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Wentworth River Flood Hazard Assessment

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Environment Waikato
REGIONAL COUNCIL

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Executive Summary

This report has been prepared to support the development of the Wentworth River Catchment Management Plan.

This report provides an updated assessment of the effects of mangroves on the Wentworth River flood hazard affecting Whangamata. This assessment is a revision on what was previously reported in May 2007. The assessment now uses updated and refined hydrological information as an input into the hydraulic model.

A hydraulic model has been developed for the Wentworth River and Moanaanuanu Estuary to assess the predicted impact of mangroves and associated sedimentation on the future Wentworth River flood hazard area in Whangamata. This report summarises the results of this investigation.

The Wentworth River hydraulic model was developed by Hydraulic Modelling Services Ltd (HMSL) on behalf of Environment Waikato (EW). The Wentworth River hydraulic model was then used to assess the flood hazard for various scenarios relating to the presence or removal of mangroves from Moanaanuanu Estuary, and the associated sedimentation levels. The scenarios modelled included the following:

- Scenario 1 - Existing scenario (based on digital terrain information dated 2004)
- Scenario 2 - Future scenario (year 2080 - allowing for climate change) with mangroves retained
- Scenario 3 - Future scenario with mangroves removed

Various assumptions were made to develop models for these scenarios, relating to the future extent of mangroves and sedimentation rates.

The results produced by the hydraulic model indicate that the Wentworth River current flood hazard is generally limited to land that is not subject to urban land-use. The exception to this was minor inundation around the Port Road/Hilton Drive intersection.

For the future scenario (year 2080) with mangroves retained, the Wentworth River flood hazard is predicted to extend to affect a small area of residential and commercial properties in parts of the Whangamata urban area that border the true right bank of the Moanaanuanu Estuary, specifically, areas on the estuary edge of Aickin and Lindsay Roads, and Beach Road and in the vicinity of the Port Road/Hilton Drive intersection. However the increase in flood hazard is only minor.

The extent of the future Wentworth River flood hazard would be reduced if the mangroves are removed. However the change in flood hazard would only be minor, and in general the model is predicting that the Wentworth River flood hazard is largely contained within the river channel and is not predicted to be greatly affected by the mangroves or future climate change.

It is recommended that:

- The mangroves in the Moanaanuanu Estuary are controlled to their existing extents so as not to exacerbate the predicted Wentworth River flood hazard area.
- Cross-section surveys be undertaken every five years in the Wentworth River and Moanaanuanu Estuary to assess sedimentation trends to inform future management options for the river/estuary system.

- Once the sedimentation rates in the Wentworth River are better established (using site specific survey data) the future flood hazard should be reassessed and flood hazard management options developed if appropriate.

There is a draft Whangamata Harbour Catchment Management Plan, which aims to control and reduce sediment runoff from the upper catchment. Once the plan is implemented and the recommended management actions have had time to take effect, the rate of sedimentation in the catchment is expected to reduce. The change in sedimentation rates should be picked up by the bed levels surveys.

This investigation has not looked into the effect of the Hetherington Road causeway and the impact of this structure on the natural sediment transport in the Moanaanuanu Estuary.

1 Introduction

This report has been prepared to support the development of the Wentworth River Catchment Management Plan. This report specifically addresses the Wentworth River flood hazard, including:

- The development of the Wentworth River hydraulic model
- A brief description of the flood hazard classification procedure
- Interrogation of the hydraulic model to produce flood hazard maps
- Discussion around the resulting Wentworth River flood hazard
- Recommendations

This report provides an updated assessment of the effects of mangroves on the Wentworth River flood hazard affecting Whangamata. This assessment is a revision on what was previously reported in May 2007. The assessment now uses updated and refined hydrological information as an input into the hydraulic model.

2 Background

The presence of mangroves in the Moanaanuanu Estuary and the associated sedimentation is likely to be reducing the hydraulic capacity of the river/estuarine system.

Sediment is currently accumulating in the Moanaanuanu Estuary and the extent of mangroves is expanding as a result. There are a number of possible reasons for this, including:

- Increased erosion in the Wentworth River catchment caused by land-use change (e.g. conversion of forest to pasture)
- Interruption of natural sediment transport due to the construction of the Hetherington Road causeway
- Entrapment of sediment by existing mangroves

Regardless of the cause(s) of the current sedimentation issue, it is likely that the effects of future climate change and the propagation of mangroves will exacerbate this current issue.

A hydraulic model has been developed for the Wentworth River to assess the predicted impact of mangroves and associated sedimentation on the future Wentworth River flood hazard area in Whangamata. This report summarises the results of this investigation.

3 Hydrological Assessment

The Wentworth River, with a catchment area of 25.25 km^2, is the major fluvial system which drains into the Moanaanuanu Estuary. The Okauanga Stream contributes a smaller flow from a smaller catchment area of 1.93 km^2.

There is no flow gauging record for the Wentworth River apart from a small number of low flow recordings taken intermittently over a number of years. Therefore it was not

possible to use site specific flood frequency analysis to generate flow estimates for input to the hydraulic model. Flow estimates were developed using several methods, including TM61, Modified Rational Method, and the Flood Frequency in New Zealand Method (McKerchar Pearson, 1989).

3.1 Revised hydrological input

As stated in Section 1, this report provides an updated assessment of the effects of mangroves on the Wentworth River flood hazard affecting Whangamata. This assessment is a revision on what was previously reported in May 2007 as the hydrological information used as an input into the hydraulic model has been reassessed and refined.

Extreme flows in hydrology are calculated on the best information at the time and previous high flow extrapolation at Wharekawa was undertaken in mid 1990's. Reassessment is usually done as a result of further information being collected during a large event. The event of April 2006 was the highest on record since records began in 1991 and exceeded the level estimated flows had been extrapolated to, hence enabling flows to be reassessed.

It should be noted that the gauged data used to assess the hydrological input for this assessment is based on a short gauging record, hence a high degree of extrapolation was undertaken to generate the 1% AEP flood flow used as an input in the hydraulic model. Assumptions based on the results of the model should be made with caution.

3.2 Comparison of the 1% AEP peak flow

In the first instance, the 1% AEP peak flood flow for the Wentworth River was estimated using the TM61, Modified Rational Method and the Flood Frequency in New Zealand Method. Each method provides varying estimates of the 1% AEP flow as shown in Table 1. For this study a flood flow derived by the McKerchar Pearson Method was used, refined with flow data form the adjacent Wharekawa catchment which is physically and climatically very similar to the Wentworth River catchment.

Table 1: Comparison of the 1% AEP peak flow estimates (m^3/s) for the Wentworth River

TM61 (using rainfall depths from HIRDS v2.0)	**Modified Rational** (using rainfall depths from HIRDS v2.0)	**Flood Frequency in NZ** (using regional multiplier and mean annual flood)	**Flood Frequency in NZ** (refined using 1% AEP Wharekawa gauging, catchment size 46.5 km^2)	**Flood Frequency in NZ** (refined using 1% AEP Tairua gauging, catchment size 177 km^2)
136	234	203	204	302

Using the Flood Frequency in New Zealand method combined with the Wharekawa flood frequency analysis by EW, we assume a good level of homogeneity between the Wharekawa and Wentworth River catchments. Both catchments are similar in shape, but in terms of size the Wharekawa River catchment (46.5 km^2) is approximately 1.8 times the size of the Wenworth River (25.25 km^2) catchment. Both catchments have a similar landuse (mix of native forest, pine plantation and farm land occupying the valley floor) and are exposed to very similar climatic conditions.

3.3 Wharekawa gauging record

A high degree of extrapolation was undertaken to generate the 1% AEP flood flow using the 15 year Wharekawa gauging record. Hence the estimate should be used with caution due to the short length of record.

At this point it should be emphasised that the aim of this study is to evaluate the relative difference in flood level before and after mangrove removal. Even though the model can not be calibrated against actual events it still serves as a useful tool for comparing flood levels and relative change. Calibration and validation is needed for prediction of flood levels for robust design of flood risk mitigation measures.

Compared to the Tairua River, which remains in bank during high flows throughout its recording period, the gauging cross section at Wharekawa exceeds bank full and overtops at around 90 m^3/s (less than the mean annual flood) spreading across a much wider floodplain. Out-of-bank flow for Wharekawa is calculated using indirect methods taking into account cross-sectional area and velocity estimates across the berm and floodplain and, there the flow estimate has considerably wider error bands than the Tairua record.

As far as scaling for the Wentworth River is concerned, the Wharekawa record is still considered appropriate. The greater error in flow gauge recording for Wharekawa compared to Tairua is compensated by the fact that the scaling error is reduced because the Wharekawa catchment is only 1.8 times the size of the Wentworth, whereas the Tairua catchment is 7 times the size.

3.4 1% AEP peak flow estimate

Another method of estimating the 1% AEP peak flow is to use the mean annual flood for a particular catchment and a regional multiplier from McKerchar and Pearson (1989). Firstly the mean annual flood of 75 m^3/s for the Wentworth River was generated by scaling the mean annual flood of 122 m^3/s for Wharekawa. The Wentworth River mean annual flood was then multiplied by 2.7 to give a 1% AEP flow estimate of 203 m^3/s (std error +/- 22%) as shown in Table 1. This flow estimate is very close to the 1% AEP estimate of 204 m^3/s which was derived by scaling direct from the 1% AEP peak flow for the Wharekawa catchment and is higher than the estimate given by TM61 but is lower than the Modified Rational Method estimate.

The importance of the Wharekawa gauging record cannot be overlooked when we assume a good level of homogeneity between the Wharekawa and Wentworth catchments. For this reason the estimate flow of 204m^3/s has been used in the hydraulic model.

3.5 Discharge hydrographs

Discharge hydrographs (1% (with and without climate change), 2%, 5%, 10%, 20% and 50% AEP) for the Wentworth River and Okauanga Stream catchment were generated using the McKerchar Pearson Method combined with a 15 year record of gauged data from the Wharekawa catchment. Only the 1%AEP flood flow (with and without climate change) has been used in the model to compare flood levels before and after mangrove removal.

3.6 Unit hydrographs

Four historic flood events for Wharekawa were chosen to approximate the shape of the Wentworth River hydrograph (Feb 2003, May 2005, July 2005 and June 2006). An overplot of each dimensionless unit hydrograph was prepared and from this a mean dimensionless hydrograph was created for the catchment, as shown in Figure 1.

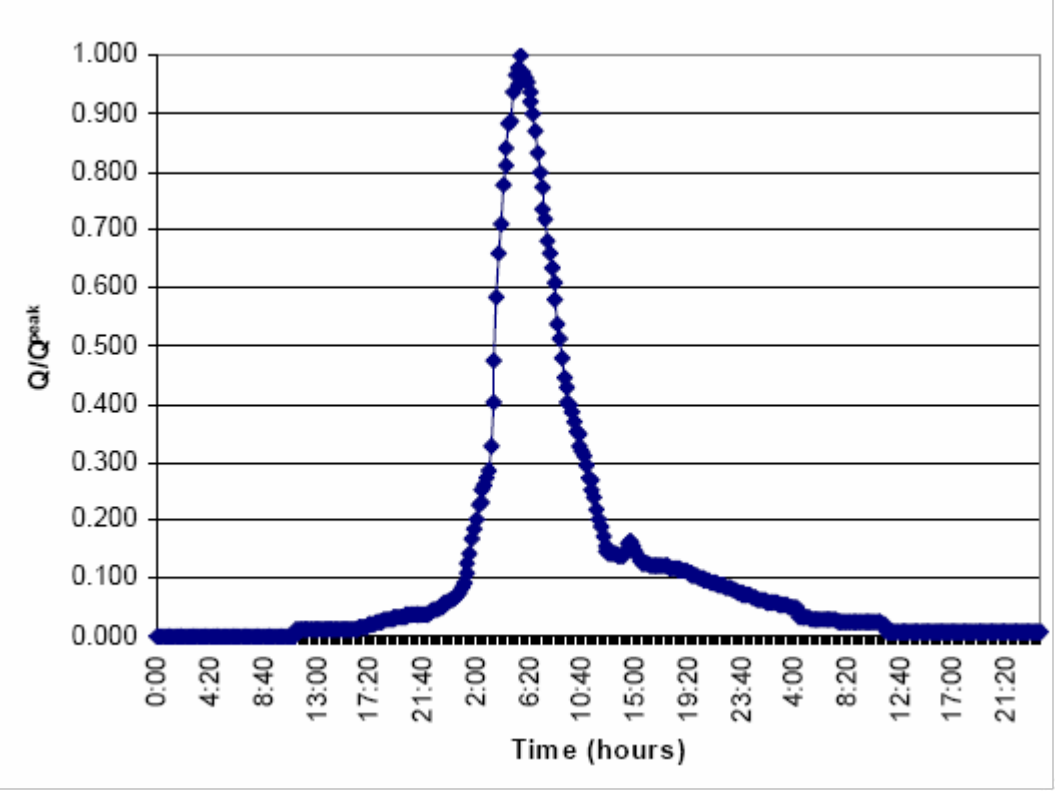


Figure 1: Mean dimensionless unit hydrograph

3.7 Time of concentration related to average time to peak

The estimated mean time of concentration for the Wentworth Catchment is 1.8 hours which was taken as the average of two values generated by two different methods, in this case the Ramser-Kirpich and the USSCS methods. The time of concentration for the Okauanga Catchment was estimated to be 44 minutes.

From the Wharekawa gauging record the average time to peak is 7 hours based on five historic events. The shortest time to peak is 4 hours during the largest event on record in April 2006. The return period for this event is close to 50 years. For this study we assumed a time to peak equal to the time of concentration as stated above.

3.8 Synthetic hydrograph

The mean dimensionless unit hydrograph in Figure 1 and flow estimate in Table 1 were used to derive a 1% AEP synthetic storm hydrograph for the Wentworth River and Okauanga Stream.

For the Wentworth River the time to peak for the synthetic hydrograph is assumed to be 2 hours, therefore the mean dimensionless unit hydrograph (Figure 1) was scaled to incorporate the 2 hour time to peak and the estimated 1% AEP discharge to generate the synthetic hydrograph (refer Figure 2). A synthetic hydrograph or the Okauanga was also developed using this method.

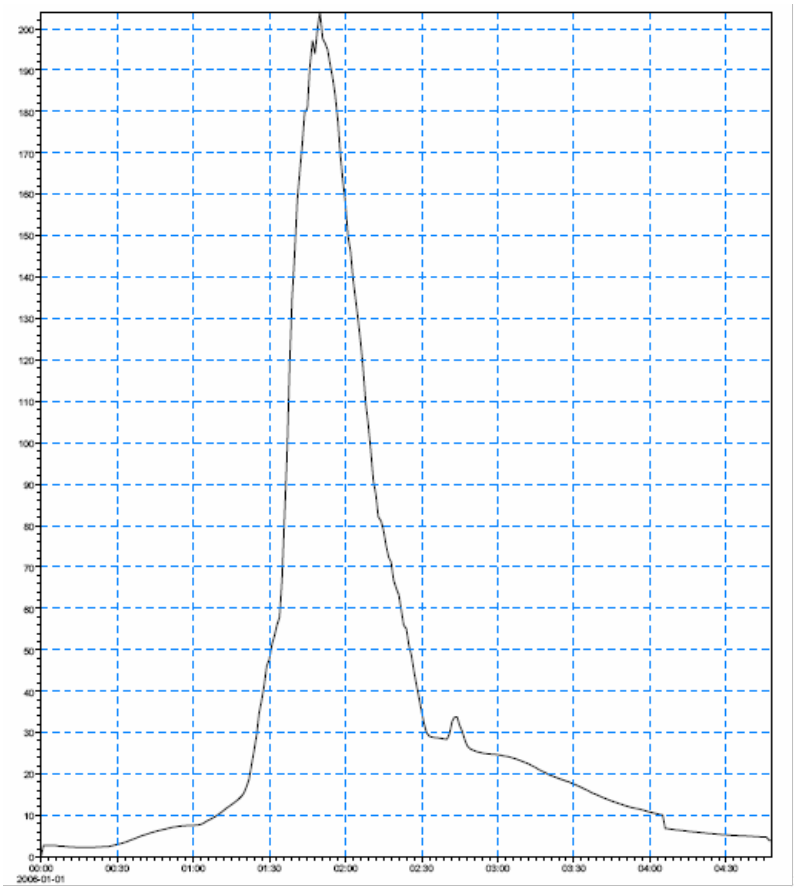


Figure 2: Synthetic 1% AEP flood hydrograph for Wentworth River

3.9 Impact of climate change

Climate change is predicted to have a range of effects on our environment. The Resource Management (Energy and Climate Change) Amendment Act requires local government to have particular regard to these effects when making decisions under the Resource Management Act.

The effects of climate change that are particularly relevant to river flooding are a rise in sea levels and an increase in rainfall intensity. The Ministry for the Environment has produced a guidance document to help assess the magnitude of these effects in New Zealand. This guidance, which is based on the Intergovernmental Panel on Climate Change (IPCC) fourth assessment report, suggests that the average annual temperature in the Waikato Region will increase by 0.6 to 5.6^{O}C by the late 21st century. This increase is predicted to:

- Increase the sea level by 0.18 to 0.59 m.
- Increase in rainfall intensity by 4 to 8 % per degree of temperature increase.

Since the purpose of this study is to assess the impact of mangrove removal on flood levels, it is important to also consider the change in flood levels for a future scenario taking into account climate change. Model simulations have been performed with a revised set of discharge values to represent flood flow up to the year 2080. Notably a 28% increase in 1% AEP peak flow with climte change (261 m^3/s) compared to the present day 1% AEP peak flow estimate (204 m^3/s).

4 Hydraulic model

The Wentworth River hydraulic model was developed by Hydraulic Modelling Services Ltd (HMSL) on behalf of Environment Waikato (EW). Further information relating to the development of the hydraulic model can be found in the HMSL reports:

- Wentworth River, Whangamata - Flood Modelling Analysis of Wentworth River and Moanaanuanu Estuary (HMSL, November 2006), EW Document 1175994
- Wentworth River, Whangamata - Flood Modelling Analysis of Wentworth River and Moanaanuanu Estuary – Supplementary Report (HMSL, Jan 2009), EW Document 1428221.

The following sections summarise the model set up.

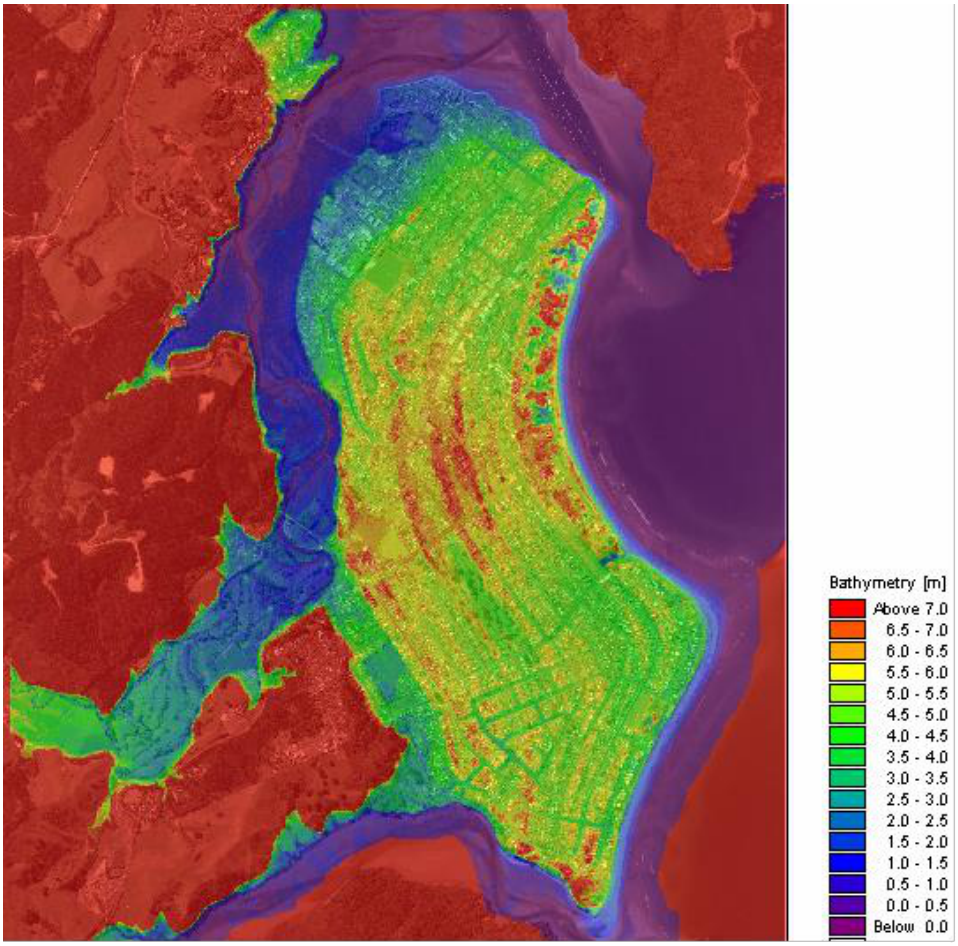
4.1 Model extent

The model extent was based on the extent of the digital terrain model that was attained for Whangamata via LiDAR survey in 2004/05, refer Figures 3 and 4.



Source: Terralink International Ltd, 2002. COPYRIGHT RESERVED

Figure 3: Extent of model (based on aerial photo)



Source: LiDAR data, flown September 2004, survey completed 2005

Figure 4: Extent of model (based on digital terrain model)

The model grid developed has an origin of NZTM 1852800 5875600 and is 3500 m (x-direction) and 4250 m (y-direction). The model grid is based on cells 5 m x 5 m, hence 700 cells (x-direction) and 850 cells (y-direction).

4.2 Datum

The original LiDAR survey was flown in September 2004 to attain the digital terrain model used in the model. For Whangamata, the reported correction from LiDAR MSL to Moturiki Datum (1953) is -0.69 m (Refer EW document number 1275578). This correction has been applied to the LiDAR survey data for the Wentworth River and levels in the bathymetry file were then checked against several surveyed ground levels (LINZ benchmarks) in Whangamata, a reasonable level agreement was achieved.

4.3 Boundary condition

For the upstream boundary condition a 1% AEP synthetic hydrograph with a peak discharge of 204 m^3/s was used as the inflow to the model (Figure 2). This was scaled up by 28% to 261 m^3/s for the climate change scenario.

The downstream boundary condition was set as a static water level of 0.93mRL which represents Mean High Water Springs (MHWS) tide. For future climate change scenarios this was increased by 0.5m to 1.43mRL. The static tide provides a conservative approach in which peak fluvial flows occur at the peak tide level.

4.4 Roughness coefficient

The roughness coefficient used for the modelling scenarios are provided in Table 2. A Mannings M value of 5 is used to represent mangrove coverage. Elsewhere in the

floodplain the roughness coefficients are set according to vegetation type and the variability in landuse. Figure 5 shows the existing extent of the mangroves in the Moanaanuanu Estuary outlined in green.

Table 2: Manning's roughness coefficients

Description	Manning's coefficients	
	'n'	M
Main channel	0.035	28.57
Pasture	0.035	28.57
Pasture and scattered trees	0.04	25
Vegetation in the tidal zone other than mangroves	0.05	20
Mangroves	0.2	5

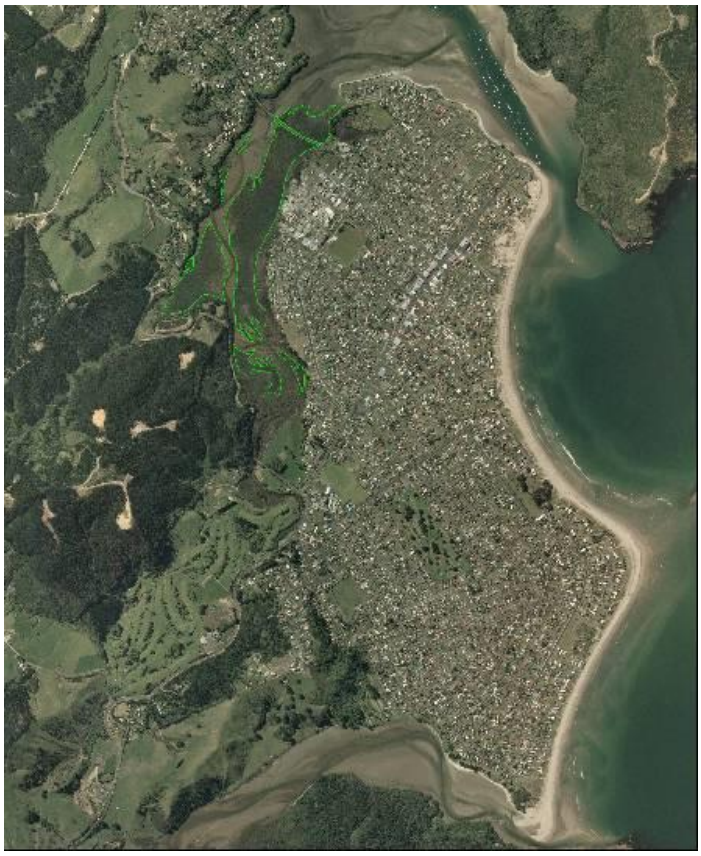


Figure 5: Existing mangroves extent

4.5 Model scenarios

The Wentworth River hydraulic model was used to assess the flood hazard for various scenarios relating to the presence or removal of mangroves from Moanaanuanu Estuary, and the associated sedimentation levels. The scenarios modelled included the following:

- Scenario 1 - Existing scenario (based on digital terrain information dated 2004)
- Scenario 2 - Future scenario (year 2080 - allowing for climate change) with mangroves retained
- Scenario 3 - Future scenario with mangroves removed

Various assumptions were made to develop models for these scenarios, as outlined below.

4.5.1 Extent of mangroves

For Scenario 1 (existing scenario), the extent of mangroves was identified using the aerial photographs for the Moanaanuanu Estuary (2002-03), refer to Figure 5 for details.

Note that the removal of mangroves in the estuary near the causeway was not taken into account.

For Scenario 2 (future scenario with mangroves retained), the interrelationships between sea level rise, sedimentation and the resulting extent of the mangroves is complex and difficult to predict with certainty. The sediment accumulation process within the mangroves may buffer the system against the effects of sea level rise (predicted with climate change), a situation that may see the mangroves either maintain their current ecological niche, or even slowly expand their extent in the harbour under future sea level rise scenarios. However, the ability of the plant to create 'new land' can also lead to the plant limiting its own advance as the 'new land' eventually has too little water and salinity to maintain the mangroves.

Due to the already significant presence of mangroves in the Moanaanuanu Estuary (upstream of the causeway) and the complexity of predicting future mangrove extents, it was decided that for modelling purposes, the existing extent would be a suitable approximation for the future extent.

For Scenario 3 (future scenario with mangroves removed), it was assumed that there were no mangroves present in the channel.

4.5.2 Sedimentation

For Scenario 1, the existing digital terrain model (based on LiDAR data) was used to develop the profile of the channel in the Moanaanuanu Estuary.

For Scenario 2, allowance was made for the predicted sedimentation over time in the channel as it impacts on the hydraulics of the system and hence the resulting flood depths and velocities. Two different rates of sedimentation were developed as sedimentation occurs at a greater rate in mangroves than in intertidal flats.

The net sedimentation rate for the intertidal flats in the Moanaanuanu Estuary was assumed to be 5mm/year – this is based on a paper by Swales and Hume (1994) which assessed the sedimentation rates at four locations in the northern arm of the Whangamata Harbour. The future scenario has been developed for the year 2080, hence the increase in bed depth in the intertidal flats was assumed to be 380mm (76 years x 5mm/year).

Mangroves are very effective at trapping sediment so the rates of accumulation in the mangroves are likely to be higher than those measured on the intertidal flats of the full estuary. This has been the case in the southern Firth of Thames, where sedimentation rates in the mangroves have been observed to be two to four times greater than those observed in the intertidal flats (Swales et al, 2006).

For the purposes of this model the sedimentation rate for the mangroves in the Moanaanuanu Estuary was assumed to be 15mm/year (three times greater than the a accumulation rate in the intertidal flats), hence the increase in bed depth in the mangrove area was assumed to be 1.14m (76 years x 15 mm/year).

These predicted increases in bed level were then applied to the relevant portion of the channel in the exiting digital terrain model to develop a predicted channel profile for Scenario 2.

As discussed above, the ability of mangroves to create 'new land' can limit the plants growth due to too little water/salinity. The altered bed level, for Scenario 2, was compared against the predicted future spring high tide level, and the majority of the mangrove areas (approximately 90%) would still be submerged under these conditions. Hence, the assumed extent of mangroves for the future scenario is deemed a suitable approximation for modelling purposes.

For Scenario 3, a sedimentation rate of 5mm/year was assumed across the entire channel, hence an increase in bed depth across the entire channel of 380mm was applied to the existing digital terrain model.

4.6 Model validation

The results produced by hydraulic models need to be validated by comparing the modelled flood extent with recorded flood extents. For the Wentworth River, the flood extent that occurred during the May 2005 event was compared with the modelled flood extent for the 1 % AEP event under Scenario 1 - the existing scenario.

The May 2005 event was smaller than a 1% AEP event, however it was a relatively significant event. Based on observations at the Golden Cross rainfall recorder, the recorder received approximately 74mm over a 4-hour period, peaking at 26mm per hour. Both of these rainfall observations are consistent with a 20% or a 10% AEP event, based on HIRDS Version 2.0.

The comparison showed that the modelled flood extent is in general agreement with the May 2005 flood extent.

5 Flood hazard classification

To assess flood risks, it is necessary to consider the nature and degree of the potential impacts of flooding, which are dependent on the magnitude of specific hazard parameters within the overall flood hazard. During flooding, the primary hazard parameters in terms of potential impacts are:

1. Flood depth: The potential impacts directly related to this parameter include:
    - Drowning (flood waters rising higher than shoulder level)
    - Damage (flood waters damaging property and contents as they rise)
    - Isolation (deep flood waters preventing escape by flood victims or access by emergency services)
2. Flood flow velocity: The potential impacts directly related to this parameter include:
    - Drowning (flood waters flowing too fast for people to maintain balance or washing away occupied vehicles)
    - Damage (the force of fast flowing flood waters damaging structures)
    - Isolation (the force of fast flowing waters preventing escape by flood victims or access by emergency services)

The severity of flooding is largely governed on the magnitude of these two primary hazard parameters. For example, the higher the combined depth and velocity, the greater the risks to people and property.

A river flood hazard classification describes the significance of river flooding with regard to the likely impact on people and property. The classification that forms part of this assessment has been developed using the following considerations:

- Floodwaters have the potential to cause a person to become unstable and unable to manoeuvre. International research suggests that there is a danger of being knocked over when the product of the flood depth and flood speed exceeds 0.5, with a significantly greater risk to life when the same product exceeds 1.0.

- Floodwaters have the potential to impede a person's ability to rescue themselves or others. When the flood depth exceeds 1.0 m (i.e. waist depth), a person's ability to navigate through flood waters (both on foot and using a vehicle) is restricted, therefore impeding the rescue of themselves and others.

- Floodwaters have the potential to damage buildings, both superficially and structurally. International research suggests that structural damage is likely when the flood speed exceeds 2 m/s. It is also likely that structurally weak points such as doors and windows will be damaged when the flood speed exceeds 1 m/s.

These considerations have been translated into a river flood hazard classification by first defining four distinct levels of river flood hazard based on the likely impact on people and property. These levels are outlined in Table 3.

Table 3: Description of river flood hazard categories

Category	Impact on people	Damage to property
Low	The combined depth and speed of floodwaters are unlikely to impede the manoeuvrability or stability of the average person.	Damage to property is likely to be non-structural and mainly due to inundation and deposition of sediment.
Medium	The combined depth and speed of floodwaters are likely to start to impede the manoeuvrability or stability of the average person.	Damage to property is unlikely to be structural provided that weak points such as windows and doors are retained above flood level.
High	The combined depth and speed of floodwaters are likely to significantly impede the manoeuvrability or stability of the average person.	Damage to property is likely to be widespread and structural, including instances where buildings have been raised above the 'flood level'.
Defended	This flood hazard category identifies land that is within an identified river flood hazard area but has been subsequently included in a flood protection scheme that is managed and maintained by Environment Waikato.	

The three levels of river flood hazard (low, medium and high) have then been quantified through the creation of a matrix that assigns a river flood hazard level based on the predicted depth and speed of flooding (refer to Figure 6).

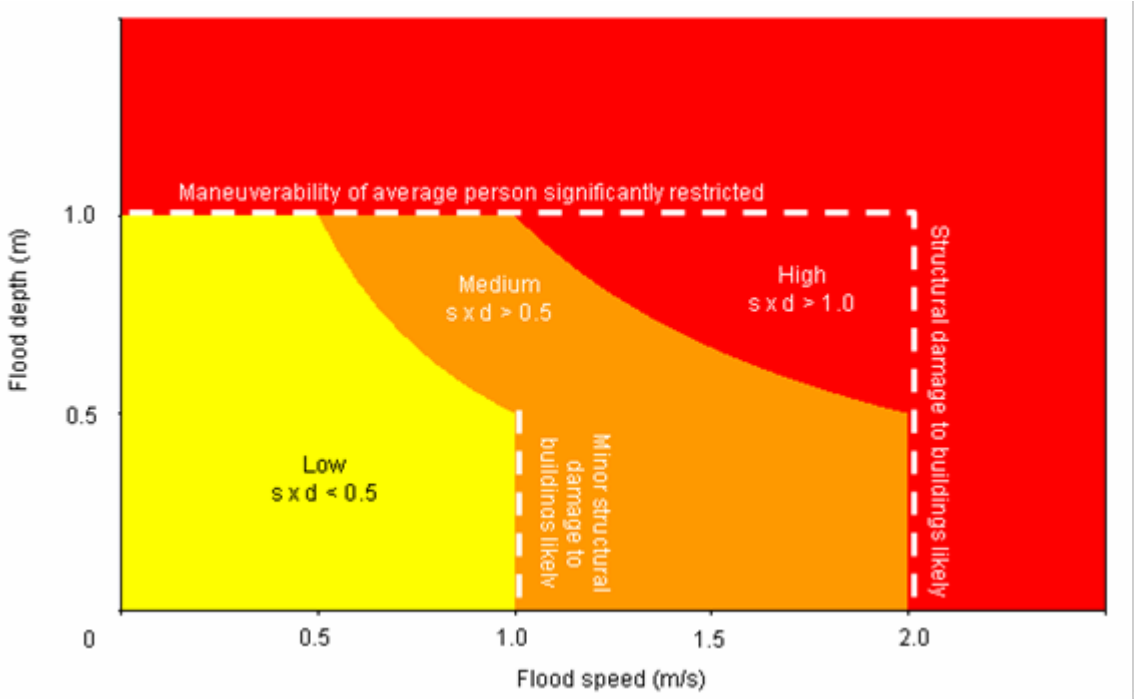


Figure 6: River flood hazard classification matrix

The following two scenarios also result in a 'high' flood hazard classification:

- Land that is surrounded by flooding that is classified as a 'high' flood hazard.
- Instances where floodwaters are directed by flood defences, including formal spillways.

The fourth level of flood hazard (i.e. defended) is intended to represent instances where a property is located within the natural floodplain but benefits from flood defences (e.g. floodwalls and stopbanks).

The model results have been reviewed against the flood hazard categories to assess the likely impact of flooding of the Wentworth River on people and property in Whangamata, and to compare the three scenarios. The results of this assessment are provided in Section 6.2 and discussion about the results is provided in Section 7.

6 Results

6.1 Wentworth River flood depths and velocities

The hydraulic model was used to predict the flood depths and velocities for the three scenarios discussed in Section 4.5 above. Street names are referred to in the following section, refer to Appendix A for a Whangamata Street Map.

6.1.1 Flood depths

Figure 7 compares the flood depths for the three different scenarios.

For Scenario 1, the flood depth is predicted to be generally contained within the channel and associated flood plain, except a slight area of inundation (<0.4m) at the Port Road and Hilton Drive intersection. The flood depth across the golf course (located in the Wentworth River floodplain) is 0.5 – 1.0m, and up to 1.8m at the north and of the golf course.

For Scenario 2, flood waters are predicted to remain generally in channel, except in the vicinity of Hethrington Causeway, where flooding extends into the fringes of the industrial area in Lindsay and Aickin Roads (up to 0.5m flood depth), and the northern end of Beach Road (up to 300mm flood depth). An area of inundation, slightly larger than for Scenario 1, is predicted at the Port Road and Hilton Drive intersection (up to 650mm). The southern portion of the golf course is flooded to a depth in the order of 1m, with the northern portion flooding to a depth of 1.5 – 2.5m.

For Scenario 3, predicted flooding is less than for Scenario 2. Floodwaters are predicted to remain generally in channel. An area of inundation, similar to Scenario 2, is predicted at the Port Road and Hilton Drive intersection (up to 650mm). The southern portion of the golf course is flooded to a similar extent to Scenario 2, to a depth in the order of 1m, with the northern portion flooding to a depth of 1.5 – 2.2m.

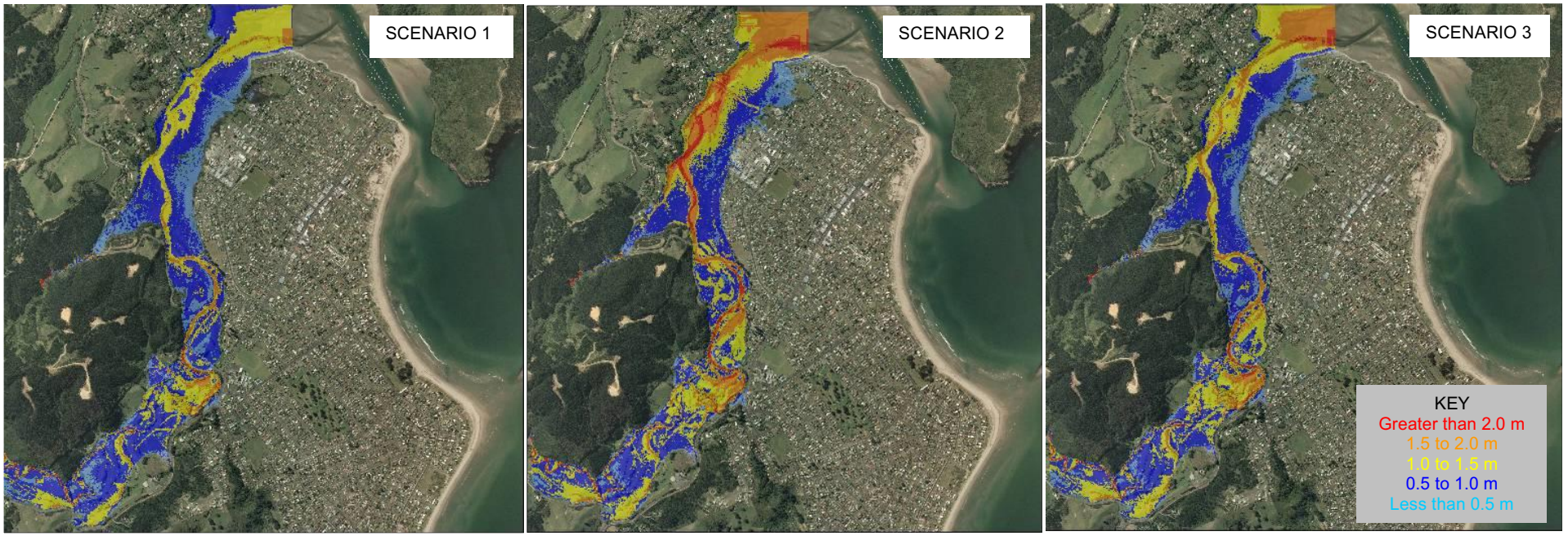


Figure 7: Comparison of Wentworth River flood depths (Scenarios 1 – 3)

6.1.2 Flood velocities

Figure 8 compares the flood velocities for the three modelled scenarios.

For Scenario 1, flood velocities on the golf course are generally predicted to be around 0.5 – 1.0m/s, with patches of 1.0 – 1.5m/s, and less than 0.2m/s around the Port Road and Hilton Drive intersection.

For Scenario 2, flood velocities on the golf course are predicted to be 0.5 – 1.0m/s, with larger patches of 1.0 – 1.5 m/s. Flood velocities in the vicinity of the Port Road/Hilton Drive intersection are predicted to be up to 0.5m/s. In the fringes of the industrial area, to the south of Hetherington Causeway, flood velocities are predicted to be less than 0.5 m/s with some patches up to 0.7 m/s. The flood velocity is generally 0.5m/s to the north of the causeway at the northern end of Beach Road.

For Scenario 3, flood velocities on the golf course are predicted to be 0.5 – 1.0m/s, with larger patches of 1.0 – 1.5 m/s. Flood velocities in the vicinity of the Port Road/Hilton Drive intersection are predicted to be up to 0.5m/s.

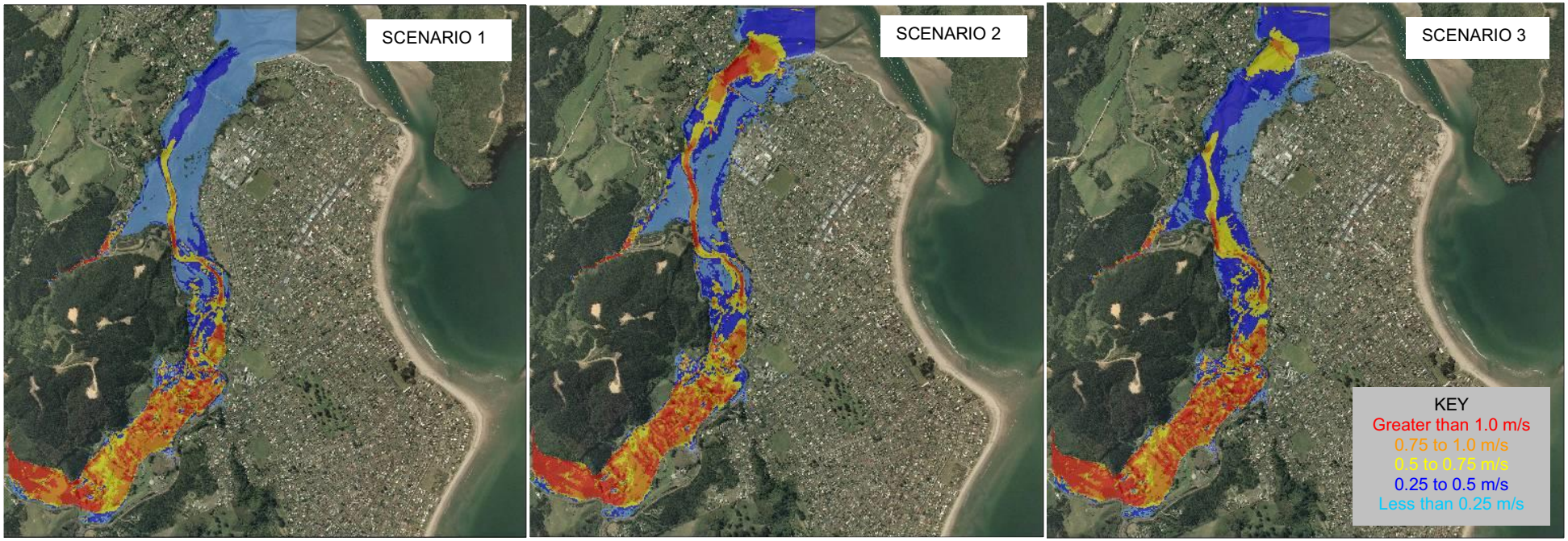


Figure 8: Comparison of Wentworth River flood velocities (Scenarios 1 – 3)

6.2 Wentworth River flood hazard

The flood hazard classification matrix has been applied to the predicted flood depths and velocities for each scenario to develop a flood hazard map for each. Figure 9 compares the flood hazard maps for the three modelled scenarios. Note that these flood hazard maps are not refined and have been developed for comparison purposes of these specific modelled scenarios only.

The Wentworth River flood hazard for Scenario 1 (existing) is generally limited to land that is not subject to urban development (refer to the flood hazard map for Scenario 1 in Figure 9).

As illustrated in Figure 9, for Scenario 2, the extent of the Wentworth River flood hazard extends to include the Port Road/Hilton Drive intersection, and the fringe of the industrial area to the south of Hetherington Causeway, and the northern end of Beach Road. However, the increase in bed level and hydraulic resistance associated with mangroves in the Moanaanuanu Estuary and the impacts of future climate change, are not predicted to have a significant impact on the predicted extent of the Wentworth River flood hazard.

The extent of the flood hazard area for Scenario 3 is slightly reduced when compared to that for Scenario 2, with the industrial fringe area and northern end of Beach Road not predicted to be affected. However in terms of influence on the built environment there is minimal difference between the flood hazard maps for Scenarios 2 and 3.

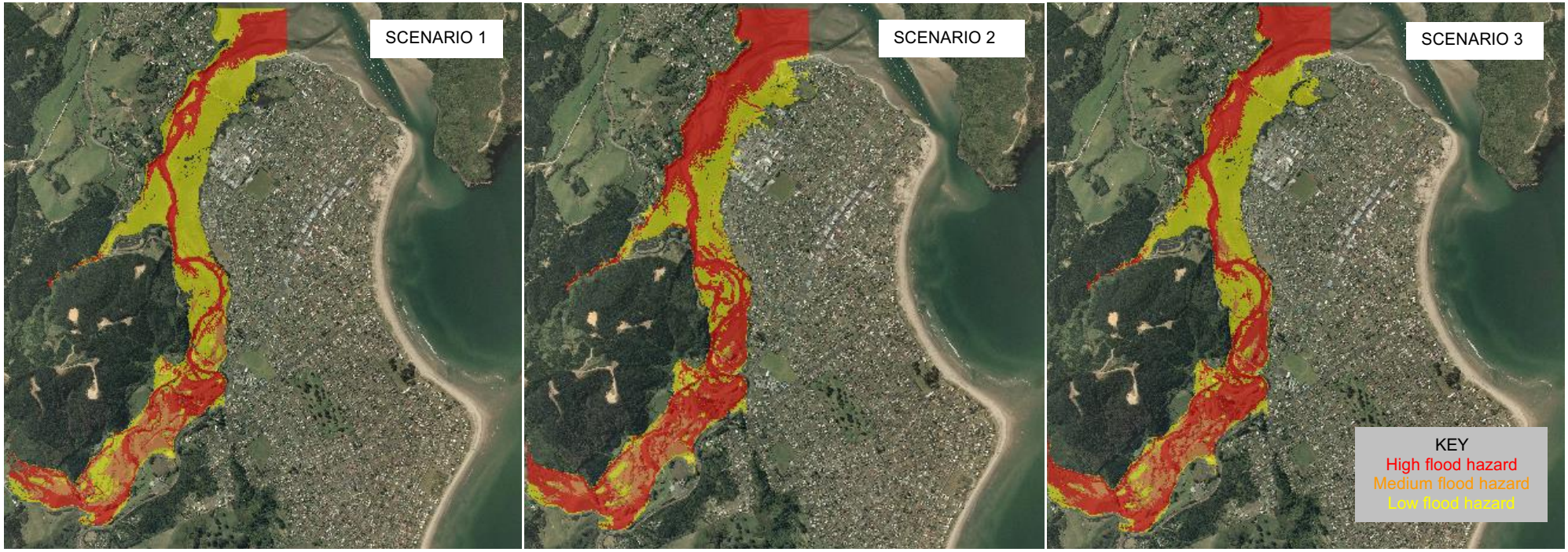


Figure 9: Comparison of Wentworth River Flood Hazard Maps (Scenarios 1 – 3)

6.3 Wentworth River flood level

Figure 10 compares the difference in predicted flood levels for Scenarios 2 and 3 (the future scenarios with and without mangroves). In general the predicted flood level is more elevated for the future scenario with mangroves retained, with the difference ranging from less than 250mm within the golf course to 250 – 500 mm in the vicinity of the Hetherington Causeway. However as noted in the discussion of the results above, the increase in flood depth is generally contained within the Wentworth River and Moanaanuanu Estuary channels.

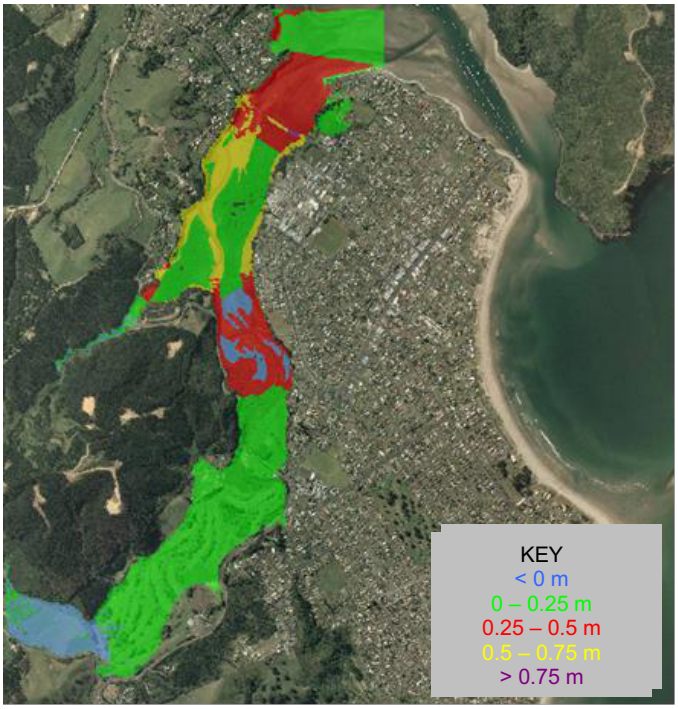


Figure 10 Difference in flood level between Scenarios 2 and 3

7 Discussion

Based on the results from the Wentworth River hydraulic model and the assumptions made during model development, by 2080, the Wentworth River flood hazard is predicted to only just affect a small area of residential and commercial properties in parts of the Whangamata urban area that border the true right bank of the Moanaanuanu Estuary, specifically, areas on the estuary edge of Aickin and Lindsay Roads, and Beach Road and in the vicinity of the Port Road/Hilton Drive intersection.

The extent of the flood hazard area is slightly exacerbated by the mangroves in the Moanaanuanu Estuary. However, the flood hazard area is largely contained within the river channel and is not predicted to be greatly affected by the mangroves and largely does not affect the built up areas of Whangamata.

Mangrove seedlings in a significant area of the harbour can now be removed under specific resource consent conditions.[1] Environment Waikato has undertaken some limited clearing of mangroves to improve drainage into the harbour from the Te Weiti

1 A 2005 consent application to Environment Waikato from Whangamata Harbour Care Inc. to pull mangrove seedlings was granted in December 2006 by the Environment Court for a 12 year period, with certain conditions to protect bird life, cultural sites and the environment. Seedlings can be removed between January and July only. The area of seedling removal excludes removing seedlings within mature mangrove areas, or in specified cultural or conservation sites, only mangrove seedlings with a single stem can be removed and the removal must be by hand.

Stream. A further consent to remove mature mangrove plants from selected areas may also be lodged as part of a wider habitat restoration and catchment management plan.

Limited survey information is available for the Wentworth River and Moanaanuanu Estuary hence little is known about actual sedimentation rates in the river/estuary system. For the purposes of developing the model, assumptions had to be made about average sedimentation rates using data from the northern Whangamata Harbour and knowledge of sedimentation rates in the Firth of Thames. It would be useful to get site specific data to assess sedimentation trends to inform future management options for the river/estuary system.

It is recommended that bed level surveys be undertaken at specific cross sections every five years over the next 10 years. A map showing the proposed locations of cross sections is shown in Appendix B. It should be noted that more frequent (annual) surveys are not likely to show measurable difference in bed levels due to the low sedimentation rates.

There is a draft Whangamata Harbour Catchment Management Plan, which aims to control and reduce sediment runoff from the upper catchment. Once the plan is implemented and the recommended management actions have had time to take effect, the rate of sedimentation in the catchment is expected to reduce. The change in sedimentation rates should be picked up by the bed levels surveys.

There is no continuous flow gauging record for the Wentworth River, therefore it was necessary to use a gauging record from the Wharekawa catchment (a nearby and hydrologically similar catchment to the Wentworth River catchment) to generate flow estimates for input to the hydraulic model. The Wharekawa gauging record is a short length record, hence a high degree of extrapolation was required to generate the 1% AEP (100-year) flood flow, hence flood estimates developed using this data need to be used with caution. For the purposes of this exercise the data is sufficient as it is the relative difference between flood hazard only that is being assessed. More robust data would be required for design purposes.

This investigation has not looked into the effect of the Hetherington Road causeway and the impact of this structure on the natural sediment transport in the Moanaanuanu Estuary.

8 Summary

A hydraulic model has been constructed for the Wentworth River and Moanaanuanu Estuary using the LiDAR survey completed in 2005 and the MIKE 21 two-dimensional hydraulic modelling software.

The upper boundary of the hydraulic model was a design flood hydrograph that is based on the analysis of data from the EW Wharekawa Water Level Recorder. The Wharekawa gauging record is a short length record, hence a high degree of extrapolation was required to generate the flood flow estimates. Assumptions made based on the findings of this assessment must be made with caution. This analysis concluded that the 1% AEP flood flow for the Wentworth River was 204m^3/s. The lower boundary of the hydraulic model was assumed equal to a spring high tide - RL 0.93m (LiDAR datum).

The impacts of future climate change were assessed based on the Ministry for the Environment guidelines for climate change in New Zealand. This resulted in the 1% AEP flood flow increasing to 261m^3/s and the tide level increasing by 0.5m to RL 1.43m (LiDAR datum).

The results produced by the hydraulic model indicates that the Wentworth River current flood hazard is generally limited to land that is not subject to urban land-use. The exception to this was minor inundation around the Port Road/Hilton Drive intersection.

For the future scenario (year 2080) with mangroves retained, the Wentworth River flood hazard is predicted to extend to affect a small area of residential and commercial properties in parts of the Whangamata urban area that border the true right bank of the Moanaanuanu Estuary, specifically, areas on the estuary edge of Aickin and Lindsay Roads, and Beach Road and in the vicinity of the Port Road/Hilton Drive intersection. However the increase in flood hazard is only minor.

The extent of the future Wentworth River flood hazard would be reduced if the mangroves are removed. However the change in flood hazard would only be minor, and in general the model is predicting that the Wentworth River flood hazard is largely contained within the river channel and is not predicted to be greatly affected by the mangroves or future climate change.

It is recommended that:

- The mangroves in the Moanaanuanu Estuary are controlled to their existing extents so as not to exacerbate the predicted Wentworth River flood hazard area.

- Cross-section surveys be undertaken every five years in the Wentworth River and Moanaanuanu Estuary to assess sedimentation trends to inform future management options for the river/estuary system.

- Once the sedimentation rates in the Wentworth River are better established (using site specific survey data) the future flood hazard should be reassessed and flood hazard management options developed if appropriate.

This investigation has not looked into the effect of the Hetherington Road causeway and the impact of this structure on the natural sediment transport in the Moanaanuanu Estuary.

9 References

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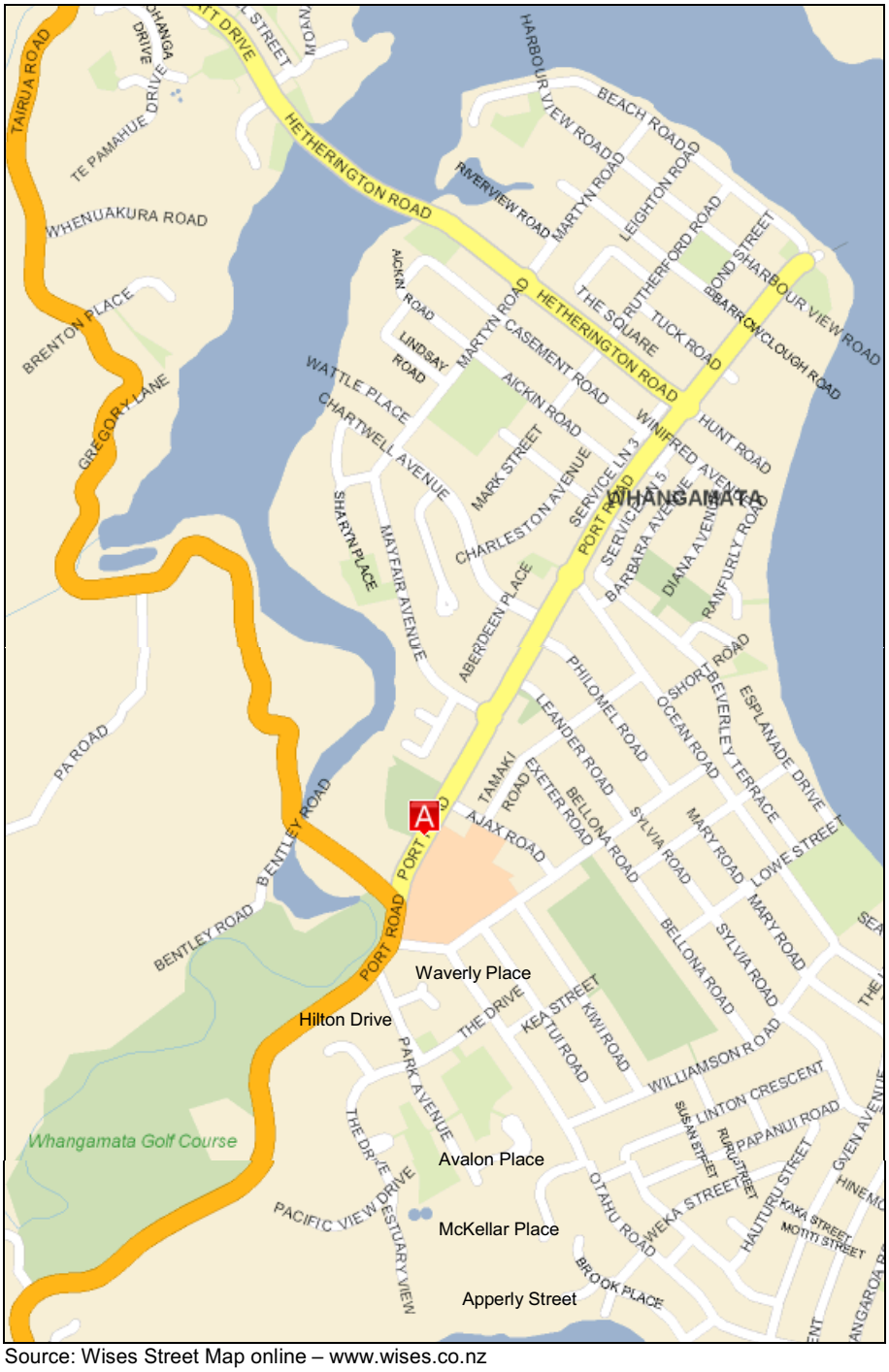
Swales A, Sorrell B, Lovelock C, Bentley S 2006. Firth of Thames mangroves. Presentation to the Mangrove Steering Group Annual Meeting, Hamilton, August 2006. (Doc# 1131578)

Appendix A Whangamata street map



Source: Wises Street Map online – www.wises.co.nz

Appendix B Survey locations

