APPENDIX S

FLOODING ASSESSMENT

GOLOVIN

FLOODPLAIN ASSESSMENT

Paewiri Recycling, Te Awamutu

November 2021

Global Contracting Solutions Ltd

Prepared by Dr Steven Joynes

FLOODPLAIN ASSESSMENT

Contents

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1 INTRODUCTION

1.1 Statement of issues

Global Contracting Solutions Ltd (GCSL) wish to build a recycling plant on an area between the Mangapiko River and the racecourse in Te Awamutu. Figure 1.1 shows the site boundary.

Some of the buildings and associated infrastructure is expected to encroach on to the Mangapiko River floodplain.

Figure 1.1 – Property location

The objective of this report is to determine

1. The extent of the floodplain of the site,
2. Examine the impact of new structures on changing the floodplain levels and extent,
3. Mitigate these impacts where necessary,

4. Minimum finished floor levels for various structures,
5. Determine the duration of flooding,
6. Determine the flood hazard risk.

1.2 Proposed strategy

The hydrology will be done using HEC-HMS to create flow hydrographs The hydraulics will be done using a 2D terrain model using LiDAR data to MVD-1953 Datum. Peak flows will be assessed using the NIWA flow forecaster will be used as a calibration/reference check and previous studies by Waikato Regional Council because given there is no long-term flow gauge in the catchment.

1.3 Sources of data

Table 1.1 – Source of Data

Attribute	**Organisation**
Catchment Plans	Waikato Regional Council Maps
Contours	LiDAR DEM 1m GRID thru WRC portal
Ground spot heights	Terra Group Ltd / Arc Civil Ltd
Flow & WL data	NIWA flow forecaster/WRC report
Flood level evidence	None
Building plans	Terra Group Ltd

1.4 Target audience

The quality, quantity and tenure of the report should consider the following audience.

a) Waipa District Council (WDC) engineering staff,
b) Waikato Regional Council (WRC) engineering staff,
c) Terra Group staff,
d) Global Contract Solutions staff.

1.5 General methodology

The following steps were executed:

1. Delineate the catchment areas of the Mangapiko and Mangaohoi Rivers,

2. Determine the local catchment area for the 2D grid,
3. Use NIWA flow forecaster and HEC-HMS to calculate flow hydrographs,
4. Check results against the Te Awamutu Flood Management Plan and iterate
5. Apply hydrology to 2D model,
6. Calculate flowpaths and peak water levels,
7. Adjust the terrain for the structure requirements,
8. Determine proposed floodplain, mitigate and test as necessary,
9. Calculate the 10-year flood level for drainage design.

1.6 Reference technical documents

- Regional Infrastructure Technical Specifications (RITS) Waikato Authority Shared Services,
- Waikato stormwater run-off modelling guideline, TR2020/06, Waikato Regional Council,
- Document E1: Surface Water, Ministry of Business, Innovation and Employment,
- Te Awamutu Flood Management Plan, Waikato Regional Council, Publication 93/10, (1993)

2 HYDROLOGY

2.1 Rainfall data

HIRDS was used to determine the historical 24-hour rainfall depths. Figure 2.1 shows the output. The 100-year rain depth is 149mm and the 10-year is 78.1mm. When adjust for climate change the increase is (8.6x2.3)%.

Figure 2.1 – Catchment Boundary

Results

Site Details | Historical Data | RCP2.6 Scenario | RCP4.5 Scenario | RCP6.0 Scenario | RCP8.5 Scenario

Rainfall depths (mm) :: Historical Data

ARI	AEP	10m	20m	30m	1h	2h	6h	12h	24h
1.58	0.633	8.73	12.2	14.7	19.9	26.4	39.2	49.0	59.8
2	0.500	9.61	13.4	16.2	21.9	28.9	42.9	53.5	65.3
5	0.200	12.8	17.8	21.4	28.7	37.8	55.7	69.2	84.0
10	0.100	15.2	21.1	25.3	34.0	44.5	65.4	81.0	98.1
20	0.050	17.8	24.7	29.5	39.5	51.7	75.6	93.3	113
30	0.033	19.4	26.9	32.1	42.9	56.1	81.8	101	122
40	0.025	20.6	28.5	34.1	45.4	59.3	86.3	106	128
50	0.020	21.6	29.8	35.6	47.4	61.8	89.9	111	133
60	0.017	22.4	30.8	36.8	49.1	63.9	92.8	114	137
80	0.012	23.6	32.6	38.9	51.7	67.3	97.6	120	144
100	0.010	24.6	33.9	40.5	53.8	70.0	101	124	149

The size of the catchment requires an area reduction factor to be applied to the total rainfall. Using equation 4.1 in TR2020/06 the ARFs for Mangapiko and Mangaohoi are 0.94 and 0.96 respectively. Table 2.1 summarises the rainfall data.

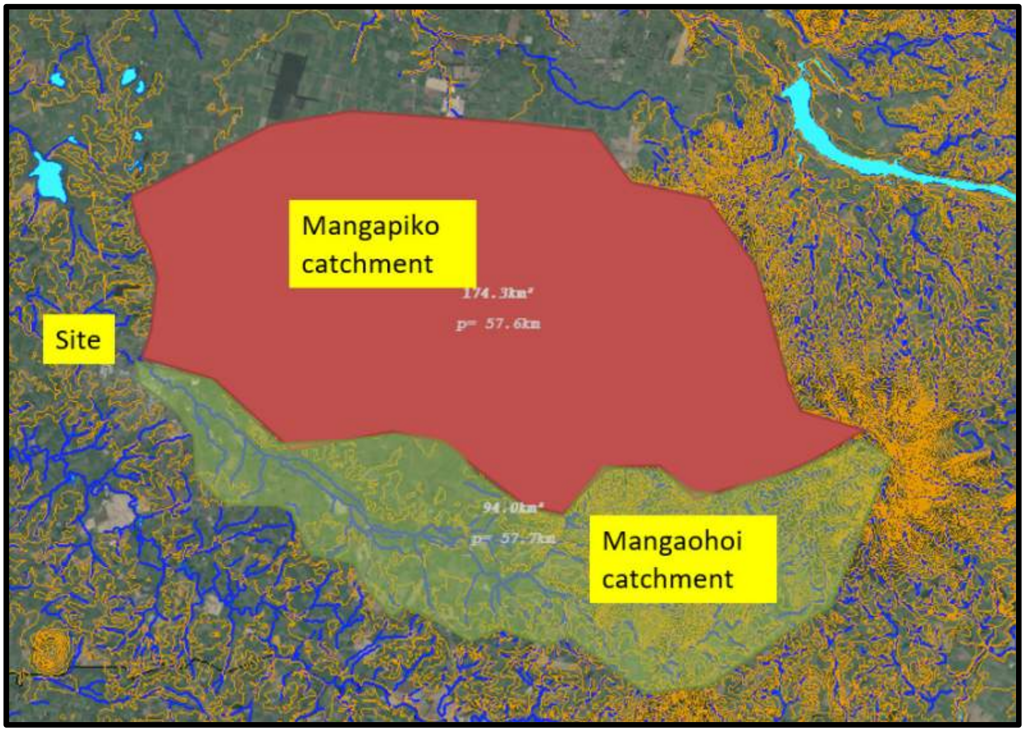
Table 2.1 – Rainfall data

	Mangapiko		**Mangaohoi**	
	100-year	10-year	100-year	10-year
HIRDS historical	149mm	98.1mm	149mm	98.1mm
ARF	0.94	0.95	0.95	0.95
Rainfall after ARF	140mm	92mm	142mm	94mm
Climate change increase	19.8%	19.8%	19.8%	19.8%
Climate change rainfall	168mm	111mm	171mm	112mm

2.2 Catchment size

The inflow to the 2D floodplain model is at the confluence of the Mangapiko and Mangaohoi Rivers. Figure 2.1 shows the approximate catchment areas. The adopted areas are 174km^2 for Mangapiko and 94km^2 for Mangaohoi.

Figure 2.1 – Catchment Boundary



2.3 Other hydrology parameters

The catchment land-use is predominantly rural. This will be used as a reference indicator for the calibration. The expected run-off C-factor is perhaps 0.2 to 0.3.

The time of concentration is determined in two ways.

Equation 7.4 in TR2020/06, WRC
Equation i), Section 2.3.2 in Document E1, MBIE

Figures 2.2 and 2.3 give the details and the time of concentration for each catchment.

Figure 2.2 – Equation 7.4 time of concentration

		Mangapiko	Mangaohoi
L	km	24.8	26.9
H	m	650	650
L3		1.53E+13	1.94651E+13
L3/H		2.35E+10	29946321538
L3/H power of 0.385		9,832	10,799
tc	minutes	192	211
Tc	hours	3.20	3.51
tp	mins	128.4	141.1

Figure 2.3 – Equation i time of concentration

		Mangapiko	Mangaohoi
L	m	24800	26900
L0.33		28.19	28.96
S	%	2.620967742	2.416356877
S 0.2		1.21	1.19
n		0.08	0.08
T	minutes	186	194
tp		124.6	130.1

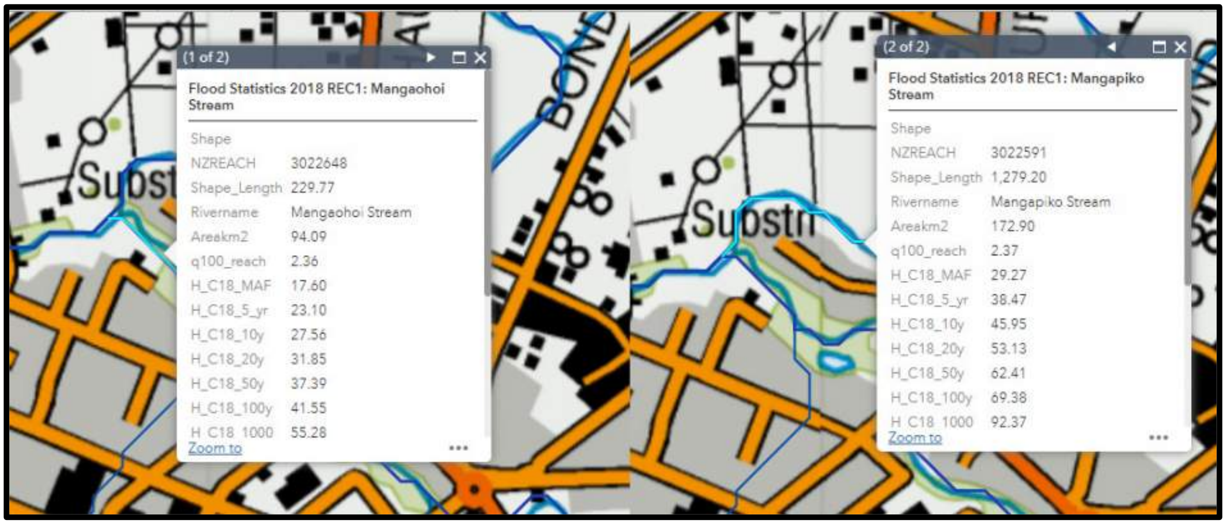
Both methods give similar results. The design time to peak is 126 minutes for Mangapiko and 135 minutes for Mangaohoi.

The curve number and initial abstraction is iterated until the reasonable peak flows are achieved. HEC-HMS was run until the peak flows for both catchments matched the desired value.

2.4 Estimate of peak flows

There are two sources to understand the peak flow from the catchment. Firstly, the NIWA flow forecaster tool can be used. Figure 2.4 gives the forecaster results for each catchment. The Mangapiko 100-year flow is 69.38m^3/s and the Mangaohoi is 41.55m^3/s. This gives a total arriving at the 2D grid of about 110m^3/s.

Figure 2.4 – NIWA Flow Forecaster



The Te Awamutu Flood Management Plan Table 1 gives the Mangapiko 100-year flow as 82m^3/s and the Mangaohoi as 48m^3/s. This gives a total arriving at the 2D grid of about 130m^3/s. Both sets of results are reasonably close. The adopted peak flow will be those quoted in the WRC report.

2.5 Reliability of peak flows

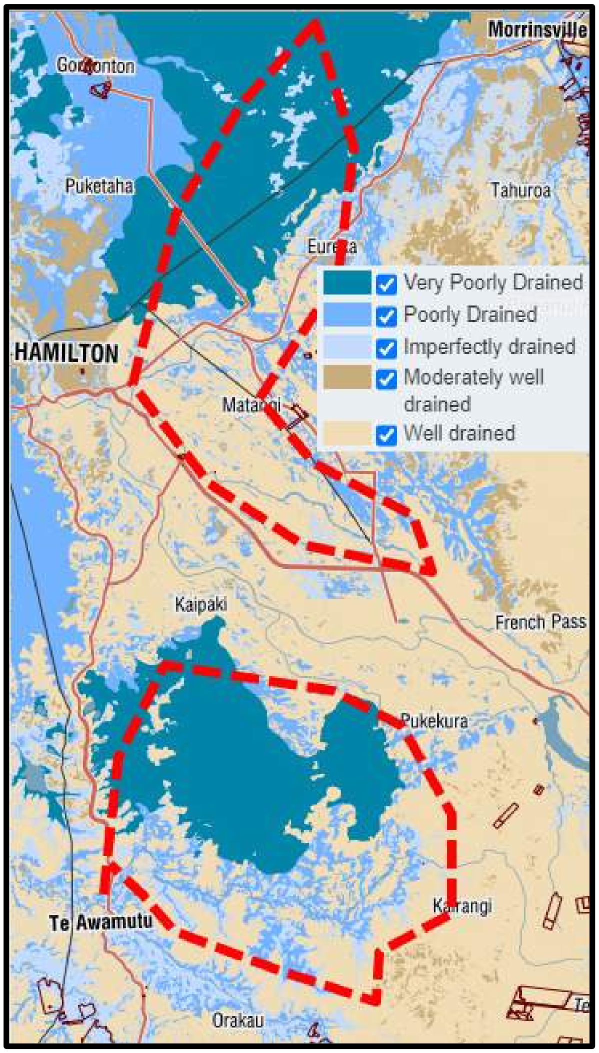
The Mangapiko has no flow gauge sites. The peak flows are determined by standard formulae. However, there is a gauged site further north in Hamilton on the Mangaonua Stream. This site has been measuring water levels since 1980. With 40 years of data the level of confidence should be good for a 50-year flow. The catchment is 180km^2 with a 100-year estimated flow of 81m^3/s. This is a yield of 0.45m^3/s per km^2. The equivalent Mangapiko flow would then be 120m^3/s. This is comparable to the adopted flow of 130m^3/s.

However, the soils may be different as well as the slopes. The soils map from Landcare Research was assessed. Figure 2.4 shows the two catchment areas and the general soil drainage. If the very poorly drained soils and the well-drained soils do not generate run-off quickly/easily to the catchment outlet then the percentages of the catchments are similar at 63% and 55%. This is equivalent to halving the expect flow.

The soil type that will generate run-off are more likely the poorly drained, imperfectly drained, and moderately well drained. They summate to a similar ratio. Thus, based on soil type the peak yield should be similar. If anything, Mangapiko flows will be lower by perhaps 10%.

The time to peak for Mangaonua is about 4 hours, for Mangapiko it is 2 hours. This suggests the Mangapiko will generate a higher peak for the same rainfall. The Mangapiko flow could be about 50% greater.

Figure 2.4 – Soil drainage characteristics for Mangapiko and Mangaonua catchhments



The conclusion from this analysis is:

- The yields are similar,
- The soil make-up is similar, but Mangapiko might have reduced run-off by 10%,
- The catchment times to peak are different meaning Mangapiko could have a greater peak flow by 50%.

It is asserted that target 100-year existing combined flow for Mangapiko and Mangaohoi should be 162m^3/s. This is based on 120 (equivalent yield) reduced by 10% (soil drainage type) increased by 50% (time to peak).

2.6 HEC-HMS model

HEC-HMS was used to replicate the historical peak flow. The climate change flow was then extrapolated using the same parameters and using a greater rainfall.
The 24-hour storm distribution was used as shown in Figure 2.5 as per the WRC runoff guidelines.

Figure 2.4 – Standard WRC rainfall hyetograph

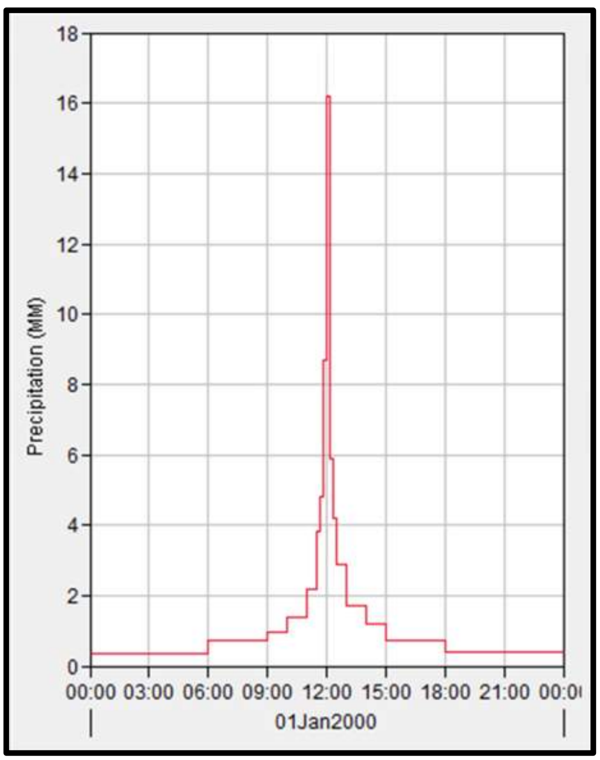
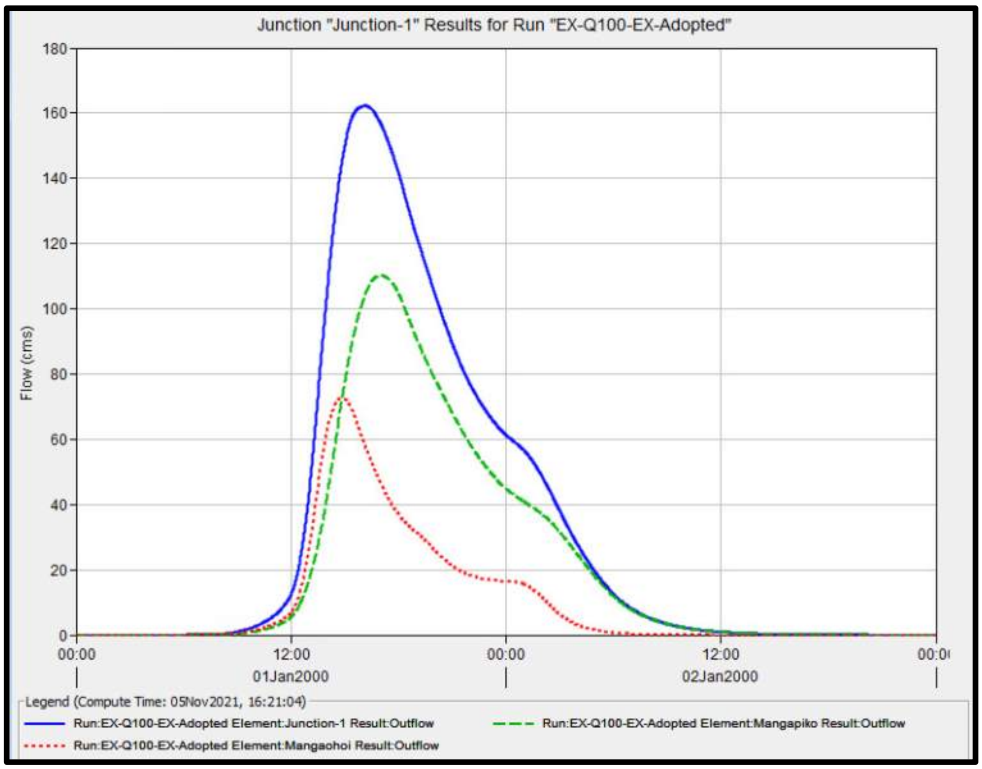


Figure 2.5 shows the hydrographs generated for the adopted flows. The combined peak flow is just above 162m^3/s. Mangapiko flow is 110m^3/s and Mangaohoi 72m^3/s. To achieve these hydrographs the Mangapiko and Mangaohoi curve numbers are 29 and 25 respectively. The corresponding initial abstractions are 13mm each. This generates a reasonable hydrograph shape although there are multiple combinations of these two parameters possible. If the parameters are converted to C-factor the values are 0.13 for Mangapiko and 0.11 for Mangaohoi. These C-factors are on the low side in terms of Document E1 values, but the analysis has been done based on comparisons with a gauged catchment, NIWA's flow forecaster and a previous report.

Figure 2.5 – 100-year historical flow hydrographs



The HEC-HMS model was then run with the climate adjusted rainfall as described in Table 2.1. Figure 2.6 show the hydrographs. The peak flow arriving at the Mangapiko/Mangaohoi confluence is 236m^3/s. This is a 46% increase.

There are now two flow hydrographs that can be input into the 2D terrain model. The rain-on-grid excess rain for the terrain model has the same hydrological parameters as the

Mangapiko catchment. Figure 2.7 show the excess rain input onto the grid.

Figure 2.6 – HEC-HMS hydrographs, historical 100-year storm

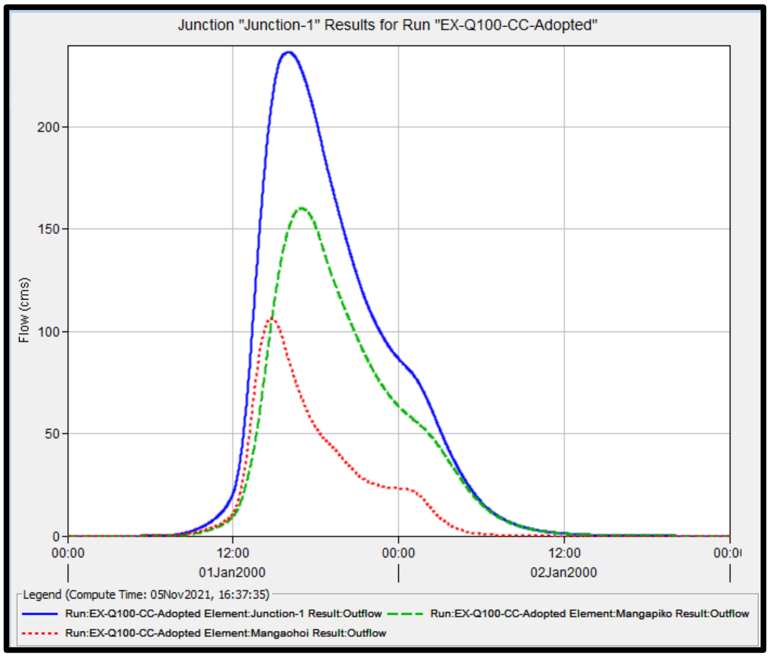
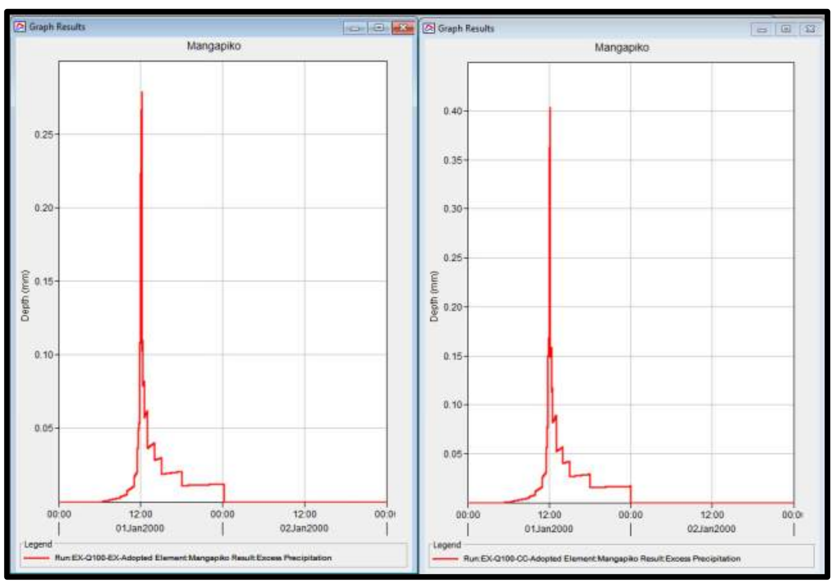


Figure 2.7 – Excess rain hyetograph LHS historical, RHS climate change (100-year storm)



The same methodology was used for the 10-year storm. The climate change peaks flow for the Mangapiko was $68.0m^3/s$ and the Mangaohoi was $43.7m^3/s$. These are 48% and 58% greater than the NIWA flow forecaster.

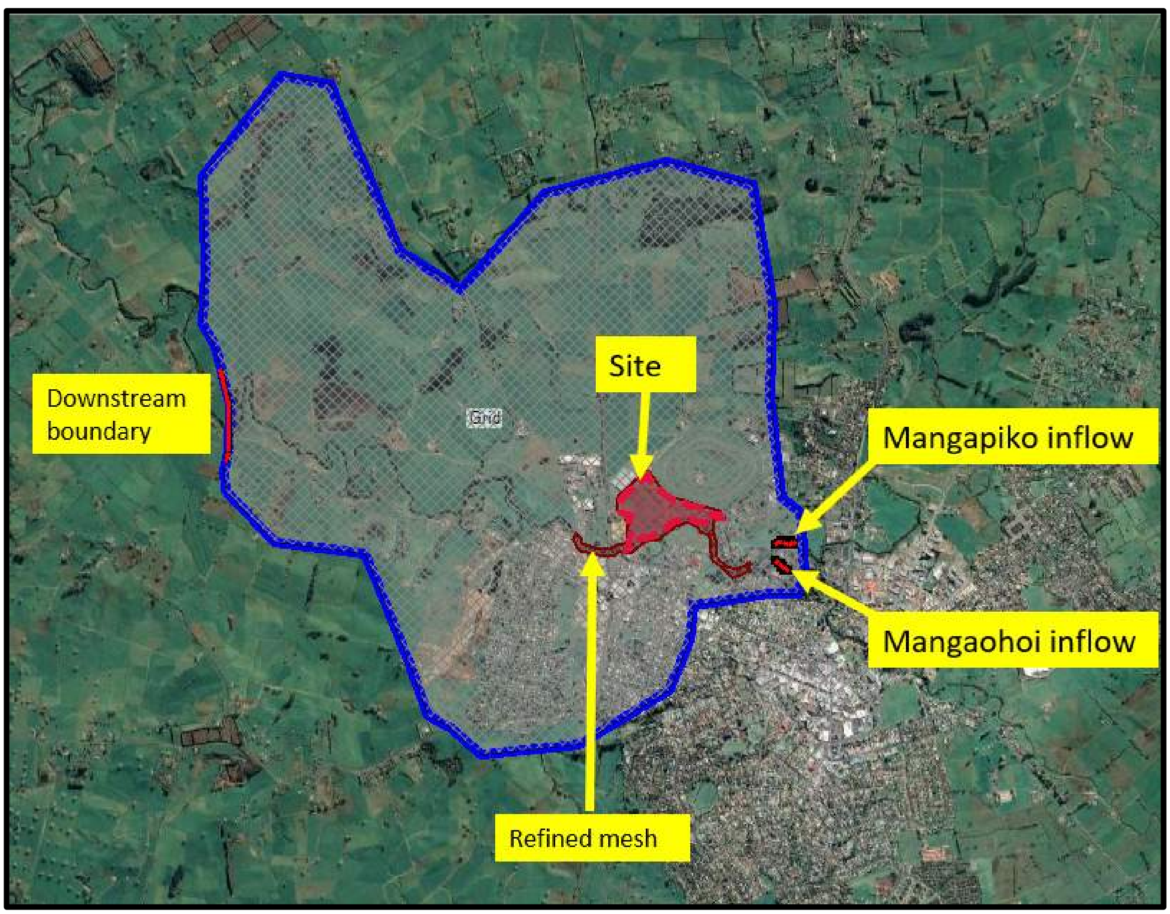
3 HYDRAULIC ANALYSIS

3.1 Model layout

HEC-RAS software was used to generate water levels in the vicinity of the site. A 2D grid was developed from the LiDAR terrain data. Figure 3.1 shows the general 20m x 20m grid. The grid was refined in the vicinity of the site and along the main channel with a 4m grid. The time step used was 1 minutes but could automatically reduce to 1.8 seconds if the Courant number exceeded 2.

The downstream boundary is a Normal Depth with a grade of 0.001. The bed roughness was set to 0.1.

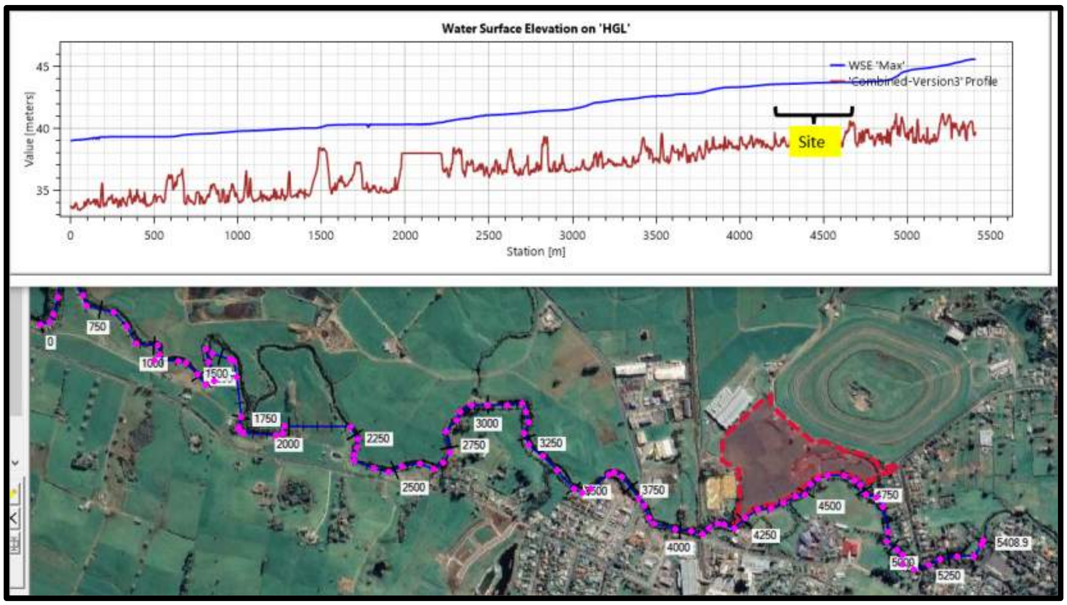
Figure 3.1 – HEC-RAS model set up



3.2 Hydraulic grade line

Figure 3.2 shows the hydraulic grade line through the whole grid fr4om the Mangapiko/Mangaohoi confluence to the downstream boundary. It is a reasonably steady profile. The site peak level is 5m above the downstream boundary 4.5km apart and thus the boundary is at a good location and a good level.

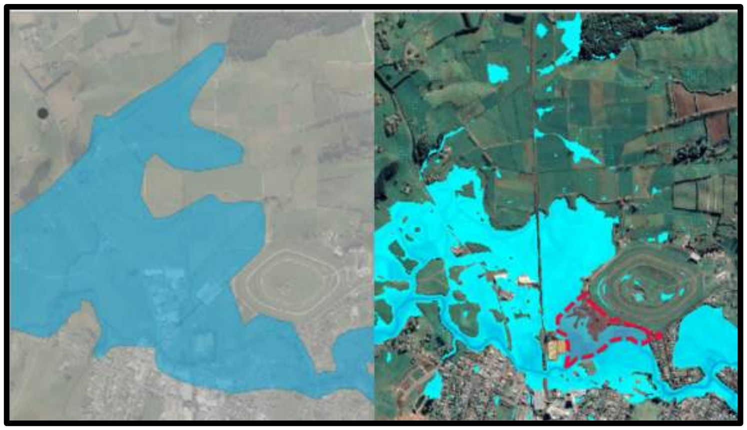
Figure 3.2 – Hydraulic grade line along the Mangapiko – 100-year historical



3.3 General flood-map

Figure 3.3 shows a flood map for the general area compared to the WRC flood hazard portal. The ground levels in the new model give a better indication of high ground and the general simplification of the WRC data. The key difference is the new analysis does not show the large flooded area to the north, otherwise a good comparison.

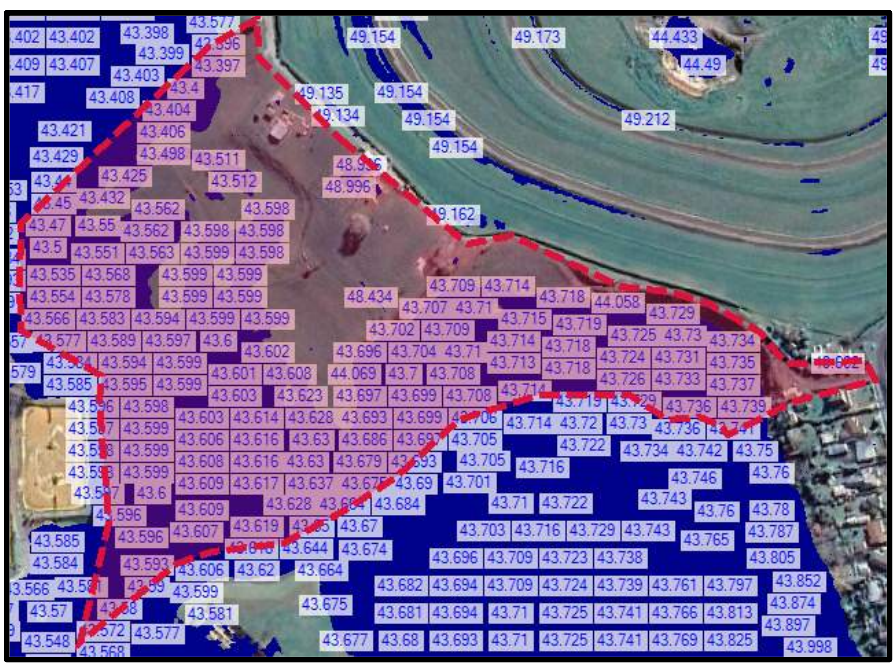
Figure 3.3 – General flood-map – 100yr-historical



3.4 Flood-map on the site

Figure 3.4 shows a flood map for the site showing peak water levels. The water level ranges from RL43.75m to RL43.30m. The WRC 1993 report gave a level at the site of RL43.00m compared to RL43.60m. The hydraulic analysis is different in terms of software and ground data used, but it is re-assuring the new model is higher. The difference in height at the railway crossing is almost 0.7m.

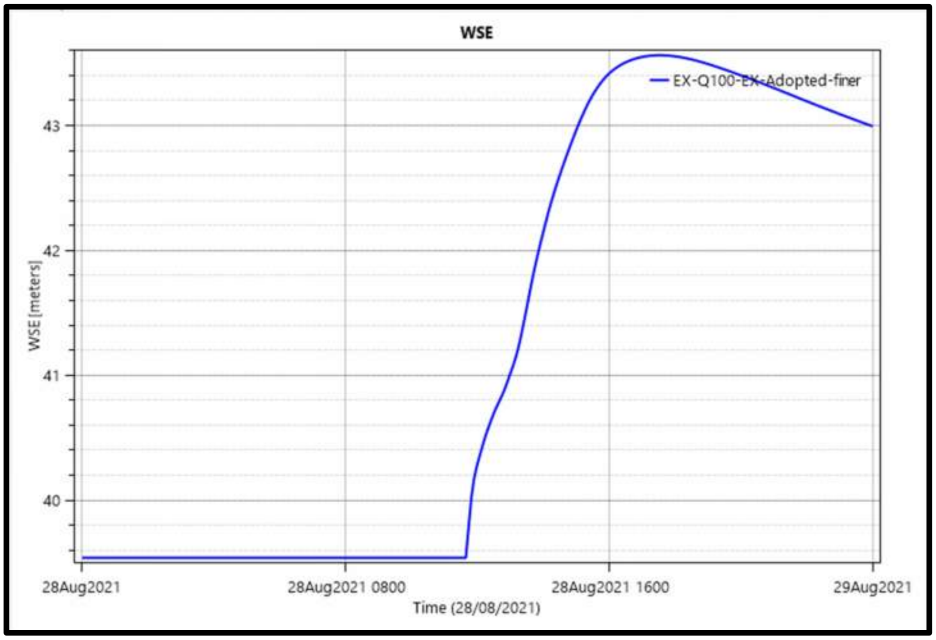
Figure 3.4 – Site flood-map – 100yr-historical



3.5 Water level hydrograph

Figure 3.5 shows water level hydrograph at the south-west corner of the site. It demonstrates the smooth stability of the model and the peak arriving 5 hours after the peak rain.

Figure 3.5–Water level hydrograph at south-west tip – 100-year historical



4 IMPACT OF DEVELOPMENT

4.1 Proposed development outline

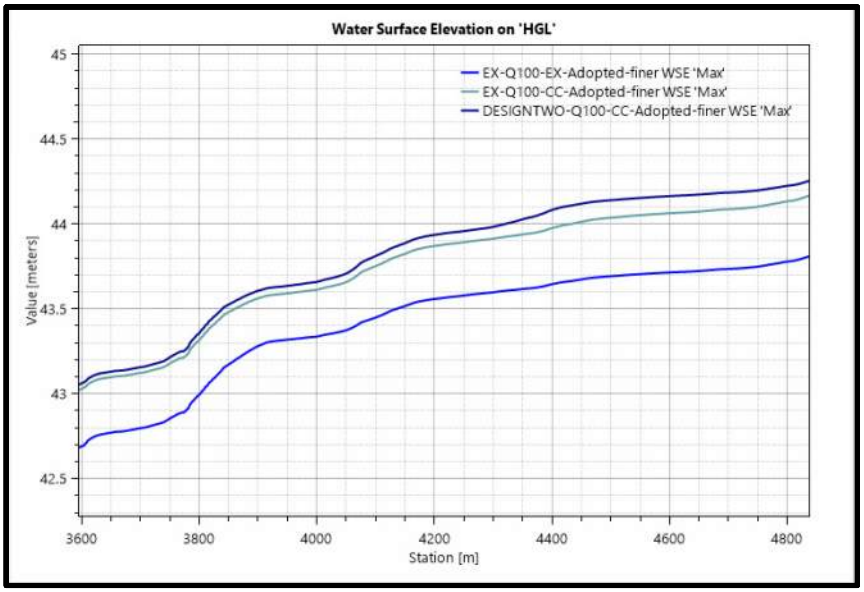
The proposed development was imposed on the terrain. Figure 4.1 shows the boundary where the ground levels are raised above the flood level. The 100-year storm results are shown for a) historical and existing terrain, b) climate change and existing terrain and c) climate change and proposed terrain.

Figure 4.1– Proposed earthworks infrastructure boundary

4.2 Hydraulic grade line changes

Figure 4.2 shows the HGL along the site boundary of the Mangapiko Stream. The sole impact of climate change is to increase flood levels by about 350mm in depths typical 5m in the main channel. More importantly the addition water level rise due to the development is 120mm.

Figure 4.2 – HGL along site boundary along Mangapiko Stream – 100-year storm



4.3 Flood spreading due to development

Figure 4.3 shows the extra spread of the flooding due to the development. This is shown in red. The flood spread covers a very small area and it is within the resolution of the model grid perhaps 2m wide.

Figure 4.3 – HGL along site boundary along Mangapiko Stream – 100-year storms

4.4 Flood Hazard

Figure 4.4 shows the flood hazard map. The blue areas are when either a) the flow depth (d) is greater than 1m, b) the velocity (v) is greater than 1m/s or c) the d x v is greater than 1.0. This is no different from the existing situation for all neighbouring properties. Essentially the water depth dominates the hazard.

Figure 4.4 – Flood hazard map – 100-year storms

5 SUMMARY AND DESIGN LEVELS

A stream flow analysis has been undertaken to determine the 100-year flood level in Mangapiko stream for the purposes of setting ground levels and finished floor level for a major recycling plant. The flow hydrographs of the Mangapiko and Mangaohoi streams have been generated using a previous flood management plan and a similarly gauged catchment. Floodplain hydraulics have been done for the incoming flows and a rain-on-grid system. Flood level have been determined for a reach almost 5km downstream of the Mangapiko and Mangaohoi confluence.

The impact of climate change is to raise the flood levels by perhaps 350mm.

The impact of the preferred development raises the water level by up to 120mm. This will cause a flood spread of 2m in isolated places and by 120mm.

Using a 300mm freeboard required for industrial zones the required **minimum finished floor levels range from RL43.9m to RL44.50m MVD-53.**

Figure 5.1– Minimum finishes floor levels through the site

In terms of the objective of this report:

1. The extent of the floodplain of the site is shown in Figure 3.4
2. The impact of new structures is to increase floodplain levels by about 120mm in isolated areas. A flood spread of 2m in a 350m wide floodplain has been determined but is within the accuracy of the 2D model grid size.
3. Mitigating this impact is not necessary, due to the scale of the floodplain.
4. Minimum finished floor levels for various structures are provide in Figure 5.1,
5. The duration of flooding at the base of the earthworks for greater than 1m deep is about 10 hours.
6. The flood hazard risk is shown in Figure 4.6 and does not change from the existing situation.