Environment Waikato Technical Report 2006/08

Waipa River – Otorohanga Primary School Modelling Report

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1 Background

Following the February 2004 flood the Otorohanga District Council (ODC) has commissioned Environment Waikato to undertake investigation of the flooding risk at the primary school, which experienced flooding during the event and recommend measures to reduce the risks.

A report on the causes of the flooding at the primary school has been carried out for Trevor Skilton of ODC. This report was based on local knowledge and indicated the existence of overland flows from the Waipa River over the right bank some 5.0km upstream of the primary school. These overflows plus the local runoff flowed through internal drains (Waipa and Rangiatea drains) and over farmland, have caused flooding of the primary school before discharging into the Waipa River.

Following the preliminary investigation, it was agreed that further investigation including hydraulic modelling was required. In order to develop the hydraulic model ODC undertook a survey for the Rangiatea Rd including ground levels at the overflow location, flood levels along Rangiatea Rd and cross sections of the local drains.

This report provides the findings of the hydraulic model which has been developed and calibrated using the information provided by ODC, existing river cross sections and gauge data. It also investigates the effectiveness of different flood relief measures, which need to be considered by the District Council.

2 Description of the model

The hydraulic model was constructed using an existing Mike11 model for the whole Waipa catchment. This existing model was developed for the Flood Forecasting project and it includes a rainfall runoff module (NAM). The model was calibrated for Otorohanga, Te Kuiti, Whatawhata and Otewa, points where EW has gauge stations.

The new model includes the identified overflows, overland flow paths, drains, culverts, weirs and local catchments.

The February 2004 flood information was used as the calibration event. The model inputs are the observed hydrographs at Otewa, Te Kuiti and Mangapu and the observed rainfall at several locations.

The downstream boundary condition is the rating curve at Otorohanga.

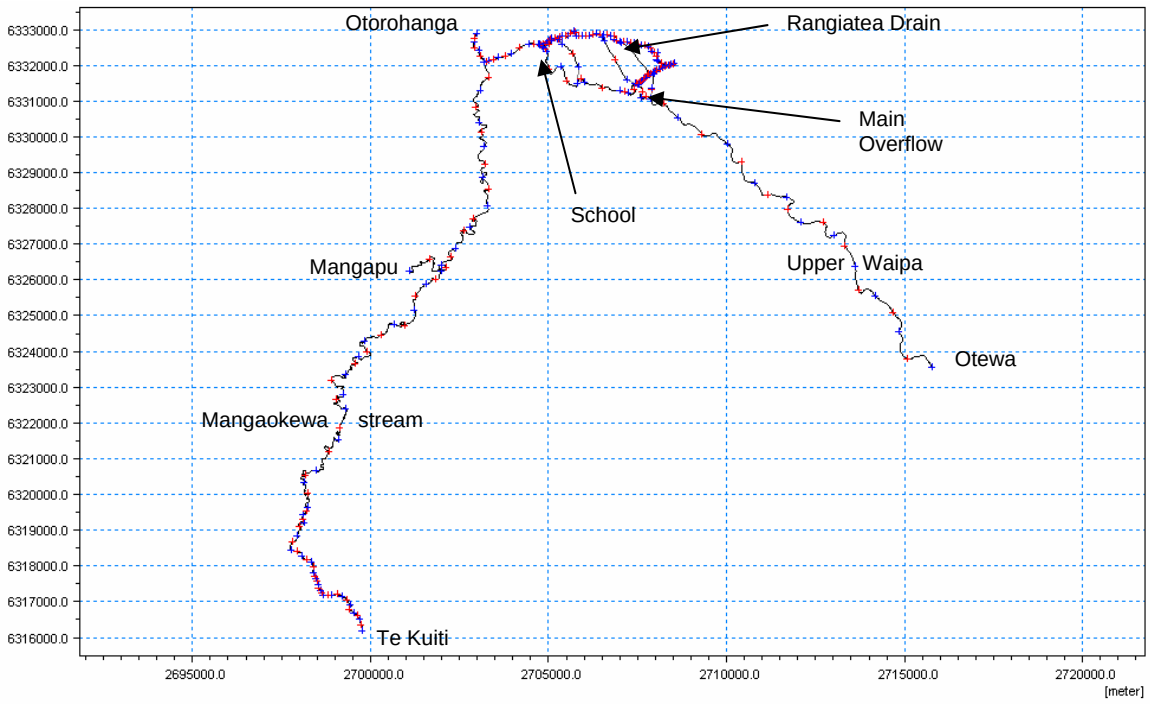

Figure 1 Complete model layout

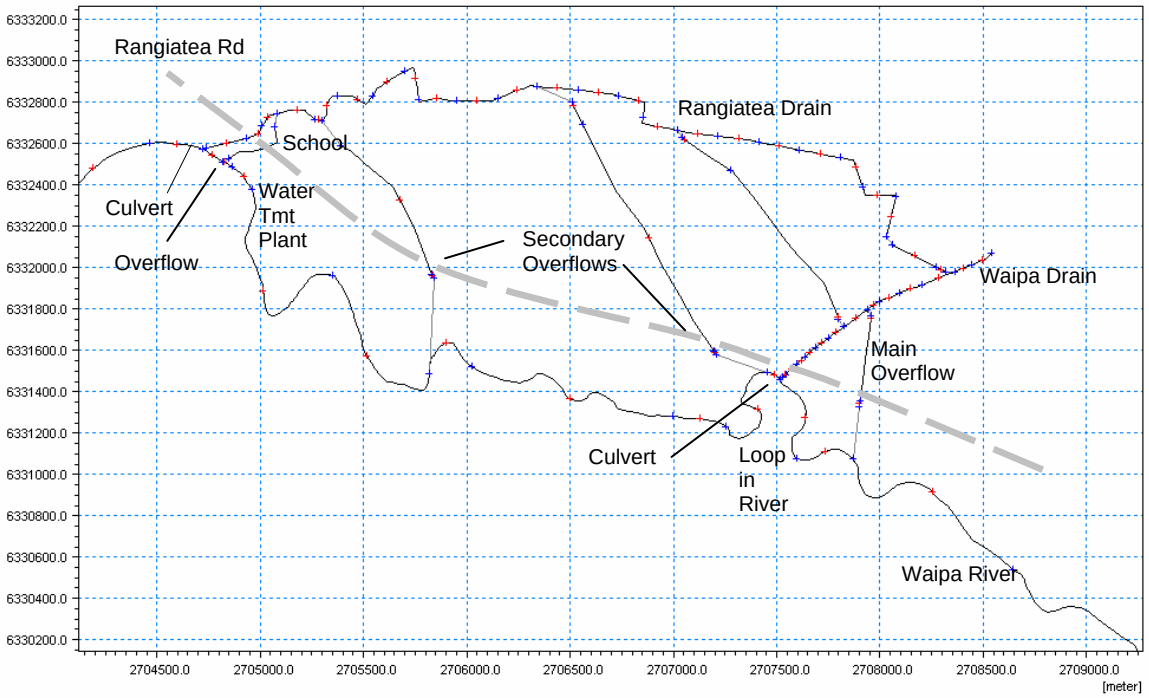

Figure 2 Flooding area layout

3 Model calibration

The model was calibrated using the February 2004 event.

The following information was used to calibrate flood levels and flows in the area of interest.

- Flood levels measured along the Rangiatea Rd more precisely at the school, at the Water Treatment plant and at the main overflow.
- Estimates of the culvert discharge and over the Rangiatea Rd at the school location. The total discharge was estimated in 35m^3/s (10m^3/s through the culvert and 25m^3/s over the road). These figures have been calculated and they differ from the first EW report.
- Observed flows and levels at the Otorohanga gauge.
- Information regarding the existence of overflows from the Waipa River and the performance of the Waipa drain culvert obtained from Trevor Skilton report and oral communication with landowners.

In order to achieve the calibration the following features were incorporated in the model:

- Waipa river cross sections include relative resistance values of 3 for sections outside the main channel.
- A manning number of 0.045 has been used for the Waipa River except at the loop which includes a manning number of 0.06. All overland flood ways channels include a manning number of 0.06.
- The Water treatment plant weir has been included in the model as a broad crested weir. In reality this is a sharp crested weir however the model does not include appropriate formulation for this type of structure.
- In order to allow small amount of water to flow over the Rangiatea Rd as mentioned by landowners who observed the Feb2004 flood, the Waipa loop needed to be modified and dummy cross sections have been included in order to raise the water levels in that area.
- 4 overland channels of 1000m width have been included. These channels discharge the overflows from the Waipa River into the Rangiatea drain through dummy broad crested weirs created in the model.
- The cross sections of the Rangiatea Drain were extended in order to include farmland storage. The manning number for these cross sections was set in 0.060. A dummy weir was created in order to include the ponding effect.
- The local runoff was incorporated in the rainfall runoff model. The NAM parameters were extrapolated from the existing NAM catchments. Two new catchments were included; Waipa Drain (22.6Km^2, time of concentration 4hrs) and Rangiatea Drain (7.54Km^2 time of concentration 2hrs).

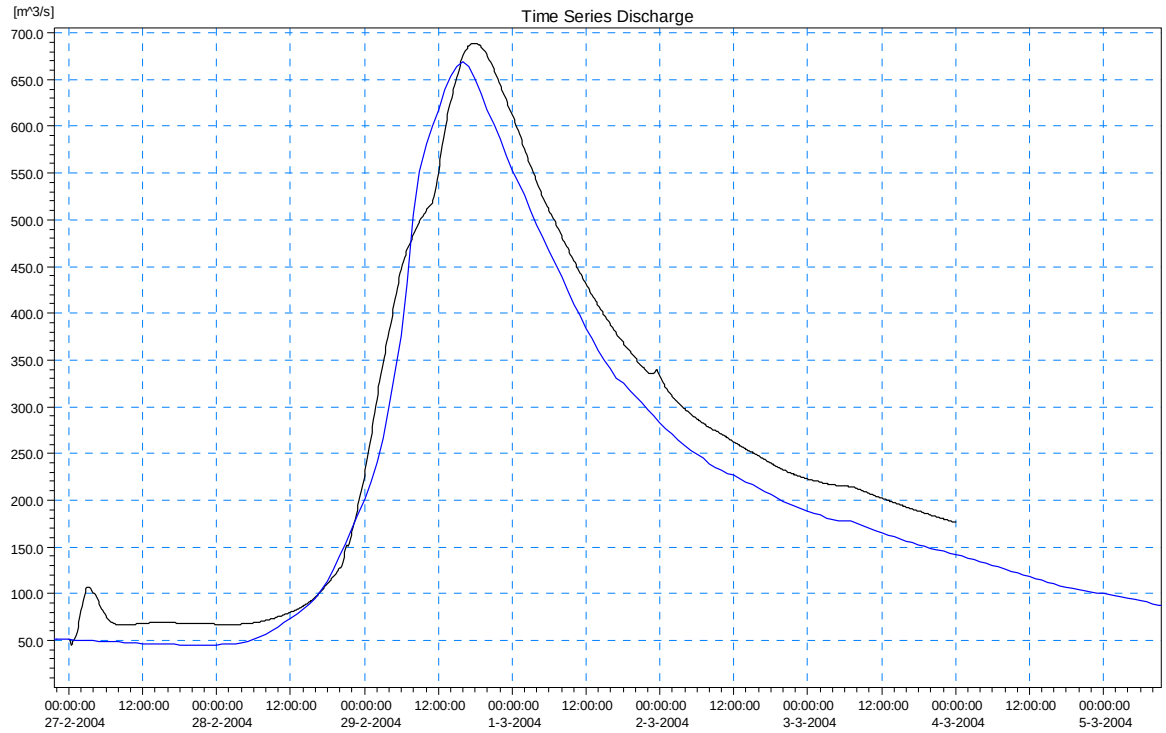

Figure 3 Observed (blue) and modelled (black) discharges at Otorohanga Bridge.

4 Results

The following table summarizes the relevant parameters for the calibration, overflows and runoff.

Table 1 Calibration results

Calibration parameter	Observed or estimated	Modelled	Unit
Flood level at WTP	37.69	37.68	R.L. (m)
Flood level at school	38.82	38.82	R.L. (m)
Flood level at main overflow	47.08	47.07	R.L. (m)
Peak discharge Rangiatea Rd culvert at school	10	10.2	m3/s
Peak discharge overflow at school	25	24.9	m3/s
Peak discharge Waipa drain culvert	No data	11.2	m3/s
Peak discharge main overflow	No data	69.9	m3/s
Peak discharge secondary overflow U/S	No data	1.8	m3/s
Peak discharge secondary overflow D/S	No data	13.5	m3/s
Peak runoff Waipa drain catchment	No data	46.0	m3/s
Peak runoff Rangiatea drain catchment	No data	18.0	m3/s

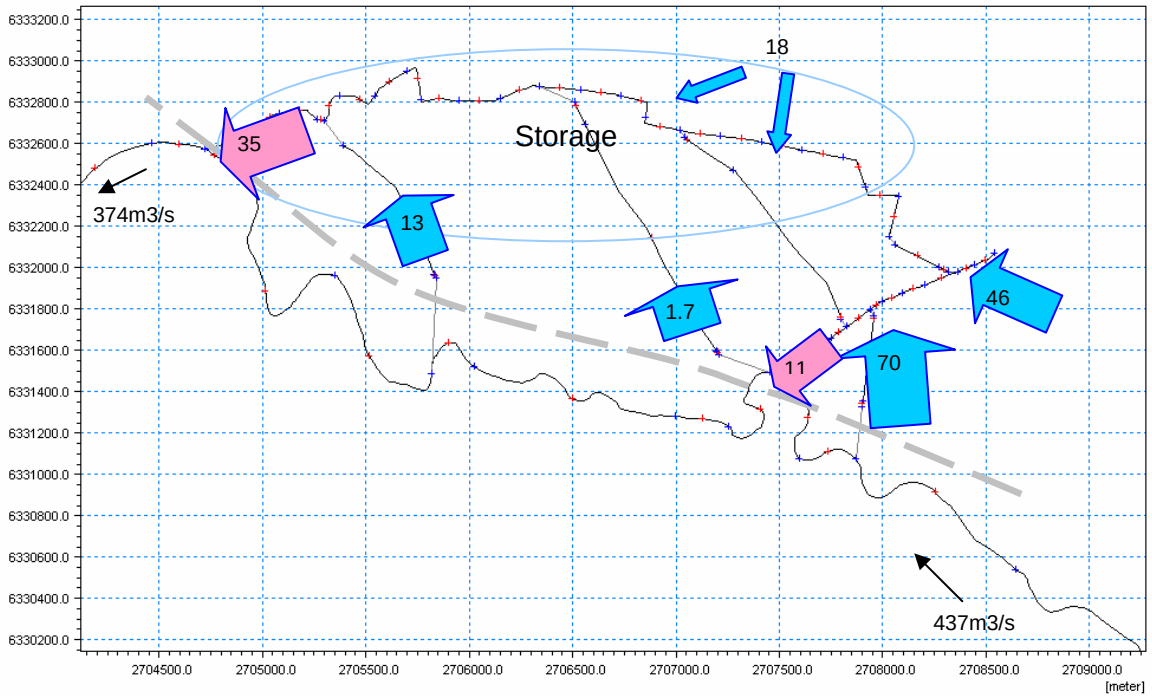

Figure 4 Peak flows layout. Numbers represent the modelled peak flows in m^3/s

The model shows that the storage area upstream to the school attenuates a peak inflow of 149m^3/s reducing it to 46m^3/s. The inflows are a combination of local runoff and overflows from the Waipa River.

The model shows that the storage area retains flood water during 4 days after the flood occurred.

4.1 Flood protection options

The hydraulic model has been used to predict the flood levels at the school under various flood protection options. The four options modelled were:

Option 1:
Raising Rangiatea Road to prevent water flowing into Rangiatea drain and behind the school. This would involve the raising of 500m of road by an average of 1m. This would prevent approximately 70m^3/s from entering the Rangiatea Drain. Further investigation to insure overflow would not occur at other locations along the road would be required.

This reduced the flood level at the School from RL 38.83 m to RL 38.30 m. As the floor level of the School is RL 38.22 m this option would not be sufficient on its own and a stopbank at the school would be required. This would cause the road to act as a stopbank and would effectively divert the 70m^3/s from its current path, Rangiatea Drain, back to the Waipa. This may not be desirable.

Option 2
Increasing the capacity of the twin culvert at the school by increasing its size to pass the full flood flow of 35 m^3/s. This will require replacement of the existing 2 x1.2m diameter pipes with a 2 x 2.5m diameter pipes. It also assumes that the full flow will remain within the channel, which is not achievable without stop banking along the channel further upstream of the culvert.

Under this scenario, the model results showed that the flood levels opposite the school will drop from the current recorded level of RL 38.83 m to RL 38.28 m. This means that

the stopbank level opposite the school site should be approximately RL 38.90 m assuming a freeboard of 600 mm.

Option 3:
Creating a spillway by lowering a 100m section of the road. The road currently acts as a dam causing increased flood levels upstream. A stopbank around the school area is still required to exclude flood flows from entering the school.

A hydraulic model was established with the assumption that the finish level of a 100-m section of the road will be set at R.L. 38.00 m. The result was lowering the flood levels opposite to school site to RL 38.34 m. If this option was undertaken in conjunction with the creation of a stopbank detailed design would be required to insure the school wasn't flooded from down stream via the road.

Option 4:
A combination of increased culvert capacity and a spillway at the road was also modelled. The resulting flood level opposite the school site was found to be lowered to RL 38.11 m. This is below the existing floor level of the school of RL 38.22 m. Under this scenario, the school site/ playgrounds will still be flooded, if not stopbanked.

Option 5:
Stopbanking around the school area could provide the necessary protection. The stopbank height needs to be above the current recorded flood level of RL 38.83 m with a freeboard. The stopbank level opposite the school site should be set at approximately RL 39.50 m. This option was not modelled but has been based on recorded flood levels.

It is obvious from the above that a stopbank surrounding the site of the school and other adjacent properties is necessary in all scenarios. Increasing the culvert capacity to pass the full flood flow would not be effective unless the channel capacity was increased to accommodate the full flow. However, a slight increase in culvert capacity to reduce the amount of heading upstream will reduce the ponding duration. Lowering the Road will also be beneficial in terms of reducing the flood duration and level.

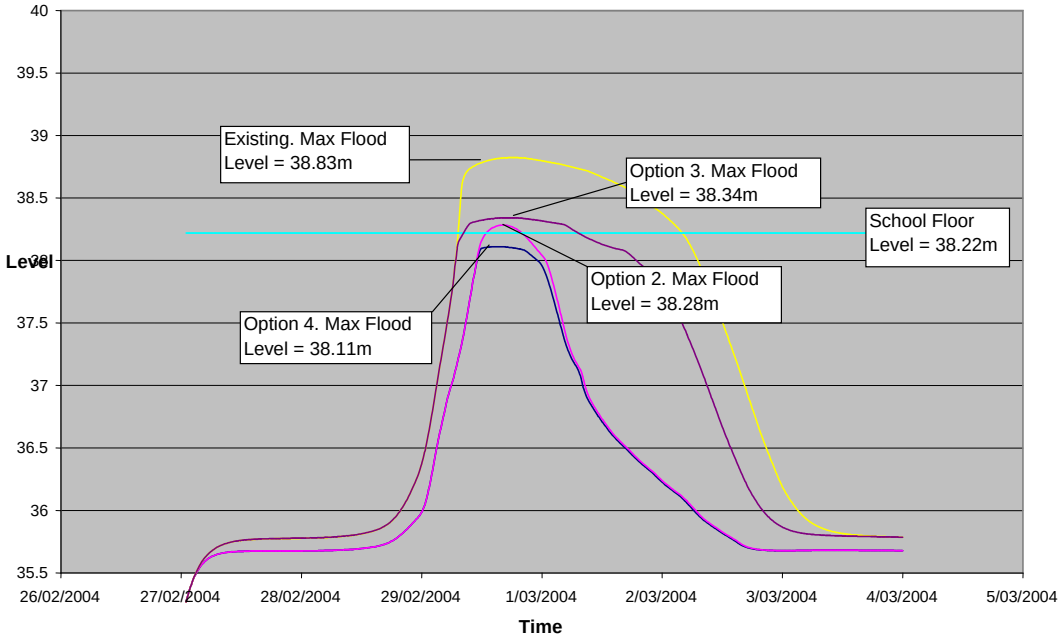

Figure 5 Flood protection options

A combination of these options with a bund appears to be most satisfactory. The bund level would depend on the option chosen. The freeboard required above the flood level has been estimated at 600mm. The recommended stopbank levels for various options are shown below.

Required bund level in combination with various options.	
Option 1	38.90 m
Option 2	38.90 m
Option 3	38.95 m
Option 4	38.70 m
Bund on its own	39.50 m

5 Conclusions

The following conclusions could be derived from this modelling exercise:

1. The February 2004 event is considered a large event (± 100 year Return period) and it's appropriate to use this event to assess the flooding risk at the primary.

2. The Waipa river cross sections currently do not include the whole extent of the flood plain and they are separated by long distances compared to the scale of the model and the resolution required for the calibration. This is particularly relevant within the reach where the overflows and loop are.

3. Uncertainties regarding the storage area and overflow paths have been estimated in order to match observed flood levels and discharges.

4. The floodplain of the Rangiatea Drain is an important storage area that provides significant attenuation during large flood events.

5. The model has been calibrated satisfactorily and it represents the overall situation observed during the February 2004 flood.

6. While the calibration of this event is satisfactory there remain uncertainties on how alterations may affect future flooding. Future decisions on flood relief work should incorporate contingencies such as additional culvert/spillway capacity and freeboard to accommodate such uncertainties.

6 Recommendations

- The hydraulic investigation represents the overall situation during the 2004 flood. Considering the extent of the modelling work, no more investigation is recommended.

- Raising the Rangiatea Rd at the overflows location is not recommended, as the attenuation of the current system will be reduced. While this option will reduce the flood levels at the school this may increase the flood risk at new locations.

- In order to reduce the flooding risk at the school and adjacent properties, five options have been examined and discussed. Under all scenarios, a stopbank surrounding the school area is recommended. The stopbank height will vary depending on the other measures undertaken in conjunction with stopbanking.