CHAPTER ONE HUNDRED TWENTY NINE

Offshore Breakwater, Wheatley, Ontario

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The safe entry during storms to the fishing harbour at Wheatley on Lake Erie was compromised by breaking waves at the harbour entrance. These waves approach the entrance from a narrow easterly sector due to storm tracks, fetch limitations, and refraction. Using a physical model, a small offshore breakwater was selected as the best solution to eliminate the breaking waves. During the six years since construction, the breakwater has performed satisfactorily and has had a negligible effect on the littoral processes as determined from regular bathymetric surveys.

Introduction

The harbour at Wheatley, Ontario (Fig. 1) is primarily used by commercial fishing vessels. Prior to 1978, storm waves from easterly directions broke over the bar at the harbour entrance producing hazardous conditions for these vessels. During these storms, fishing vessels returning to port had difficulty maintaining control and entering the harbour safely. In several cases vessels had to seek shelter at other harbours, the nearest being over two hours away.

The objective of this study was to find an entrance configuration that would eliminate wave breaking and reduce the wave height to an acceptable level over the bar at the harbour entrance. The solution was to build an offshore breakwater.

Wheatley Harbour

Wheatley Harbour (Fig. 2) is the most important freshwater commercial fishing harbour in Canada. The harbour is the home port for approximately 45 fishing tugs and provides berthage for up to four transient tugs. The typical vessel size which utilizes the harbour is about 20 metres in length, 4.2 metre beam and 2.0 metre draft.

The entrance channel is dredged to a depth of 3 metres and has a minimum width of 21 metres. Ice generally restricts fishing activity in January and February.

The shoreline to the east of Wheatley Harbour consists of eroding clay bluffs and sand beaches. The net movement of littoral material is towards the southwest and has been estimated to be about 50,000 m^3/year (2). As a result of this transport material, about 4,700 m^3 of sand on average had to be dredged from the entrance channel each year.

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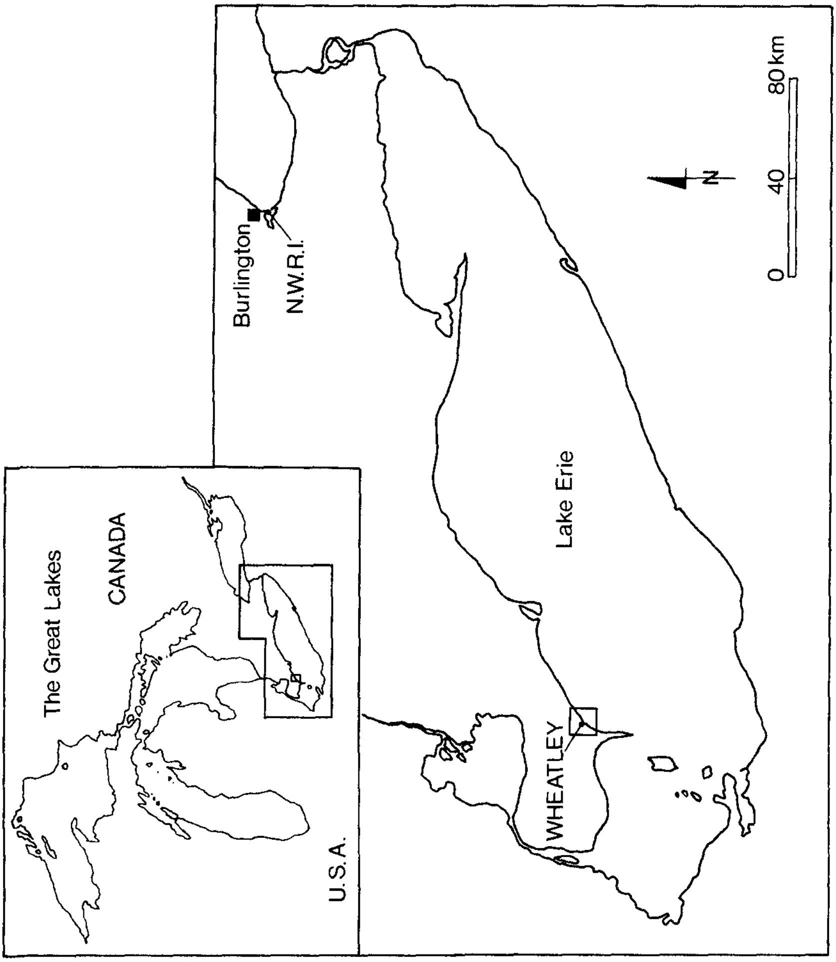

Figure 1. Location Map.

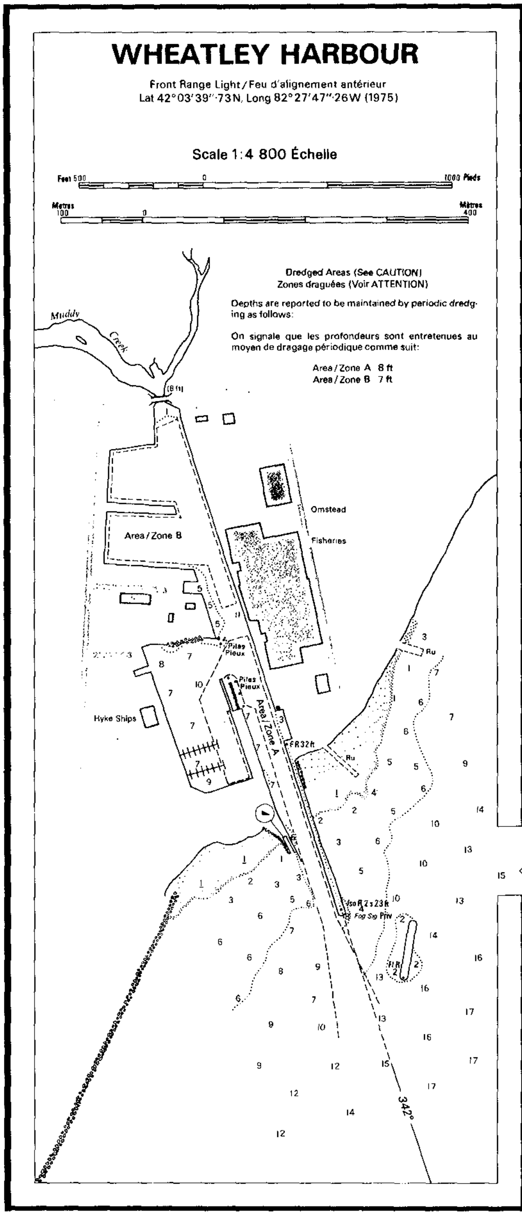

Figure 2. Hydrographic Chart, Wheatley Harbour.

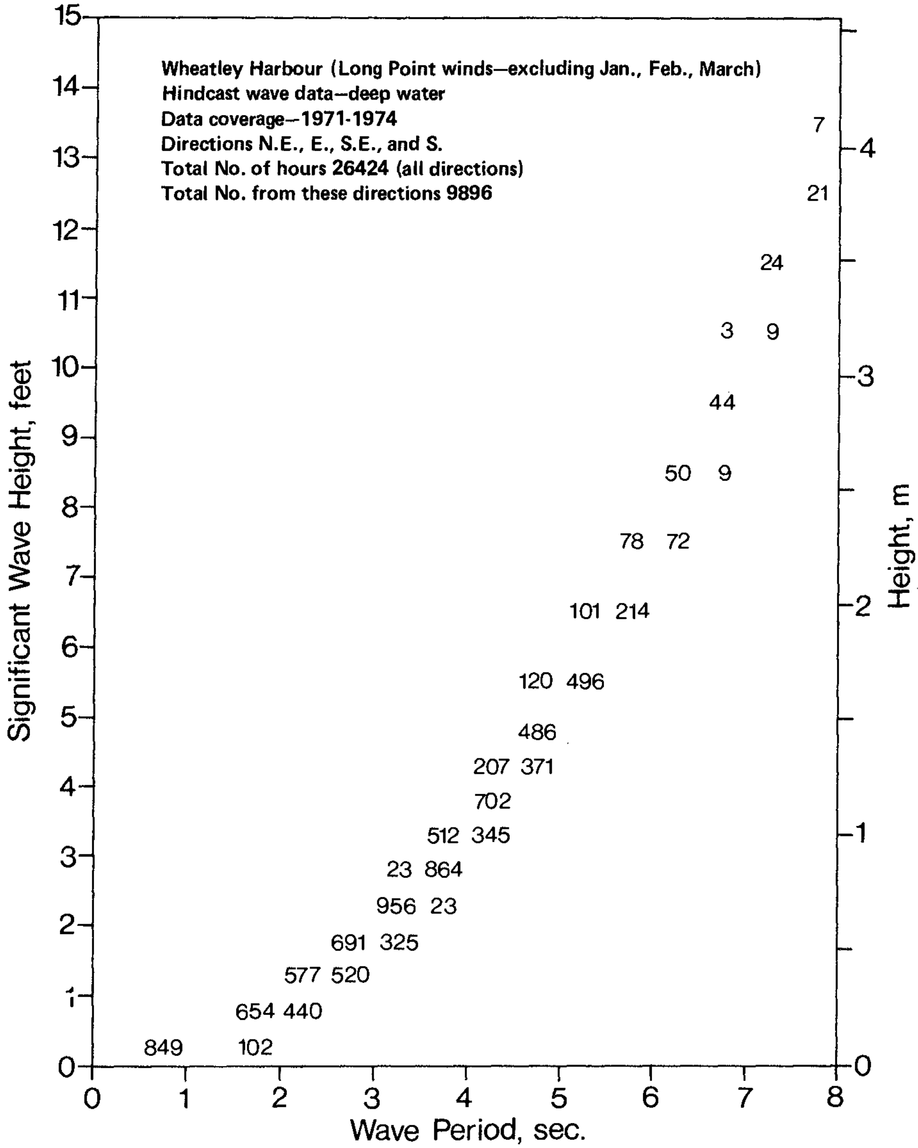

Figure 3 Hindcast scatter diagram

Figure 4. Breaking Wave at Harbour Entrance, Model.

Wave Climate

The harbour is exposed to waves generated by northeast, east, southeast and south winds. The most severe conditions are from easterly storms which generate waves of from 5 to 7 second periods with deep water significant heights of 6 to 12 feet (1.8 to 3.7 metres). The wave climate was hindcasted (Fig. 3) using a procedure based on Bretschneider's equations (1).

Refraction analysis showed that the large waves, which cause the navigation problem, approach the harbour entrance from a small sector of 90° to 105° true.

Model Study

A fixed bed model of the harbour and its approaches to the 4 metre contour was constructed to a geometric scale of 1 to 60 in the Hydraulics Labortory at the National Water Research Institute (3). Irregular waves were used to simulate prototype waves from the east sector. A refraction analysis was used to define the wave direction at the model boundary.

The model tests, combined with the wave climate, indicated that severe breaking wave conditions could be expected during four storms in an "average" year. This conclusion was verified in discussion with the local fishermen. Reproduction in the model of the severe breaking condition is shown in Figure 4.

It was established that the significant wave height should be less than 1.2 metres to prevent breaking and to ensure safe entry and exit from the harbour. By keeping the waves as large as possible, but under this limit of 1.2 metres, the structure would have a minimal effect on the littoral processes.

Numerous offshore breakwater configurations were studied in the model until a suitable configuration was determined.

The variable design features in each breakwater configuration were length, distance form the harbour entrance structures, and orientation.

Recommended Solution

The structure that was recommended met the following design criteria:

- it was sufficiently far from the entrance not to represent a hazard to navigation;

- it provided protection during easterly storms to eliminate breaking waves (reduced the significant wave height to less than 1.2 metres);

- it did not reduce the wave height more than necessary, to interfere as little as possible with littoral processes;

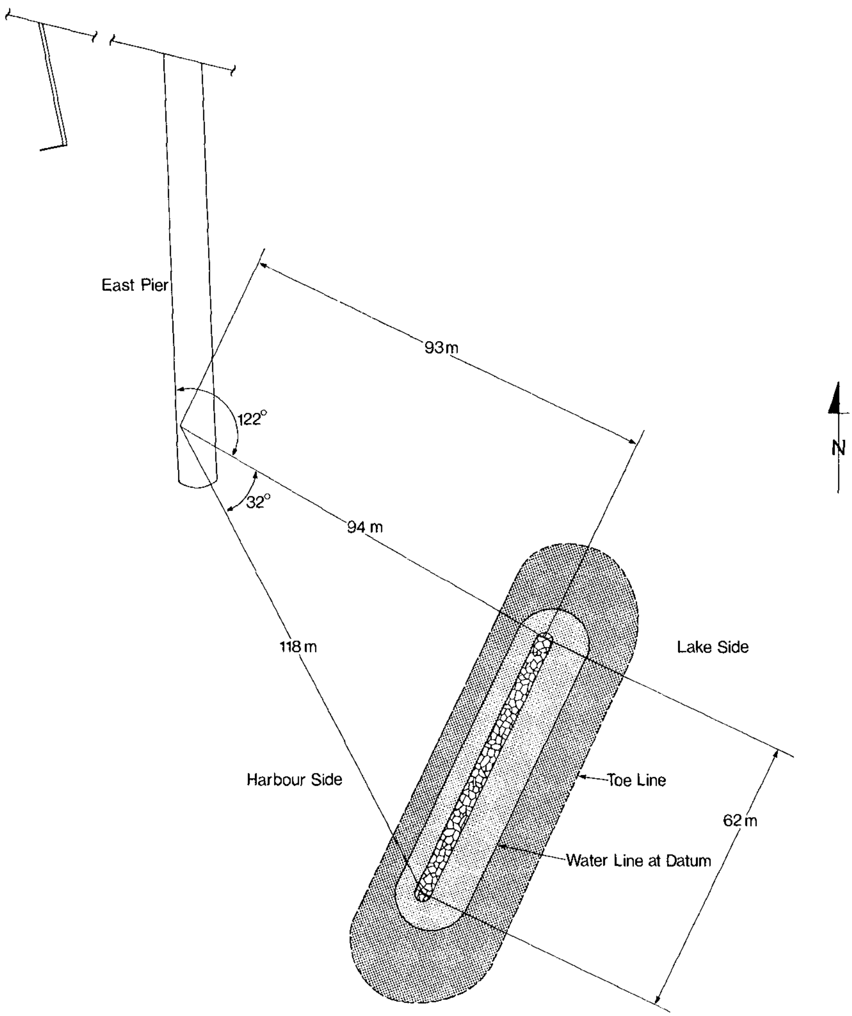

Figure 5 Layout plan, recommended solution

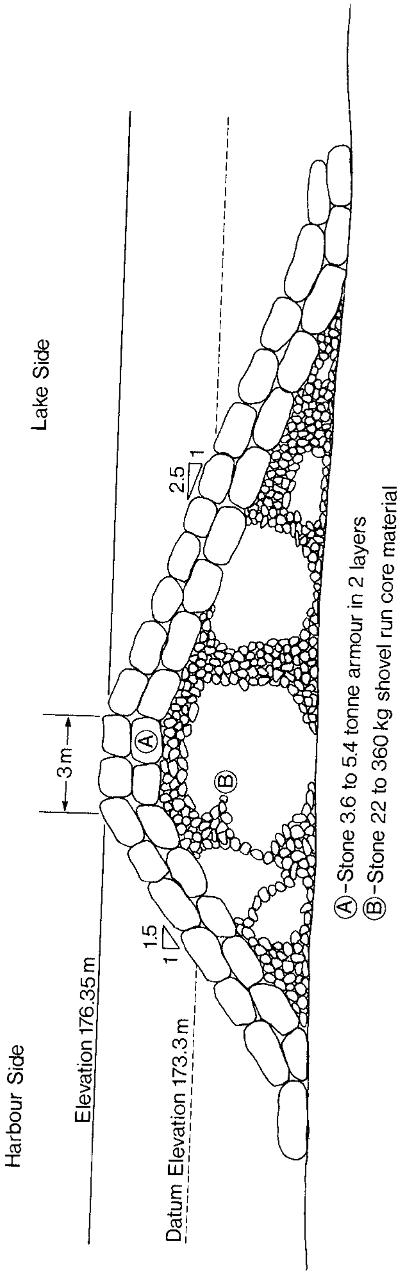

Figure 6. Cross-Section of Recommended Breakwater.

Figure 7. Oblique Aerial Photo of Wheatley Harbour.

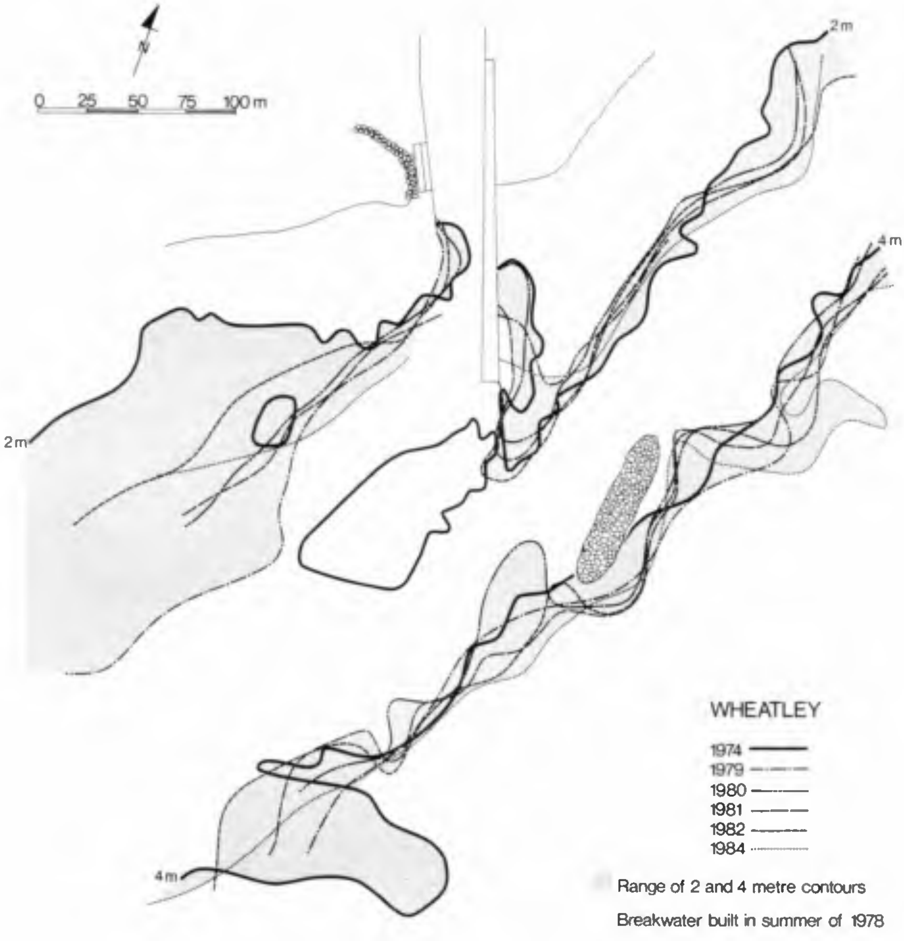

Figure 8 2 and 4 metre contours

- it represented the least cost of all structures meeting the above criteria.

A breakwater approximately 62 metres long was selected, located as shown in Figure 5 and Figure 7. It consists of a rubble mound core protected by two layers of armour stone. The core material is 22 kg to 360 kg shovel quarry run material, with 50 percent greater than 225 kg. The armour stone is 3.6 - 5.4 tonnes with 70 percent of the stone greater than 4.5 tonnes (Figure 6).

The top elevation of the breakwater is at 3 metres above datum which is about 2.5 metres above average lake level and about 1.5 metres above the all-time average monthly high.

The breakwater was constructed in the summer of 1978 at a cost of $320,000 (Canadian). During its six years of existence, wave breaking has been reduced so that fishing vessels are now able to return to the harbour under storm conditions. The fishermen of Wheatley Harbour are entirely satisfied with the structure.

Changes to the Nearshore

The major uncertainty with the offshore breakwater as a solution to the navigation problem was the effect on the movement and deposition of littoral material. Hydrographic surveys have been conducted regularly since the construction in 1978. To illustrate the changes that have occurred, the 2 metre and 4 metre contours from the various surveys have been reproduced in Figure 8. The location of the contours has remained relatively stable since 1978. There has been minimal shoaling behind the breakwater and in the channel.

Summary

A relatively small offshore breakwater has been precisely positioned off Wheatley Harbour to provide protection from breaking waves approaching from a narrow easterly sector. This solution allows fishing tugs to enter the harbour safely during storm conditons. Little or no interference with the movement of sediment in the littoral zone has been observed since the breakwater was constructed six years ago.

Acknowledgements

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