# 3. Modelling tsunami inundation

## 3.1. Model grid – topography and bathymetry

Two model grids were developed that divided the land areas to be modelled into the northern group (Houhora, Rangiputa, Hihi, Cable Bay, Coopers Bay, Mangonui, Tauranga Bay, Taupo Bay and Te Ngaire Bay), and the southern group (Opua, Bland Bay, Helena Bay, Omapere, Dargaville/Ruawai and Langs beach). A refined version of the EEZ grid was used (see Figure 2). This grid spans from approximately 157 to 210 degrees east longitude and 22 to 65 degrees south latitude. Both of these grids were refined in the areas of interest around the Northland coast (see Figure 3). Bathymetric data were derived from a number of sources. For the EEZ area, existing data were used. Digitised RNZN bathymetry charts were used for various bays and harbours. Local inundation grids were created for the 15 areas listed above. The coastline around these locations was further refined to a resolution of around 20 metres and a land grid was created for each area. The topography of the land grid was taken from LiDAR (Light Detection and Ranging) data provided by NRC. These data are referenced to One Tree Point in the vertical, which was assumed to be approximately mean sea level for the entire coast of Northland. This assumption was justified by surveying done by NRC (Bruce Howse, *pers. comm.*).

The finite element model grid has a number of requirements to ensure that model calculations will be accurate and free from excessive numerical errors (Henry and Walters, 1993). The primary requirements are that the triangular elements are roughly equilateral in shape and their grading in size is smooth from areas of high resolution (small elements) in the coastal zone and on land grids to areas of low resolution (large elements) offshore.

The grid was generated using the programmes GridGen (Henry and Walters, 1993) and TriQGrid (under development at NIWA) according to the requirements described above. Areas of interest were cut out and refined by altering the distance between boundary points. Layers of elements were then generated along the boundaries using a frontal marching algorithm (Sadek, 1980). The areas of interest are rejoined to the main grid. Once a satisfactory computational grid was created and quality assurance tests were performed, water depth and land elevation values were interpolated at each node from the above reference datasets.

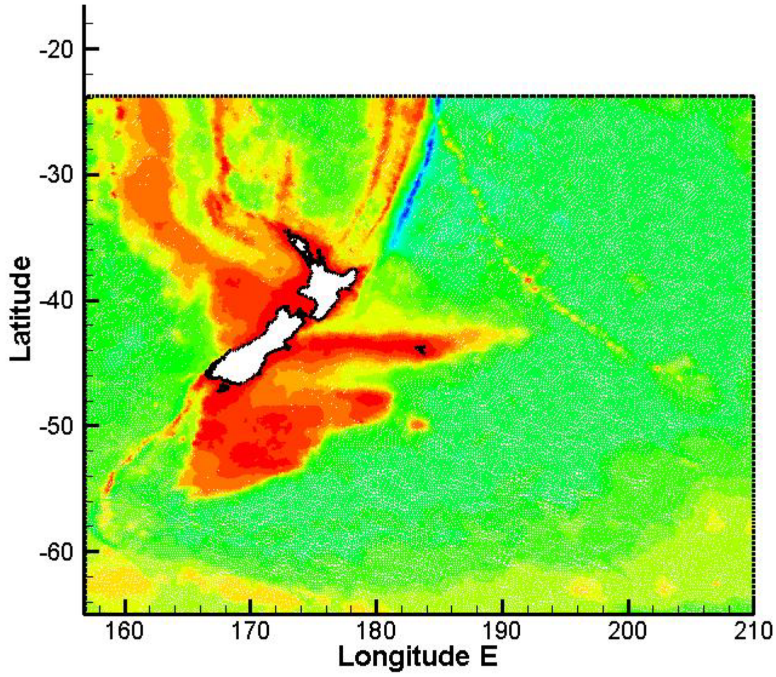


**Figure 2:** **Far-field Tsunami grid. Colour represents water depth. Denser colour shows extra refinement of elements in shallower coastal areas and areas of rapidly changing bathymetry.**

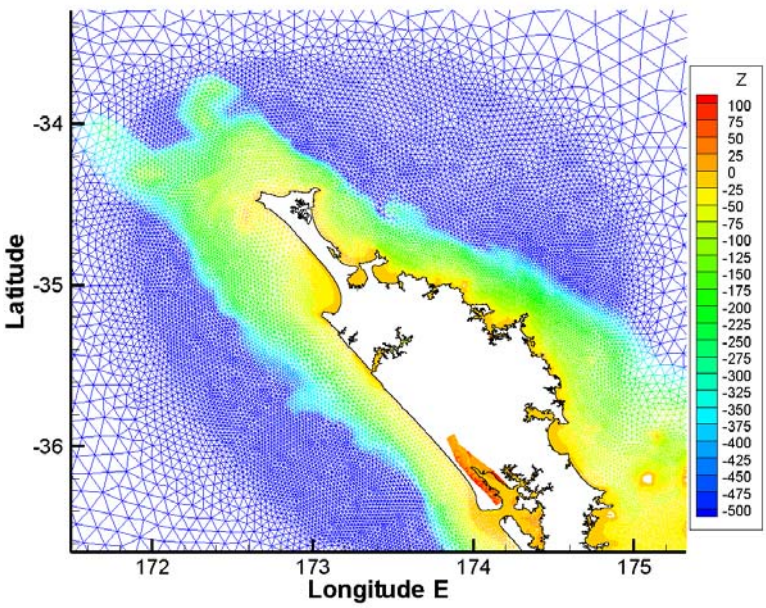


**Figure 3:** **Close-up of the Region 2 grid around Northland. Colour represents water depth. The size of the elements can clearly be seen to grade in towards the complex coastline.**

## 3.2. Numerical model

The numerical model used in this study is a general-purpose hydrodynamics and transport model known as RiCOM (River and Coastal Ocean Model). The original model has been continuously refined for several years, and has been evaluated and verified throughout this process (Walters and Casulli, 1998; Walters, 2005; Walters et al., 2006a; 2006b). The hydrodynamics part of this model was used to derive the results described in this report.

The model is based on a standard set of equations - the Reynolds-averaged Navier-Stokes equation (RANS) and the incompressibility condition. In this study, the hydrostatic approximation is used so the equations reduce to the shallow water equations.

To permit flexibility in the creation of the model grid across the continental shelf, finite elements are used to build an unstructured grid of triangular elements of varying size and shape. The time intervals that the model solves for are handled by a semi-implicit numerical scheme that avoids stability constraints on wave propagation. The advection scheme is semi-Lagrangian, which is robust, stable, and efficient (Staniforth and Côté, 1991). Wetting and drying of intertidal or flooded areas occurs naturally with this formulation and is a consequence of the finite volume form of the continuity equation and method of calculating fluxes (flows) through the triangular element faces. At open (sea) boundaries, a radiation condition is enforced so that outgoing waves will not reflect back into the study area, but instead are allowed to realistically continue through this artificial boundary and into the open sea. The equations are solved with a conjugate-gradient iterative solver. The details of the numerical approximations that lead to the required robustness and efficiency may be found in Walters and Casulli (1998) and Walters (2005).