COASTAL FLOODING AND TIDAL SURGES

Gerard J Farrell ME, MEngSc, PhD, CEng, FIEI
Chief Engineer
Department of Communications, Marine and Natural Resources

INTRODUCTION

Two types of flooding occur in Ireland. The more common type is associated with heavy rainfall and occurs when the flow in a river channel exceeds its carrying capacity, overflows the riverbanks and floods on to neighbouring areas. The second type is associated with the sea and occurs when high tides, surges and wave overtopping combine to flood coastal areas (Figure 1).

Figure 1 Tidal Flooding at Bray, Co Wicklow

In the current administrative arrangements, as set out in the report of the Flood Policy Review Group (Office of Public Works (OPW), 2004), the OPW has responsibility for fluvial flooding, the Department of Communications, Marine and Natural Resources has responsibility for tidal flooding and the OPW has responsibility for areas where tidal and fluvial influences interface.

COASTAL FLOODING

Tides

Tides vary in a predictable manner over time. Higher than average tides occur every two weeks around the time of full and new moons when the gravitational pull of the moon and sun are aligned. These are known as spring tides and vary over time, with three or four particularly high tides occurring each year. Lower than average tides follow a similar two-week pattern when the sun and moon are at right angles and are referred to as neap tides. High spring tides can be over one metre higher than high neap tides. Coastal morphology and coastal development have adapted themselves to this natural tidal rhythm with the result that tides on their own generally do not give rise to coastal flooding concerns.

Surges

Tide levels are rarely exactly as predicted. The difference between a higher than expected sea level and the predicted tide level is referred to as a surge. Surges can be up to one metre in height, or more in extreme cases. A surge occurs when high onshore winds pile the water up on the coast or when an area of low barometric pressure causes the water level to rise. Surges of varying magnitudes occur frequently around our coasts and generally pass unnoticed. Surges only come to attention in the infrequent event that they coincide with a high spring tide. This is what happened on the East coast in February 2002 when a large surge coincided with one of the highest spring tides of the year.

Wave Overtopping

Tides and surges on their own generate high still water levels and flood low lying areas by simply flowing onto them. Waves on the other hand, when driven by storms, can batter down coastal defences, erode beaches and dunes, run up sea walls and embankments and flood hinterland areas by overtopping. The effect of these storms is greatly magnified when they coincide with high spring tides and surges.

COASTAL PROTECTION STRATEGY STUDY

Coastal flooding and coastal erosion are issues with serious economic and social impact. In 2002 the Department of Communications, Marine and Natural Resources initiated a National Coastal Protection Strategy Study to review Coastal Protection generally, examine policy options and set out a basis for effective decision making in regard to resource allocation. This study is currently in progress. Consultants have been appointed to assist in the process. Attention is at present being focussed on detailed studies in a pilot area of coast stretching from Killiney, Co. Dublin to Carnsore Point, Co. Wexford (Figure 2).

Figure 2

In the pilot area information is being assembled on the current and historic position of the coastline, the nature of the coast, its vulnerability to erosion and flooding and the nature of the hinterland in terms of economic, heritage and environmental assets. The information is being collated on a Geographic Information System (GIS).

DELINEATION OF FLOOD RISK AREAS.

Areas at risk of tidal flooding in the pilot area are being delineated at two levels of probability. An extreme flood outline (EFO) is being determined for the combined storm surge and high tide event with a 0.1% annual exceedance probability. Converted into a band on a digital terrain model (DTM), this will define the outer limit for damage estimates and planning guidance. High tide, surge and wave

inundation levels with an annual exceedance probability of 0.5% are being determined which will show on the GIS the indicative flood plain.

STORM SURGE MODEL

Very limited data is available on storm surges around the coast of Ireland so it is necessary to develop a hydrodynamic tidal model to simulate tides and surges from historical meteorological data. The two dimensional depth-integrated Mike 21 Flexible Mesh (FM) model developed by the Danish Hydraulic Institute was selected for this purpose. The flexible mesh allows the tides in areas such as those inside the east coast banks and Wexford harbour to be simulated more accurately. The model boundaries are shown in Figure 3.

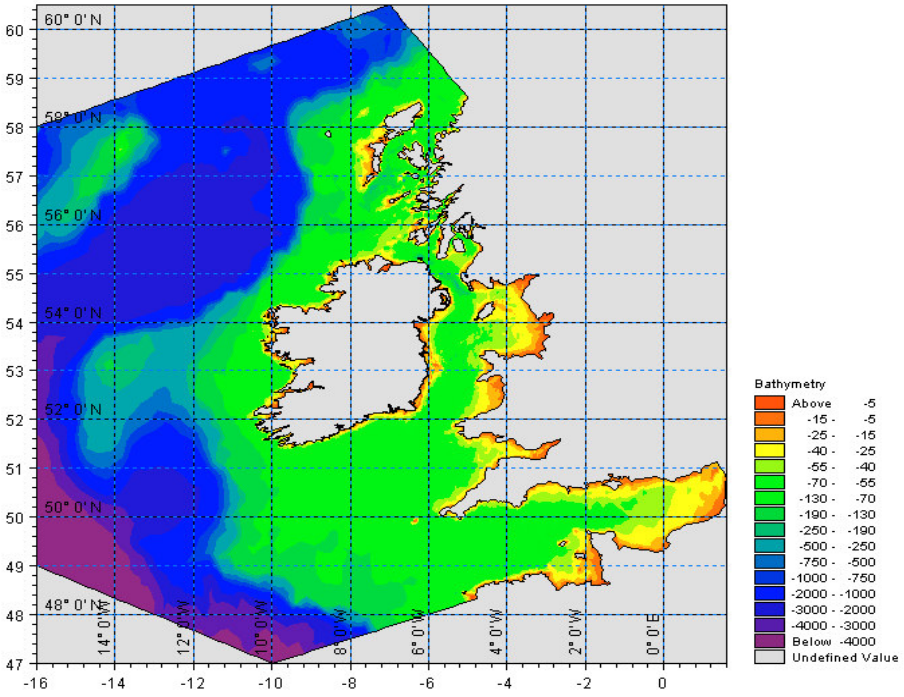

Figure 3 Tidal Model Boundaries

These boundaries result from a number of trials on boundary effects minimisation. The model uses the most up to date bathymetry information from the National Seabed Survey. Calibration of the model has proved to be very difficult. Tide gauge data is limited around the Irish coast and the data that is available frequently has question marks over its quality.

Storm surge modelling is ongoing. All events identified as extreme storm surges between 1956 and 2002 have been simulated and water levels have been extracted at locations along the pilot area coastline.

DIGITAL ELEVATION MODELS

The extreme water level data produced by the tidal simulations is combined with land elevation data to generate the maps of at-risk areas. Conventional Ordnance Survey maps are not detailed enough to yield the elevation data required so special Lidar surveys were flown in the pilot area. This technology captures elevation data over wide areas using laser pulses. Two surveys were flown. The first from a fixed wing aircraft yielded one ground point per 25 square metres. This data while comprehensive gave rise to serious concerns regarding vegetation cover and isolated high spots. A second survey was flown in selected areas using a helicopter mounted Lidar which had a ground coverage rate of 10 points per square metre. Both these sets of data were supplemented by detailed conventional ground surveys. Typical contoured output from these surveys is shown in Figure 4.

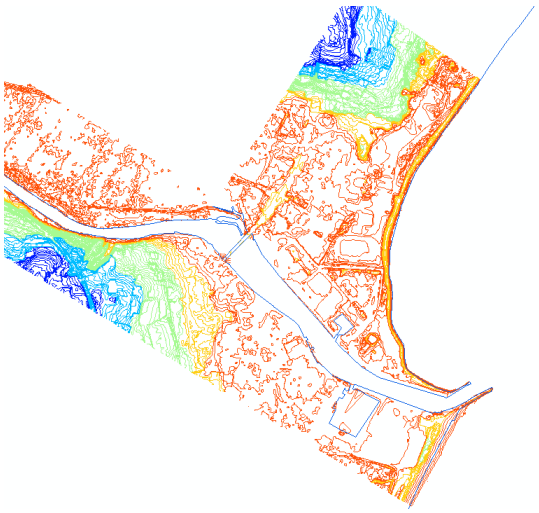

Figure 4 Contoured LIDAR Data, Arklow, Co Wicklow

FLOOD WARNING SYSTEMS

It is unlikely that economic analyses will support the funding of coastal defence infrastructure in all cases, so coastal flooding will continue to be a feature on at least parts of the Irish coast. In these cases flood warnings are an important part of the coastal flood risk management strategy as they permit measures to be taken in advance to minimise economic and social damage. Such a coastal flood warning system is envisaged in the National Coastal Protection Strategy Study.

Five numerical storm surge models covering Irish waters are operational at present: one Norwegian, one Dutch and three British. These models are of course oriented towards flood prediction in the host countries. A sixth model – the model developed for the coastal protections strategy study – now exists and could be adapted for forecasting purposes. A seventh model PRISM (Predictive Irish Sea Model) is being developed as a joint Ireland - Wales INTERREG Project for surge prediction on the Irish Sea.
These models typically are run twice every day and produce a forecast up to two days ahead. All of the models are currently being reviewed by the Department to determine which would form the basis for a robust predictive surge model for Irish coastal waters.

ACKNOWLEDGEMENTS

The following organisations are working with the Department of Communications, Marine and Natural Resources on the studies described above. Coastal Engineering and Tidal Model Development studies are the responsibilities of RPS Consulting Engineers and DHI Water and Environment respectively. Infoterra Ltd and BKS Surveys Ltd are engaged in LIDAR data acquisition. LIDAR/GIS work is by Era-Maptec Ltd. The Predictive Irish Sea Model is being developed by the National University of Ireland Galway, the University of Wales Bangor and Compas Informatics Ltd.