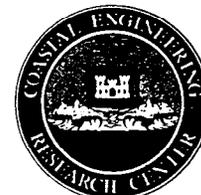




# Coastal Engineering Technical Note



## JET PUMP SAND BYPASSING - CASE STUDY I: NERANG RIVER ENTRANCE, AUSTRALIA

**PURPOSE:** This technical note describes the jet pump (eductor) sand bypassing system installed in 1986 at the Nerang River Entrance, near the town of Gold Coast, in Queensland, Australia. The Nerang system is noteworthy due to the magnitude of sand bypassed (650,000 cu yd annually) and a number of technical innovations including automated operation.

**BACKGROUND:** The Gold Coast region of Queensland is located along the mid east coast of Australia (Figure 1). Local interests felt that further development of the region was hampered by lack of safe passage to the Pacific Ocean. Due to strong northerly sediment transport, the existing Nerang River entrance had migrated north at an average of over 120 ft per year through this century, and was extremely treacherous. This situation required the entrance be stabilized to create a safe navigation channel. However, the effort and expense of a stabilized entrance would be wasted without sand bypassing. Otherwise, littoral drift would quickly fill the area next to the south jetty, naturally bypass it, create a new bar across the entrance, and cause erosion on South Stradbroke Island.

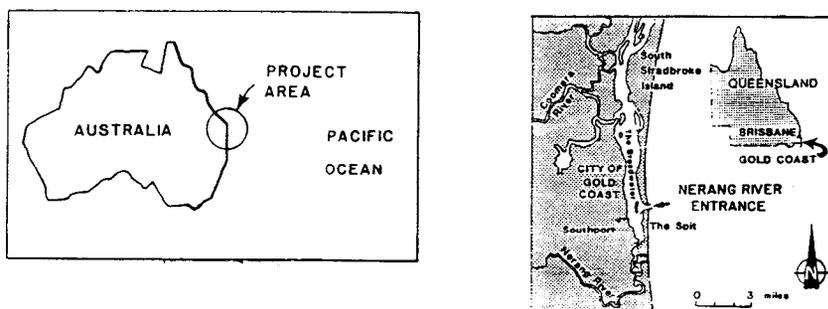


Figure 1. Location map

During the 70's and early 80's several studies were conducted, including numerical and physical models, to determine how to best stabilize the entrance. Plans for sand bypassing were included from the start. Construction of the jetties and dredging of the new channel were completed by November 1985. Sand bypassing system trials were completed and the system started operations in June 1986.

**LITTORAL PROCESSES:** This section of the Australian coast has a moderately active wave climate, similar to the west coast of the United States. Longshore transport for the area is almost unidirectional. Average northerly longshore transport (see Figure 2) is estimated at 760,000 cu yd/yr and average southerly longshore transport is estimated at 110,000 cu yd/yr for an average net longshore transport of 650,000 cu yd/yr to the north. For bypassing purposes, transport rates over shorter time periods are needed

unless substantial storage areas are available. For the Nerang Bypassing System, the following criteria were established:

Maximum 5 day transport	130,000 cu yd
Average yearly transport	650,000 cu yd

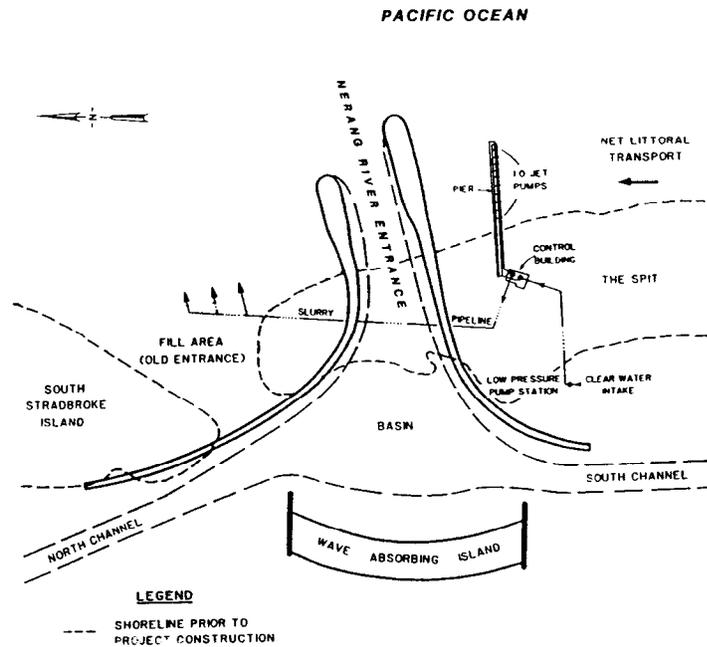


Figure 2. Nerang River Entrance Bypassing System, plan view

**BYPASSING SYSTEMS CONSIDERED:** Several different bypassing schemes were initially considered including: 1) a low weir section in the south jetty with deposition basin, 2) an offshore breakwater with sand trap, 3) a land-based fixed dredge, 4) a land-based mobile dredge, and 5) floating dredges operating at the inlet mouth or just south of the inlet. Eventually a trestle mounted jet pump system was considered and ultimately selected. Discussions of the alternatives and selection process can be found in Clausner (1988).

Jet pumps (also known as eductors) are hydraulically powered pumps with no moving parts, relying instead on exchange of momentum to do work (Richardson and McNair, 1981). In a simple jet pump (Figure 3), a stream of high velocity clear water from a supply pump is forced through the nozzle. On exiting the nozzle, the high velocity jet draws in and transports the surrounding fluid through the mixing chamber into the diffuser. This movement of the fluid into the diffuser creates a negative pressure, inducing flow into the suction opening. If the suction opening is buried in the sand, a sand-water (slurry) mixture will be drawn into the jet pump. A conventional dredge pump downstream of the jet pump can be used to help move the slurry through the discharge pipe.

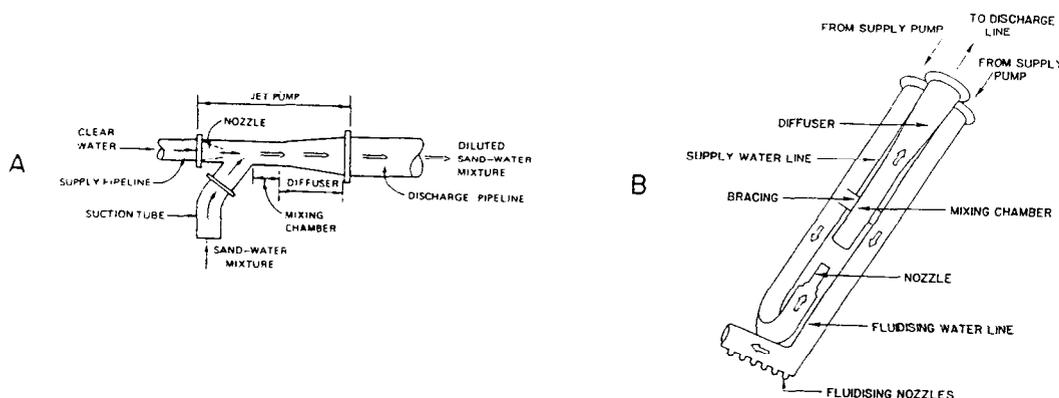


Figure 3. A - Schematic of a simple jet pump.  
B - Genflo Sand Bug jet pump used in the Nerang River Bypassing system.

BYPASSING SYSTEM DESIGN DETAILS:

Rate: The design bypassing rate was based on the maximum transport rate over 5 days, 130,000 cu yd. Assuming the sand trap is initially empty (capacity originally estimated to be 39,000 cu yd), the system would have to bypass 91,000 cu yd in five days (or 18,200 cu yd per day). Assuming the plant will operate 24 hours per day during storms, the design bypassing rate during storm conditions would be approximately 750 cu yd/hour. This high rate will probably seldom be needed, consequently the system was designed to operate at lower rate the majority of the time. The selected normal operating bypassing rate is 435 cu yd/hr, approximately 60 percent of maximum.

Dimensions: The final design of the system is shown in Figures 2 and 4. The trestle is located 820 ft south of the south jetty. Overall trestle length is 1,600 ft and the deck is 20 ft above Australian Height Datum (AHD), which is approximately mean sea level. Ten jet pumps are spaced approximately every 100 ft along the outer 900 ft of the trestle. For reference, the jet pumps are numbered 1 at the seaward end of the trestle through pump 10 closest to shore. The sand trap therefore extends approximately 900 ft from what was the mid-tide line when the system started out to - 20 ft (AHD).

Jet Pumps: Each individual jet pump is a 3-1/2 inch Genflo "Sand Bug" jet pump, rated at 135 cu yd/hr (Figure 3B). The jet pumps are attached to wide flange steel beams which slide down a second set of steel support beams attached to the back of the trestle concrete piles. Stops on the support beams prevent the jet pumps from penetrating past their design depth of 33 feet below AHD.

Hydraulic Design Details: Water to power the jet pumps is drawn from the estuary using two low pressure supply pumps (250 hp each). Water from these pumps flows through a pipeline 2,300 ft long to the main pump house, where it feeds dual 450 hp supply pumps. The supply pumps can operate in parallel and provide motive water to power the jet pumps. High pressure water from the supply pumps flows from the pump house through a pipeline to the jet pumps. Supply water can also be directed to fluidizers on the jet pumps, which are used during installation and removal, and to improve transfer capacity when debris have collected around the jet pump.

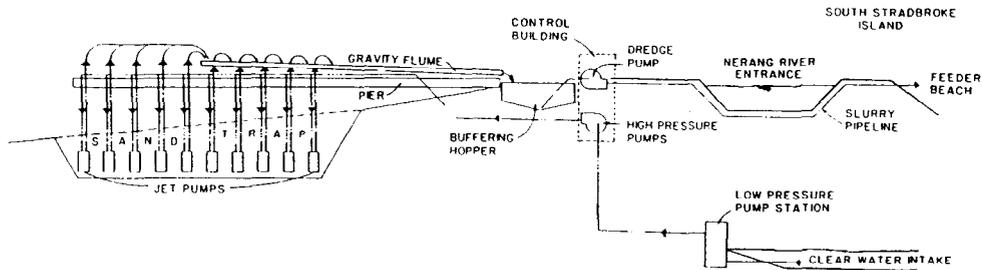


Figure 4. Nerang River Entrance Bypassing System, elevation view

Slurry is removed from the hopper and transferred across the inlet to South Stradbroke Island by a 950 hp, variable speed dredge pump. A fluid drive controls pump speed. Slurry concentration is monitored by a nuclear density meter, flow is measured by a magnetic flowmeter.

From the dredge pump, the discharge flows north under the navigation channel to South Stradbroke Island. The discharge line is a 16 inch diameter steel pipe with a polyurethane lining. The total length of the discharge line is 3,870 ft, with the most distant of the three discharge points on South Stradbroke Island 1,710 ft from the north jetty.

Bypassing Operations: The Nerang River Entrance has a number of unique or unusual features associated with its operation. Most noteworthy is the fact that the system operation is controlled by computer, allowing unattended bypassing operations at night to take advantage of lower electric rates.

The bypassing system is operated by employees of the Gold Coast Waterways Authority. Two full time employees are on site 40 hours per week, from approximately 7:30 AM to 4 PM. During the day they perform maintenance operations and adjust discharge pipe locations. Prior to leaving, the operators check the level of sand in the jet pump craters with a lead line and program the sequence of jet pumps to be operated that night by the computer.

Electricity rates in Australia are \$.15/kWh during the day, but fall to \$.05/kWh from 9 PM to 6 AM. Obviously, it is much less expensive to operate the plant, which is totally electric, during the low cost hours. This is possible because a) the plant has been designed for automated operation by computer, and b) the discharge site, South Stradbroke Island, is uninhabited. Consequently there are no safety problems on the downdrift beach associated with the unattended bypassing operation.

The system normally operates four jet pumps at one time. This requires the use of one of the low pressure pumps at the estuary and one of the high pressure, supply pumps in the pump house. Operation of seven jet pumps requires using two low pressure and two high pressure supply pumps.

SYSTEM PERFORMANCE: During the first 1-1/2 years, the system has met nearly all design standards. Bypassing performance is summarized in Table 1. Sediment transport has been below normal since bypassing operations began. This has allowed the system to bypass the estimated littoral drift of 390,000 cu yd (May 1986 to Apr 1987) plus 390,000 cu yd of the estimated 1,100,000 cu

yd which were trapped next to the south jetty during the time lag between jetty construction and bypassing system start-up. Maximum measured output from a single jet pump has been 140 cu yd/hr.

Table 1.  
Summary of Bypassing Performance

<u>Time Period</u>	<u>Amount Bypassed</u>
May 86 to July 87 (57 wk)	900,000 cu yd
May 86 to Feb 88 (1.8 yr)	1,310,00 cu yd
Maximum Performance (1 wk)	54,000 cu yd
Maximum Performance (1 month)	117,000 cu yd
Average Monthly Performance	40,000 - 50,000 cu yd

As might be expected, the nearshore jet pumps have bypassed considerably more sand than the offshore jet pumps. On the average, jet pumps 1 - 4 have 80 to 100 percent more operating hours than pumps further offshore.

Offshore craters tend to remain for several weeks after creation unless there is significant wave action. Nearshore craters, as expected, generally fill in much faster due to increase wave influences.

The amount of energy required to date has been somewhat higher than predicted. The system was designed to require only 2.4 kWh of electricity per cu yd of sand bypassed. In fact, energy requirements have been somewhat higher due to reduced jet pump performance caused by debris. Projected annual operating costs, supplied by the Gold Coast Waterways Authority are approximately \$0.60 per cubic yard, with electricity accounting for \$0.25 per cubic yard. A detailed breakdown of operating costs can be found in Clausner (1988). The operating costs are in Australian dollars, which are roughly comparable to US dollars. The operating costs do not include amortization of the original cost of the bypassing system, which was over \$7.2 million dollars (Australian). This amount included a two year maintenance agreement on the components.

PROBLEMS, SOLUTIONS AND RECOMMENDATIONS: The two main problems experienced by the system have been wear on the jet pump nozzles and debris in the jet pump craters reducing performance. After trying several different materials, stainless steel nozzles are now being used, more for their corrosion resistance than hardness. They are expected to have a useful operating life of 700 to 800 hours. Additional impressed cathodic protection has been applied to the overall structure to reduce corrosion of the components.

The other major problem has been debris. Actual clogging of the jet pump is an occasional problem, caused primarily by filter cloth from jetty construction and timber pieces from the Nerang River Entrance. This, along with nozzle replacement, requires periodic hiring of a 20-ton crane to remove jet pumps as necessary for servicing.

Debris that collects at the bottom of the crater is the biggest problem. Virtually any item entering the littoral system (rocks, bricks, wood, trash) tends to find its way to the bottom of the jet pump craters. Eventually, this debris restricts the flow of sand enough to reduce bypassing ability from the system average of 400 cu yd/hr to 250 cu yd/hr. Early attempts to alleviate the problem consisted of pushing a tube down to the jet pump and blowing compressed air through it. This would solve the problem for a short time, but the debris would soon move back. The exceptionally steep crater slopes do not permit divers to work safely at the crater bottom.

However, the Gold Coast Waterways authority has developed what appears to be a solution to the problem. A clean-out jet pump, with a diffuser opening of 9 inches, as opposed to the 3.5 inch opening on the normal jet pumps, has been constructed and was tested in late 1987 and early 1988. It was able to bypass a significant amount of large trash. Plans are to operate it periodically at each jet pump location, hopefully restoring performance of the regular jet pumps to design level. The one clean-out pump requires the entire output from the supply pump, making it impractical to install multiple debris clearing pumps. In addition, the shrouds on the existing jet pumps are being removed in an attempt to improve performance.

**ADDITIONAL INFORMATION:** For additional information contact Mr. Tim Welp at (601) 634-2083, *Timothy.L.Welp@erdc.usace.army.mil* of the Coastal and Hydraulics Laboratory.

Clausner, J.E. 1988, "Jet Pump Sand Bypassing at the Nerang River Entrance, Queensland, Australia," Proceedings Beach Preservation Technology '88, Florida Shore and Beach Preservation Association, Gainesville, FL.

Richardson, T.W. and McNair, E.C., Jr. 1981. "A Guide to the Planning and Hydraulic Design of Jet Pump Remedial Sand Bypassing Systems," Instruction Report HL-81-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS.