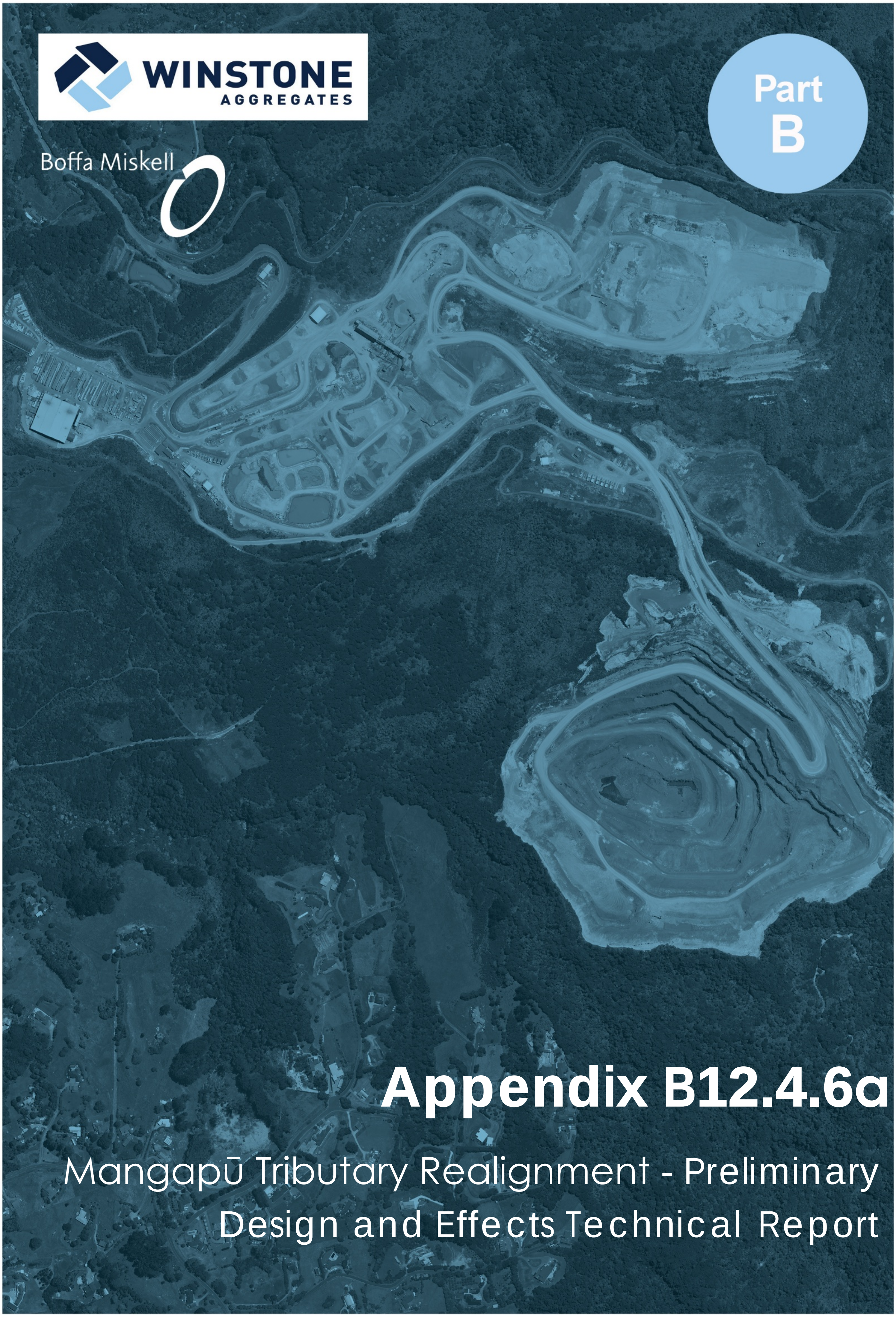

WINSTONE AGGREGATES

Boffa Miskell

Part B

Appendix B12.4.6a

Mangapū Tributary Realignment - Preliminary Design and Effects Technical Report

Mangapū Tributary Realignment – Preliminary Design and Effects Technical Report

Prepared for

Winstone Aggregates: a division of Fletcher Concrete and Infrastructure Limited

March 2026

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Limitations:

This report has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of information provided by Winstone Aggregates: a division of Fletcher Concrete and Infrastructure Limited (FCIL) and others not directly contracted by PDP for the work. PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the report. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

This report has been prepared for Winstone Aggregates: a division of Fletcher Concrete and Infrastructure Limited (FCIL) in respect of its application for all approvals under the Fast-track Approvals Act 2024 for the Hunua Quarry. The Panel appointed to consider the application for the Hunua Quarry Project may rely on this report for the purpose of making its decision under the Fast-track Approvals Act 2024. PDP accepts no liability if the report is used for a different purpose or if it is used or relied on by any other person. Any such use or reliance will be solely at their own risk.

This report has been prepared in accordance with the Environment Court's Code of Conduct for expert witnesses, contained in the Environment Court's Practice Note 2023. The authors of this report agree to comply with the Code of Conduct, and confirm that unless otherwise stated, the issues addressed in this report are within the area of expertise of the authors. No material facts have been omitted that might alter or detracted from the opinions expressed in this report.

Executive Summary

This technical report presents the preliminary design and assessment of effects for the realignment of the Mangapū Tributary, a critical component of the Hunua Quarry development. The primary objective of this realignment is to facilitate the development of the Symonds Hill Pit, ensuring the long-term operational viability of the quarry while maintaining ecological and hydraulic functions.

The proposed realignment involves the construction of a new, naturalised stream channel southeast of the existing pit. This channel will feature meandering paths, riparian vegetation, in-stream habitat features, and sediment control measures. The design aims to replicate the existing stream environment, providing equivalent aquatic and riparian habitats.

Key design objectives include:

- Integration of flood management strategies to mitigate impacts on the quarry and surrounding areas.
- Replication of stream and riparian habitats found in the existing Mangapū Tributary.
- Inclusion of appropriate stream plant species to promote biodiversity.

The hydraulic model developed for this project was used to assess the impact of the proposed realignment on flood levels, velocities, and erosion. The model indicates that while there will be minor increases in flood depths and velocities, these changes are primarily confined to the reach between the new and existing confluences of the Mangapū Stream within the quarry owned land. The design incorporates in-stream features to mitigate these effects, ensuring that the realigned channel performs hydraulically without adverse impacts on the quarry site or adjacent land.

The report concludes that the realignment will support the quarry's development while minimising adverse impacts. The new stream channel will provide equivalent ecological and hydraulic functions, supporting the long-term sustainability of the quarry operations and the surrounding environment.

Table of Contents

Table of Figures

Table of Tables

Appendices

1.0 Introduction

Winstone Aggregates ("Winstone"), a division of Fletcher Concrete and Infrastructure Limited, is seeking to develop the Symonds Hill Pit at its Hunua Quarry at 489 Hunua Road, Hunua, Auckland, through a substantive application for approvals under the Fast-track Approvals Act 2024 (FTAA).

The Hunua Quarry Development is a Listed Project in Schedule 2 of the FTAA, reflecting its regional and national significance. The proposal is to expand the existing quarry to increase annual quarry production to a peak of approximately 5.4 million tonnes of aggregate, and to enable the continued extraction of aggregate for a further 80 years. Through this approval process, Winstone propose to update the consent conditions and quarry management plans applying to the site to incorporate the changes and enable greater operational efficiency.

To support the substantive application for approvals under the FTAA, Pattle Delamore Partners (PDP) have been engaged by Winstone to provide a technical assessment to develop a preliminary design and undertake an assessment of effects for the proposed Mangapū Tributary realignment. Winstone Aggregates have also engaged several other consulting companies to provide technical (geotechnical, landscaping, planning and ecological) inputs for this project. A collaborative design approach has been utilised between the consultancies and PDP to deliver the preliminary design presented in this report.

This technical report has been prepared to accompany the resource consent application under the Fast track Approvals Act 2024 (FTAA). The objective of this technical report is to set out the development of the preliminary design for the realignment of the Mangapū Stream Tributary and to assess the hydraulic effects arising from the realignment. This report should be read together with other technical assessments supporting the application for substantive approvals, including the geotechnical assessment and the groundwater and hydrology assessment.

This report has been prepared by Verity Kirstein, an experienced river engineer, and Tylan Collins, an experienced environmental engineer. The experience and qualifications of the authors are outlined in Appendix E. Both authors have read and agree to comply with the Environment Court's Code of Conduct for Expert Witnesses, contained in the Environment Court Practice Note 2023. Other than where it is stated that reliance is placed on the advice of another person, the authors confirm that the issues addressed in this EEA are within their area of expertise. The authors have not omitted consideration of any material facts known to them that might alter or detract from the opinions expressed.

1.1 Project Overview

The Hunua Quarry development seeks to expand and deepen the existing Symonds Hill Pit, enabling sustainable extraction of additional greywacke resource, and the continuation of the quarrying within Winstone's existing site for up to 80 years. The proposed development initially focuses on the southern and northwestern ends of the quarry complex. The new extraction footprint will initially expand the existing Symonds Hill Pit to the south and east, followed by areas to the north and west. These development works will occur entirely within Winstone owned land and integrate with existing quarry infrastructure.

The proposed Symonds Hill Pit expansion will cover an area of approximately 108 hectares, with a maximum depth of approximately (minus) 50 metres RL and enabling quarrying beyond that in later years to access further resource. Quarry development will use benches ranging from 10 m – 15 m in height and 9 m – 20 m in width. The resource comprises Waipapa Group greywacke, with an estimated total volume exceeding 225 million tonnes. Over the life of the quarry, anticipated to be around 80 years, approximately 24 million m^3 of overburden will be removed, supporting a peak production rate of 5.4 million tonnes per annum.

This expansion will necessitate the realignment of approximately 941 m of a tributary of Mangapū Stream to allow for the pit expansion. Refer to Figure 1 identifying the existing Symonds Hill Pit extent, anticipated maximum development outline and the section of tributary requiring realignment.

This will include clearance of indigenous and exotic vegetation, overburden stripping and earthworks, stream realignment, followed by revegetation within the new stream corridor. Ecological offset planting will also occur within other parts of the landholding, and this will also achieve landscape mitigation and compensation for the removal of an area of the Outstanding Natural Landscape. Additional ecological offset planting and compensation works will also be undertaken in locations beyond the site.

The proposal will also utilise the current site access, along with the existing processing facilities, staff facilities and bores.

In summary, the key aspects of the proposed quarry development include:

- Diversion and reclamation of approximately 941 m length of a tributary to Mangapū Stream to enable the expansion of the extraction footprint. This includes construction of a temporary 7 m wide bridge to enable access for construction of the stream realignment channel.
- Draining and modification of up to 21 identified natural inland wetlands.
- Providing additional overburden capacity within the Site (from Stage 7), primarily by backfilling the Symonds Hill Pit.

- Construction of new sediment retention ponds, haul road, drainage networks, and Mangapū Stream Tributary diversion integrated with the existing quarry systems.
- Increasing average daily traffic movements during both the AM and PM peak hours when the quarry is operating at peak capacity:
  - AM peak hour – 161 truck movements corresponding to approximately 80 entry and 80 exit truck movements; and
  - PM peak hour – 135 truck movements corresponding to approximately 68 entry and 68 exit truck movements.
- Removal of 44.46 ha of indigenous vegetation, associated with the stripping of overburden including within an SEA and ONL, and removal of 4.15 ha of exotic scrub.
- Constructing the western haul road, including two culverts, to provide a more efficient connection between the pit and the processing yard as part Stage 2. The haul road will then be removed during Stage 7 and a new haul road constructed.
- Amending the consented groundwater takes and discharges to Mangapū Stream.
- Providing for some in-pit crushing to enable a greater volume, and more efficient, processing of aggregate.
- Providing for the placement of a greater volume of overburden within the site.
- Implementing progressive rehabilitation (where practicable), ecological offsetting, landscape mitigation, compensation and stream enhancement measures throughout quarry development. The expansion necessitating the Mangapū Stream Tributary diversion is the first stage of the project, and the ecological offsetting needed for this will occur in the early phases.
- Enable quarry development below RL-50m as part of the long-term development of the Symonds Hill Pit, recognising that this deeper resource would only be accessed once the earlier stages of the pit have been quarried. The final Life of Quarry Strategy will be confirmed prior to any excavation below RL-50 m and will detail further investigations necessary to ensure that adverse environmental effects associated with later-stage extraction and/or rehabilitation are appropriately identified, assessed, and managed (including obtaining any regional consents required).

Winstone is seeking resource consent under the FTAA for both district and regional activities to enable the development of the Symonds Hill Pit. The land use consents (earthworks, vegetation clearance and the disposal of overburden) are being sought in perpetuity (unlimited duration), and a 35-year duration on all water take and use and all discharge permits. Winstone are also seeking a Wildlife Act Authority, an Archaeological Authority and a Complex Freshwater Fisheries Activity Authority.

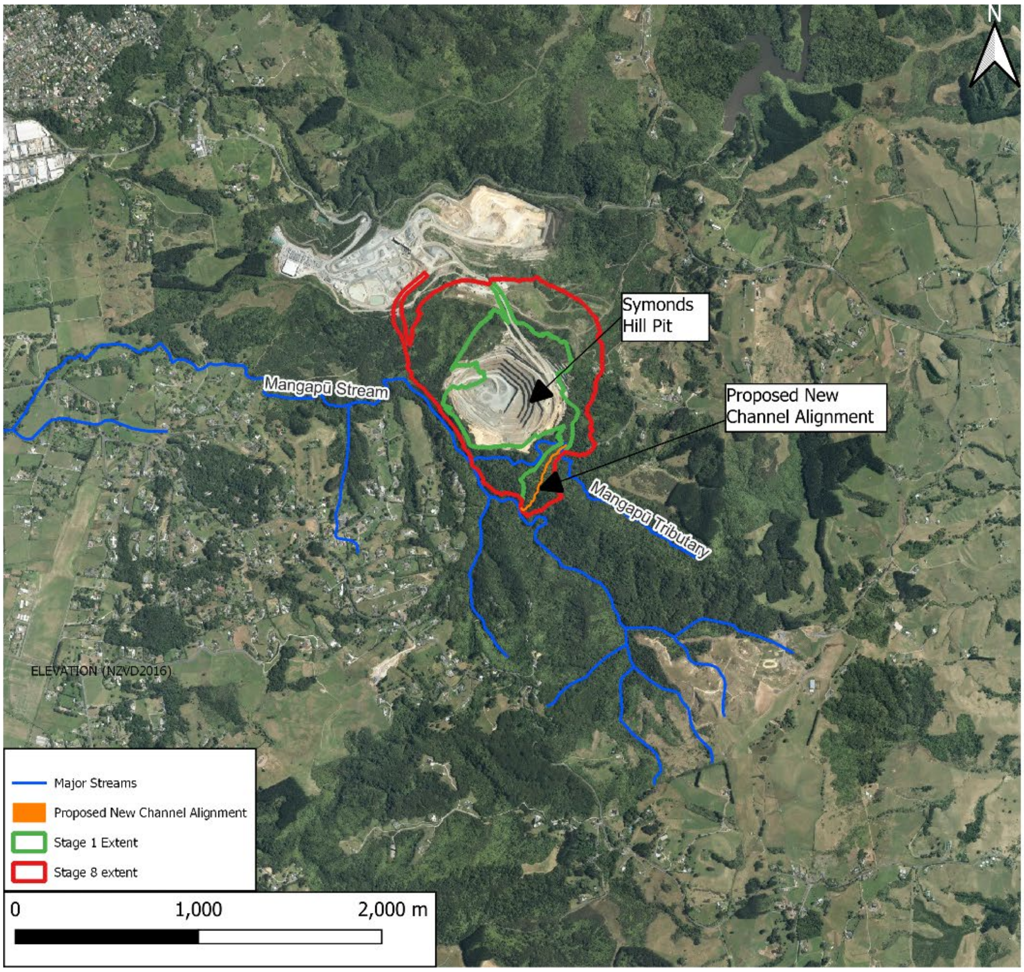

Figure 1: Existing Symonds Hill Pit and proposed development

1.2 Mangapū Stream Tributary Realignment

The proposed realignment of the Mangapū Stream tributary will be constructed southeast of the existing Symonds Hill pit to facilitate pit expansion. This realignment will feature a meandering, naturalised channel incorporating riparian vegetation, in-stream habitat features, sediment control / energy dissipation measures, and a clear separation from active surface water management systems particular to the quarrying operations. As outlined in

Section 2.1, construction of the proposed stream channel will be undertaken as enabling works (pre-quarrying activity) and the existing stream channel will continue to exist and function until the realignment has been fully commissioned.

Key design objectives include:

- Integration of flood management strategies to mitigate flood impacts to the quarry and surrounding areas.
- Replication of stream and riparian habitats found in the existing Mangapū Stream tributary.
- Maintenance of water quality and implementation of effective sediment control measures.
- Inclusion of appropriate stream plant species to promote biodiversity.
- Targeted management of invasive plants and animal species.

The proposed tributary realignment area and location specific to this assessment are as illustrated in Figure 2 below.

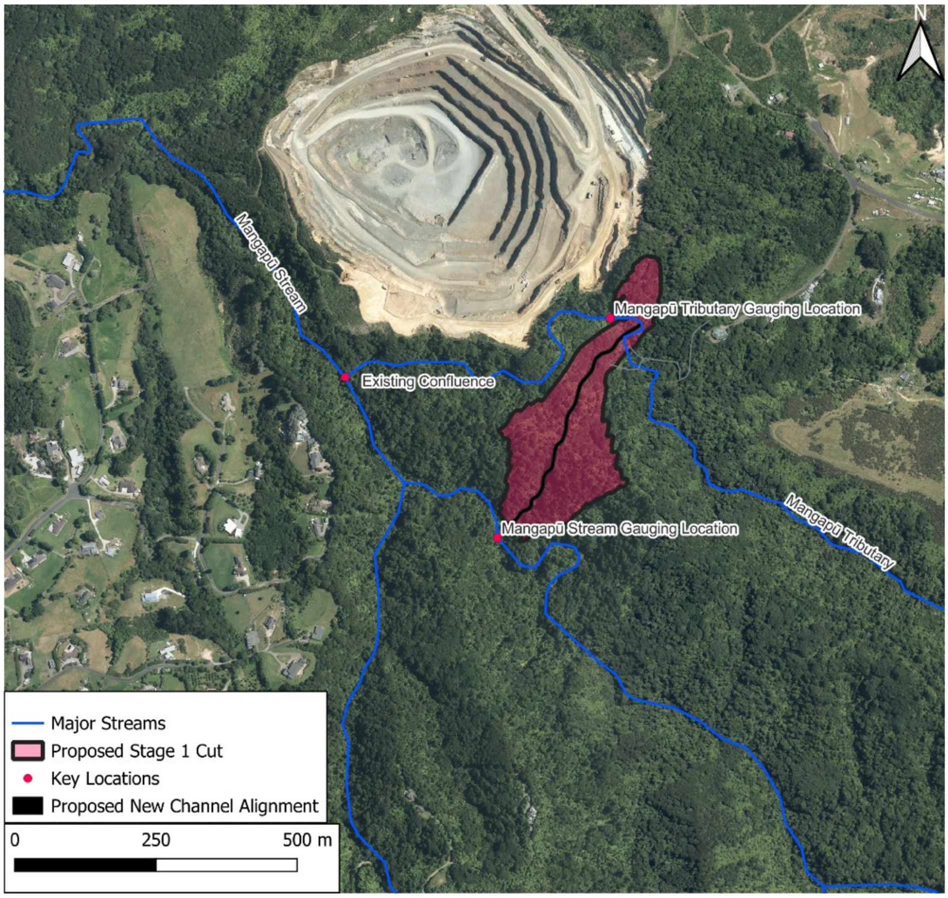

Figure 2: Proposed tributary realignment area

2.0 Site Description

2.1 Existing Environment

The proposed tributary realignment area is characterised by a steep vegetated catchment comprising both native and exotic species. Much of the site is largely inaccessible and currently covered in dense vegetation.

2.1.1 Site Visit

A site visit was undertaken on the 20th of November 2025 by four PDP staff, Verity Kirstein (Project Manager/Engineer), Phil Hook (Hydrologist), Gareth Bailey (Hydraulic Modeller/Engineer) & Tylan Collins (Hydraulic Modeller/Engineer). Prior to the site visit, 52 mm of rain had fallen on the 19th of November resulting in slightly increased stream flow.

The purpose of the site visit was to:

- Understand the site layout and potential constraints.
- Obtain flow data to develop the design flows.
- Capture and record information about the existing stream characteristics, including hydraulic features, stream morphology and bed substrate.
- Identify the location of the proposed realignment connection points with the existing watercourses.

Photos from the site visit are attached in Appendix A.

2.1.2 Stream Characteristics

The characteristics of the stream can be split into three main reaches: the Mangapū Tributary, the upper Mangapū Stream and the lower Mangapū Stream downstream of Coal Mine Road.

2.1.2.1 Characteristics of the Mangapū Tributary:

- Steep longitudinal channel gradient (~5%).
- Incised channel with steep banks ranging from approximately 1V:3H – 1V:1H (some slopes near vertical in places).
- Upper stream banks vegetated with mature trees and thick undergrowth.
- Average width of 2-3 m.
- The stream features steep waterfall sections and shallow pool/riffle runs.
- At the downstream confluence with the Mangapū Stream, there is a steep waterfall system which is likely to be a natural fish barrier to non-climbing fish.

- The stream has a significant number of large boulders, with sediment ranging from course gravels to silty sand and some clay.

2.1.2.2 Characteristics of the Mangapū Stream:

- Steep longitudinal channel gradient (~2.5%).
- Incised channel with steep banks ranging from approximately 1V:3H – 1V:1H (some slopes near vertical in places).
- Average width of 3-4m.
- An existing waterfall, with downstream pool and riffle sections upstream of the proposed tie-in location.
- A significant number of large boulders, with a sediment typically characterised by course gravels to silty sand and clay.
- Exposed bedrock present in some stream sections indicating the bed substrate was limited and relatively shallow.

2.1.2.3 Characteristics of the Lower Mangapū Stream:

- Moderate gradient (0.87%) and mild meanders.
- An incised channel approx. 5m wide.
- a floodplain approx. 50-60m wide.
- This part of the stream runs through rural / residential land with predominantly grazed pasture on the stream banks and sparse bush/tree coverage.
- Erosion is present along the stream banks near bends in the stream and around culverts.

2.2 Catchment Hydrology

The proposed realignment will modify the confluence location of where the Mangapū Tributary flows into the Mangapū Stream. Figure 3 identifies the proposed new confluence location, realigned steam channel location and proposed corridor required to establish the proposed realignment.

The existing catchment areas are:

- Mangapū Tributary upstream of the confluence: 1.67 km^2.
- Mangapū Stream at proposed tie in location: 1.84 km^2.
- Confluence of Mangapū Stream and Mangapū Tributary: 4 km^2.

The modified catchment areas following the stage 1 works are:

- Mangapū Tributary at the diversion: 1.55 km^2 (7.2% reduction).
- Confluence of Mangapū Stream and Mangapū Tributary after diversion: 3.88 km^2 (3% reduction).

This is an approximate 0.12 km^2 reduction in catchment area in the lower portion of the Mangapū tributary catchment. This will cause a slight reduction in flows to the Tributary and Mangapū Stream.

2.2.1 Flow Gauging

Limited flow gauging was undertaken on the Mangapū Tributary and the Mangapū Stream by PDP during the November 2025 site visit. As there is no permanent, continuous flow gauge (recording the full range of flow) on the Mangapū Stream or the tributary, flow data from a nearby Auckland Council recorder located at Mangawheau Weir (approximately 6 km from the proposed site), with a 37-year flow record was used. This catchment was considered appropriate to use due to the proximity and similar catchment characteristics. The geographical closeness means that the rainfall profiles are similar, and the catchment characteristics similarities have a similar response to rainfall. It is recommended that a condition is proposed to undertake continuous flow gauging across the full range of flow on both the Mangapū Stream and the tributary to refine the hydrological assessment prior to final design sign-off.

A widely recognised and appropriate method known as flow scaling was utilised to provide comparative flows for catchments of similar characteristics (terrain, gradient, morphology) as outlined within the Ministry for the Environment (MFE) River Environment classification database. These flows were gauged at 78 L/s (Mangapū Stream) and 67 L/s (Mangapū tributary).

The data retrieved from Mangawheau Weir has been used to perform an extreme value analysis on flow data using Log Pearson III to obtain design flows for both Mangapū tributary and Mangapū Stream. Using stream flow gauging, this allowed a synthetic flow record of the past 37 years to be created for each stream based on the Mangawheau weir, which was then fit to a Log Pearson III distribution to obtain the design flows for different events shown in Table 1.

Table 1: Mangapū Tributary and Mangapū Stream Estimated Flows

Stream	AEP % (ARI)	Flow (m^3/s)
Mangapū Tributary	42.9 (MAF)	1.8
	10 (10YR)	3.1
	2 (50YR)	5.6
	1 (100YR)	7.1
	0.5 (200YR)	9.0
	0.2 (500YR)	12.1
	0.1 (1000YR)	15.0
Mangapū Stream	42.9 (MAF)	2.2
	20 (5YR)	2.9
	10 (10YR)	3.8
	2 (50YR)	6.7
	1 (100YR)	8.5
	0.5 (200YR)	10.8
	0.2 (500YR)	14.5
	0.1 (1000YR)	17.9

2.2.2 Rainfall

A rainfall runoff model was developed for the catchment downstream of the gauging locations using rainfall data from NIWAS's High Intensity Design System (V4) for Auckland (updated and calibrated since the Auckland Anniversary event). Rainfall conditions were developed following the Auckland Design Manual Infrastructure Codes of Practice Chapter 4 (Stormwater Code of Practice). A comparison of the 1% AEP hyetograph with and without climate change is shown in Figure 3.

The rainfall model was calibrated to the 1% AEP to the Mangapū Tributary flows (7.1 m^3/s). The calibration resulted in a Curve Number of 52.5 which was applied to all events.

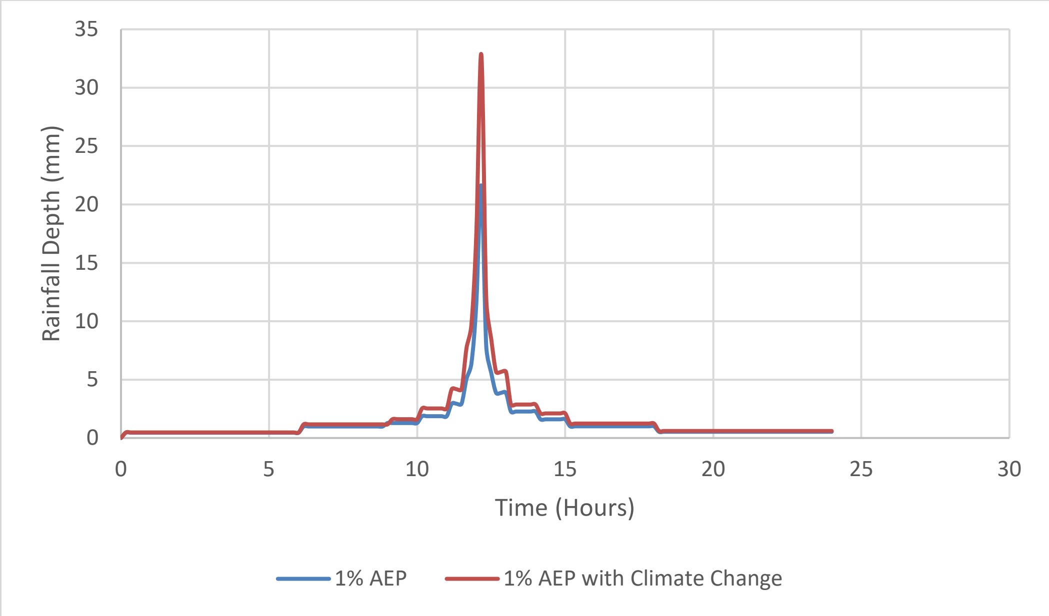

Figure 3: 1% AEP rainfall comparison

2.2.3 Climate Change

Climate change has been accounted for in the modelling with a 3.8-degree warming scenario and adjustments to rainfall were made in line with the Stormwater Code of Practice. The updated climate adjusted hyetographs were put through the hydrological model, resulting in a climate change increase factor of 2.1 which was applied to the current estimated flows.

A comparison of flows based on the current catchment areas is shown in Table 2. Due to the minor change in catchment area following the diversion, it is considered appropriately conservative to keep the existing design flows.

Table 2: Climate change adjusted design flows

Stream	AEP % (ARI)	Flow (m^3/s)	Climate Change Adjusted Flows (m^3/s)
Mangapū Tributary	42.9 (MAF)	1.8	3.8
	10 (10YR)	3.1	6.5
	2 (50YR)	5.6	11.8
	1 (100YR)	7.1	15.0
	0.5 (200YR)	9.0	18.9
	0.2 (500YR)	12.1	25.4
	0.1 (1000YR)	15.0	31.5

Table 2: Climate change adjusted design flows

Stream	AEP % (ARI)	Flow (m^3/s)	Climate Change Adjusted Flows (m^3/s)
Mangapū Stream	42.9 (MAF)	2.2	6.5
	10 (10YR)	3.8	9.5
	2 (50YR)	6.7	13.4
	1 (100YR)	8.5	17.0
	0.5 (200YR)	10.8	21.5
	0.2 (500YR)	14.5	28.9
	0.1 (1000YR)	17.9	35.9

3.0 PART A: Preliminary Design

3.1 Basis of Design and Assumptions

The following design parameters have been used to develop the design for the stream channel diversion, stream tie in locations, low flow channel, and design events.

- The new channel will convey a minimum of a 1% AEP event with climate change and 500 mm freeboard below the proposed quarry haulage road.
- The design climate change scenario is for 3.8 degrees of warming.
- A meandering channel will be designed into the cut surface with capacity to convey the present day Mean Annual Flood.
- A meandering normal flow channel will be incorporated into the cut channel to provide for fish passage and habitat.
- Fish passage will be provided for in a 7-day low flow event with a maximum depth of 50 mm across a 300 mm channel.
- The tie-in locations at the upstream and downstream ends will require a waterfall and cascade sequence to connect into the existing streams due to the large elevation changes at the upstream end and to mimic the natural environment downstream. Waterfall features are also required to prevent exotic fish species from migrating upstream.
- Existing stream features will be included into the stream design, as advised by the project ecologists. These include riffle run sequences, pools, cascades and waterfall and, where practicable, undercut bank sections.

- An impermeable liner (compacted low permeability overburden material) will be designed to be placed under the stream bed to prevent seepage into the rock.
- Planting requirements will be determined by a suitably qualified ecologist and tested hydraulicly to confirm they will impact conveyance of flood waters.
- The low flow and typical day-to-day flow channels will incorporate rock and plant debris with ecological functions as advised by the ecology experts.
- The proportions of required stream features (riffles, runs, etc) have been provided by the ecological experts and incorporated into the stream design drawings.

3.1.1 Design Standards

The following design standards and guidelines have been used:

- Auckland Council Stormwater Code of Practice Version 4.
- New Zealand Fish Passage Guidelines Version 2, 2024, NIWA.

3.2 Stream Re-alignment Area

The stream realignment area was selected by Winstone Aggregates following confirmation of the proposed quarry development footprint.

3.2.1 Proposed Earthworks

The construction of the proposed realigned stream area will require significant earthworks. The estimated earthworks volumes (provided by Winstone Aggregates) are as follows:

- Soil / overburden material – ~900 bank cubic metres (BCM).
- Rock - ~420,000 BCM.

3.2.2 Ecological design inclusions

The coordinated ecological design between PDP and Boffa Miskell has incorporated the following features to create equivalent stream habitat characteristics to provide for equivalent aquatic and riparian values:

- Low flow channel design with in-stream features including riffles and runs. These features will provide habitat for fish and invertebrates to reside.

- Waterfalls, pools and cascade features have been included with the aim to accommodate the design constraints and best replicate the existing environment and in-stream habitats.
- Native planting and the inclusion of a riparian zone.

For further information, please refer to Boffa Miskell's ecological impact assessment report provided as part of the substantive application.

3.3 Hydraulic Model

A hydraulic model was developed to assess the impact of the proposed stream alignment, in order to:

- Assess the impact of the proposed re-alignment on the rural residential area downstream.
- Assess the impact of the proposed stream re-alignment on the quarry.
- Determine the realignment design's suitability for low flow events; to provide sufficient low flow water depths and velocities, catering for typical environmental factors.
- Determine whether features of the stream design have hydraulic effects which need to be mitigated.
- Assess the effect of the stream realignment on the downstream catchment of the Mangapū Stream.

The hydrodynamic model was constructed using Tuflow. Tuflow is a computational software which contains a 1D and 2D engine to numerically model free surface flows. The 2D depth averaged, momentum and continuity equations for free-surface flows are solved using a 2nd order semi-implicit solver.

The model extent is shown in Figure 4. The existing quarry pit can be seen on the right-hand side. Also shown are the LIDAR (ground elevations) and location of the boundary conditions applied in the model. A smaller model extent for the realignment channel was also developed as shown in Figure 5.

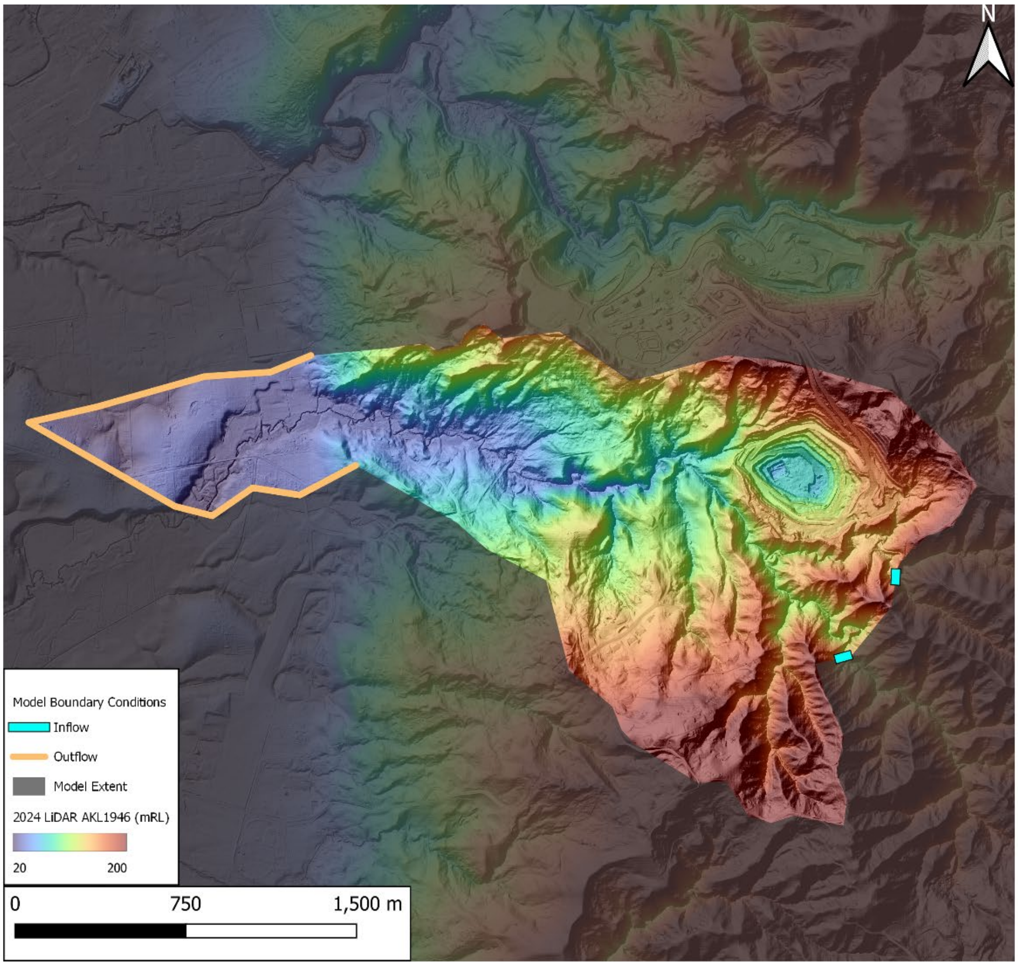

Figure 4: Tuflow model extent for catchment analysis

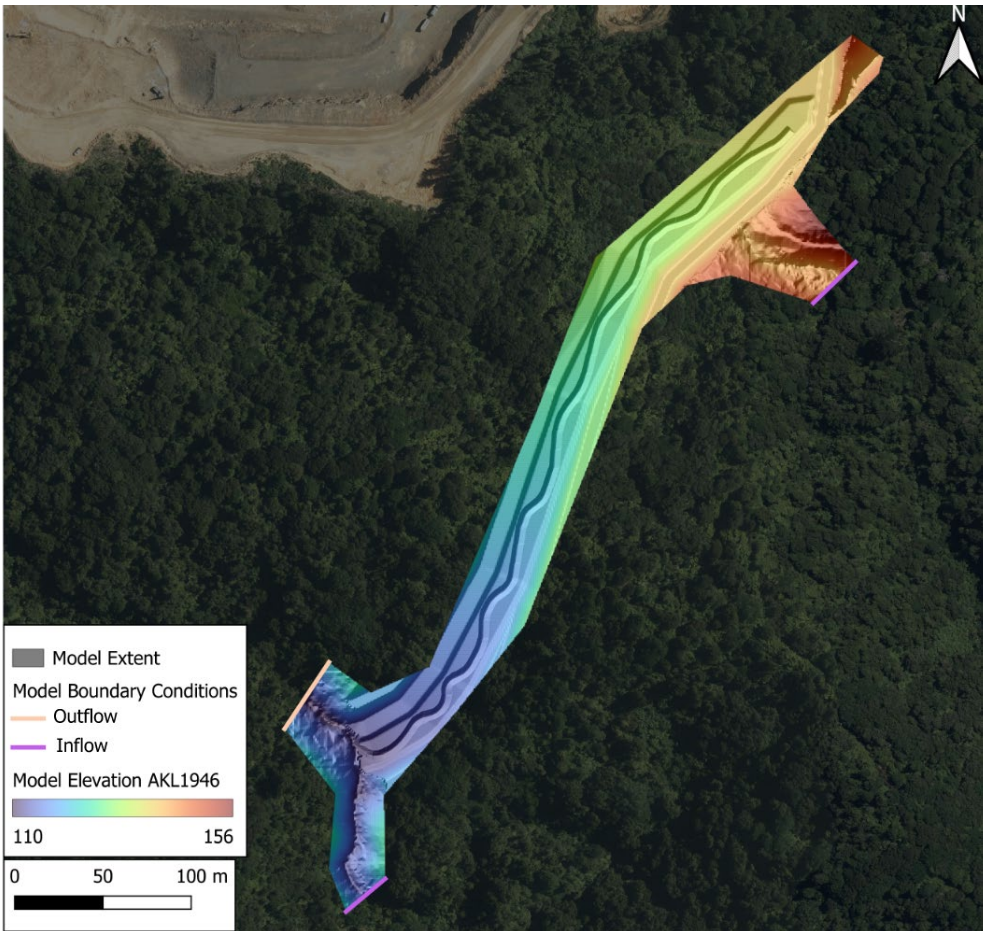

Figure 5: Tuflow model extent for the realigned channel design and analysis

3.3.1 Coordinate system and datum

The hydraulic model uses the following coordinate systems and datum:

- Horizontal Datum is New Zealand Transverse Mercator (NZTM) 2000 (ESPG2193)
- Vertical Datum is Auckland vertical datum 1946 (AKL1946).

3.3.2 Elevation data

The digital elevation model was constructed from the following sources:

- LiDAR captured in 2024,
- Survey data captured by CKL in December 2025.

The design surface of the proposed quarry development was supplied by Winstone Aggregate in November 2025 and used in the digital elevation model to illustrate the difference in land change. Details on the LiDAR sources are given in Table 3.

Table 3: LiDAR sources applied to the hydraulic model

Name	Resolution	Source	Vertical Datum (as supplied)	Horizontal Datum (as supplied)	Vertical accuracy (95%)	Horizontal accuracy (95%)
New Zealand LiDAR 1m DEM (2024 for Auckland)	1 m	LINZ	NZVD 2016	NZTM2000	+/-0.2 m	+/-1 m
CKL Survey	0.5 m	LINZ	NZVD 2016	NZTM2000	N/A	N/A
Winstone Aggregate Stream Surface	1 m	LINZ	AKL 1946	Mount Eden 2000	N/A	N/A

Figure 6 below shows the output of the digital elevation model and specifically a comparison between the existing quarry layout and the completion of Stage 1 involving the construction of the stream realignment.

Figure 7 shows a comparison between the current quarry layout and the completion of Stage 8 which is the complete development of the quarry.

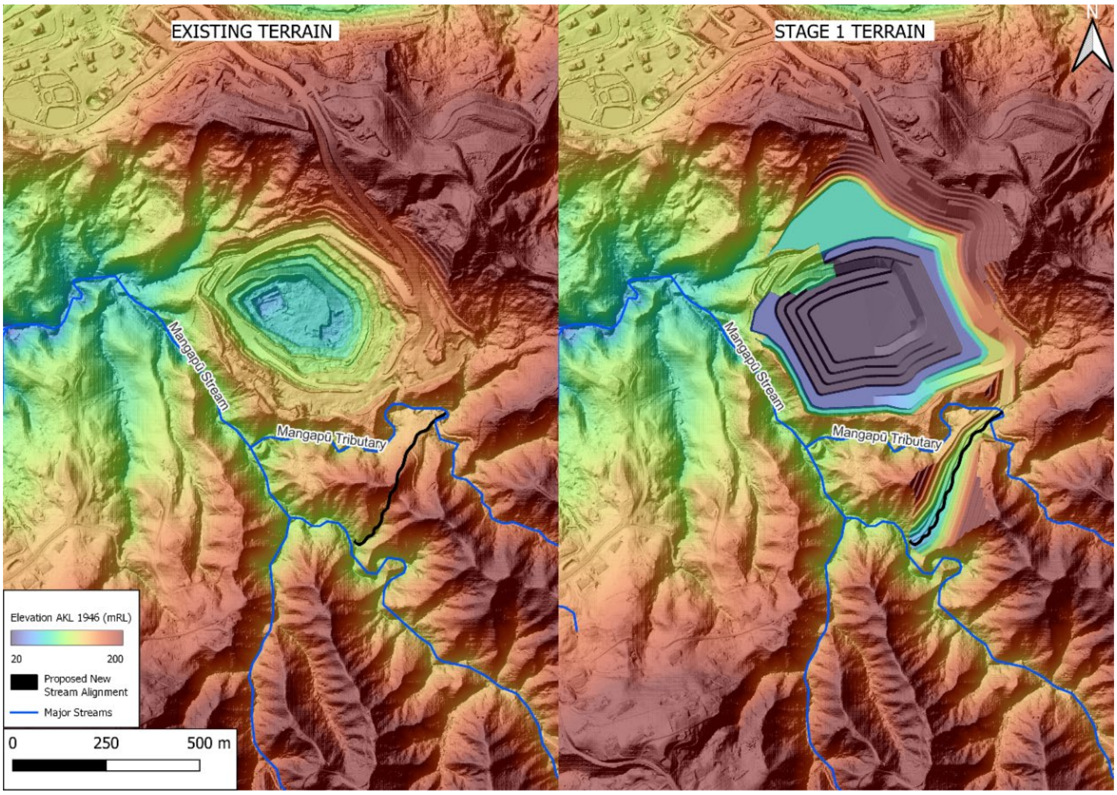

Figure 6: Existing quarry and Stage 1 quarry expansion terrain comparison

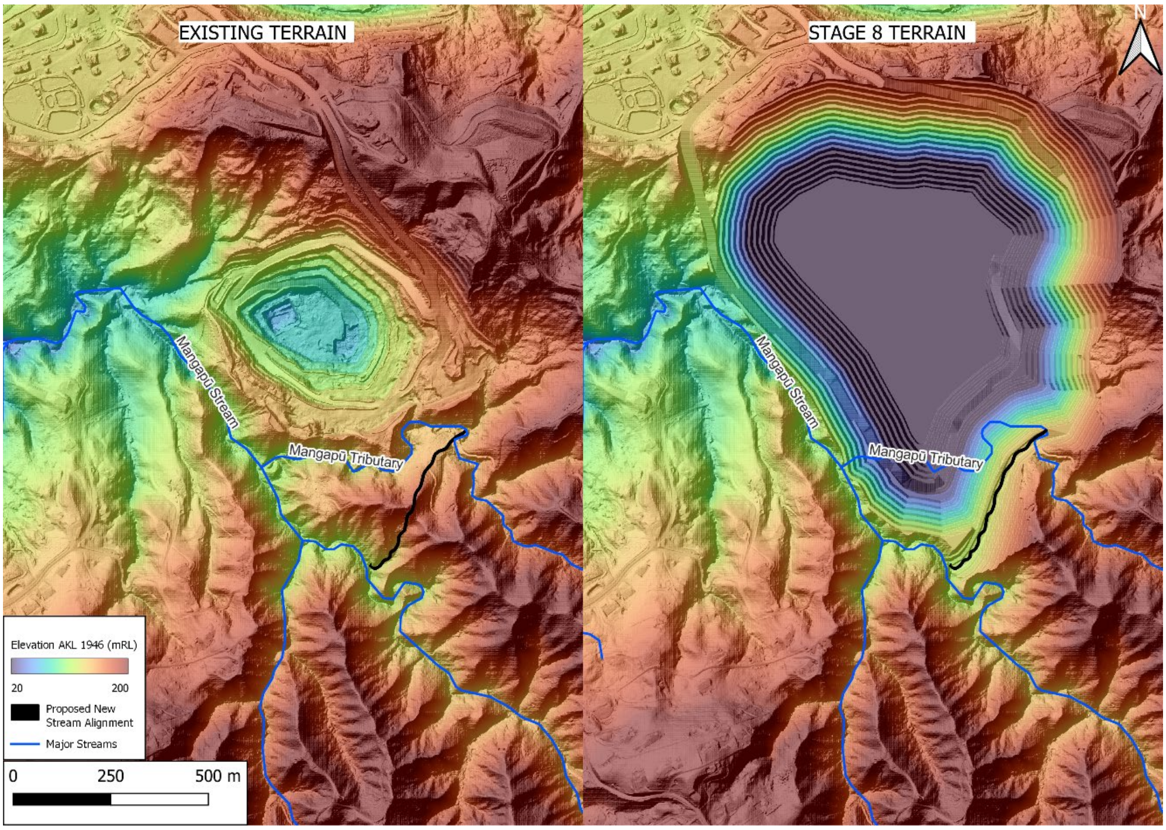

Figure 7: Existing quarry and Stage 8 quarry expansion terrain comparison

The images in Figures 6 and 7 have been included in this report to illustrate the power of the digital elevation model in detailing the local topography and to show the quarry development changes over time. In the development of the hydraulic model, a true depiction of the lay of the land is needed so that a true presentation of the local topography is applied to the stream hydraulics.

3.3.3 Model Resolution

A high model resolution is often desirable as it will provide a greater level of detail and accuracy, however the higher the resolution the longer the simulation time. The Australian Rainfall and Runoff (2019) guideline states that:

"The resolution of a 2D model grid/mesh determines the scale of physical features and flow behaviour that can be modelled for a given study area. Selection of an appropriate resolution is generally driven by a combination of the following factors:

- The scale of topographic and/or flow phenomena to be modelled;
- The desired level of detail to be achieved in the model outputs;
- The length of event time and consequent run time; and

- The size of the area of interest."

Tuflow recommends testing cell size convergence to determine a suitable maximum resolution of the model.

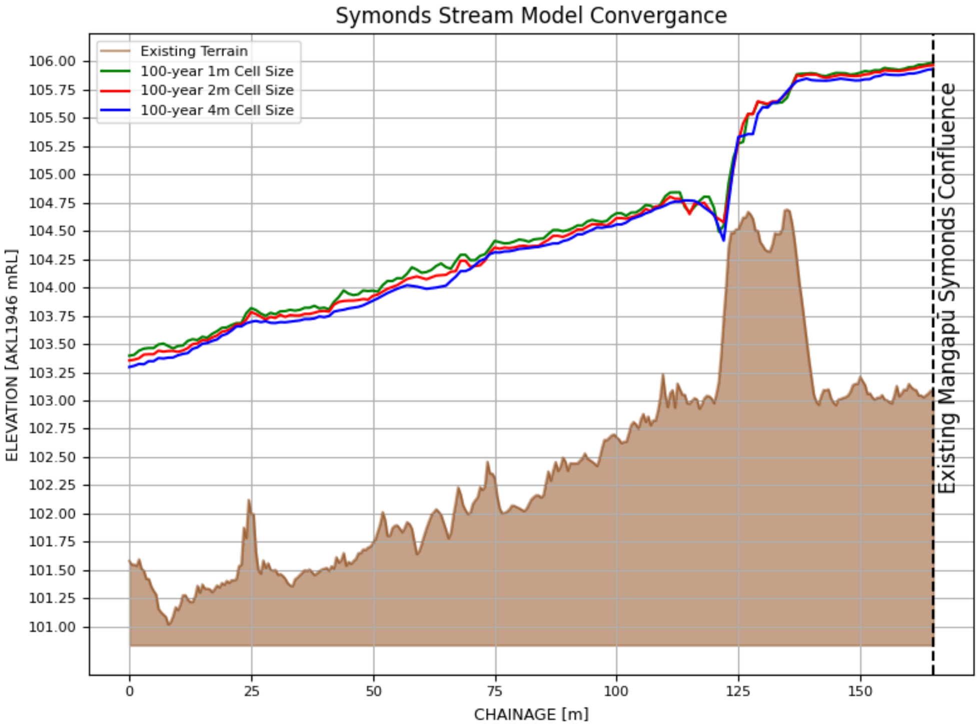

Figure 8: Model cell size convergence

Figure 8 shows a long section of the Mangapū Stream downstream of the Mangapū tributary confluence for the 1% AEP flood levels at model resolutions of 1 m, 2 m, and 4 m (green, red, blue lines) in relation to the existing ground level (brown line/area). In reviewing the flood level datasets, there is a difference of approximately 100 – 200 mm between the 1 m and 4 m resolutions and less than 50 mm difference between the 1 m and 2 m. Therefore, the model resolution with the least difference ranges was 2 m, which has been adopted for this study.

At a 2 m cell size, model convergence is demonstrated and therefore is deemed sufficient for this study.

3.3.4 Roughness

Another variable to consider in the model is roughness. This represents the friction losses incurred by the water body as it traverses over the topography, as different ground surfaces induce different level of friction on flowing water, affecting the velocity of the water. The model roughness is determined by utilising multiple sources to define land cover. These include:

- LINZ Road Parcels;
- LINZ Building footprints;
- LRIS Land Cover Version 5.0;
- Aerial imagery and google street view; and
- Condition from the site visit.

Roughness of the land cover type is categorised by Manning's roughness values, with different land cover types having different values. The higher the Manning's roughness value the greater the friction induced and the effect on flowing water. The Manning's roughness values are selected based on values typical for the respective land cover within the catchment.

Table 4 shows the Manning's values used in the model. There has been no model calibration for the roughness values, with roughness values based on values from guidance values.

Table 4: Model roughness

Land Cover	Manning's n	Typical Range[2][3]	Depth Varied Roughness[4]
Building	1.000[1]	-	-
Roads and Hardstand Areas	0.025	0.020 - 0.030	-
Pasture (default)	0.045	0.020 - 0.080	0.05, 0.1, 0.1, 0.045
Forrest	0.08	0.045 - 0.160	0.1, 0.2, 0.3, 0.08
Quarry	0.04	-	
River Upstream of Coal Mine Road	0.08	0.025 – 0.060	0.1, 0.2, 0.2, 0.08
River Downstream of Coal Mine Road	0.04	0.025 – 0.060	-

Notes:

1. *This high manning's rough value allows for floodplain storage within the building footprint but prevents any significant conveyance.*
2. *Sources: Cardno. (2021). Flood Hazard Modelling Standard. Wellington: Greater Wellington Regional Council.*
3. *Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors) Australian Rainfall and Runoff: A Guide to Flood Estimation, © Commonwealth of Australia (Geoscience Australia), 2019.*
4. *Depth varied roughness is applied as lower depth limit, mannings n, upper depth limit, mannings n with a linear interpolation in between the two depth values.*

The model uses a depth varied roughness which allows for improved accuracy of the rainfall component by slowing water down at shallower depths. A depth varied roughness has also been applied to the primary stream channel to account for the large boulders that are present, this allows for a higher roughness at lower depth and a lower roughness at a higher depth. This is expected to be a more realistic representation of the bed roughness as the bed material represents a larger proportion of the flow profile at shallower depths.

The roughness for the modelled stream has been split into two due to the different characteristics in the upper and lower catchment as described in Section 2.1.2.

Roughness values are typically varied as part of the model calibration process. For this model, the roughness values were increased by 30% and decreased by 20% to determine optimum calibration performance.

The associated roughness numbers for the various land cover of the study area used in the hydraulic are shown in Figure 9.

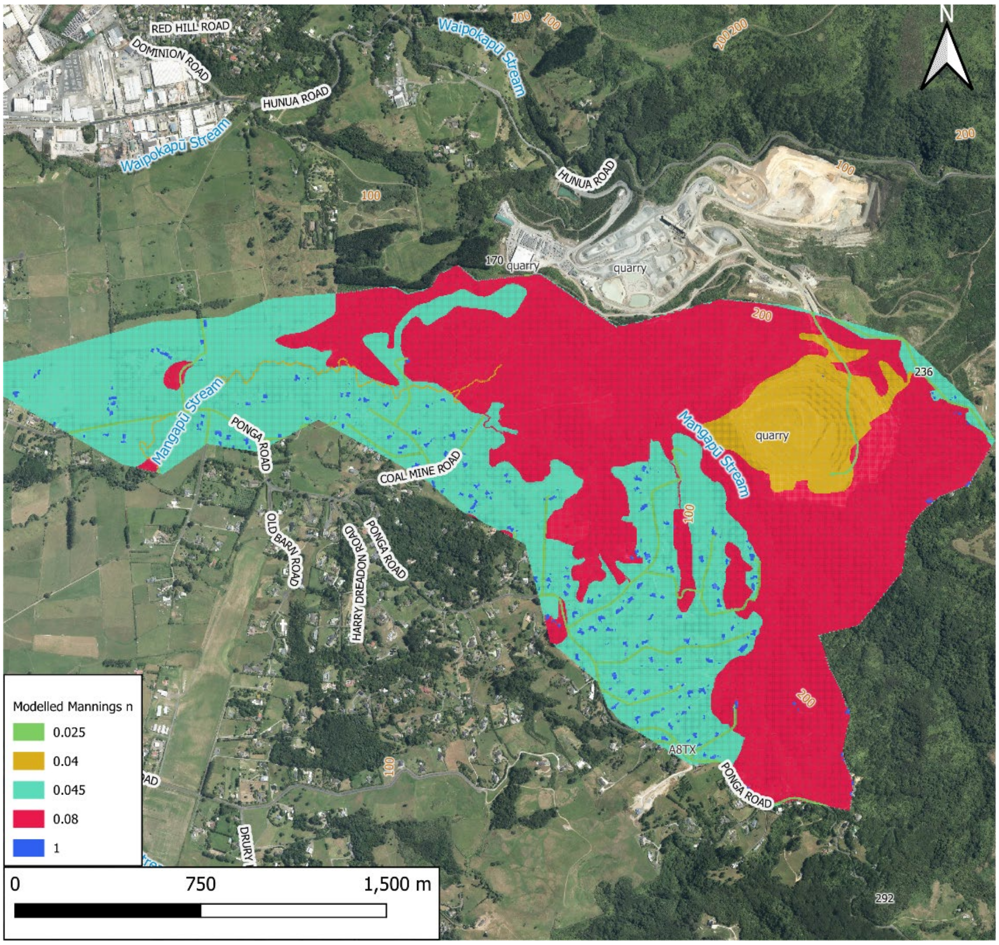

Figure 9: Modelled Manning's roughness (note only ultimate roughness values are displayed)

3.3.5 Boundary Conditions

Boundary conditions for a hydraulic model are a key element as they define how the water interacts with the model's environment, influencing flow calculations and overall model accuracy.

3.3.5.1 Inflow

The peak flow values (1% AEP + CC) for the Mangapū Stream and the Mangapū tributary (Table 2), were plotted to the hydrograph for the largest recorded event in 2023 for the Mangawheau Stream (see section 2.2.1) to produce a hydrograph for all events, as shown in Figure 10. This was used for inflow data for the model.

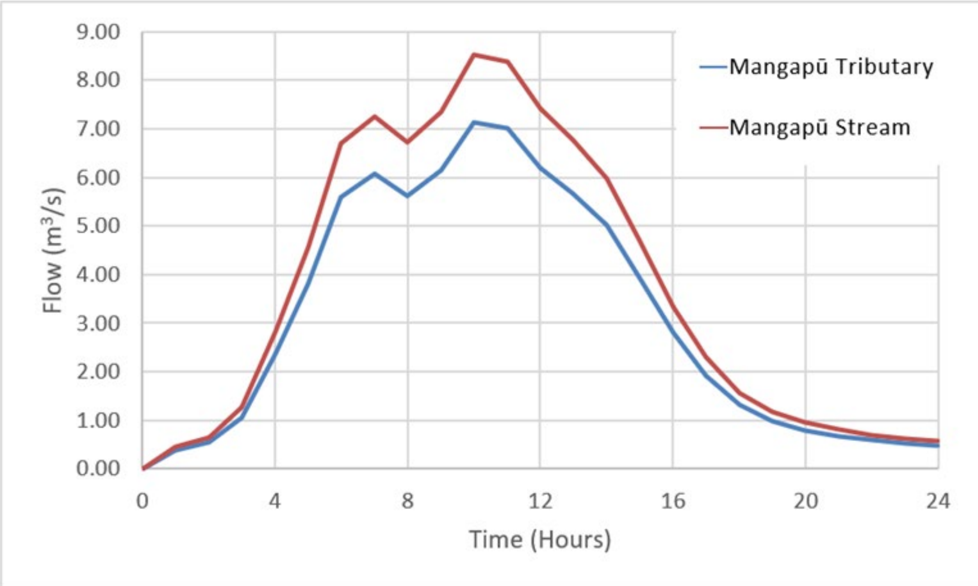

Figure 10: 1% AEP hydrograph shape

3.3.5.2 Rainfall

Rain was added to the model downstream of the site flow gauging locations, assuming a convergent peak with the static inflow. This is considered the most conservative scenario. The rainfall hyetographs are described in section 2.2.2.

3.3.5.3 Downstream Boundary

The downstream boundary is set to a slope boundary condition of 1% approximately matching the stream gradient.

3.4 Hydraulic Channel Design

The new channel will be constructed in fractured rock and will be created by blasting the rock to create a channel that is deeper than the proposed finished level and built back up with a low permeability liner and rocks to prevent the channel seeping into the rock.

The channel will have two main components: a large out-of-bank flood channel incorporating a smaller, meandering low flow channel. The new flood channel has been designed to the following parameters:

- The stream cut will convey the 1% AEP flow with climate change to 3.8 degrees of warming and include a minimum of 500 mm of freeboard below the proposed haulage road on the true right bank.
- A meandering channel designed to convey regular rainfall events up to the mean annual flood.
- Waterfalls / cascade sequence at the tie in with the existing upstream channel (Mangapū Tributary) to allow for the level transition.
- A low flow channel in the base of the meandering channel designed to accommodate minimum flows to sustain aquatic life.

3.4.1 Normal-flow Channel Design

The average flow channel will be designed with stream features to create equivalent stream habitat characteristics to provide for equivalent aquatic and riparian ecological values. It is expected that the stream will have:

- Suitable connections with existing streams and tributaries that will provide for fish passage.
- Large rocks and tree debris placed along the stream to offer diversity and provide habitat for in stream fauna.
- Varying stream profile with riffle/run and waterfall and cascade sections.
- Planting on the banks outside of the low/regular flow channel.
- A channel design that will account for regular flow conditions and seven-day low flow conditions.
- The upper section of the stream will range from 0.5 - 4 m wide with good mix of cobbles, gravel, bedrock and silt /sand and few boulders.
- The lower section will range from 0.5 - 2.5 m wide with a dominance of large boulders with mix of cobbles, gravel, bedrock and silt/sand.

The following features have been recommended by the ecological specialists and are included in the in-stream design. These are illustrated in the Assessment of Ecological Effects report (section 11.5) provided by Boffa Miskell.

Stream Runs

Stream runs will make up approximately 40 - 60% of the total stream profile in 3 - 80 m sections with a low to moderate grade and slow-moving water. The width of the channel will be relatively narrow.

Stream Riffles

Stream riffles will make up approximately 15 - 20% of the total stream profile and typically be 0.5 - 10 m in length at a low gradient with a wider cross-sectional profile.

Stream Cascades

Rock cascades will make up approximately 5 – 15% of the stream profile with height and widths ranging from 0.5 m to 1.5 m. The gradient is typically moderate and will be used to create changes in grade.

Pools

Pools will mostly feature at the downstream end of waterfalls. They will be of a low gradient, 1.5 - 3 m radius and 0.3 - 1 m deep. Pools will make up 5 - 10% of the total stream length profile.

Waterfalls

Waterfalls are needed to address the elevation differences at the upstream and downstream ends of the stream diversion and to provide some grade variation within the stream. They will typically be 1 - 3 m high (suitable for native climbing fish) and make up 5 - 10% of the total stream length profile.

Backwaters

Backwaters will be hydraulically connected to the flow channel and positioned adjacent to the flow channel. They will be 1 - 3 m wide and where possible make up 2 - 5% of the stream profile.

3.4.2 Flood Channel Design

The flood channel design is made up of two components a meander normal flow channel designed to convey up to the mean annual flood, with larger events to be conveyed in the wider cut channel. The cut channel will be designed to convey up to the 1% AEP event with climate change and 500 mm freeboard below the proposed haulage road.

An over-design event within the flood channel has been modelled to understand what the effects of this might be on the channel and wider realignment corridor. Initial outputs demonstrated that overtopping would occur in some locations, however this can be managed by constructing a bund on the channel bank or the outer edge of the haul road to ensure flood flows do not spill into the pit once excavated. At this stage this the bund has not been incorporated into the preliminary design drawings but will be developed into the detailed design drawings to follow.

3.4.3 Erosion Protection

Whilst the realigned stream channel will be formed in rock, there will be soft materials used to create the channel and features which will be prone to erosion caused by the flowing water, such as the channel liner and the bedding material for the stream banks and cut face planting.

It is expected that erosion protection will be required along the stream in high energy locations such as at the waterfall sites and prominent bends in the stream. The erosion protection incorporated into the design includes:

- Plunge pools/scour basins at the downstream end of waterfalls and cascade features. These areas allow for the energy of the flowing water to dissipate.
- Linear rock placement with suitably sized rock to arrest lateral and erosion and downwards scour.
- Protection of the new confluence of the Mangapū Stream and the Mangapū Tributary by the considered placement of rock.

3.5 Fish Passage / Barrier

The preliminary design of the stream channel has been developed with the project ecologists, following the guidelines of the New Zealand Fish Passage Guidelines (2024) where applicable, to accommodate the fish species identified in the ecological surveys (longfin eel, shortfin eel, banded kokopu). These species can climb and will be able to traverse the stream in both directions. It has been noted that there is an absence of swimming fish in the Mangapū Tributary. Fish-friendly features are illustrated on the design drawings, in Appendix D.

The channel is comprised of a multi-staged channel – a low flow channel to contain the 7-day low flow within a 7 – 8 m wide (normal flow) channel to contain the mean annual flood, within a wider channel to contain the 1% AEP flood (Refer to Drawing A035680017-WR-202 in Appendix D).

The low flow channel will vary in width according to the range of in-stream features. Table 5 below details the proposed dimension of the features and the calculated water depths and anticipated velocities when the stream is flowing at a typical day-to-day flow.

Table 5: Channel features metrics

In-stream Feature	Width (m)	Water depth at low flow (m)	Velocity at low flow (m/s)
Pool	2.0 – 3. 5	0.3 – 0.5	0.010 – 0.014
Riffle	1.8 – 3.2	0.2 – 0.4	0.013 – 0.019
Run	1.6 – 3.0	0.1 – 0.3	0.019 – 0.027
Cascade	1.0 – 2.0	0.1 – 0.2	0.049 – 0.069
Waterfall	0.8 – 1.3	0.1 – 0.2	0.067 – 0.075

Notes:

1. *Low flow range 3.4 – 15 l/s*

Key inclusions have been made in the preliminary design to allow for movement of these fish species, including areas where fish can rest and feed, and appropriately sized and staged in-stream features (also needed for grade and energy control) that can be traversed. The sizing and sequencing of these features have been determined following advice from the project's ecology technical experts.

The ecological assessment of effects report by Boffa Miskell, states that banded kokopu have a mean max swim speed of 0.25 m/s and a mean critical swim speed of 0.36 m/s. Longfin elver has a mean max swim speed of 0.22 m/s and a mean critical swim speed of 0.41 m/s.

The calculated velocities for each of the features are less than the swim speeds of the noted fish species, and as such the flow conditions are appropriate for the species that will populate the realigned stream.

Due to the change in elevation (8m vertical differential) from the Mangapū Tributary and the lesser eastern tributary down to the realigned channel (due to local topography and the broader pit development requirements) the connection to the realigned channel requires a waterfall / cascade sequence to avoid a sharp change in grade. This cascade feature consisting of placed rock of variable sizes will allow the native fish species to travel upstream as they do currently and provides a safe route downstream.

The downstream end of the realigned channel includes appropriately sized waterfall features which the native climbing fish will be able to traverse but will act as a barrier for non-climbing exotic fish which may inhabit further downstream. This will prevent the exotic fish from entering and populating the realigned channel.

The construction of the realigned channel will be completely off-line from the Mangapū Tributary, so that normal flow regimes will continue in the Tributary until such as time that the realigned channel will become live. A staged approach will be taken to bring the realigned channel on-line, by diverting portions of the flow over a set period into the new channel.

To achieve the diversion of flow, the Mangapū Tributary will be blocked, and water directed to the new channel. Presently, the finalised design of the diversion has not been agreed but the concept is to use materials such as sandbags, geotextile fabric and rock to create a barrier. As the flow into the Mangapū Tributary is reduced and eventually stopped, a fish recovery plan will be implemented. This is in general accordance with the separate Stream Realignment Management Plan, which details the implementation of the realigned stream.

Once the staged livening of the new channel is completed, all flow from the Mangapū Tributary will be diverted into the new channel and the Mangapū Tributary permanently blocked. This will become the permanent flow regime with all flows from the upper catchment entering the realigned channel and existing into the Mangapū Stream. In terms of water quantities, the stream diversion maintains the status quo for flow entering the realigned channel, with no net loss as it exits into the Mangapū Stream, thus maintaining like-for-like conditions for fish species. The technical report for groundwater effects produced by PDP (section 4.6) concluded that flow reductions will be negligible on both the Mangapū Tributary and Mangapū Stream during the stream realignment stages (stages 0 – 2) of the quarry development, but noted that as the quarry development progresses (stages 3 – 8), low flow losses will be greater on the Mangapū Stream downstream of the realignment channel due to the migration of groundwater to the future pit.

If following regular flow gauging in the realigned channel, the water quality diminishes, the flow will be augmented.

3.6 Maintenance Requirements of the Channel

Monitoring and maintenance of stream channel will be required for a time as this is an engineered watercourse; whilst all best endeavours are made to create a natural stream, there is likely the need for intervention at times.

Ongoing monitoring of the realigned channel to inform maintenance needs will be required and planned. Maintenance activities such as vegetation control will be fundamental in preventing adverse flood effects and maintaining the design channel alignment and conveyance. Inspections following large rain events will be necessary to check for debris blockages, sedimentation and erosion of the channel, which may need remedying.

Maintenance activities within the active channel/flowing water are anticipated to be required following large rain events resulting in high flow or flood events, to maintain hydraulic capacity and remediate in-stream features if damaged.

Maintenance tasks will include the removal of obstructions which affect the passage of water. Depending on the size and scale of possible blockages (vegetative debris or rock), this could be completed by hand or may require the use of excavators accessing the stream bed via the haul road.

Erosion and sedimentation are natural processes and are expected to occur within the channel. However, there may be times when intervention by maintenance practices will be required, such as erosion of the channel banks progressing close to the haul road or sedimentation that potentially allows water to exit the channel. Operational responses should be timely so that problems do not progress. Steps to address erosion could include placement of rock to protect banks, placement of rock to divert flows back onto an appropriate route or additional planting to provide a buffer. Areas of sedimentation which pose an outflanking or overtopping risk should be addressed by removal or redistribution of the material.

The proposed Stream Realignment Management Plan will address monitoring requirements to determine if and when maintenance is necessary and what activities are required to mitigate or remedy the effects of erosion and/or sedimentation.

4.0 PART B: Assessment of Effects

4.1 Stream Environment

The development of Symonds Hill Pit requires the re-alignment of a tributary of the Mangapū Stream. Therefore, the existing stream channel and environment will be reconstructed on a new alignment with the replication of equivalent characteristics before the existing channel of the Mangapū tributary is removed by quarrying operations.

Construction of the new (engineered) channel will result in the total removal of the existing stream channel and associated environment and the creation of a new stream environment with equivalent features. To mitigate environmental impacts, the proposed channel design has been developed to replicate the characteristics and features present in the existing stream habitat and wider catchment. Key features such as engineered meanders, riparian vegetation / native planting on the banks, and in-stream structures such as woody debris, boulders and waterfalls have been incorporated into the design with the aim of provision of habitat as well as enabling fish passage through the realigned stream reach, with potential effects on stream habitat to be assessed in the ecological impact assessment.

4.1.1 Stream morphology and planting

The stream realignment design has included as many of the features of the existing channel to replicate its shape and overall morphology. Engineered meanders have been incorporated throughout the length of the realigned channel to simulate a natural sinuosity and form of the stream and to regulate flow depth and velocity under normal and low-flow conditions. The meander pattern provides more length to the channel than if it were straight, increasing the length from ~470 m if it were straight to ~570 m with meanders.

Noting the existing stream environment is characterised by densely vegetated bush, planting along the realigned stream banks will be undertaken to best reflect the benefits provided by the existing environment including provision of habitat and thermal regulation achieved by shading. However, given requirements for access and ongoing maintenance of the proposed adjacent quarry haul road, this planting will be managed and is not anticipated to reflect pre-development density or diversity. The assessment of effects with regards to ecology is in the separate ecological impact assessment.

4.1.2 Structural Features

Structural habitat inclusions, such as the strategic placement of large boulders and woody debris within the streambed, have been included in the design to promote hydraulic diversity and develop refuge areas. These features will reflect the natural channel characteristics present in the existing stream environment.

In addition, waterfalls will be constructed to emulate existing morphological features of the existing stream, ensuring continuity of aesthetic and ecological functions. Waterfall features are also a requirement of the design to facilitate grade transitions at either end of the diversion and to break up the gradient to create sections of flatter grade and variable velocity.

The inclusion of waterfalls along the longitudinal profile will influence sediment transport dynamics, deposition patterns, and flow velocities. Waterfall features have been designed to comply with fish passage requirements as discussed in Section 3.5.

The inclusion of in-stream features aims to preserve the natural aesthetic while supporting hydraulic variability and ecological resilience. This approach seeks to ensure that the reconstructed channel reflects the form and function of the original stream system. As such the effects to the stream environment (ecology, flow patterns, conveyance) from construction of the new channel will be mitigated by incorporation of the morphological and physical in-stream channel and bank features outlined above. Over time these features will support natural stream behaviours and development allowing the stream to establish a new steady state.

Conversely considering the stream without these structural features, the hydraulic performance of the stream would be very different. Given the existing ground levels, the difference in elevation from the upstream end of the stream to the downstream end creates a steep gradient. Were the stream channel to follow this gradient, it would effectively be performing as a high velocity flume.

The adverse effects with taking this approach would be increased uniform flow velocities, leading to rapid discharge into the Mangapū Stream. There would be increased erosion of the channel bed and sides and of the receiving Mangapū Stream channel due to the high speed of the water. Sediment transport would be increased in both quantity and speed with more deposition occurring in the Mangapū Stream in sections of the stream bed where the gradient flattens.

4.1.3 Enabling Works

To facilitate the construction of the channel realignment, enabling works are required to access the area where the channel will be excavated. One key element of the enabling works is the construction of a bridge over the Mangapū Tributary. This bridge will be in place for the duration of Stage 1 until the establishment of the channel is complete and the Mangapū Tributary flows are permanently diverted, at which point the bridge will be removed.

Winstone Aggregates (FCIL) have developed a concept design which involves a 7 m wide clear span deck to be placed over the stream. This will be footed on abutments set approximately 3 m out from the top of the channel banks. The soffit of the deck will be 3 m above the bed of the stream, as shown in Figure 11.

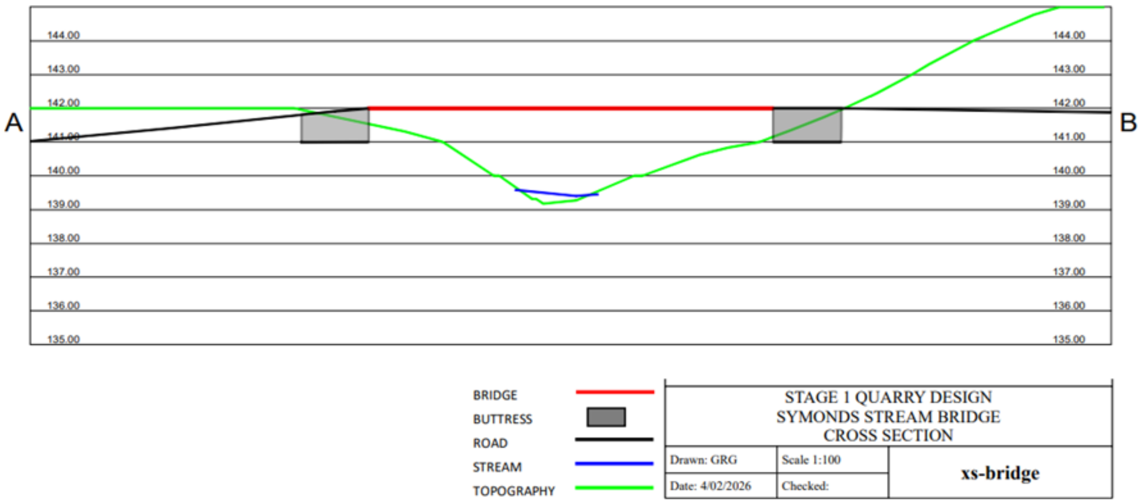

Figure 11: Proposed bridge cross section

The proposed bridge has not been modelled at this stage to determine whether extreme flood carrying capacity can be achieved. It is recommended that the bridge is modelled with several flood events to ensure the deck is sufficiently high enough for a flood to flow unimpeded.

Based on our experience, PDP believes that the bridge will not cause any adverse effects when typical day-to-day flows are experienced. During extreme flood events, the bridge could be overtopped preventing vehicle crossings, however this is considered unlikely given the amount of clearance under the bridge deck. It is likely, however, that the bridge will create a blockage potential in extreme flood events if flood debris is carried by the stream, resulting in potential overtopping on the stream bank on the true left (south) side, with flows outflanking the bridge to re-enter the Mangapū Stream channel further downstream. This would be a localised minor effect which would need to be managed by Winstone (FCIL) for the duration that the bridge is in place.

4.2 Flood Hazard

The proposed realigned channel will be shorter than the existing Mangapū Tributary, will exhibit a steeper longitudinal gradient, and incorporate a modified cross-sectional geometry. Consequently, the hydraulic and flood behaviour of the realigned channel will differ from pre-development conditions.

The hydrodynamic model has been used to aid the assessment of flood hazard. The realigned channel has been modelled as a varying width channel with meanders and with a uniform gradient to assess the effects of a range of flood events within the model boundaries. Further refinement of the model is needed to model the individual in-stream features and their performance. As such this assessment considers the effects of the stream realignment without the in-stream features which will mitigate the effects as detailed.

The following sections outline the changes in flood effects due to the channel realignment to assess the flood hazard. The proposed channel for the Mangapū Tributary connects to the existing Mangapū Tributary within its 1% AEP floodplain, therefore triggering Policy E36.3(3), E36.3(4A) and E36.3(4B) of PC120 of the Auckland Unitary Plan.

Velocity and flood depths have been assessed for a range of Annual Exceedance Probabilities to determine potential changes to flood risk and to identify potential effects. Figure 12 shows the locations where these assessments have been made.

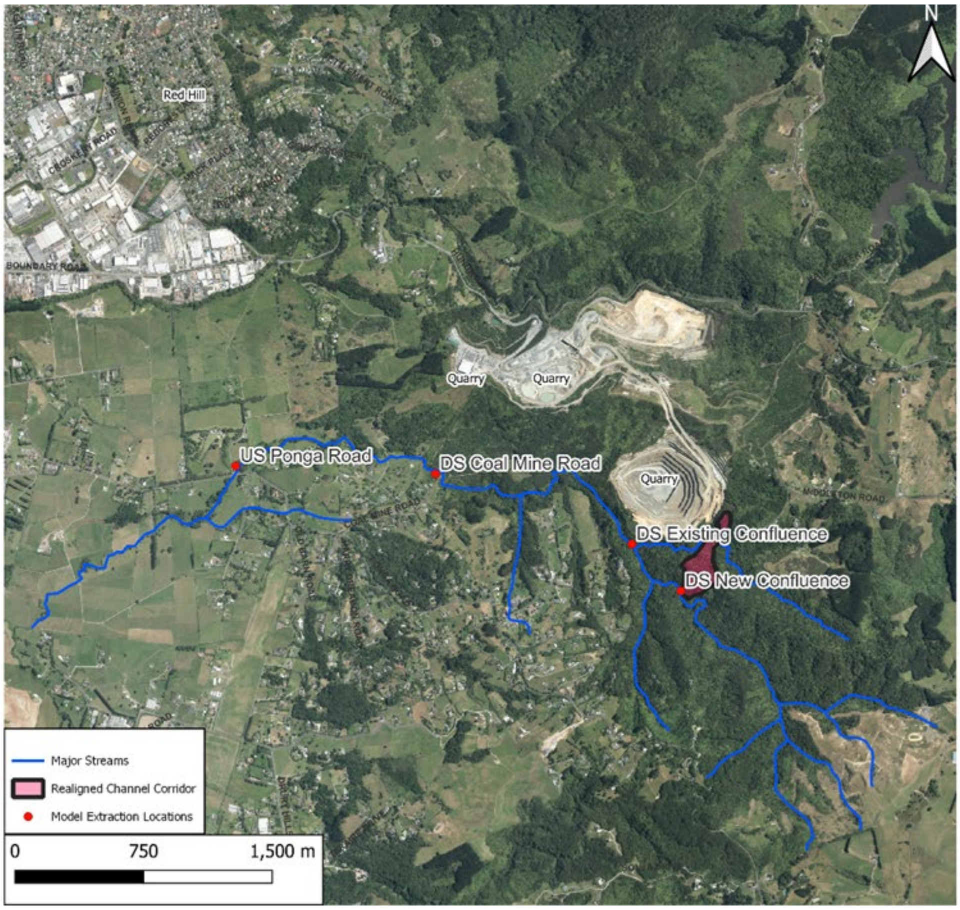

Figure 12: Water level and velocity assessment locations

4.2.1 Effect on flood levels and flood hazard

There is no formal guidance available nationally or locally which can be applied as a framework for assessing effects on flooding and flood hazard, and the recently issued National Policy Statement for Natural Hazards (December 2025) does not apply for quarrying activities. Therefore, when considering effects on flooding, we use the following framework:

- Magnitude of Effect: In this instance, the effect is quantified by changes to the flood depth / level, velocity and changes to the flood hazard classification.

- Event Probability: An effect for a smaller, more frequent event is considered worse than the same effect for a larger, less frequent event.
- Land use: The land use of the affected property is considered. Rural land used for grazing/cropping/horticulture is considered to have a greater tolerance to flood effects when compared to residential dwellings.
- Scale of the proposal: While less critical than the factors above, the size of the proposal generating the effect should be considered. A significant proposal, such as a large subdivision generating an effect is more acceptable than a smaller proposal (for example a single proposed dwelling) generating the same effect.

A comparison of pre- and post-stream realignment scenarios for the 100-year event inclusive of climate change (+3.8°C by 2110, RCP 8.5 as per Auckland Council Guideline Document 15 and the Stormwater Code of Practice) are presented in Appendix B: . The results show that:

- Flood depths increase by more than 100 mm on the Mangapū Stream between the new and existing confluence, due to the increase in flow volumes received on this reach compared to pre-development.
- Downstream of the existing confluence to Coal Mine Road, increases in estimated flood depths typically range from 15 – 50 mm.
- Downstream of Coal Mine Road within the rural residential area, the increase in flood depth is generally less than 15 mm.
- No buildings are affected by flooding in both the pre and post development scenarios.
- Three small areas within the model extent experience flooding, where they did not pre-development (refer to Figure 13 below).

Figure 13: Red circles highlighting areas where flooding will occur post-development that did not pre-development

When considering the diversion of the water from the existing Mangapū Tributary channel to the new realigned channel, the most notable effect is the increase in flood depths on the reach of the Mangapū Stream from the downstream end of the realigned channel and the current downstream confluence of the Mangapū Tributary (refer to Figure 14 for the reach locations). This is due to this portion only of the Mangapū Stream receiving increased flow post development. This reach is confined to a deep, steep sided gully, where this increased flood depth remains contained, cannot spill from the gully to adjacent land and does not affect neighbouring private property. Therefore, it is considered that this is a negligible effect.

The expected changes to flood levels of up to 50 mm in rural forested areas (downstream of the existing confluence to Coal Mine Road), and 15 mm in residential rural areas (as shown on the flood difference map in Figure 13 and in Appendix B) has no impact on people and communities, other properties, infrastructure or the environment. As the only notable increased depths are on rural land (owned by FCIL) and with a negligible difference in extents, the increase in flood levels will not have an impact on the residential land. As such the effects from increased flood levels are considered less than minor.

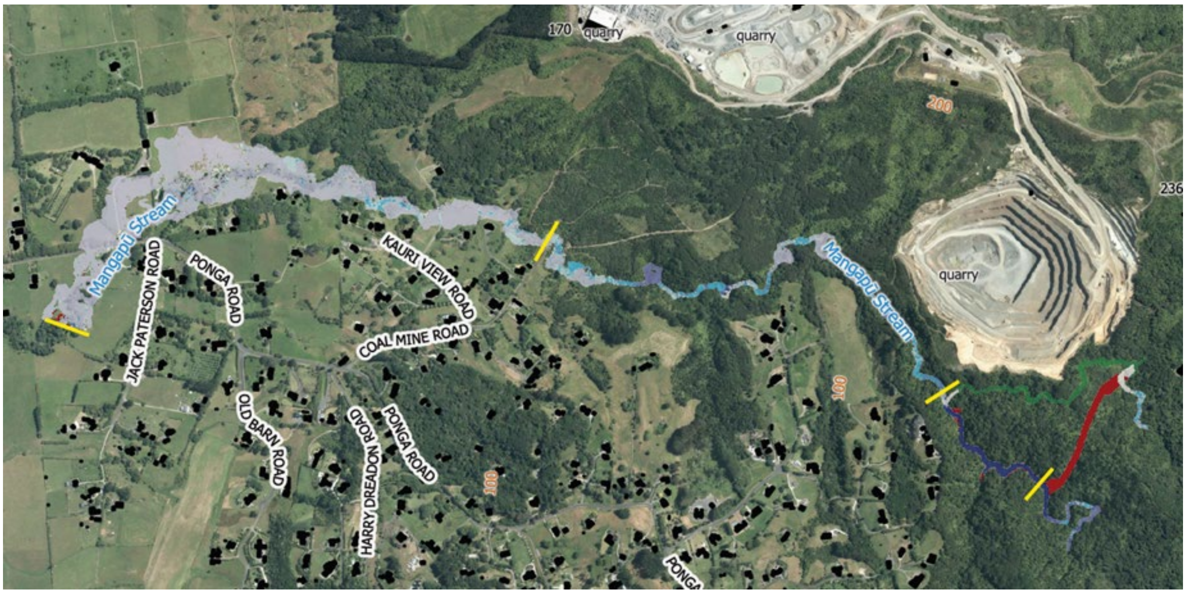

Figure 14: From right to left - yellow markers indicating the reach between the confluences, the reach downstream of the existing confluence to Coal Mine Road (rural forested) and the reach downstream of Coal Mine Road (residential rural)

4.2.2 Temporal changes to flood depth and velocity

An evaluation was made of the potential changes in flood depth and velocity and the effect on the stream environment downstream of the proposed stream realignment. Three design events were selected with comparative flood data extracted at four locations downstream of the realigned channel confluence. For this investigation, PDP assessed relative flood levels and velocity for 1% AEP (100-year ARI), 10% AEP (10-year ARI) and 50% AEP (2-yr ARI) events at the locations shown in Figure 11.

The temporal changes to flood depths are shown in Appendix C (Figures C1-C4) and described below:

- Figure C1 shows the Mean Annual Flood (MAF), 2-yr ARI (50% AEP) and 10-yr ARI (10% AEP) events, which shows an increase in flood depths is expected for all events with depths higher across the entire event; with increases in flood depths of up to 250 mm in between the new and existing confluence and less than 100 mm elsewhere within the model boundaries.

- Figure C2 shows the 100-yr ARI (1% AEP) event with and without climate change showing an increase of 500 mm in between the new and existing confluence, with changes in flood depths elsewhere in the model being less than 50 mm.

The temporal changes to flood velocities are shown in Appendix C (Figures C3, C4) and described below:

- Figure C3 shows that in the MAF and 10-yr ARI (10% AEP) event an increase in velocity of 0.1 - 0.15 m/s in between the new and existing confluence and an increase of 0.05 m/s or less elsewhere within the model boundaries.

- Figure C4 shows that in the 100-yr ARI (1% AEP) event there will be an increase in velocity of up to 0.2 m/s from the new to existing downstream confluence, downstream of the existing confluence the effect is negligible.

4.2.3 Erosion

The erosion effects of the stream realignment will vary depending on location, with the reach of the Mangapū Stream between the existing Mangapū Tributary confluence and new downstream realignment confluence experiencing the greatest effect from the increase in flow and velocity. However, the stream is bedded on rock and has limited soft sediment features to erode. Further downstream of this reach the impact will be less as the predicted velocity and water levels are less. The impact on erosion is described for both sections below.

4.2.3.1 Reach between the confluences (Mangapū Stream)

- The proposed new channel will have a steeper gradient than the existing Mangapū Tributary at approximately 7.5% compared to 5% for the existing. The steeper gradient will result in a higher-than-average water velocity in the stream and more erosive power. Over time, the stream may alter slightly in shape due to the increased velocity to become wider where banks are comprised of soils. However, it is anticipated that due to the underlying geology (i.e. that the stream is positioned on rock), this widening will be limited by the bed and bank material and will be localised. This is a less than minor effect.
- Erosion of softer stream substrates will occur leading to localised changes in channel shape. As the channel increases in size through the removal of bank material, this will lead to a slowing down and shallowing of the stream flows as the stream reaches a natural equilibrium and a reduction in erosion. Note that erosion of the softer substrates occurs naturally in the current scenario and the rate of erosion could increase

marginally as the volume and velocity of water increases. Accordingly, this is a less than minor effect.

- Any increased sediment transportation through the new channel into the Mangapū Stream could result in increased sediment deposition into the Mangapū Stream especially around the new confluence with the realigned stream as the gradient flattens. However, the estimated velocity increases are based on modelling the channel without the in-stream features. The inclusion of in-stream features in the design will slow the water down in places by altering the gradient and breaking up the flow, allowing for natural deposition of sediments within the constructed channel and mitigating the effects outlined above.
- As there will be a notable increase in flood depths and velocities (250 mm, 0.2 m/s) with the extreme flood events (1% AEP) without inclusion of the design features, the channel could experience erosion of softer bed and channel materials, with more bed rock becoming exposed and increased sediment transport. However, the inclusion of in-stream features is designed to mitigate these effects for smaller flood events. For more extreme flood events, these features will not mitigate these effects, but it should be noted that erosion already occurs in the pre-development scenario for large flood events.
- It is expected that the increase in flow volumes, particularly on the more extreme event spectrum, will cause the stream to widen where the channel exists in softer ground (soil as opposed to rock) and create a similar profile to the reach downstream of the existing downstream confluence of the Mangapū Tributary. The rate of widening will depend on the frequency of high flow events and the duration. The widening of this reach will cause the stream flows to slow and become shallower, thus reducing the erosion and restricting more widening, as the stream finds a natural equilibrium without the need for intervention. The effect of widening is considered less than minor as it will not negatively affect the conveyance of flows.

4.2.3.2 Downstream of the existing Mangapū Tributary confluence

- In the 100-year event the model demonstrates negligible change in flood velocities, with a minor increase in flood depths (<30 mm, Figure A1, Appendix B). The erosion potential is expected to be less than minor.
- In the 10-year ARI (10% AEP) and MAF there is a minor increase in velocities of up to 0.05 m/s. This is a small increase in velocity and is expected to have a less than minor effect on the erosion risk.
- The changes to the confluence location will have a localised impact on the sediment load in the stream around the existing confluence, as

sediment will no longer be entering at this location. Any deposition which is currently occurring will slowly cease, which could alter the shape of the stream channel at this location. These would be gradual changes such as natural removal of accumulated sediments and a slow altering of the channel shape. Downstream of the existing confluence the effect is likely to be minor.

5.0 Summary of Effects

This report has assessed the effects of the realignment of the Mangapū Tributary on flood levels / depth and flood velocities for extreme flood events to determine the impact of erosion and geomorphic change in the stream and to flood risk to people, properties, infrastructure and the environment.

The effects on flood levels are summarised as:

- flood levels are expected to increase up to 50 mm in forested areas (FCIL land), up to 15 mm in rural residential areas, and with no effect on existing buildings. The effects on flood levels are less than minor.

The effects on erosion and stream morphology are summarised as:

- The proposed stream realignment will have an impact on flood depths and velocities with increases of up to 500 mm and 0.2 m/s respectively for extreme flood events (1% AEP). For smaller events the increases are notable.
- These increases due to extreme events are expected to locally widen and deepen the Mangapū Stream in places as the stream finds a natural equilibrium. Any erosion due to increased flows and velocities will likely transport more of the softer, looser stream bed sediments and expose more bedrock. The increased transportation of sediment will lead to deposition downstream in areas of the stream where velocities drop (i.e. on the inside of bends).
- Increased velocities will be mitigated by the stream channel design incorporating in-stream features to slow the flow and reduce the hydraulic energy, thus reducing the erosion potential and the transport of sediment. However, these features will not mitigate these effects when more extreme event flows are encountered.
- Downstream of the existing confluence of the Mangapū Tributary changes in flood depths (increase of less than 50 mm) and velocity (increases of less than 0.05 m/s) are considered minor. Although some changes to the streams sediment load and condition are expected due to changes upstream, the impact downstream of the existing confluence is less than minor.

6.0 Operational Maintenance

As part of operating and maintaining the realigned stream channel, an operational maintenance plan will be prepared to align with the Stream Realignment Management Plan. The plan will detail key operational requirements such as routine inspections to inform maintenance needs along with flood response and associated repairs in order to maintain the design intent and mitigate adverse effects.

Maintenance of riparian vegetation

Riparian planting maintenance is essential for achieving long-term objectives in water quality, erosion control, habitat enhancement, and channel stability. Neglecting maintenance can lead to ecological failure, increased sediment loads, and costly remedial works.

Riparian management maintenance activities include:

- Regular inspections to monitor plant survival, removal of invasive species and to maintain stream bank integrity.
- Replacement of dead plants to maintain continuity in vegetation/ riparian buffer (particularly important in early growth stages)
- Removal of sediment/ debris following a flood event that may hinder growth.
- Rehabilitation following flood events.

Flood and Erosion Response

The proposed realigned stream channel incorporates a dual low flow and flood channel design that has been designed to not overtop for events up to a 1% AEP event. It is acknowledged that maintenance and repair work will likely be required following significant flood events, particularly in the early establishment years of the channel. The Stream Realignment Management Plan will incorporate a post-flood response protocol which will detail the necessary process and repair provisions should the realigned channel and banks be damaged during a flood event. Such damage may include bank washout, loss of channel meanders, loss of boulders/ woody debris as well as localised scour and erosion throughout the stream corridor.

7.0 Conditions

The following conditions are proposed:

1. The Consent Holder must undertake continuous flow gauging on the Mangapū Stream and Mangapū Tributary on the granting of the consents, to refine the hydrological assessment for the detailed design phase.
2. The Consent Holder must develop and finalise the detailed design on the basis of the design drawings (A035680017-WR-101 – 104, A035680017-WR-201 – 202, A035680017-WR-301). Final plans must be submitted to the Manager for approval prior to commencing construction.
3. The Consent Holder must follow the monitoring conditions as set out in the Stream Realignment Management Plan.

8.0 Conclusions

The proposed realignment of the Mangapū Tributary is a critical component of the Hunua Quarry development. This realignment is designed to facilitate the expansion of the quarry while ensuring the preservation of the stream's ecological and hydraulic functions. The preliminary design incorporates in-stream features found on the Mangapū Tributary and aims to replicate the stream environment whist also enabling the stream to perform hydraulically without adverse effects within the quarry site or the adjacent land. The design accommodates the requirements for fish passage by including appropriately sized features that do not prevent fish travelling up and downstream, that manage stream velocities to enable fish movement and provide habitat for the noted species.

The hydraulic modelling and assessment of effects indicate that the realignment will result in minor increases in flood depths and velocities, primarily confined to the reach between the new downstream diversion confluence and existing Mangapū confluence (FCIL land). These changes are expected to lead to natural adjustments in the stream's morphology, with potential erosion and sediment transport effects being managed through the design features and ongoing maintenance.

Overall, the realignment of the Mangapū Tributary will support the development of the quarry while minimizing adverse environmental impacts. The design ensures that the new stream channel will provide equivalent ecological and hydraulic functions, supporting the long-term sustainability of the quarry operations and the surrounding environment.