

Appendix B

Transformation of GWRC's MIKE11 Model to MIKEFLOOD Model

General Description of Existing Situation Model

Figure B-1 shows the branch layout of the main “channels” forming the primary drainage system for the Mangaone Stream and Overflow past the NIMT railway line and SH1. The branches include:

- the main stream channel from a point 1.2km upstream of the NIMT railway line to a point 1.75km downstream;
- the Mangaone Overflow from a point 20m upstream of the NIMT railway line to a point 190m downstream;
- the School Road drain; and
- the roadside drain on the east side of SH1 (i.e. between the NIMT railway line and SH1).

These drainage elements were defined by means of cross-sections in the one-dimensional MIKE11 component of the MIKEFLOOD model.

The alluvial fan and floodplain within the area indicated in Figure B-1 was defined geometrically by means of a digital terrain model (DTM) based on LiDAR sourced topographic data. The hydraulic behaviour of flood flows over this surface was simulated using a two-dimensional MIKE21 component coupled to the MIKE11 component to form the complete MIKEFLOOD model. The one and two-dimensional components of the MIKEFLOOD model were stitched together with link channels along both sides of the one-dimensional drainage network.

Cross-Sections for Main Stream Channel and Overflow in MIKE11 Component of Model

The alluvial fan upstream of the NIMT railway line is very open with little vegetation covering it and the main stream channel forming only a shallow depression across the surface. The main stream channel over this part of the alluvial fan was therefore defined by means of cross-section data obtained from the LiDAR sourced topographic data. Downstream of the SH1 culvert, the main stream channel is more hidden and incised more deeply into the fan surface so that the LiDAR sourced topographic data would provide a poor definition of it. Cross-sections defining the main stream channel in the lower part of the MIKE11 component of the model were therefore obtained from the original MIKE11 model developed for the 2002 flood hazard assessment (MWH, 2002b) undertaken for GWRC.

The Mangaone Overflow upstream of the NIMT railway culvert was also defined by means of cross-sections obtained from the LiDAR sourced topographic data for the alluvial fan and floodplain. However downstream of the SH1 culvert, the Mangaone Overflow was defined by means of single typical field-surveyed cross-section and a similarly longitudinal invert level profile which terminated where the excavated overflow channel sandwiched between residential properties on the west side of SH1 transitioned back to the alluvial fan surface (Figure B-1).

The School Road drain was defined by means of on-site field measurements and observations of width and depth in conjunction with the LiDAR-sourced topographic data.

MIKE21 Alluvial Fan and Floodplain Component

The two-dimensional MIKE21 alluvial fan and floodplain component of the MIKEFLOOD models was defined based on LiDAR-sourced topographic data using a 5m x 5m grid.

Culvert Geometries and Representation for Existing Situation

The sizes and invert levels of existing culverts within the one-dimensional drainage network were generally defined from field survey measurements. As-built drawings obtained from Kiwirail were used to define the geometry of the relatively new NIMT railway culvert on the Mangaone Overflow.

These culvert dimensions and levels are summarised in Table 4-1.

Initial model trials identified numerical instabilities when the NIMT railway culvert and the SH1 culvert on each of the main branches of the MIKE11 model network were defined as conventional culvert structures. This appeared to be because of some interaction between the numerical calculations for the two structures in close proximity to each other where the downstream structure exerts outlet control on the whole system. The numerical instability problem was circumvented by retaining the conventional culvert description for the downstream (SH1) structure and defining the upstream (NIMT railway) culvert by means of two closed cross-sections at either end and an upstream contraction loss element ($k = 0.5$ for a sharp contraction) and a downstream expansion loss element ($k = 0.7$ for an expansion into a downstream channel only slightly wider than the culvert).

Bridge structures on the main stream channel along Te Horo Beach Road (to the west of SH1) were generally defined as conventional culvert structures in the MIKE11 component of the model although some very light property access bridges with a thin deck and easily overtopped were ignored.

Flow Resistance

The flow resistance of the main stream channel in the MIKE11 component of the model was defined by means of a Manning's n channel roughness value. Upstream of the NIMT railway culvert where the stream channel meanders across the fairly open alluvial fan surface (see Figure D-1 in Appendix D), the flow resistance is determined primarily by the form roughness of the gravel bed and the meandering planform of the channel (as well as the skin friction of the gravel bed particles) so that a Manning's n channel roughness value of 0.040 is suitable. However the choice of channel roughness value will be of no consequence immediately upstream of any road embankment which causes floodwaters to pond.

Downstream of the SH1 culvert where the main stream channel is more incised into the alluvial fan surface, stream bank vegetation also contributes significantly to the flow resistance of the channel (see Figure D-4 in Appendix D) so that the same Manning's n channel roughness values used in the original MIKE11 model developed for the 2002 flood hazard assessment were retained. Table B-2 provides a summary of these channel roughness values.

Table B-2 Channel roughness values for main channel of Mangaone Stream downstream of SH1 culvert (after MWH (2002b))

Stream Reach	Model Branch Name	Chainage	Manning's n Channel Roughness
SH1 culvert to private access bridge (Bridge 7)	RIVER	6472 - 6730	0.060
Private access bridge to downstream boundary of model	RIVER	6730 - 8210	0.040

The relatively high Manning's n channel roughness value of 0.060 for the first reach downstream of the existing SH1 culvert reflects the fairly thick bankside vegetation seen in Figure d_4 of Appendix D. Downstream of the first private access bridge across the stream (approximately 260m downstream of the SH1 culvert), the stream channel becomes more open as it follows a course close to Te Horo Beach Road. The selected channel roughness value of 0.040 for the second reach is more appropriate for a channel of this nature.

The existing School Road drain is also fairly congested by bankside vegetation so that a fairly high Manning's n channel roughness value of 0.060 was also applied to this channel.

The Mangaone Overflow is predominantly grass-covered and fairly open along its defined length (see Figure D-8 in Appendix D). Flow depths along this channel will be fairly shallow and flow velocities fairly low so that the grass surface will interact with the slow-moving flow and exert a reasonable degree of resistance. A Manning's n channel roughness value of 0.04 was again judged to be reasonable.

For the same reason, the flow resistance of the alluvial fan surface and floodplain within the two-dimensional MIKE21 component of the MIKEFLOOD model, which also has a largely pastoral type land use (i.e. mainly grass-covered) was defined with a Manning's n surface roughness value of 0.040 (see Figures D-1 and D-5 in Appendix D).

Normally the Manning's n channel and surface roughness values for a computational hydraulic model are determined by means of calibration and verification against measured flood level and flow data. In this case, there is no way to confirm the validity of the selected Manning's n values as there is no calibration data of any substance. Although the stream flow is measured at the Ratanui gauging station upstream, this only captures runoff from a small part of the total catchment. Consequently there remains a degree of uncertainty with the extrapolated flood estimates given in Section 2 of this report.

The only possible way of confirming that the MIKEFLOOD model configured in the manner described above provides a reasonable representation of flood inundation patterns across the alluvial fan and floodplain surface is to compare the model predictions against anecdotal observations of the flood inundation extent for an historic flood event. This is done in Appendix C for the 28 October 1998 flood for which some aerial photos after the flood peak are available.

Notwithstanding these comments about the inability to quantitatively calibrate the MIKEFLOOD model, the model in this context is used in a comparative sense to compare the relative effect of the proposed Expressway construction on flood inundation patterns with those induced by the existing NIMT railway and SH1 crossings of the Mangaone Stream and Overflow. This makes the influence of any errors in the model as it has been configured much less significant.

The culvert structures within the MIKE11 component of the MIKEFLOOD model were generally defined with a Manning's n surface roughness value of 0.016 to reflect their concrete surfaces. For relatively short structures 10-15m in length, the friction loss induced by the surface roughness is negligible compared to the entrance and exit head losses so that the magnitude of this surface roughness value is insignificant. For the longer Expressway culverts the surface roughness induced friction loss is more significant and the choice of surface roughness value will have more of an influence.

Boundary Conditions

Figure 2-3 in the main body of the report shows the inflow locations at the upstream boundary of the MIKEFLOOD model. Inflow hydrographs similar to those shown in Figure 2-4 were defined for each inflow location based on the peak discharge values given in Table 2-5 and the relative proportions of the total discharge given in Table 2-7.

Figure B-2 shows the assumed downstream boundary condition for the MIKEFLOOD model. This is based on an extrapolated stage /discharge rating sourced from the original MIKE11 model developed for the 2002 flood hazard assessment (MWH, 2002a and 2002b)⁷. This extrapolation used the characteristics of the channel cross-section at the selected downstream boundary location to empirically fit a curve to the stage / discharge data from the original MIKE11 model using Manning's flow resistance equation (based on the observation that flood levels at the boundary location were controlled by the geometry and frictional characteristics of the downstream channel).

The precise nature of the downstream stage / discharge rating curve boundary condition has no influence on the flood inundation patterns and flow distributions past the local link road / Expressway / NIMT railway line / old SH1 corridor which is of primary interest to these investigations.

Modifications to MIKEFLOOD Model for Proposed Situation

It is proposed to construct a bund along the upstream side of the Expressway to act as a flood detention barrier and provide the required level of service for the new road. This barrier was represented in the MIKE21 component of the MIKEFLOOD model as a raised line of grid elements in the DTM. The rectangular grid of the DTM was carefully aligned with the horizontal alignments of the Expressway, the NIUMT railway line and SH1.

The local link road on both sides of the Expressway was similarly represented as a raised group of grid elements within the MIKE21 model DTM. However, since the local link road has a curved horizontal alignment, the representation of this curved alignment in the DTM was slightly irregular.

⁷ The original MIKE11 model extended to the outlet of the Mangaone Stream and accordingly used a tidal boundary condition. The MIKEFLOOD model for these investigations truncated the MIKE11 model component at a location upstream of the stream outlet where flood levels were controlled only by the downstream channel capacity as well as the magnitude of a flood.

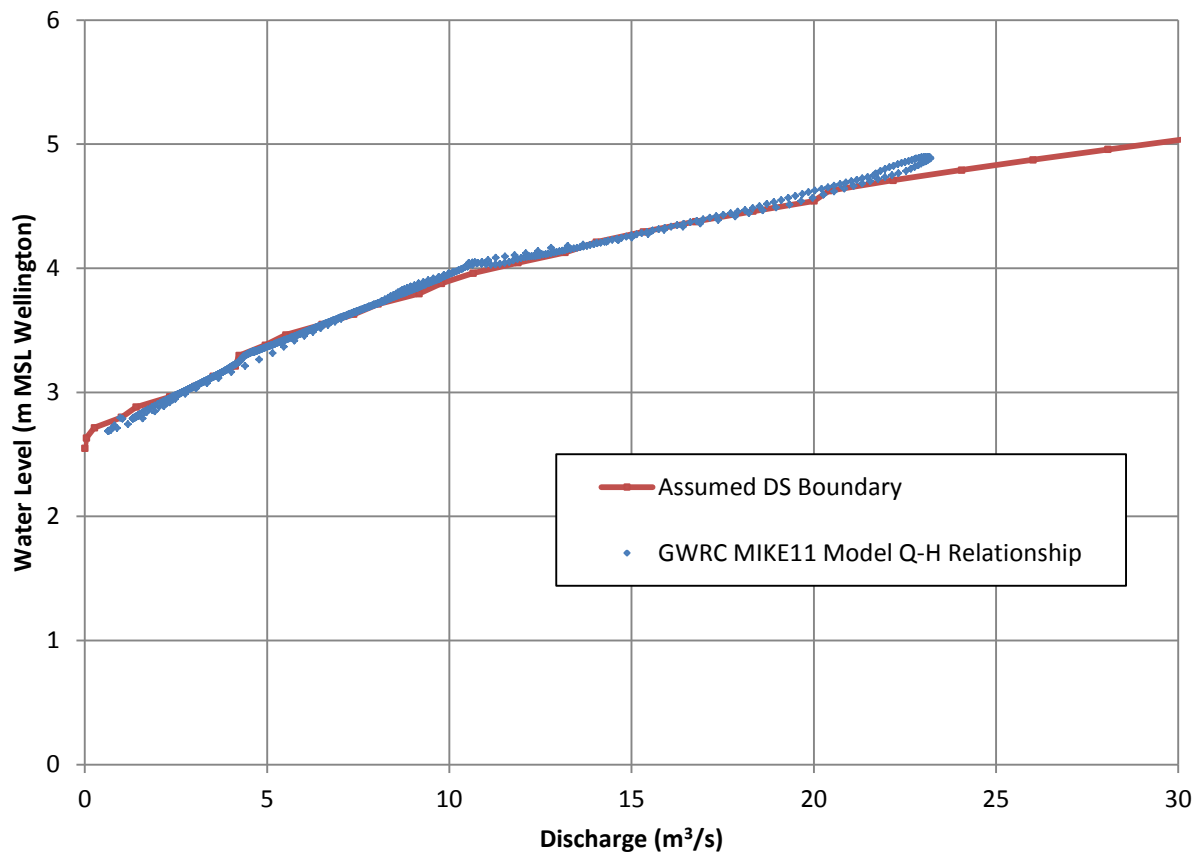


Figure B-2 Stage / discharge rating assumed as downstream boundary condition for MIKEFLOOD model

The Expressway and local link road culverts were represented as conventional culvert structures in the MIKE11 component of the model.

With the vertical alignment of the Expressway now defined to be only slightly elevated above natural ground levels, there is only limited vertical space available to locate the culvert on the Mangaone Overflow. In order to achieve the required discharge capacity at this crossing point, the overflow channel has been defined as a slightly depressed channel about 1m below the alluvial fan surface.

