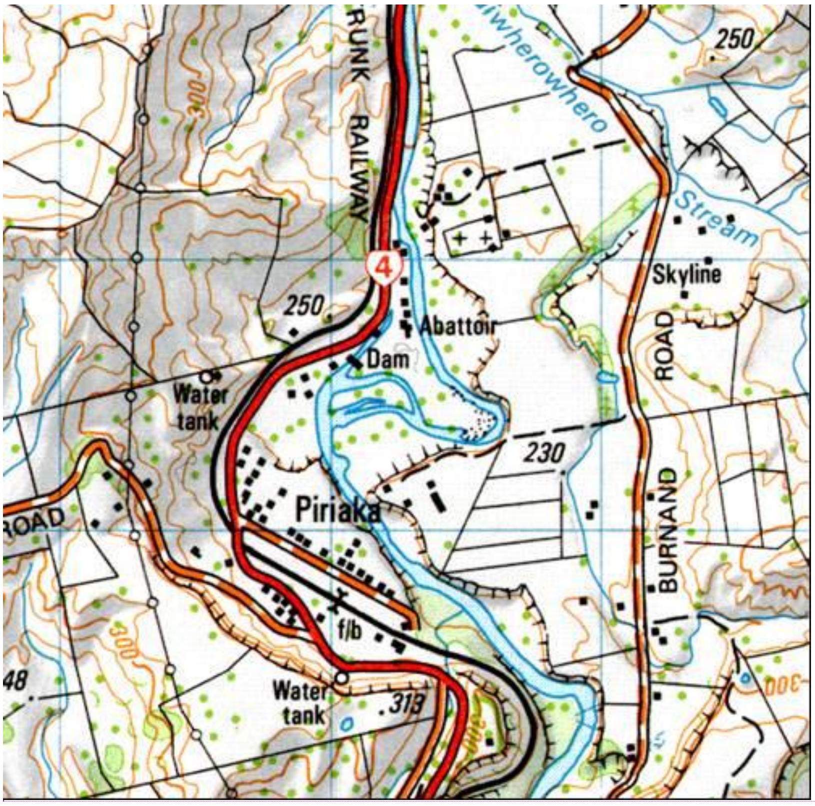
Flood Plain Mapping

Piriaka (Taumarunui)



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Flood Plain Mapping,
Piriaka (Taumarunui)

April 2011

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1 INTRODUCTION

1.1 Background and Scope of Work

This report presents flood level mapping of about 2km of the Whanganui River valley at Piriaka, upstream of Taumarunui, and complements an earlier DHI report (Ref./1/) which presented flood level mapping of Taumarunui itself and its environs. Horizons Regional Council (HRC) engaged DHI Water & Environment to undertake "*a Flood Plain Hazard Assessment for a range of Annual Exceedance Probabilities for the township of Taumarunui and the surrounding rural and semi-rural area*".

The present report effectively covers that part of the valley immediately upstream of the region covered by the earlier report, with the two modelled areas overlapping by about 1 km. The main goal of the present study is to provide information on possible flooding of the power station and on the settlement of Piriaka.

1.2 Modelled Area

The Piriaka Power Station takes advantage of a relatively abrupt fall in valley level, where the river flows steeply (and in multiple channels when in flood) through a pair of meanders. Water supply to its intake channel is effected by rock bunds across the main river channel and across two "minor" or overflow channels. Relatively flat terrain on the true left bank near the intake channel may make it possible for floodwaters to leave the river here and flow overland towards the power station.

As well as some low-lying flood plains, the valley contains some higher terraces on both banks. Piriaka settlement sits on one of these terraces.

In this study the Whanganui River has been modelled from immediately upstream of Piriaka settlement to downstream of Piriaka Power Station. Preliminary results obtained from running the MIKE 11 river model on its own have demonstrated that some parts of the valley are too high to be at risk of flooding from the river, and the areas of floodplain modelled have therefore been restricted to (1) left bank areas close to the weirs and intake channel for the power station, and close to the power station itself; and (2) the region of multiple river channels immediately downstream of the rock bunds. In particular, Piriaka settlement has been excluded, as it sits on a high left-bank terrace and is not threatened

1.3 Design Hydrological Events

The brief for the Taumarunui study (and by inference the present work) requires as the main deliverable maps of flooded areas with annual exceedance probabilities (AEPs) of 2%, 1% and 0.5%. The rationale behind the choice of these three events is discussed briefly in the Taumarunui report.

Neither Piriaka settlement nor the power station is adjacent to any tributary streams that might contribute to flooding. This makes it unnecessary to consider events dominated by local rainfall, and so the study has been limited to the three "design" river flow events considered in the Taumarunui study: Whanganui River floods of 2%, 1% and 0.5% AEP.

The rationale behind the choice of these three events is discussed briefly in the Taumarunui report.

1.4 Delivery

The deliverables for this study are in principle the same as for the Taumarunui study. However, the present results are based on assumed rather than surveyed bund levels, and in any case indicate very little flooding (no flooding, in fact, for the 2% AEP event). The deliverables have therefore been taken to comprise:

- The MIKE FLOOD numerical model (operational so that HRC can carry our further modelling for other flood events);
- This report, including maps of the extent and depth of flooding and of peak velocities, for the 2%, 1% and 0.5% AEP events.
- Numerical modelling output files:
  - .dfs2 files from the MIKE 21 FM two-dimensional model;
  - .res11 files from the MIKE 11 one-dimensional model

2 DATA OVERVIEW

2.1 Land Level Data

The modelled area is covered by the LiDAR survey HRC obtained in early 2009, for which the specified vertical accuracy was 0.15m. The LiDAR data includes "bare earth, unthinned" topography (i.e. with vegetation, buildings and structures removed). These data have sufficient horizontal resolution for fine-scale modelling and are not a limitation to eventual model grid size. The data have been processed to generate a 1m GIS grid which will be used as the basis for the model development.

Horizons also supplied the 1:5000 ortho-photography from 2004-2005, as well as unrectified aerial photographs taken with the 2009 LiDAR survey.

2.2 Hydrological Data

The requirements of the brief imply that design flood hydrographs for the Whanganui River are needed, describing events of 2%, 1% and 0.5% AEP.

The ultimate source of Whanganui River flow data for this study are the two gauging sites: Whanganui @ Piriaka (1970 – present) (NZMG S18:134531) and Whanganui @ Matapuna both within the study area and upstream of the Ongarue confluence. The Matapuna record extends from 1964-1973 only, but has previously been used to synthesize extend back to 1964 the Piriaka peak flows.

The Taumarunui report includes an analysis of these data to produce "design" flow hydrographs for that model, whose upstream boundary was close enough to the Piriaka gauging site for the same flow hydrographs to apply. With no tributaries between the gauging site and the upstream boundary of the present model, the same design flow hydrographs have been applied in the present study.

The water level hydrograph to apply at the downstream boundary of the present model was obtained for each event from the corresponding results from the Taumarunui model. The particular cross-section is close to the Piriaka gauging site, which was used to calibrate the Taumarunui model and might therefore be regarded as the ultimate source of the water level hydrographs also.

2.3 River Data

2.3.1 Cross Sections

The present model includes 1.4 km of river channel also forming part of the Taumarunui model, and the same surveyed cross-section for this reach were used.

Further upstream, three cross-sections were surveyed for HRC for the present study, including the weir (main channel only) diverting water into the power station intake channel. These surveyed cross-sections, and three interpolated cross-sections, have been extended to higher ground by capturing levels from the LiDAR survey.

The model extends further upstream, however, and it has been necessary to use an assumed upstream cross-section, derived from the nearest surveyed channel section (assuming a 0.4% fall). This has been done presuming that model runs will show that Piriaka settlement cannot be flooded from the river, but a surveyed cross-section will be needed should it prove that flooding of the settlement is possible with a plausible choice of upstream cross-section.

2.3.2 Power Station Weir and Intake Channel

Operational water levels at the intake channel are kept high enough by rock bunds across the adjacent Whanganui River, which just at that location flows as a main channel plus minor channels to the true right. The bund across the main channel was included in the cross-sections surveyed for this study, and has been included as a cross-section in the MIKE 11 model.

However, the bunds across the minor channels were not surveyed, and preliminary model runs have shown that their levels have a significant effect on water levels in the general area of the intake channel. It is clear from aerial photographs that these channels do not now carry any flow in low-flow conditions, but that they do operate in high flows. Beyond that, no information is to hand about their crest levels.

A definitive modelling of flood levels must therefore await surveying of the bund levels. In the meantime, the model study has progressed using assumed levels, in the interests of making more immediate progress.

A preliminary model run (with these bunds set too high to allow any flow) was carried out to establish the water levels corresponding to a flow of 400 m3/s. These levels were chosen for the crests of the bunds, a choice that should be conservative (i.e. high). The 400 m3/s flow has a computed AEP of 0.8 (Figure 2-1), and is therefore a significant fresh, if not a flood.

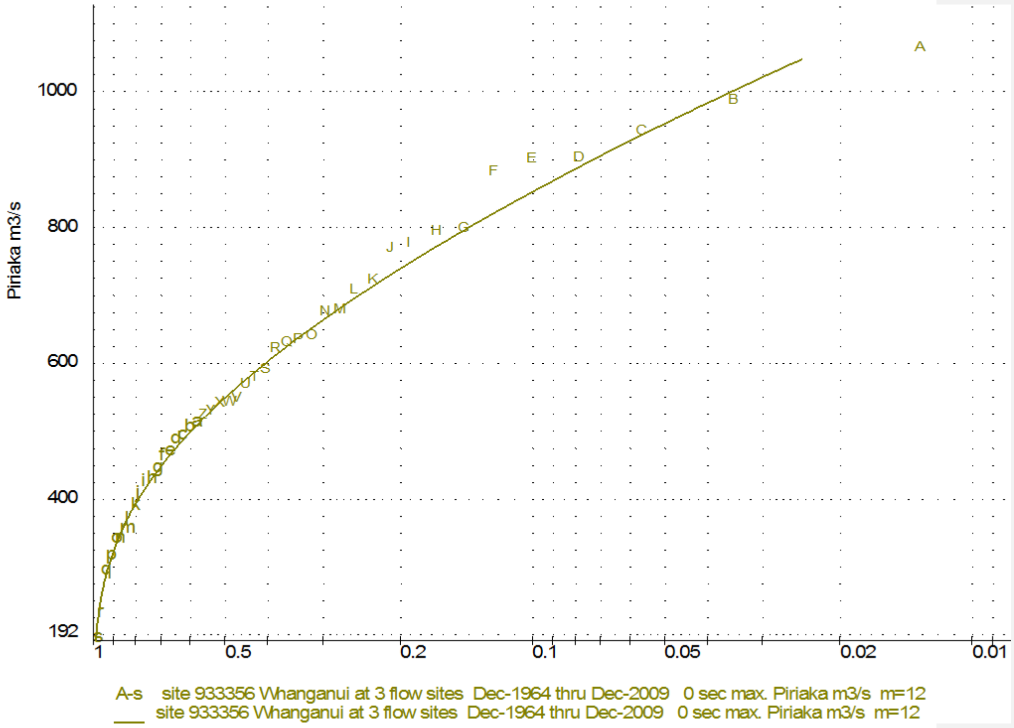

Figure 2-1 Annual gauged flow peaks at Piriaka

Zero flow through the power station has been assumed. This is most likely a realistic assumption for the peak of a flood, but in any case the peak flow through the station (understood to be about 50 m3/s) is insignificant compared to the design peak river flows. However, the power station channel might convey floodwater that then flows overland. A channel cross-section has been surveyed, and the channel has been included with zero flow at its end.

3 MODEL SCHEMITISATION

3.1 General Approach

The modelled area has both floodplain areas and defined channels, for which it is appropriate to use a numerical model combining two separate parts. Using the best-suited computational model for each of the flow categories allows for more accurate model results.

1. The Whanganui River and the intake channel are best modelled with a traditional one-dimensional model, which can readily capture their important flow characteristics. These have been represented in a MIKE 11 model.
2. With LiDAR data available for the floodplain areas, a two-dimensional modelling approach is best. The overland flow here has been modelled using the MIKE 21 flexible mesh module.

These two models –2D floodplain model and 1D channel model - are dynamically linked using the MIKE FLOOD software (Ref./2/). MIKE FLOOD allows the models to communicate and synchronise water levels and flows in real simulation time, and therefore forms a combined model describing in detail the complete physical flow characteristics.

Water enters and leaves the model through just the one pathway: river flow through the upstream and downstream boundaries of the MIKE 11 model.

Figure 3-1 illustrates the model area, showing the components of the model: the river and intake channel modelled in MIKE 11, and the two areas covered by the 2D overland model in MIKE 21FM (the flexible mesh allowing a better fit to irregular areas than the comparable rectangular mesh). Note that 2D flood maps can be available only for these two areas.

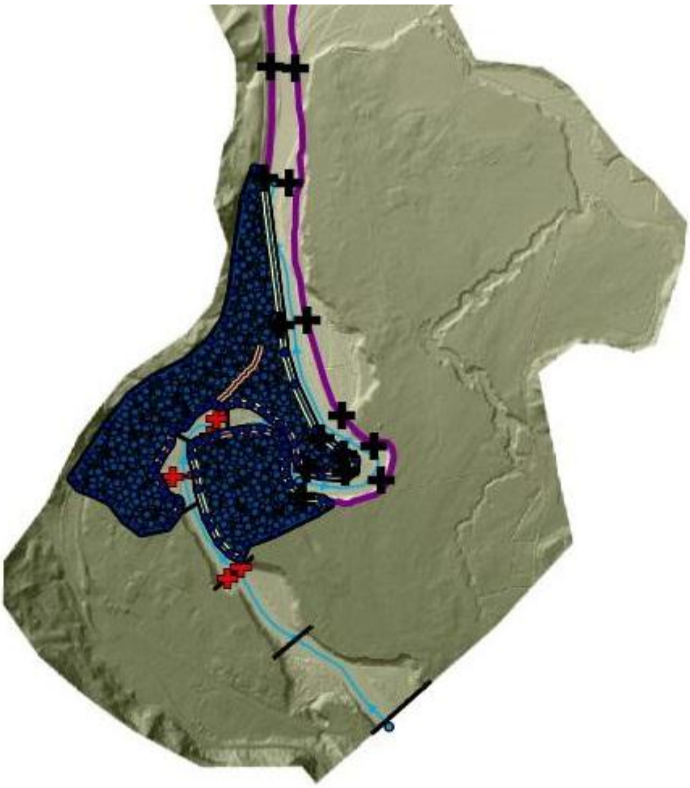

Figure 3-1: MIKE Flood Model Coverage:
Surveyed sections used in the MIKE 11 model are marked by crosses
The two further cross-sections marked upstream are assumed (not surveyed: see 2.3.1 above) and also form part of the MIKE 11 model.

3.2 Model Parameters

3.2.1 River network

No calibration data were available for this part of the Whanganui River. Given its proximity to the Piriaka gauging site, the same Manning's n value of 0.05 was used as for the adjacent reaches of the Whanganui River in the Taumarunui model. This value was obtained by calibrating that model against the gauging site rating.

3.2.2 Overland Flow

The overland flow is modelled using the MIKE 21 Flexible Mesh, in this case made up solely of triangular elements of varying sizes.

A constant eddy viscosity of 0.002 m^2/s was used, a nominal low value. This arbitrary choice is sufficient because bed friction dominates in determining the velocity pattern in overland flow on floodplains such as these.

Most of the modelled area is pasture, with an assigned Manning's n roughness value of 0.05. It is difficult to assess the roughness of the river bed area just below the weirs, and a Manning's n roughness value of 0.05 has been used here also.

3.2.3 MIKE Flood: 1D – 2D coupling

MIKE FLOOD (Ref./1/) is the software that dynamically couples the models to synchronise water levels and flows in real simulation time. Lateral links have been used to model flow between the river reaches (and the intake channel) within the MIKE 11 model and the adjacent floodplain modelled in MIKE 21. These lateral links typically connect several MIKE 21 cells to each MIKE 11 **h** node, and (following standard practice) the maximum distance between MIKE 11 cross-sections has been limited to 50 m to avoid significant inaccuracies in the overland flow water levels.

The links are coded as simple weirs, which are intended to reflect the free over-bank weir flow that will generally occur. The coupling is bi-directional, allowing for both inflow to the stream channel and outflow from it. The default values for weir friction (0.05) and coefficient (1.838) are applied for the links.

In most of the model the spill level is chosen as the higher of the MIKE 11 cross section bank marker and the level in the linked 2D element.

The exception is the rock bunds (upstream of the power station intake channel and on the true right of the main channel) that obstruct flow into the minor channels there. The approach taken for these bunds is discussed in Section 2 above.

4 RESULTS

Three aspects of the computed flows and flood levels are presented here:

- The stage hydrograph at the head of the power station intake channel (Figure 4-1);
- Maps of peak water levels from the MIKE 21 overland flow model (Figures 4-2 and 4-3 for the 1% and 0.5% AEP events respectively); and
- The flow hydrograph for water spilling overland adjacent to the intake channel and power station (Figure 4-4).

In all three events, the model predicts substantial overflows over the rock bunds and down the subsidiary channels. However, on the true left bank near the power station intake channel, the 2% event is not predicted to cause any overflows. The left bank overflows predicted for the larger events (Figure 4-4) are very minor when compared to the total flow in the river, less than 0.2%.

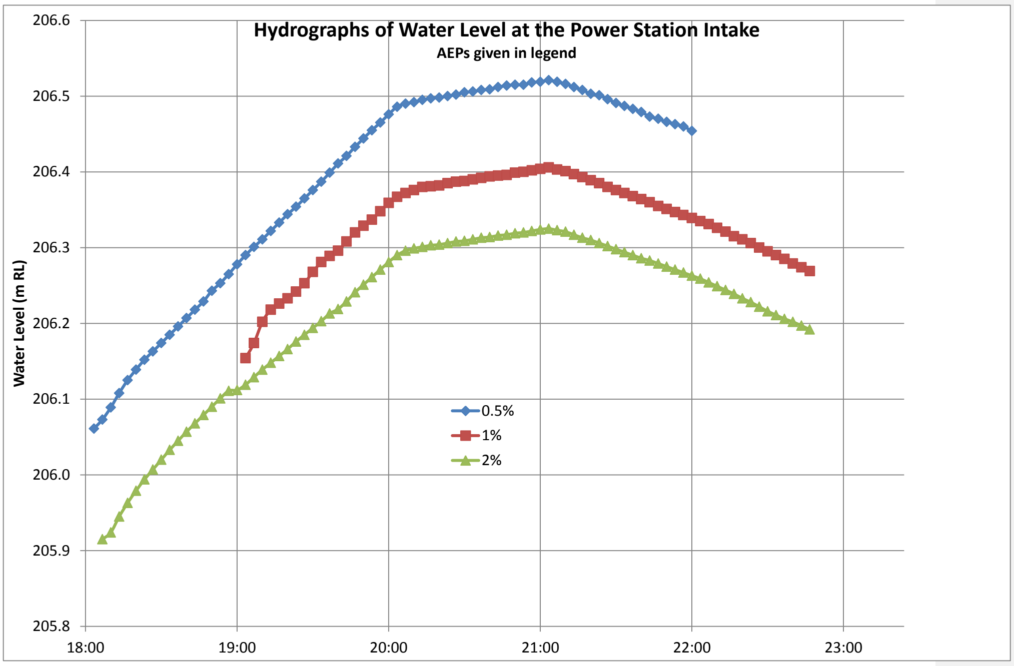

Figure 4-1 Modelled stage hydrographs at the head of the power station intake channel

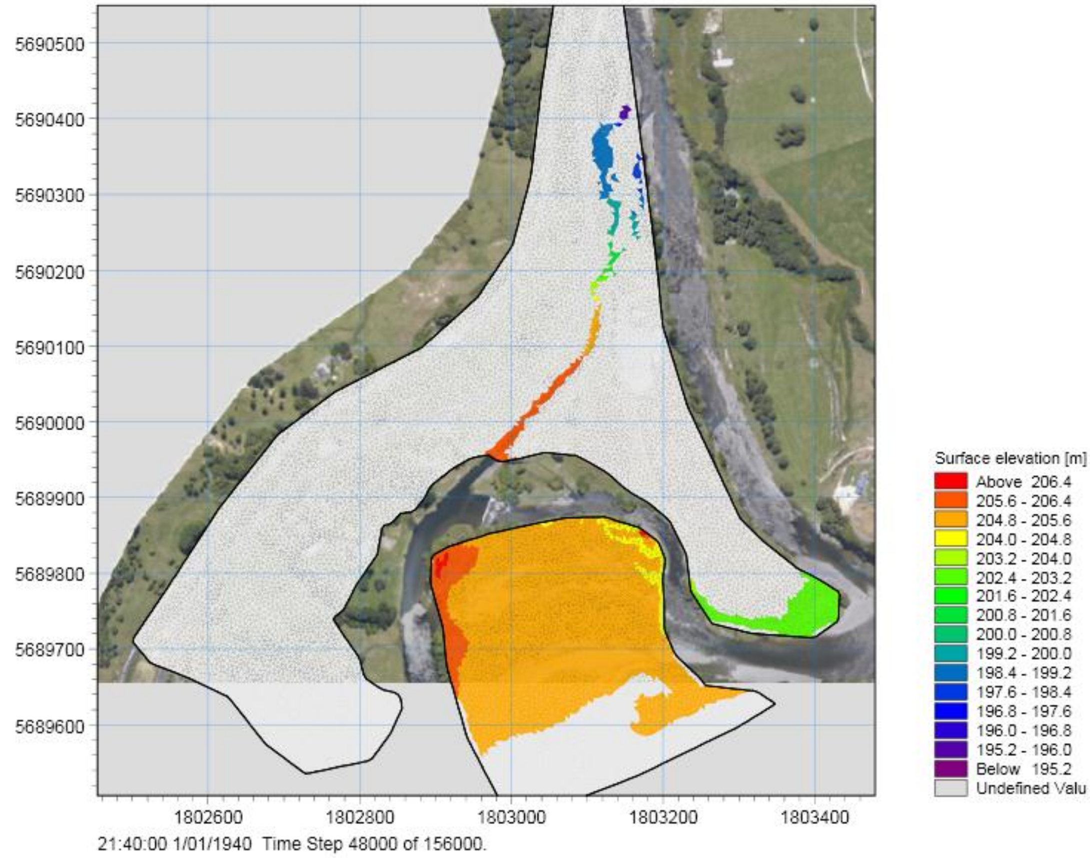

Figure 4-2 Map of peak water levels from the MIKE 21 overland flow model, 1% AEP event

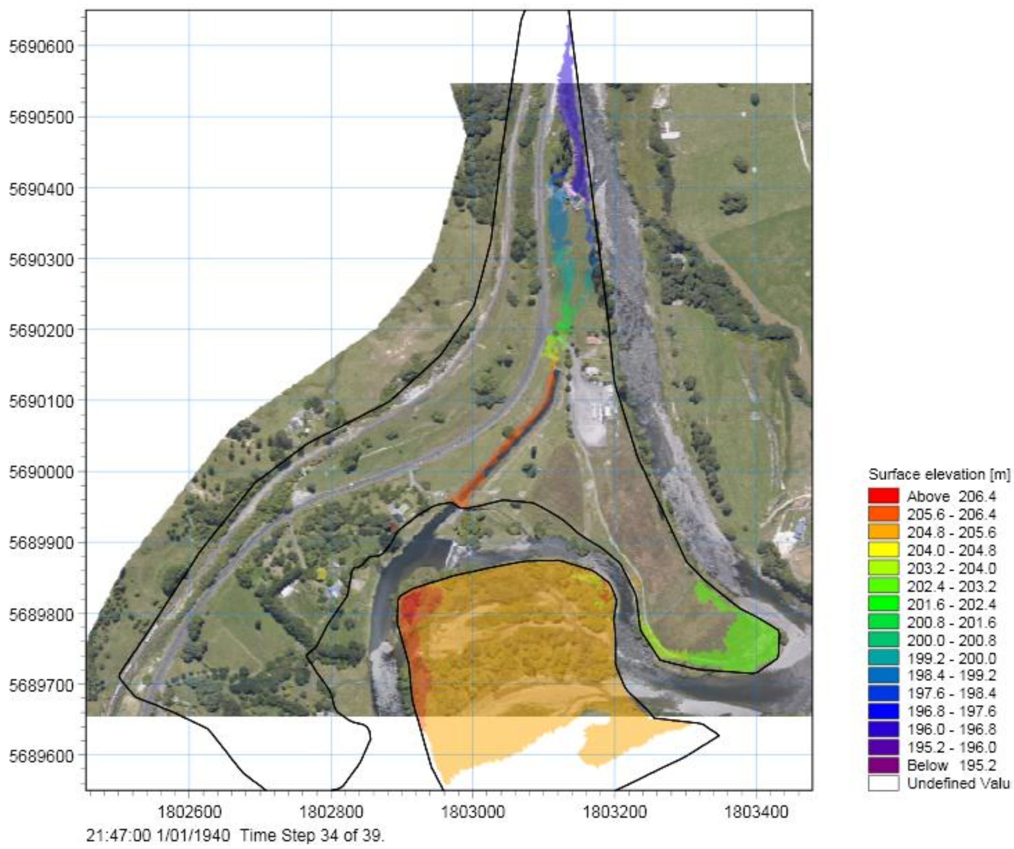

Figure 4-3 Map of peak water levels from the MIKE 21 overland flow model, 0.5% AEP event

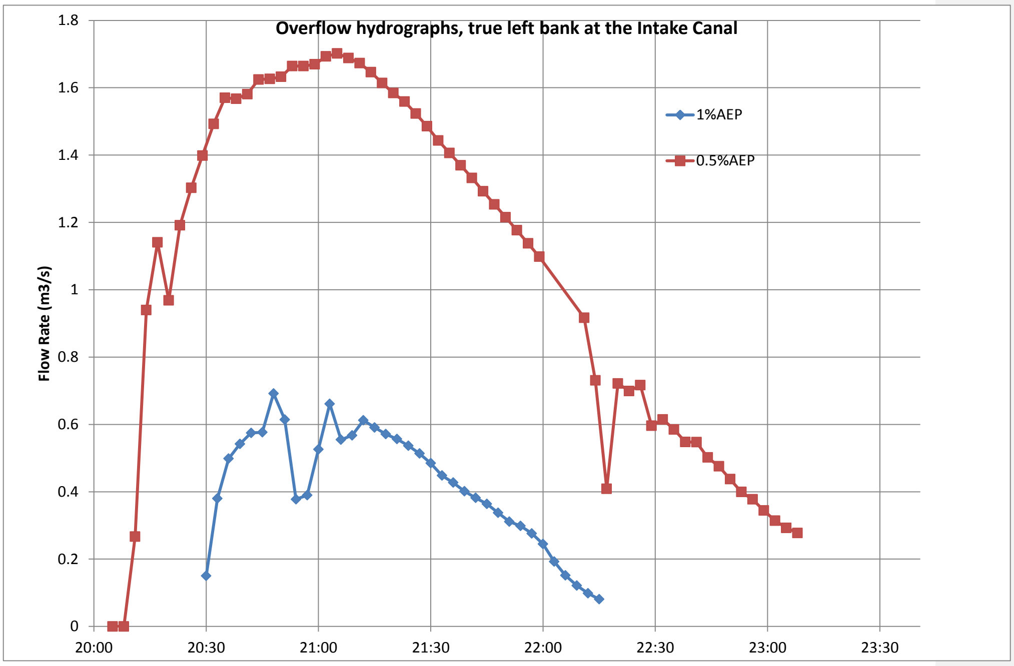

Figure 4-4 *Flow hydrographs of water spilling overland adjacent to the intake channel and power station, in the 1% and 0.5% AEP events.*

5 DISCUSSION AND CONCLUSION

These results show that in significant flood events a significant part of the flow overtops the rock bunds to flow down the subsidiary channels on the true right side (south of the main channel). This is so even with the assumption made for the present model runs, that overtopping starts only when river flows exceed about 400 m^3/s.

As a consequence, the left bank is overtopped only during extreme floods. Figures 4-2 to 4-4 show this overtopping in the 1% and 0.5% AEP events, with up to 1.7 m^3/s flowing past the power station and eventually back into the Whanganui River.

This overland flow can be regarded as almost trivial, on two counts. First, it is a very small fraction of the total flow in the Whanganui River. Second, even the peak flow in the 0.5% event represents a nuisance rather than a flood hazard, and should have no impact on the functioning of the power station.

It would be prudent to reconsider the present model results once the true crest levels are known of the rock bunds blocking the subsidiary channels. However, it is likely that they are lower than has been assumed for this study, and that the minor overland flow past the power station will be even more minor, or very likely non-existent.

Piriaka settlement and its environs have been shown to be elevated above any risk of flooding from the river. This and the insignificant overflow identified above lead to the conclusion that there is no significant flood risk in the area around Piriaka.

6 REFERENCES

/1/. Flood Plain Mapping, Taumaranui Township, Project No NZ50211, 2010

/2/. DHI Water & Environment: MIKE FLOOD Reference Manual, 2009.