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Wave setup on beaches and in river entrances

by

Peter Nielsen, PhD, D Eng, Associate Professor, Department of Civil Engineering
The University of Queensland, Australia 4072,
fax +61 7 3365 4599, e-mail P.Nielsen@mailbox.uq.edu.au

The prediction of wave setup is an important part of modelling coastal inundation and flooding in coastal rivers but there are still some gaps in our knowledge particularly with respect to the conditions in river entrances.

One of the reasons that wave setup is still not fully understood, almost fifty years after it was first observed in the field and subsequently reported by Thorndike Saville (1961) and by Dorrestein (1961), is that it is difficult to measure accurately in the field.

Several Authors have tried to measure wave setup with pressure transducers but it is by now clear that this approach has very serious drawbacks. Firstly, in order to derive a surface level from a pressure it is necessary to know the elevation of the pressure sensor.

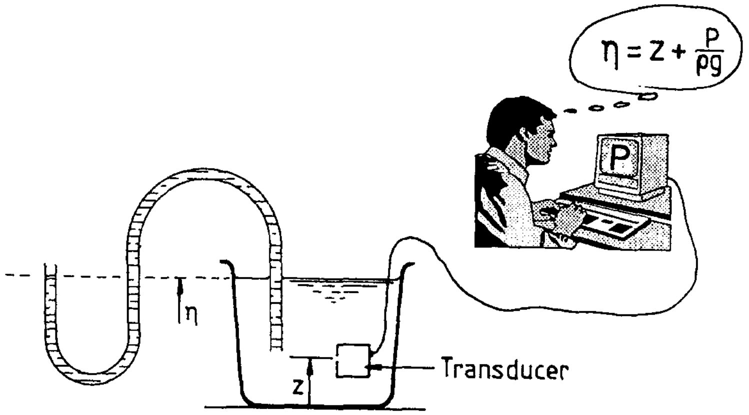


Figure 1: Measuring surface levels with pressure transducers requires knowledge of the transducer elevation. Manometer tubes need no survey information.

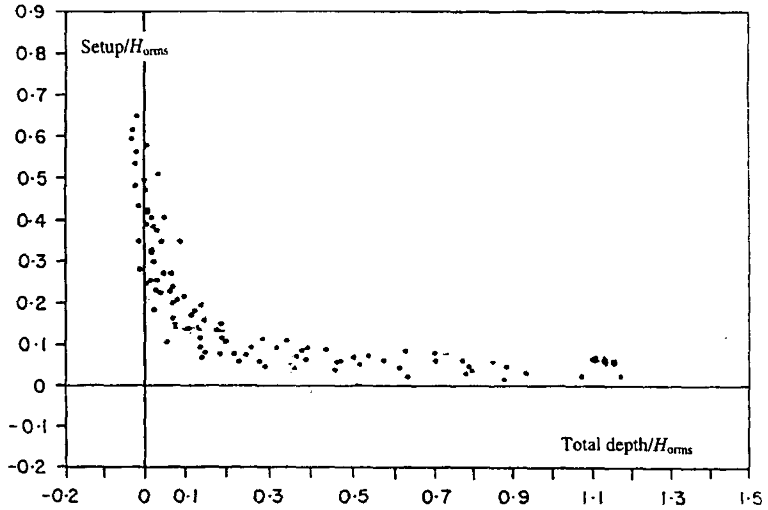
Secondly, even the best available pressure transducers have a tendency to "drift". Hence, centimetre accuracy cannot be counted on during deployments that last for months or years. The manometer tubes will automatically give correct relative levels for the corresponding offshore positions. Compared with pressure transducers, simple manometer tubes have therefore been much more productive with respect to high quality field data on wave setup. Details of manometer tube systems for coastal hydrodynamics investigations are given by Nielsen (1988) and Nielsen & Dunn (1998).

Measurements from many different beach topographies and many different wave conditions have shown that the setup profiles follow an almost universal relationship of the form

$$\frac{\textit{local setup}}{\textit{local, total depth}} = F\left(\frac{\textit{local, total depth}}{\textit{offshore wave height}}\right) \qquad (1)$$

That is, the shape of the beach profile does not influence this relation very much. A typical set of setup data is shown in Figure 2.

Figure 2: Typical distribution of the dimensionless setup versus the dimensionless total depth.



Correspondingly, the shoreline setup, i e, the setup at the point where the mean water surface intersects the beach (where the total depth is zero) varies very little with changing beach morphology. Thus, the shoreline setup formulae

$$\textit{Shore line setup} \approx 0.4 H_{orms} \qquad (2)$$

or with a slightly better goodness of fit

$$\textit{Shore line setup} \approx 0.048\sqrt{H_{orms} L_o} \qquad (3)$$

apply to a very wide range of beach topographies as illustrated by the data in Figure 3. In these expressions H_{orms} is the root mean square deep water wave height ad L_o is the deep water wave length corresponding to the spectral peak period.

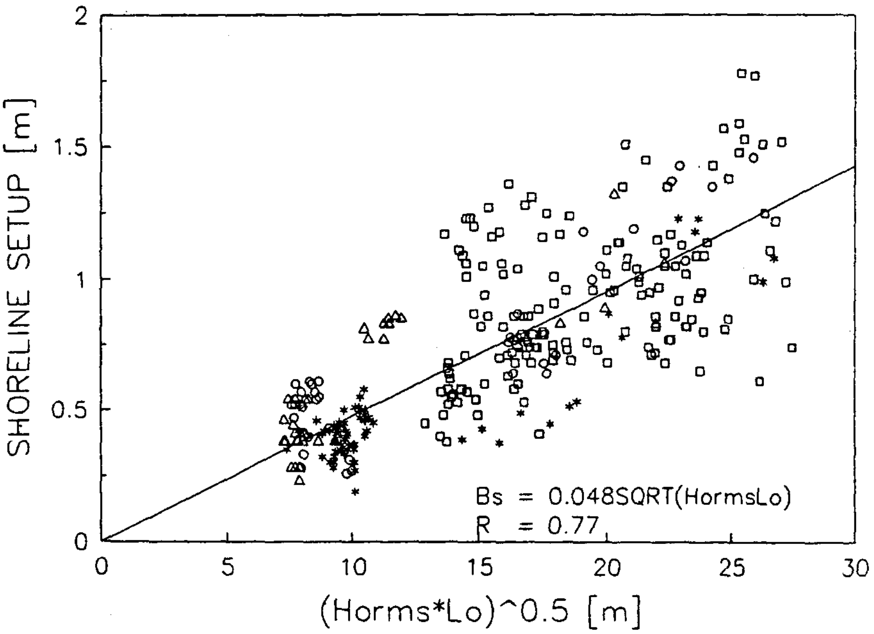


Figure : The straight line corresponding to Equation (3) gives a good prediction for a very wide range of beach topographies. The star corresponds to one of the flattest beaches in New south Wale and the circles correspond to one of the steepest sand beaches. For further details see Hanslow and Nielsen (1993).

Unsolved problems still remain with respect to modelling the underlying radiation stress distibutions in the inner surf zone and the swash zone. However, as far as empirical predictions and qualitative understanding are concerned wave setup in surf zones is by now fairly well covered. Our current level of the setup processes in river entrances are not nearly as well undestood. The big unanswered question is related to the large scour hole in Figure 4.

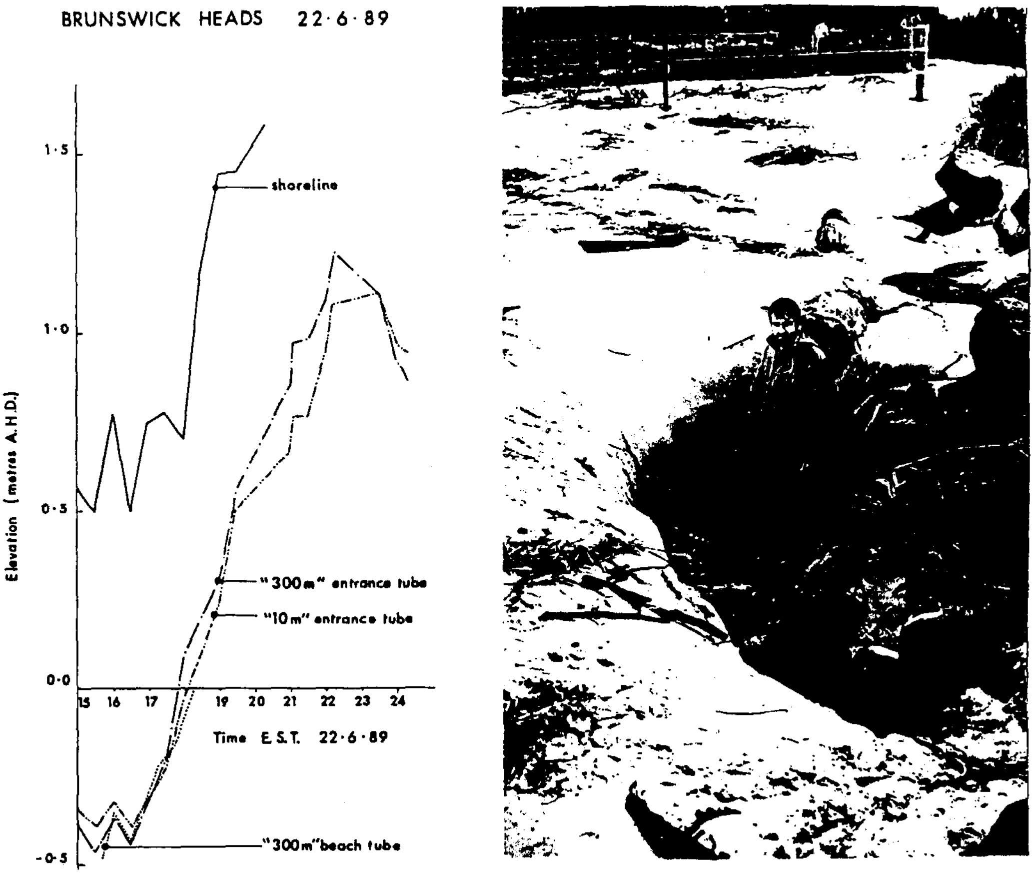


Figure 4: **Left**: waterlevel time series at the "*shoreline*" on the beach next to the river entrance. Outside the break point: "*300m*" and inside the wave breaking in the river: "*10m*". **Right**: Scour hole resulting from water rushing through the breakwater driven by the 1m head difference betweeen the "shoreline" on the beach and the "10m" station inside the river.

Our measurements from river entrances show consistently the situation of Figure 4. That is, even when the shoreline setup on the beach next to the river is more than 1m, there is no measurable setup inside the wave breaking in the river. It does not seem to matter much whether the tide in the river is running out or running in.

The plan in Figure 5 shows the measuring positions and the scour hole position of Figure 4.

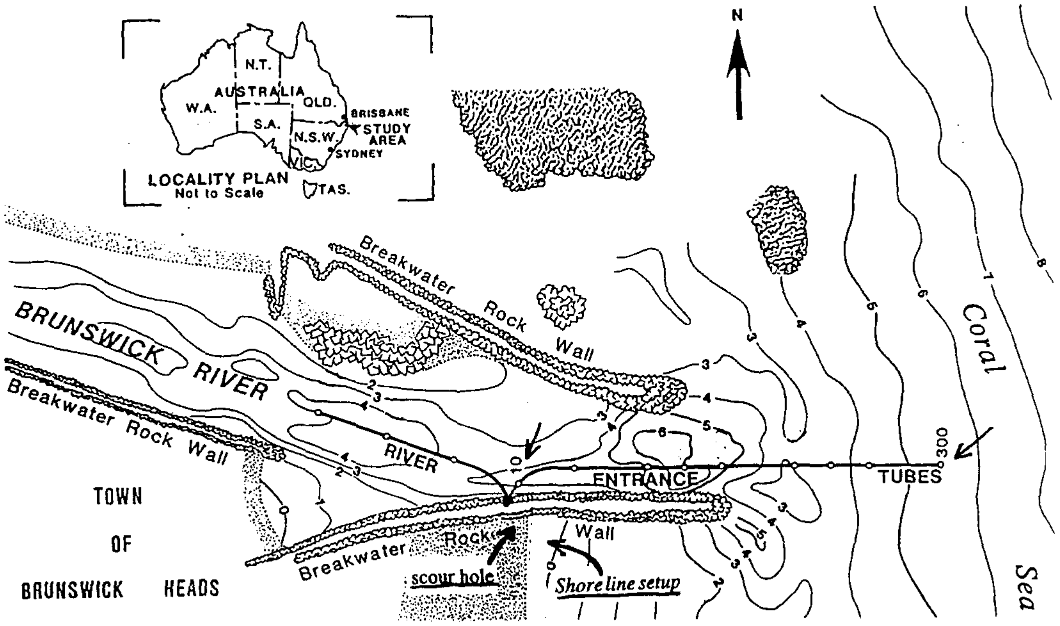


Figure 5: Topography of the Brunswick river entrance and locations of the scour hole and the masuring points of Figure 4.

It also shows that the Brunswick River entrance is very shallow so that if wave setup were expected at any navigable river entrances the Brunswick River should get it.

It will be illustrated that the situation in Figure 3 cannot be explained using 1D modelling even if it accounts for the momentum fluxes in the current as well as in the waves. Some progress has however been made by considering the 2D wave patterns in the river entrance and the momentum flux transfer into the rock walls which becomes possible with curved wave fronts

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