# REALTIME WAVE ANALYSIS, NEWCASTLE, AUSTRALIA

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## 1. INTRODUCTION

The Port of Newcastle, N.S.W., Australia, is being deepened from 11m to 15.2m below chart datum to permit the navigation of 120,000 D.W.T. bulk coal vessels. Part of this project, which is expected to reach a cost of approximately A$90 million, involves the removal of two million cubic metres of rock, some of which is located outside the breakwaters and exposed to ocean waves (see Fig. 1).

Drilling and blasting of rock in the area subjected to ocean wave activity is being carried out by two self elevating platforms. On completion of drilling and prior to blasting the platform must make a transition from being supported by its legs to floating so it can be removed from the blasting area. While the two self elevating platforms have been built with a very fast jacking rate of 6m/minute, with a sophisticated shock absorbing system connecting the legs to the platform, the rigs cannot be jacked up or down when wave conditions exceed a certain limit. Even though the rigs can survive worse conditions than those allowable for jacking down by remaining on their legs at a sufficient height above the water, this would entail loss of drilling time, and the presence of the rigs in the channel could close the port to shipping.

Thus from an operational point of view it is vital that present wave conditions are reliably described. Estimation of wave height by observation is difficult enough during daylight hours but is virtually impossible in darkness (drilling operations are carried out 24 hours/day). The dredging contractor (WestHam Dredging Co. Pty. Ltd.) therefore decided that a real time wave analysis system should be established and co-operated with The Maritime Services Board of N.S.W. in a joint project for this purpose.

## 2. THE SYSTEM HARDWARE

A block diagram of the system hardware is shown in Fig. 2. Because of the large investment that the system is designed to protect it has been designed for maximum reliability.

Three Waverider buoys are used as the water surface elevation sensing instrument. The location of these buoys is shown in Figure 1. The offshore buoy and one inshore buoy were part of a traditional type Waverider installation which had been operating since 1975 (Lawson and Youll, 1977). The second inshore buoy (closest to the shore) was installed to add reliability to the system and to ensure that at least two buoys were always operating.

The Waverider buoy signal is received at a shore based station. Each buoy has its own receiver/ phaselock loop/digitiser circuit with an additional spare set of circuits to ensure minimum down time.

Each buoy is continuously monitored and the signal is digitised once every ½ second to indicate the average position of the buoy over the previous ½ second. An arbitrary datum is established 2000cm below mean water level and the position of the buoy in elevation is resolved to 1cm. A multiplexor samples all three channels and sends the 3 x 4 ASCII characters through the leased line, prefaced by a status character which indicates which buoys are not in position.

The characters are collected from the leased line by a PRIME 400 minicomputer running under a real time operating system. The Prime performs the required calculations and interpretations and sends these results back through the leased line to the WestHam site office. Input data is stored in a buffer while the calculations are performed so that no input data is lost, and all raw data and results of analysis is stored on disc, to be dumped to magnetic tape at fortnightly intervals.

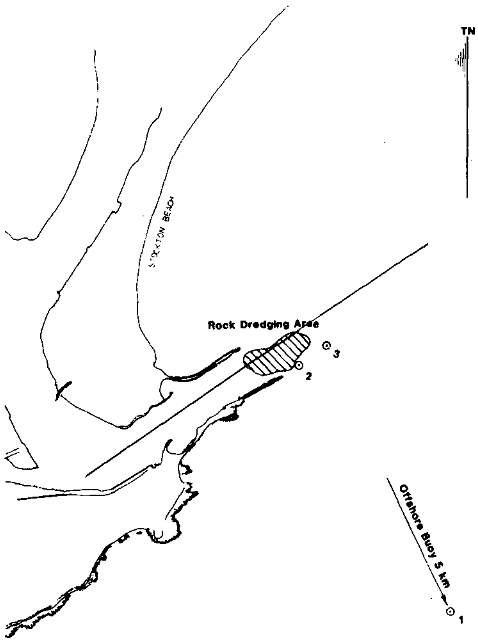


FIG 1 LOCATION PLAN FOR NEWCASTLE HARBOUR

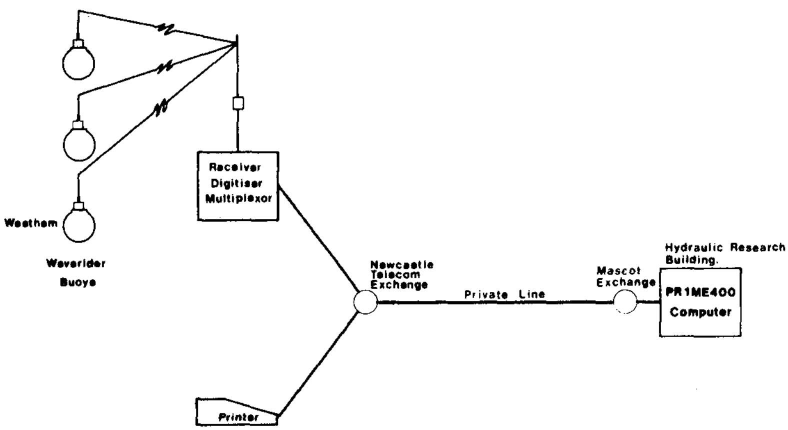


FIG 2 REALTIME WAVE ANALYSIS SYSTEM-NEWCASTLE

## 3. THE SYSTEM SOFTWARE

The system software performs the following functions :-

(a) Collects the data from the leased line and checks for errors in line transmission, parity errors and for a Waverider buoy being hit or spun, which is usually indicated by a large displacement.

(b) If it is recognised that the buoy has been hit or spun, a message is immediately sent to Newcastle with advice as to which buoy has been tampered with, and the appropriate action which should be taken.

(c) Every 10 minutes, calculates for the previous 20 minutes of data, a wave-by-wave routine analysis and an auto-correlation type spectral analysis yielding the parameters of significant wave height ($H_s$), maximum wave height in 15 minutes ($H_{max}$) and peak period in the energy spectrum ($T_p$) (Abernethy and Lawson, 1973, Lawson and Abernethy 1975).

(d) Following calculation $H_s$, $H_{max}$ and $T_p$ values are sent to Newcastle with $H_s$ and $T_p$ also being represented graphically.

(e) If the value of $H_s$ for any buoy has exceeded 1.75m since the previous computation, a message to that effect is sent to Newcastle with a warning bell to alert WestHam personnel.

(f) The programme also checks the amount of energy at 0.0 Hertz. If the value is large, a message is sent to Newcastle indicating that a buoy is faulty, either due to interference or a twisted accelerometer suspension.

The system is in continuous operation, producing 144 analyses per day. CPU demand is very low at about 2 minutes/hour for data logging and analysis.

## 4. RECENT DEVELOPMENTS

While the system has been able to provide the dredging contractor with sufficient warning on most occasions, the provision of information from the waverider system at Botany Bay, 160Km to the south, would give earlier notice of waves arriving from the south. This addition to the system is at present being installed.

## 5. EXAMPLES

In the examples shown in Figures 3 and 4, the isobar spacing is 4mb. The two examples have been selected to show the two types of wave conditions which can occur off Newcastle :-

(a) where Newcastle is within the wave generation area (Fig. 3).

(b) where the swell generation area is some distance away from Newcastle (Fig. 4).

In Figure 3 a reasonably intense high pressure system and associated front formed over south eastern Australia during the early hours of 23rd September, 1979. Prior to its formation, low background type swell conditions existed from a weak high pressure system to the east of Newcastle. The significant wave height was about 1.1m while the peak period about 12 seconds. With the arrival of the locally generated waves from the south the amount of energy in these shorter period waves soon became larger than the underlying swell reducing the peak period from about 12 seconds down to 5 seconds. As the locally generated waves became larger the peak period became longer. In this example the warning that waves were going to get larger would have been accepted at about 1200 hrs. on 23rd September, 1979 providing more than the required 2 hours notice that waves inshore were likely to rise above 1.75m.

Figure 4 illustrates a classic example of swell waves arriving from a distant generation area. In this case the low pressure system is moving south east from Tasmania towards New

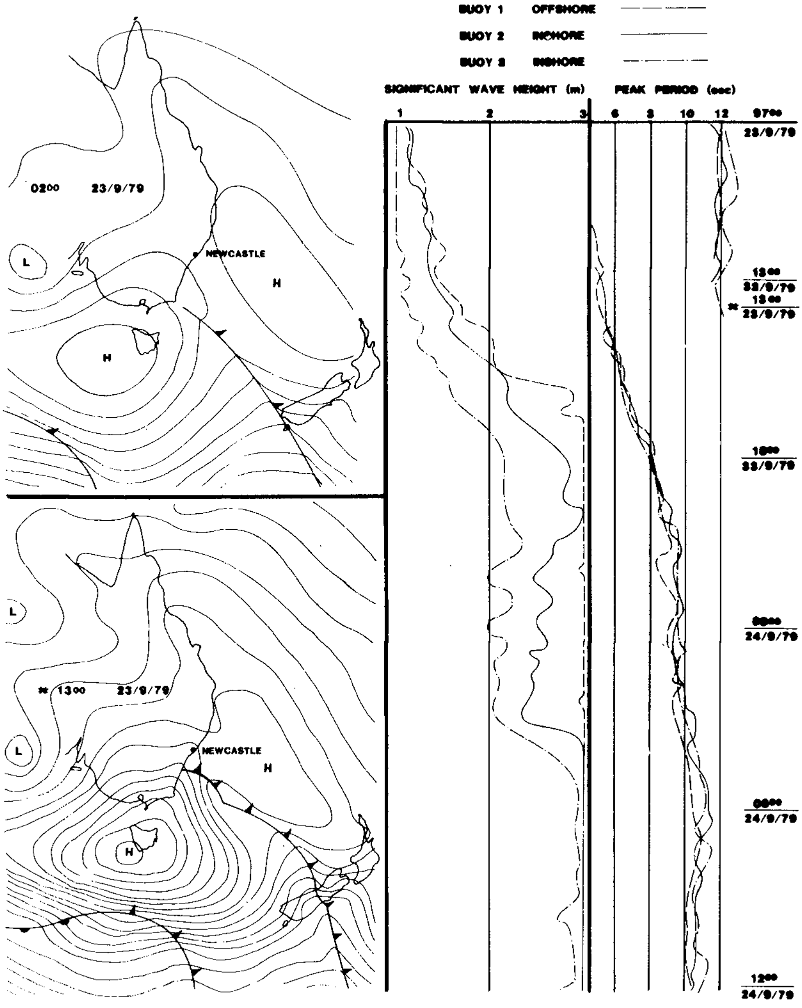


**FIG 3 WAVE ANALYSIS OUTPUT**

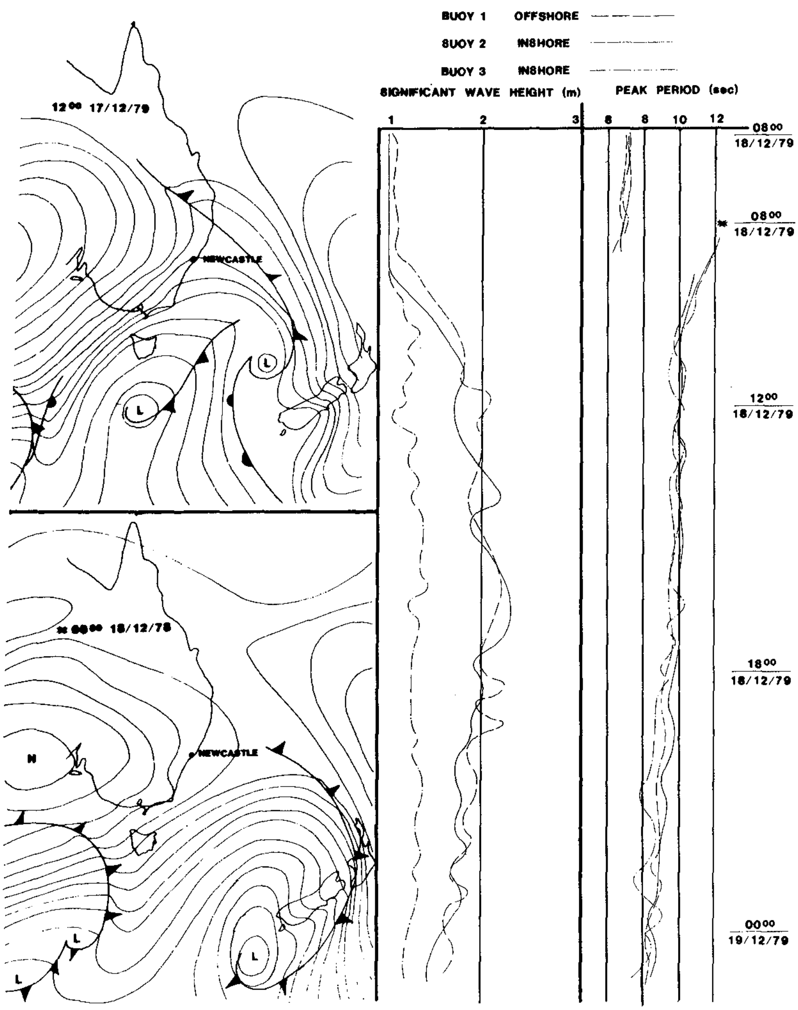


FIG 4 WAVE ANALYSIS OUTPUT

Zealand. The longer period waves of low wave height arrive first resulting in an abrupt change in peak period with no apparent immediate increase in wave height. However, this change is a clear indication that larger waves will follow within the next few hours. In this case the warning of increasing waves would have been accepted just after 0800 hours on 18th December, 1979, again providing at least the required 2 hours notice.

Situations similar to these two examples have been repeated on numerous occasions since the installation of the system during April 1979. The output format was chosen to provide clear results, requiring no interpretation. All the operator has to look for is a sudden change in peak period, either up or down, associate the change with the synoptic situation from a Facsimile (Fax) receiver, and issue a warning. It would be possible to provide more warning if the amount of energy in discrete period bands had been investigated, but this approach was rejected because of the additional interpretation required. With the system chosen all the operator needs to do is look for a change in peak period.

## 6. CONCLUSIONS

The system has now operated with good reliability for over 12 months. The most unreliable section of the system has proven to be the leased telephone line between Newcastle and Mascot. The system has provided the dredging contractor with a reliable warning system which on the great majority of cases has provided at least 2 hours notice that waves will rise above 1.75m.

This system has real advantages over traditional methods of wave data collection and analysis :-

(a) There is an increase in reliability of the total system resulting from the early warning of a Waverider being hit or tampered with.

(b) Data collection and analysis is a one step process rather than 2 or 3 steps resulting in less manhours in wave analysis and data storage.

(c) There are significant benefits in the description of storm events. This type of recording will eventually allow more reliable and rational methods of describing and predicting return intervals of storms.

## 7. ACKNOWLEDGEMENTS

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