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Northland Regional Council

Report for Kaeo Floodplain Maps

Summary Report on Floodplain Maps

April 2009

Contents

1. Introduction

This summary report provides a brief description of the modelling undertaken to develop floodplain maps for the Kaeo River Catchment. The intention of this summary report is to provide supporting information to the floodplain maps. It is not intended that the summary report provide a full account of modelling undertaken to develop the floodplain maps.

2. Floodplain Maps

2.1.1 Datum

New Zealand Map Grid projection along with OTP (One Tree Point) vertical datum were used in this study.

2.1.2 Map Generation

Two models have been used to model the catchment and generate the floodplain maps. The river model (1 Dimensional MIKE11 model) models the flows in the river system. The terrain model (2 Dimensional MIKE21 model) receives flows from the river system as soon as flood levels exceed the bank level and simulates flows in the floodplain. MIKEFLOOD has been used as interface to combine these models so that the overflows from the river model are managed in the Terrain model. The 2-D model domain in MIKE21 also includes the river system and to avoid double account of the volume in river channel, the cells covering the river channel have been blocked.

2.1.3 Viewing the Maps

The river channel has been blocked to produce the floodplain maps as the channel is already filled up in the river model (MIKE11). The alignment of the river channel can be seen clearly on the maps produced. If the river channels were not blocked, the alignment would not be seen clearly. The purpose of the maps is to give an indication of the variability of flooding across the floodplain.

2.1.4 Types of Maps

The following maps have been produced;

- Maps showing maximum depth of flooding – these are at the peak but the timing of the peak should be expected to be different at various locations because of the difference in travel from the subcatchment flow to a downstream location in the river system. The maximum flood depths over the MIKE21 domain (2-D) have been obtained from the entire simulation period using post-processing facility of the DHI software packages.
- Maps showing maximum flood depth elevation - these are at the peak but the timing of the peak should be expected to be different at various points. The maximum depth over the 2-D model domain has been selected similarly to that of maximum flood depth.
- Maps showing maximum speed – these are the maximums from the entire simulation period. The maximum speed over the 2-D model domain has been selected similarly to that of maximum flood depth.
- Maps showing flood hazard – these are from depth (d) /speed (s) criteria which are based on the following:
  - Low Risk – Depth (d) x Speed (m/s) $\leq$ 0.5
  - Medium Risk – Depth (d) x Speed (m/s) $>$ 0.5 and $\leq$1.0
  - High Risk – Depth (d) x Speed (m/s) $>$ 1.0 or Depth (m) $>$1.0

2.1.5 Extent of Maps

The extent of the floodplain maps has been restricted to 2-D (MIKE21) model area. The floodplain covers much of the lower catchment up to the inter-section of the Waiare Road and SH10. Flooding in the catchment above this point is not shown.

3. Modelling Background

Two models – MIKE11 (1-D) and MIKE21 (2-D) models have been developed separately using available catchment data. MIKEFLOOD, an interface, was used to combine the two models to facilitate the floodplain mapping of the catchment. The following sections briefly described various components of the two models.

3.1 Location

The Kaeo River Catchment covers a total land area of some 11,560 hectares and has its headwaters located to the north of Sandy Road/Punagre Road in Kerikeri. The Kaeo River along with its large number of tributaries passes through the alluvial foothills and down to the lowlands ultimately discharging into Whangaroa Harbour. All stormwater discharges to the Whangaroa Harbour with no flow passing to adjacent catchments.

3.2 MIKE11 Model

The hydrology and river system have been modelled in MIKE11. The following sections briefly describe the processes involve.

3.2.1 Hydrological Model

The hydrology of the catchment has been modelled using the MIKE11 Urban Runoff Module. The hydrological component of the MIKE11 Runoff Model is represented as 186 subcatchments connected to nodes within the river network of the MIKE11 model. Catchments were delineated with consideration of:

- The stormwater network configuration
- Catchment contours – LiDAR and available 5m contours in the area beyond LiDAR extent
- Catchment characteristics
- Property boundaries
- The soil types
- Landuse

The subcatchment size varies from 0.2 hectares to about 440 hectares with only 27 catchments larger than 100 hectares. The larger subcatchments are mainly located at the headwaters in the hilly region of the catchment.

3.2.2 Imperviousness

Existing

The existing development imperviousness area was estimated using the aerial photographs of the catchment. For each sub-catchment used in this study, the land use and impervious area were analysed for input into the hydrological module model under two categories of pervious and impervious area. Each category was then assigned different hydrological parameters as required to describe actual processes.

The assessment of sub-catchment road surfaces imperviousness was undertaken as a GIS integration of the sub-catchment boundary and the road surface. The resultant impervious area was assigned as flat impervious area within the model. This was carried out by GIS integration of the available aerial photographs. The existing imperviousness data was used to calibrate the model using the measured post flood levels of July 2007 storm events at various locations in the catchment.

Future

Based on the FNDC District Plan allowances the Maximum Probable Development (MPD) impervious area percentages for various landuse categories were used. The MPD imperviousness was used for the floodplain mapping.

3.2.3 Rainfall

The recorded rainfall at Kaeo Bramley automatic raingauge was used for the calibration of the model using July 2007 storm event.

Design rainfalls of specific intensity and duration were used to drive the catchment runoff using MIKE11 Urban Model B Module. These design rainfalls have been derived from the HIRDS model based on NIWA rainfall records. The HIRDS model allows for point rainfalls to be estimated for any latitude and longitude around New Zealand. Considering the size of the catchment and rainfall variability across the catchment point rainfalls was derived at 5 different locations across the catchment. The locations of these point rainfall are shown in Figure 3 attached to this report. The estimated rainfalls at all the five stations and the site location coordinates were entered into the runoff Module B of the MIKE11 model to generate subcatchment runoff. MIKE11 generates the runoff for a particular subcatchment based on the rainfall of the nearest rainfall point. In case of a subcatchment covering several rainfall points, Mean Area Weighting of all the rainfall points was estimated using the Thiessen polygon option. The Mean Area Weighting rainfall was used to generate catchment runoff using MIKE11 model.

3.2.4 Hydraulic Model

Cross-section

Cross-sectional and asset information utilised for development of this model network was derived from:

- Stormwater asset data from FNDC
- The Northland Regional Council (NRC) surveyed cross-sections for the major river system and a total of approximately 93 cross-sections were surveyed. In addition, 10 bridges and 2 culverts were surveyed and were incorporated in MIKE11 river model. The recent LIDAR (**Li**ght **D**etection **A**nd **R**ange) information available from NRC was used to generate approximate 460 cross-sections for river tributaries and major overland flowpaths. These cross-sections were used in MIKE11 model for modelling the river system.
- Contour and topographical data supplied by NRC

Network

The model network nodal locations were digitised from aerial photos and model chainage was derived accordingly. Reach cross-sections were derived either from the surveyed cross-sections or cross-

sections generated using LiDAR contours and interpolated as required to account for conveyance and floodplain storage refinements.

The major components of the MIKE11 model network include:

- 43 branches
- 2672 nodal points representing the alignment of the river/drainage system
- surveyed cross-sections and cross-sections generated using LiDAR contour
- 10 bridges
- 14 culverts. There are limited number of pipes in the catchment and they were modelled as culverts
- 86 weirs. They weirs were implemented either on top of the culverts/bridges to account for overtopping of the structures or along the steep slope river reaches.

MIKE11 offers either uniform or a Triple Zone Approach for the bed resistance in a cross-section. There are three types of resistance options available in MIKE11 - Manning's M (reciprocal of Manning's n), Manning's n and Chezy Number. The current Kaeo River Catchment Model adopted the uniform bed resistance approach with variable resistance over depth of flow with Manning's n as the resistance type. The Manning's n-value adopted for the river system varies from 0.04 to 0.075 with higher value being used in the hilly region having dense bush/vegetation. Initially the roughness coefficients were assigned for each cross-section based on aerial photographs, site inspections, literature values and modelling experience. Final roughness values were estimated through the calibration process.

3.2.5 Tidal Boundary

There is no tide record available at the outfall of Kaeo River during the calibration event of July 2007. Therefore, the tidal boundary during the calibration event at the outfall of the Kaeo River was obtained from NIWA Tide Simulator.

A statistical analysis of tide records was available from NIWA website at various locations in Northland. A Mean High Water Spring (MHWS) of 1.00 m RL (OTP) was used for the Kaeo River catchment as the tidal boundary for the simulation of 100 year MPD landuse floodplain mapping. The tidal boundary for 100 year MPD climate change scenario used was the MHWS (1.00 m RL) plus 0.20 m to account for the rise in sea level due to global weather warming.

3.3 MIKE21 Model

3.3.1 Grid Generation

NRC supplied LiDAR data that was utilized to generate grid for the MIKE21 model. To facilitate accurate flood prediction with a reasonable model simulation time grid sizes of 5 m x 5 m were generated for input into MIKE21 model. Each grid point was assigned an elevation using the LiDAR information. The area outside the MIKE21 model domain was not included in the computations domain of the MIKE21 model.

3.3.2 Tidal Boundary

Tidal boundary for the MIKE21 model was the same as that of the MIKE11 model.

3.3.3 Model Simulation

MIKEFLOOD model was simulated for the duration of 9 hour to 16 hour with a time step of 0.60 seconds. The peak rainfall occurs at about 12 hours and therefore, the simulation starting time of 9 hours will allow all the losses to occur well ahead of peak rainfall. The flows at various locations in the catchment occur between 12 hours to 15 hours depending on the location. Therefore, the simulation until 16 hours is well past the time of peak flow. The results were saved with a frequency of 1 minute during simulation period starting from 9 hours to 16 hours. The maximum flood levels, depths and speed at all grid points from the result file were used using MIKE21 post processing facilities for plotting in GIS environment.

The model run times varied depending on the number of computational grid points of the model. The run time for simulations was about four days.

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