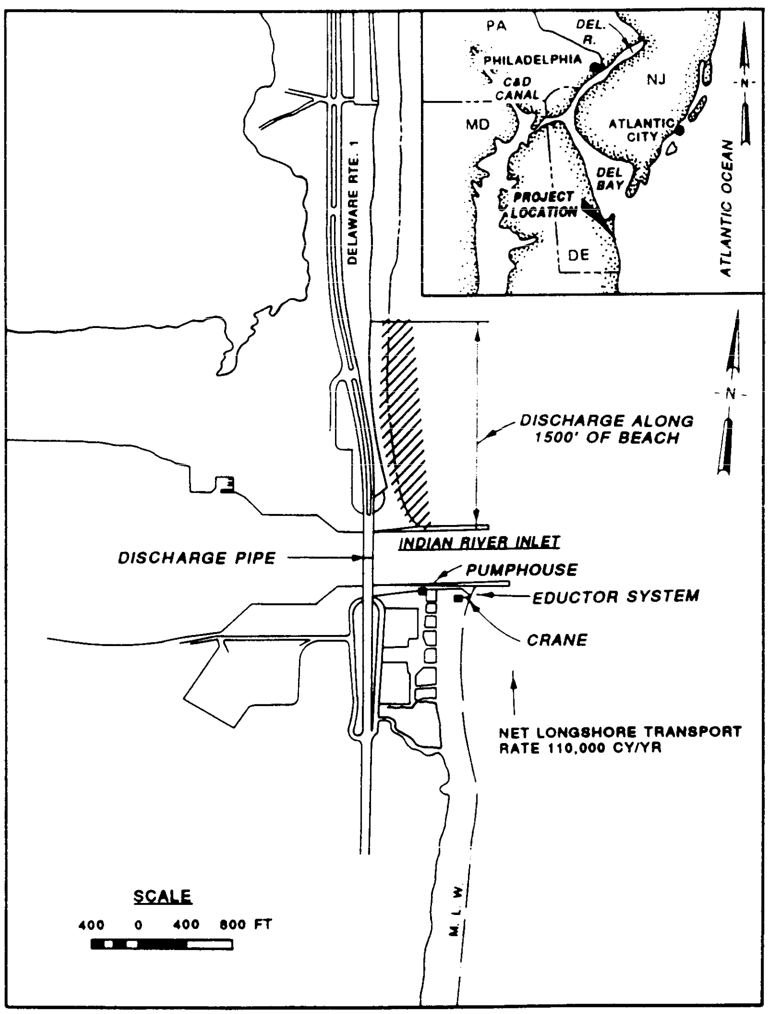

Figure 5. Indian River Inlet Bypassing System

Delaware, which is operating and maintaining the system. Final cost of the system, including the 2,000-ft-long discharge pipeline, was $1.6 million. Rambo and Clausner (1989) provide additional background details on the bypassing system.

System Details

The jet pump is being deployed between the high and low tide lines using a crawler crane. The crane provides an efficient method to deploy and retrieve the jet pump. Movement of the crane along the beach allows flexibility in positioning the jet pump.

Both the supply and booster pumps are housed in a pump house adjacent to the south jetty. Hydraulic details are summarized in Table 4. The discharge line crosses the inlet via the Route 1 bridge. The discharge line extends up to a maximum length of 1,500 ft on the beach north of the inlet. Along the north beach, the discharge pipeline can be shortened or extended for discharge at any point.

Table 4
Hydraulic Design Data for the Indian River Inlet Bypassing System

Supply pump	320 hp (2,500 gpm at 400 ft)
Booster pump	330 hp (3,200 gpm at 276 ft)
Discharge line	11 in. ID, HDPE, 2,000 ft
Jet pump	Genflo 2.5-in. nozzle, 6-in. mixer (200 cu yd per hr)
Sand size (D50)	0.30 mm
Deployment crane	135 tons, 120-ft-long boom

System Performance

Performance of the system steadily increased through the spring of 1990 as the operators gained experience. Originally designed to bypass 200 cu yd per hr, the system was initially bypassing 220 cu yd per hr. In April 1990, after making the jet pump more rigid to withstand deployment by the crane, production has again increased. The operators are now getting 40 to 43 percent solids by weight, and regularly bypass over 300 cu yd per hr with some hourly rates of nearly 400 cu yd.

Through the end of July 1990, the system had bypassed 69,000 cu yd. The total hours available for pumping were 383. Of that time, they actually pumped 245 hours, for an average hourly bypassing rate of over 280 cu yd per hr.

Best production occurs when the eductor is placed in the water on a rising tide with some wave action (Figure 6). The combination of rising tide and wave activity keeps sand flowing into the eductor crater, minimizing repositioning of the eductor to once or twice a day. On falling tides with little wave action, the eductor

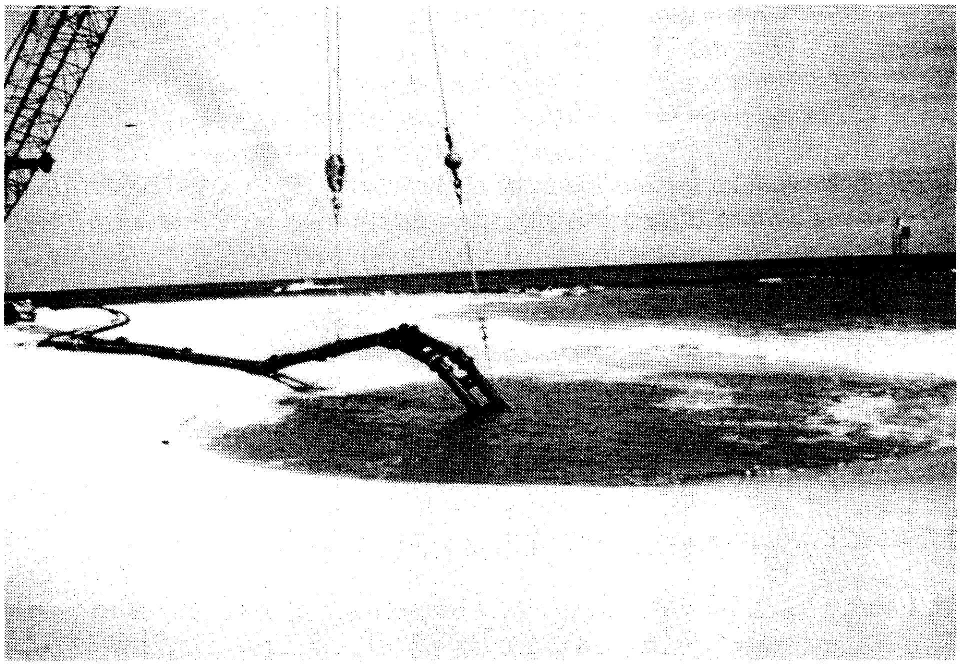

Figure 6. Crawler crane deploying jet pump at Indian River Inlet, Delaware

must be moved to the side about 10 ft every 15 to 30 min to maintain high production rates.

Like most other sand bypassing projects, social and environmental limitations have impacted this project. The state of Delaware has done an exceptional job working with the resource agencies to overcome limitations originally placed on the project. The land on either side of the inlet is a state park. Because of the heavy public use of the beaches north and south of the inlet, no bypassing was originally scheduled between Memorial Day and Labor Day. Park officials have also limited pumping during the spring due to fears that too much of the heavily used beach south of the inlet would be bypassed to the north side. The operators have convinced the park staff to allow bypassing during the summer, since the northerly transport will provide sand to the bypassing plant, maintaining beach width and maximizing the amount of sand bypassed.

The piping plover is an endangered bird species which has been sighted nesting on the beach north of the inlet. Should a piping plover nest be observed (nesting season is March through August), discharge of sand during this time will be limited to avoid habitat disruption. The plant operators have worked with the state resource agencies to provide nesting birds a wide buffer zone and to build walkovers to allow the young birds to cross the discharge pipe.

Summary

The differences in these three plants are due to the local coastal processes and plant purposes. The Nerang River Bypassing System with its ten jet pumps spaced over 1,000 ft has been successful in intercepting the sand prior to settling in the entrance channel. The littoral processes at Oceanside are very complicated, forcing an innovative bypassing system design. The mobile pumping platform allows bypassing from two locations depending on the season. The system will attempt to both reduce maintenance dredging of the channel and reduce downdrift beach erosion. The Indian River Inlet Bypassing System is the simplest of the three, using swash zone mining of the updrift fillet to nourish the beach on the downdrift side of the inlet.

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