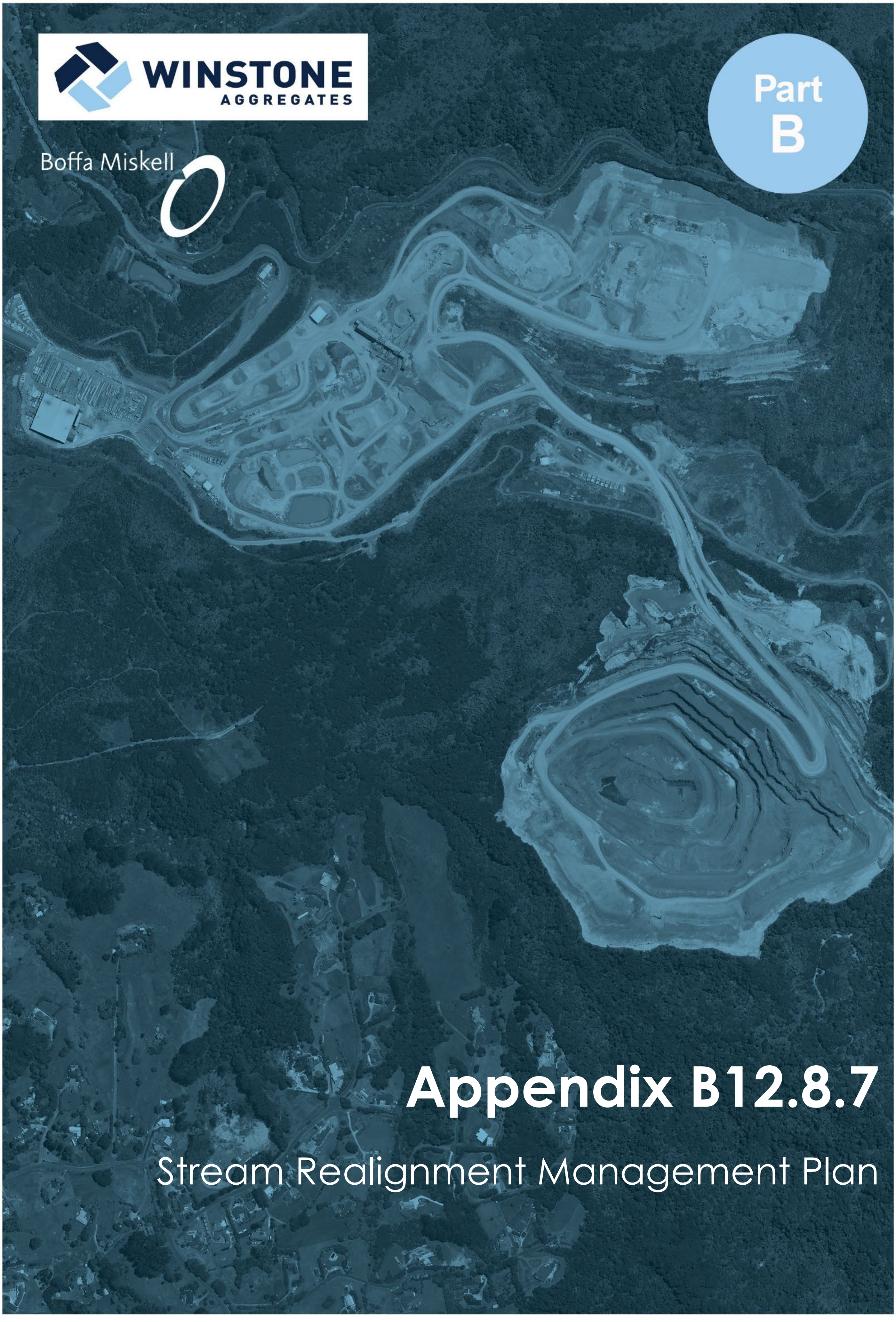

Part B

Appendix B12.8.7

Stream Realignment Management Plan

Boffa Miskell

HUNUA QUARRY DEVELOPMENT

MANGAPŪ STREAM TRIBUTARY REALIGNMENT MANAGEMENT PLAN

30 MARCH 2026

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Boffa Miskell Limited, March 30, 2026 10:41 am. Mangapū Stream Tributary Realignment Management Plan Report prepared by Boffa Miskell Limited for Winstone Aggregates Ltd.

For any information regarding this report please contact:
Stephanie Styles | Planner | Associate Partner | stephanie.styles@boffamiskell.co.nz

REVISION / VERSION:	ISSUE DATE:	CONTRIBUTORS:	DESCRIPTION:	REVIEWED BY:
Final	30/03/2026	Ian Boothroyd | Partner | Ecologist | Boffa Miskell John Goodwin | Consulting Partner | Registered NZILA Landscape Architect | Boffa Miskell Amanda Anthony | Associate Principal | Registered NZILA Landscape Architect | Boffa Miskell Thomas Guthrie | Senior Professional | Registered NZILA Landscape Architect | Boffa Miskell Lance Roozenburg |Associate Principal | Registered NZILA Landscape Architect | Boffa Miskell Verity Kirstein | Service Leader – River Engineering | Pattle Delamore Partners Ltd Parviz Namjou | Technical Director – Water Resources | Pattle Delamore Partners Ltd Phil Mathewson | Engineering Geologist | Tonkin+Taylor Jade Wikaira |Tumu Whakarae I Managing Director | Wikaira Consulting Limited	Final report issued for lodgement	Lucy Deverall Associate Principal | Planner Stephanie Styles Associate Partner | Planner

APPROVED FOR ISSUE:
Stephanie Styles | Planner | Associate Partner | 30 March 2026

RELEASE AND RELIANCE

This report has been prepared by Boffa Miskell Limited on the instructions of our Client, in accordance with the agreed scope of work. If it is intended to support an application under the Fast-track Approvals Act 2024, it may be relied upon by the Expert Panel and relevant administering agencies for the purposes of assessing the application.

While Boffa Miskell Limited has exercised due care in preparing this report, it does not accept liability for any use of the report beyond its intended purpose. Where information has been supplied by the Client or obtained from external sources, it has been assumed to be accurate unless otherwise stated.

File name & Project number: [Document1] BM250939

File ref: BM250939_Mangapū_Stream_Tributary_Realignment_Management_Plan_20260330

Cover photograph: Mangapū Stream Tributary, © BML, 2025.

Tonkin+Taylor pdp WIKAIRA CONSULTING

CONTENTS

1.0 INTRODUCTION

MANGAPŪ STREAM TRIBUTARY REALIGNMENT

A new alignment of a tributary to Mangapū Stream will be established along the southern boundary of the Winstone Aggregates Quarry Development Area to accommodate the pit expansion. Refer to **Figure 1**. The realignment will create a meandering, naturalised channel with riparian vegetation, in-stream habitat features, sediment control devices (if required) and separation from operational surface water controls. The new stream channel will be fully commissioned before any realignment of water occurs.

The realignment of the Mangapū Stream Tributary has been designed to minimise the ecology, landscape and natural character effects. The design focuses on restoring stream and riparian habitats that will be lost as a result of the Stage 1 quarry development, while ensuring water quality is maintained, and sediment is effectively controlled. Wetland and riparian plant species will be integrated to promote greater biodiversity, supported by targeted pest plant and animal control within the surrounding area. In addition, flood management measures have been incorporated into the overall design to improve flood resilience and ecological function.

PROPOSED WORKS

Initially, it is proposed to install a 7m wide bridge over the Mangapū Tributary to provide access to the works area. The bridge piles will be located outside the stream bed, which will ensure that the tributary remains intact prior to the new stream channel being constructed and fully commissioned. Vegetation clearance may be required and will commence once gecko salvage has been undertaken and outside the kereru nesting season (September to April). Approximately 5.5 hectares of vegetation (including low kanuka shrubland, tall kanuka forest, and mature podocarp-broadleaved forest) will be removed during the first season of works to enable machinery to access the tributary and works area. The bridge will be installed during April or May, when water flows are low, and once vegetation clearance and gecko salvage have concluded. The bridge will be removed following completion of the stream realignment works (Stage 2). The detailed construction methodology for the bridge installation is provided in The Stream Crossing Report prepared by Winstone Aggregates.

Once vegetation clearance has commenced, baseline and detailed topographical surveys can be undertaken to inform the design of the required earthworks. A 10m wide access road on the western side of the future tributary alignment will be constructed, and sediment control infrastructure will be installed during the earthworks season (October-April). Erosion and sediment control will be undertaken in accordance with the Hunua Quarry ESCP. In particular runoff containing sediment will initially discharge to the existing 150RL ponds. Once the clearance of vegetation has been completed, a new sediment pond will be constructed at the same location as the 150RL ponds and have the same discharge location.

The crest/starting position of the overburden stripping will be established, ensuring a minimum 10 m offset from the neighbouring property boundary. The stripping of overburden will occur from the top of the slope above the access road, working down towards the existing quarry pit. The soil and overburden that is able to be free-dug (i.e. no drill and blast) will be removed first using a 100t excavator and 100t ridged axel trucks. A 10m high noise bund will be retained at the southern end of the cut to provide noise and dust mitigation for properties beyond the site boundary. This will be lowered as the earthworks progress down the slope, with the bund being removed to enable the formation of the discharge point of the realignment. A total of approximately 900 BCM of overburden material will be removed to the Hunua OBDA.

The aggregate will then be extracted, creating a series of benches as per standard quarrying practice, requiring drill and blast to then dig and cart the product to the processing facility. The batter faces will be designed to be 10m in height at 50º with 7m benches above the realignment to the east and west. A total of approximately 420,000 BCM of rock will be removed, which will be used as production feed and sold. The last bench of this stage will be at least 30m wide, enabling sufficient space to create a meandering tributary with riparian planting and to construct an access road to the west of the new tributary alignment. The 30m wide bench will enable:

- A 1m offset from the toe of the eastern slope,
- 19m wide high flow stream channel,
- 1m wide low flow channel that meanders within the 19m wide high flow corridor,
- 10m wide access road on the western side of the realignment corridor; and
- 470m of stream length when measured as a straight channel at 1:16.6 grade from inlet to outlet (and 570m in length when measured as a meandering channel).

Soil material will be placed on the west-facing benches and planted or hydroseeded to improve visual amenity of the cut face and improve integration with the backdrop of the outstanding natural landscape.

The tributary channel will be formed using a bulldozer and excavators. The 'U' shaped meandering bed will be approximately 1m wide, with boulders placed within it to create features to manage flow velocity and create a more diverse habitat. In addition, waterfalls will be constructed to emulate existing morphological features of the existing stream, ensuring continuity of natural character, aesthetic and ecological functions. They are also needed to provide for and facilitate grade transitions and to achieve the required longitudinal stream profile. These design features will also provide fish passage for native climbing fish.

The entire flow corridor including the channel will be lined with low permeability material and be of sufficient width to contain a 1 in 100-year

1.0 INTRODUCTION

flood. To enable planting in the riparian margins/flow corridor, topsoil will need to be spread and stabilised with native plant species (similar to that being cleared) along with boulders and rocks. There will be a need to step the channel down using cascades consistent with the existing tributary. Once the channel is complete, water from the existing tributary will be diverted to the new tributary in phases. This will be achieved through careful placement of rock, gravels, sandbags and geotextile fabric at the head of the new channel. The rate and realignment of flow will be adjusted by adding / removing materials.

The works will take approximately 4 years, with the tributary proposed to be commissioned in June 2031 and will form part of the enabling works, reliant upon the long term construction noise limit.

Engagement with Ngāti Tamaoho, Te Ākitai Waiohua and Ngāti Te Ata is underway and will continue throughout the project. Key interests in discussion include extending mana whenua involvement beyond cultural monitoring during stream works to include expectations around restoration, ecological connectivity, and landscape outcomes.

PURPOSE

The purpose of the Mangapū Stream Tributary Realignment Management Plan (referred to as 'the Management Plan' in this report) is to guide the design, implementation, and long-term establishment of a realigned stream channel that supports a healthy, resilient and culturally aligned freshwater ecosystem. This plan integrates hydrological, geomorphological, groundwater, landscape, ecological, and cultural considerations to ensure the realignment achieves the desired water quality, habitat and biodiversity outcomes.

Central to this approach is the recognition that a well-designed and ecologically functioning stream realignment constitutes remediation of environmental effects and therefore avoids the loss of stream extent and values, consistent with the requirements of the National Policy Statement for Freshwater Management 2020 (NPSFM). The plan sets out a detailed framework for establishing a diverted stream reach that functions as a connected, self-sustaining ecosystem, supporting both ecological integrity and mana whenua values.

The outcome is, as much as practicable, aimed at designing and creating a realigned stream with the equivalent characteristics and ecological values of the existing Mangapū Stream Tributary.

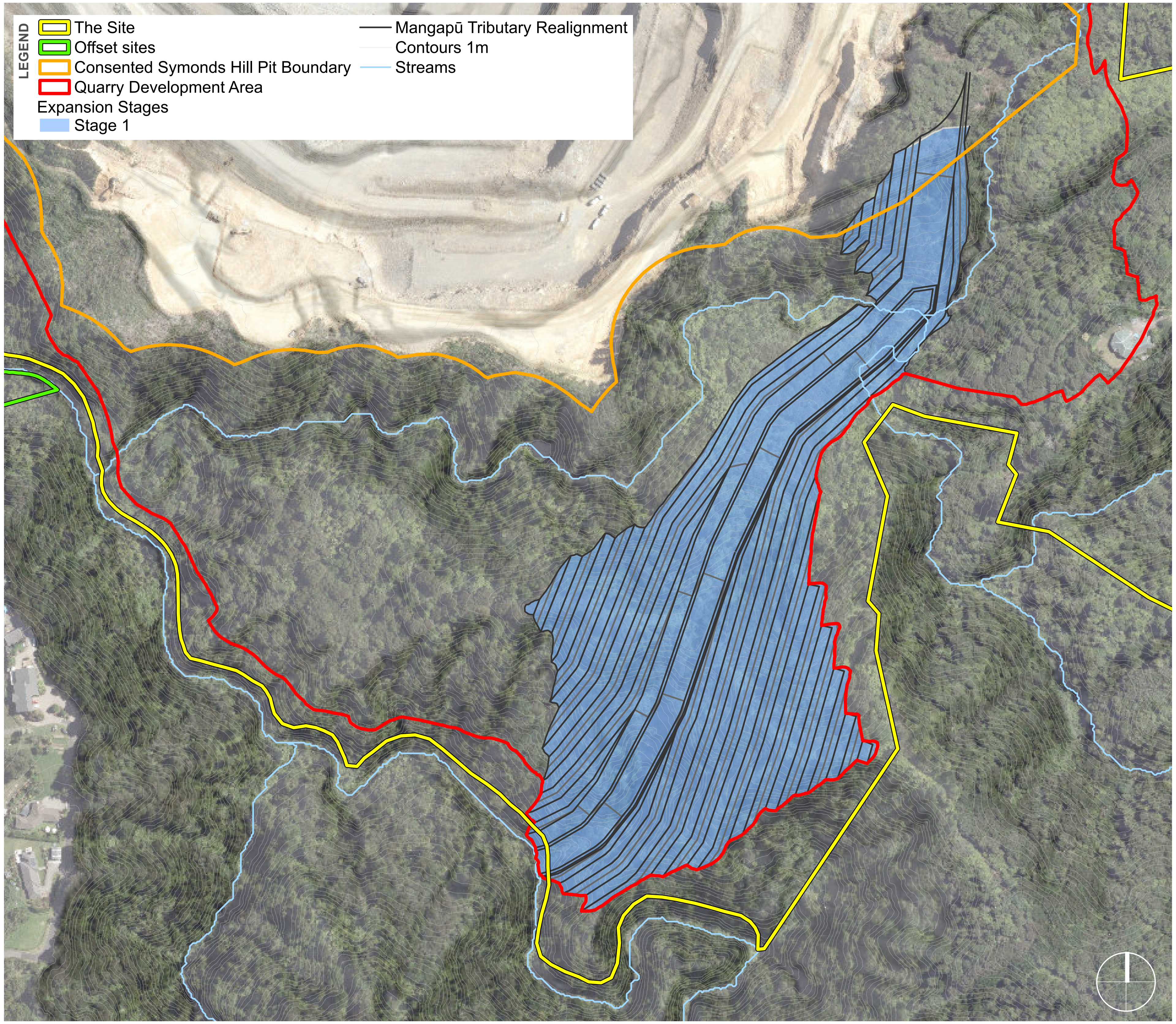


Figure 1: Indicative realignment of the Mangapū Stream Tributary.

1.0 INTRODUCTION

OBJECTIVES

To realign and rehabilitate the Mangapū Stream Tributary in a manner that restores natural stream processes and form, enhances ecological values, and protects and strengthens the natural character of the waterway and its margins, while supporting long-term freshwater health and resilience. This will be achieved by:

- Realigning the Mangapū Stream Tributary to mimic natural channel morphology, hydrology and habitat diversity; and
- Incorporating riparian planting and instream features to support aquatic biodiversity and natural character attributes.

POLICY CONTEXT

Stream realignments are directly influenced by several key requirements in the NPSFM. The NPSFM sets a national direction that prioritises the health and well-being of freshwater bodies and requires councils and applicants to avoid loss of river extent and values wherever possible. In summary, under the NPS-FM, a stream realignment must:

- Avoid loss of river extent and values wherever possible;
- Demonstrate a functional need for the activity;
- Apply the effects management hierarchy systematically;
- Prioritise the health and wellbeing of the river under Te Mana o te Wai;
- Create an ecologically functioning stream that maintains or improves ecosystem health.

Under the provisions of the Auckland Unitary Plan (Operative in Part), the existing quarry is zoned Special Purpose – Quarry Zone (SPQZ), but the proposed expanded works will extend the quarry into the adjoining Rural - Mixed Rural Zone. The expanded quarry site is also subject to the following overlays:

- Quarry Buffer Area (Chapter D27)
- Outstanding Natural Landscape (ONL) (Area 60 Ponga Road),
- Significant Ecological Areas (SEA) (SEA_T_5323 and SEA_T_7032),
- High Use Stream Management Area (HUSMA) and
- Natural Stream Management Area (NSMA).

The site is also subject to the Council's Proposed Plan Change 120 Housing Intensification and Resilience (PC 120). This proposed plan change includes provisions to better manage development for natural hazards across the region. In the case of the Hunua Quarry, the site and wider area is identified as containing flood hazard areas, flood plains, flood prone areas and being subject to landslide susceptibility hazards. These provisions have immediate legal effect.

INFORMATION SOURCES

This Management Plan has been prepared using the baseline data, analysis, and findings contained within the technical documents listed below as they relate to the Hunua Quarry Development. The following technical reports shall be read in conjunction with this Mangapū Stream Tributary Management Plan.

a. Cultural Values and Consultation Summary Report, prepared by Wikaira Consulting, dated March 2026.

b. Assessment of Ecological Effects, prepared by Boffa Miskell, dated 18 March 2026.

c. Mangapū Tributary Realignment - Preliminary Design and Effects Technical Report, prepared by PDP, dated 19 March 2026.

d. Erosion and Sediment Control Assessment Report, prepared by MPD Environment Limited, dated March 2026.

e. Technical Report – Geotechnical Assessment, prepared by Tonkin & Taylor Ltd, dated March 2026.

f. Groundwater Effects Assessment, prepared by PDP, dated March 2026.

g. Landscape Effects Assessment, prepared by Boffa Miskell, dated 23 March 2026.

h. Landscape Rehabilitation Strategy and Management Plan, dated 17 March 2026.

i. Pest Management Plan, prepared by Boffa Miskell, dated March 2026.

ASSUMPTIONS

The Management Plan has been developed based on the best available information at the time of writing. The following assumptions underpin the plan and its recommended approach:

a. Evolving Technical Inputs: It is assumed that hydrological, geomorphological, ecological, groundwater, landscape, and cultural assessments will continue to be refined as additional data is collected. The plan anticipates iterative updates as specialist investigations progress and as site-specific information becomes available through design development and field validation.

b. Provisional Design Parameters: The realignment design, including channel geometry, riparian establishment, and hydraulic performance criteria, is based on preliminary assessments. These parameters may be adjusted as modelling, environmental monitoring, and expert reviews provide further clarity.

c. Availability of Baseline Information: It is assumed that baseline data relating to existing stream conditions, water quality, cultural values, and ecological characteristics are sufficiently accurate for early-stage planning. Any discrepancies identified during subsequent investigations may require refinement of methods, design detail, or implementation sequencing.

d. Stakeholder and Mana Whenua Engagement: The plan assumes ongoing collaboration with mana whenua and relevant stakeholders, with the understanding that cultural considerations and recommendations may evolve and will be incorporated into revised plan iterations.

e. Responsive Management Approach: The plan assumes that responsive management principles will be applied during design finalisation, construction, and post-construction phases. This includes the ability to modify construction sequencing, vegetation specifications, erosion-control methods, or ecological enhancement measures in response to monitoring outcomes or unforeseen site conditions.

f. Construction Feasibility: Implementation assumes that physical conditions (geotechnical constraints, groundwater behaviour, flood events, access needs) remain broadly consistent with technical assessments. Any unexpected site constraints may necessitate alterations to timing, methodology, or design detail.

2.0 EXISTING ENVIRONMENT

MANGAPŪ STREAM CATCHMENT

The Mangapū Stream forms part of the Slippery Creek catchment (along with Slippery Creek, Hays Waipokapū Stream and Waihoihoi Stream). Refer to **Figure 2**. These discharge via Slippery Creek to the upper Pāhurehure Inlet of the Manukau Harbour beneath the Southern Motorway Over bridge.

Auckland Council (2015) report that some 50% of the Slippery Creek catchment is pastoral land, over 25% of the catchment is dominated by indigenous forest and a further 5% in exotic forestry blocks. Less than 15% of the total catchment is currently built up, however under the AUP, this may double to 30% of the total catchment area.

Auckland Council (2015) surveyed a total of 20 km of Mangapū Stream, including 2.6 km of intermittent to ephemeral stream. The catchment was classified into three mainstream types:

- Low land agricultural.
- High land native forest.
- High Land agricultural.

Auckland Council (2015) describe the high land native forest streams (upper 7 km of the main channel of Symonds Stream), as typically 2.5 to 3 m wide but up to 5 m wide in places with an average depth of approximately 0.4 m except for parts of the mainstem, which averaged 0.7 m deep with pools up to 1.3 m deep. Banks averaged 0.4 to 2 m high with less than 20% erosion. The three highest scoring SEV sites (SC1, SC9, SC10) were within the High Value Indigenous Forest Management Zone, with all three sites scoring higher than 0.83. (i.e., high-quality stream function).

Auckland Council (2015) recommended the following goals and objectives for the High Value Indigenous Forest:

- Protect high value natural streams and gullies within significant ecological areas to maintain reference conditions.
- Protect shortjaw kokopu habitat.
- Improve fish passage downstream to enable access to high-quality habitat.
- Support Kauri dieback disease control programmes.
- Control feral goat and deer populations to reduce damage to watercourses and riparian vegetation within existing covenant areas.

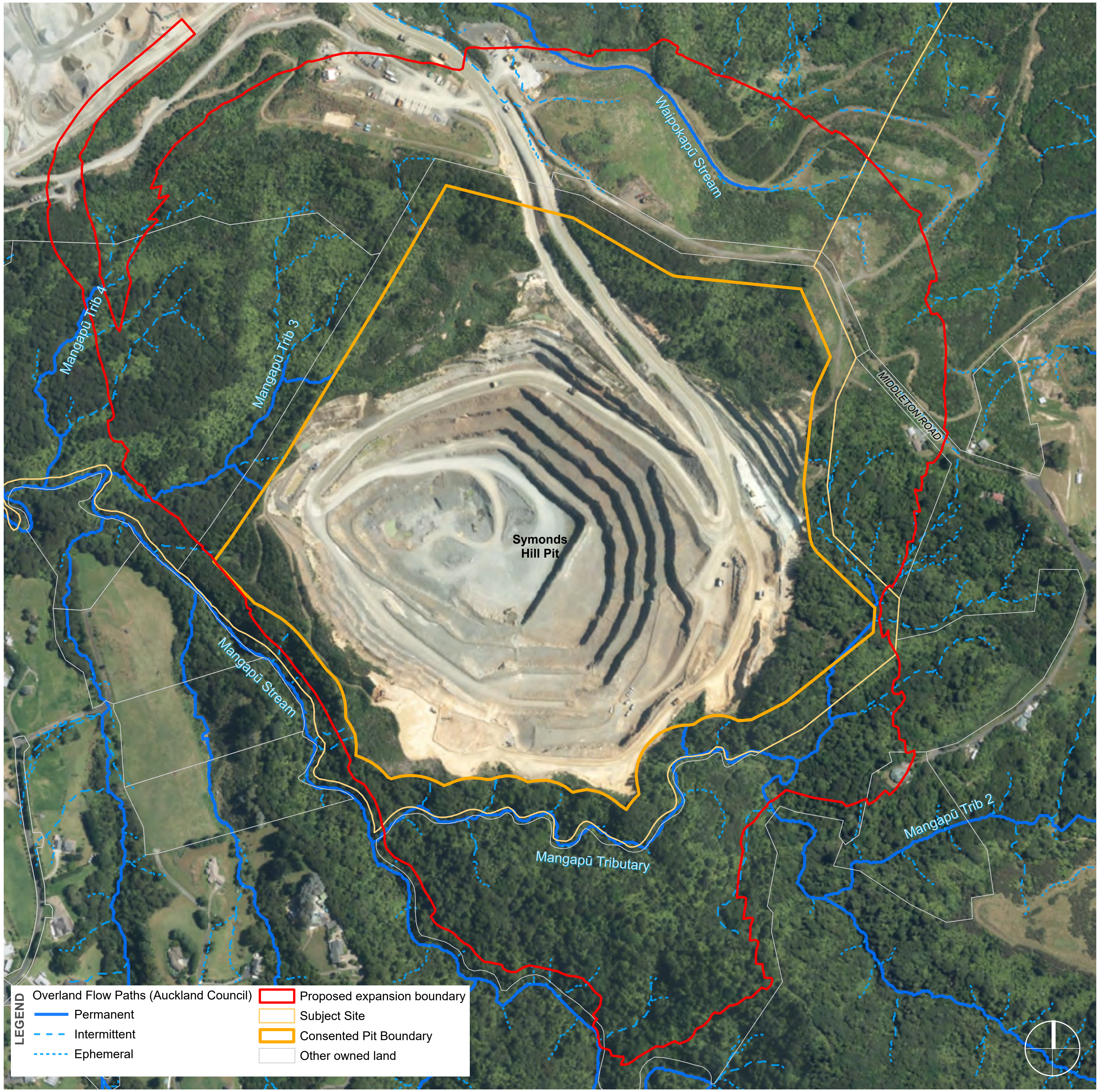


Figure 2: Freshwater Catchments, BML.

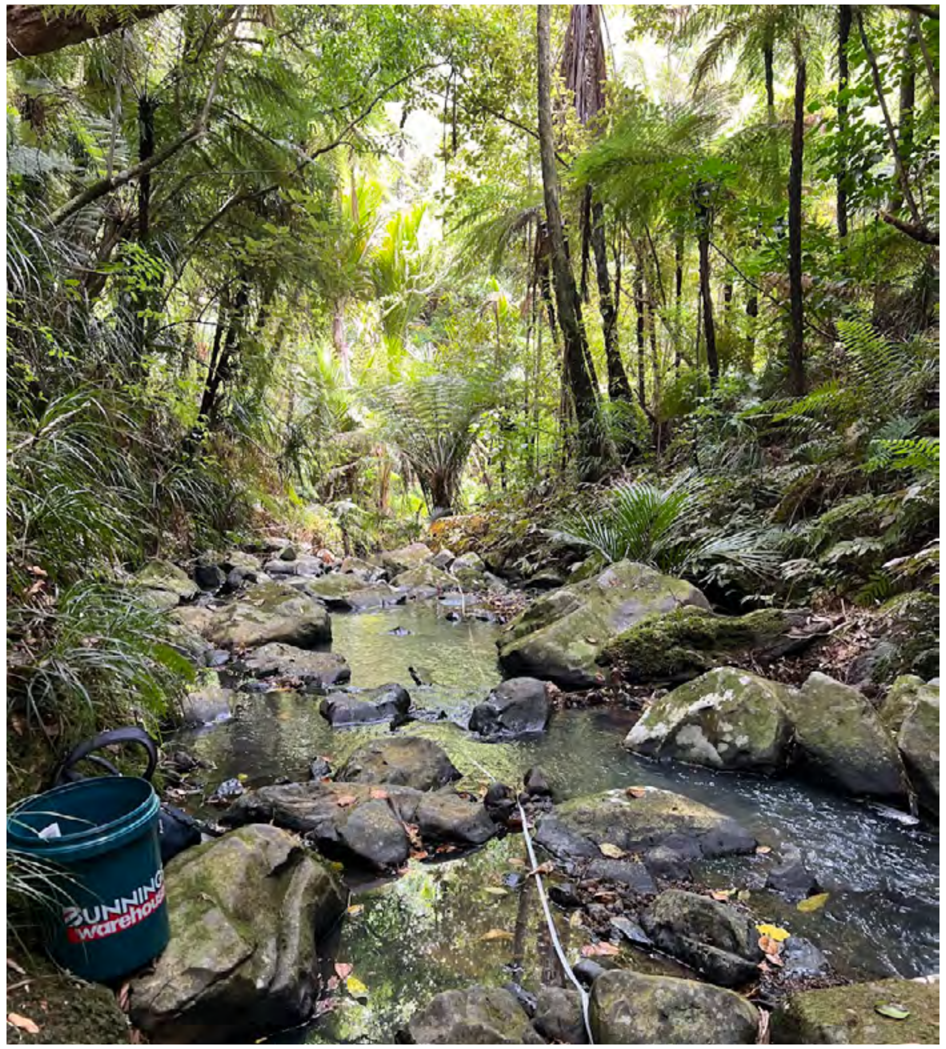
2.0 EXISTING ENVIRONMENT

ECOLOGICAL CONDITION AND VALUES

STREAM HABITAT

LOWER REACHES

In the lower reaches of the Mangapū Stream Tributary, the stream channel ranges from 0.9 – 5.7 m wide, with depths ranging from 0.02 - 0.90 m. Hydrological heterogeneity is high along the reach with a mix of slower runs, riffles and deep and shallow pools present. Large boulders and bedrock are abundant, with cobbles and gravels common. Small streamside gravel bars are present. Stream banks are highly variable, from 0.2 m in some locations to >2m high near vertical in other areas. Riparian vegetation is well established with a thick canopy and abundant understorey, providing shade to over 90% of the stream surface. The riparian community consists of abundant nikau and ponga and abundant parataniwha (*Elatostema rugosum*) along the stream banks. Bryophytes are abundant on large boulders and bedrock banks.



MID-REACHES

In the mid-reaches of the Mangapū Stream tributary (upper reaches of the stream to be realigned), the channel is some 1.5 – 5.5 m wide, with a depths ranging from 0.41 - 0.49 m. Hydrological heterogeneity is high along the reach with a mix of riffles, runs and deep and shallow pools present. The stream substrate is dominated by a strong mix of cobbles, gravel, bedrock and silt /sand with fewer large boulders than the lower reaches. Riparian vegetation is well established with a well-developed canopy and abundant understory. This vegetation provides shade to approximately 75-85% of the water surface, with some areas of open sunlight. The riparian community consists of abundant nikau and ponga and abundant smaller ferns along the stream margin. Wood debris and undercut banks are present within the mid-reaches.

HEADWATERS

Although not subject to the realignment, this section briefly describes the nature of the headwaters which continue as that feature and remain connected to the proposed realigned section of the tributary. Sampling and observations of the headwater gullies was undertaken in 2021 as part of earlier proposals for pit expansion, that did not progress at that time.

The headwater streams occur in an area of varied topography including a series of gullies running generally north to south through the SEA_T_5323. Most headwater watercourses were classified as ephemeral, with some intermittent reaches also identified. This classification was based on the overland flow path GIS layer, observations from the ecologists and sampling on site. The headwaters of the gully features were formed with a mix of broad and narrow gullies, with mostly no evidence of stream channels or banks. The classification of intermittent streams commenced where incised stream channels were apparent and/or shallow pools were evident in accordance with AUP stream classification criteria.

Where intermittent streams were evident, the channel was typically shallow, with a streambed that was predominantly silt/sand with areas of small gravels and woody debris. The stream channel was narrow, with low immediate channel banks within the wider gully. Stream shade was relatively high, with some open patches in the lower reaches.

2.0 EXISTING ENVIRONMENT

ECOLOGICAL CONDITION AND VALUES

VEGETATION COMMUNITIES

The typical vegetation of the Mangapū Stream tributary catchment occurs as remnant areas within lowland areas of the site, typically on fertile alluvial or colluvial soils with good moisture availability. These areas have experienced comparatively limited historic disturbance and retain characteristics of mature indigenous forest. Refer to **Figure 3**.

Structurally, this vegetation is a tall forest with a well-developed vertical profile. Canopy height typically ranges from approximately 18–25 m, with four distinct strata evident: an upper canopy dominated by mature trees, a subcanopy of shade-tolerant species, a shrub layer, and a fern-dominated ground layer. Canopy cover is generally high (>90%), creating shaded understory conditions.

Dominant canopy species include taraire (*Beilschmiedia tarairi*), tawa (*Beilschmiedia tawa*), and pukatea (*Laurelia novae-zelandiae*). These species are diagnostic of this vegetation type and occur consistently throughout remnant stands, with a diverse assemblage of broadleaved shade-tolerant understorey species present beneath, often dominated by pūriri (*Vitex lucens*), nīkau (*Rhopalostylis sapida*), ponga, mahoe, pigeonwood, kohekohe (*Dysoxylum spectabile*), rewarewa (*Knightia excelsa*), and parataniwha (*Freycinetia banksii*) as a common groundcover. Less commonly, white maire (*Nestegis lanceolata*), rimu (*Dacrydium cupressinum*), kahikatea (*Dacrycarpus dacrydioides*) and tōtara (*Podocarpus totara*) are present as subcanopy and canopy trees in some slope areas.

This vegetation best fits the description of the WF9 vegetation type in Singers et al. (2017): Taraire, tawa, podocarp forest. This ecosystem type has a regional threat status of "Endangered" under the IUCN ecosystem threat classification (Singers et al., 2017).

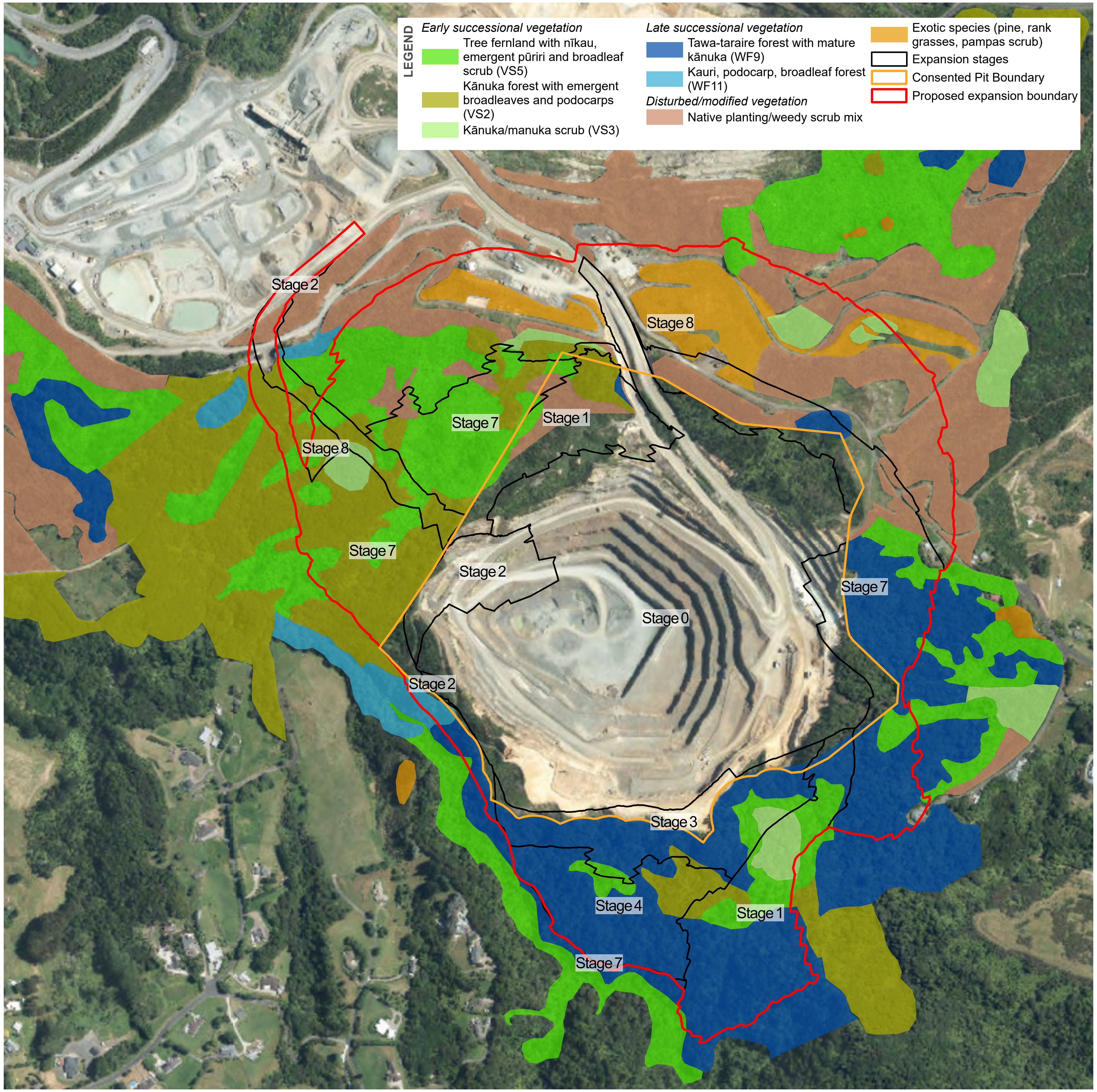


Figure 3: Vegetation types of the Site, BML.

2.0 EXISTING ENVIRONMENT

ECOLOGICAL CONDITION AND VALUES

The freshwater sampling areas are illustrated on **Figure 4** and the findings are described below.

ENVIRONMENTAL DNA: AQUATIC BIOLOGICAL COMMUNITIES

The eDNA results confirmed the presence of climbing fish species (eels and banded kokopu), including longfin eel (At Risk declining) and the absence of swimming species (refer to **Table 1**). Detection strength of eels was greatest in the lower-mid-reaches of the tributary, and the reverse for banded kokopu. Nevertheless, the tributary provides passage for these climbing fish throughout its extent. The eDNA also confirmed the presence of two mayfly species Zephlebia pirongia and Z. aff. tuberculata sp.1 both of which are classified as naturally uncommon.

Common name	Scientific name	Māori Name	Threat status	Site 1 Downstream of tributary	Site 2 Mangapū Stream tributary	Site 3 Mangapū Stream tributary
Fish						
Longfin eel	*Anguilla dieffenbachii*	Tuna	At Risk – Declining	✓✓✓	✓✓	✓
Shortfin eel	*Anguilla australis*	Tuna	Not threatened	✓✓	✓	✓
Banded kōkopu	*Galaxias fasciatus*	Kōkopu	Not threatened	✓	✓	✓✓
Crustacea						
Freshwater crayfish	*Paranephrops planifrons*	Kōura	Not threatened	✓	✓	
Mollusca						
Mud snail	*Potamopyrgus antipodarum*		Not threatened	✓✓	✓	✓
Freshwater limpet	*Latia*		Not threatened / data deficient	✓		
Insecta						
Single gill mayfly	*Deleatidium lilli*		Not threatened	✓✓	✓	
Double gill mayfly	*Zephlebia pirongia*		Naturally uncommon	✓	✓	✓
Double gill mayfly	*Zephlebia aff. tuberculata sp.1*		Naturally uncommon	✓	✓	✓

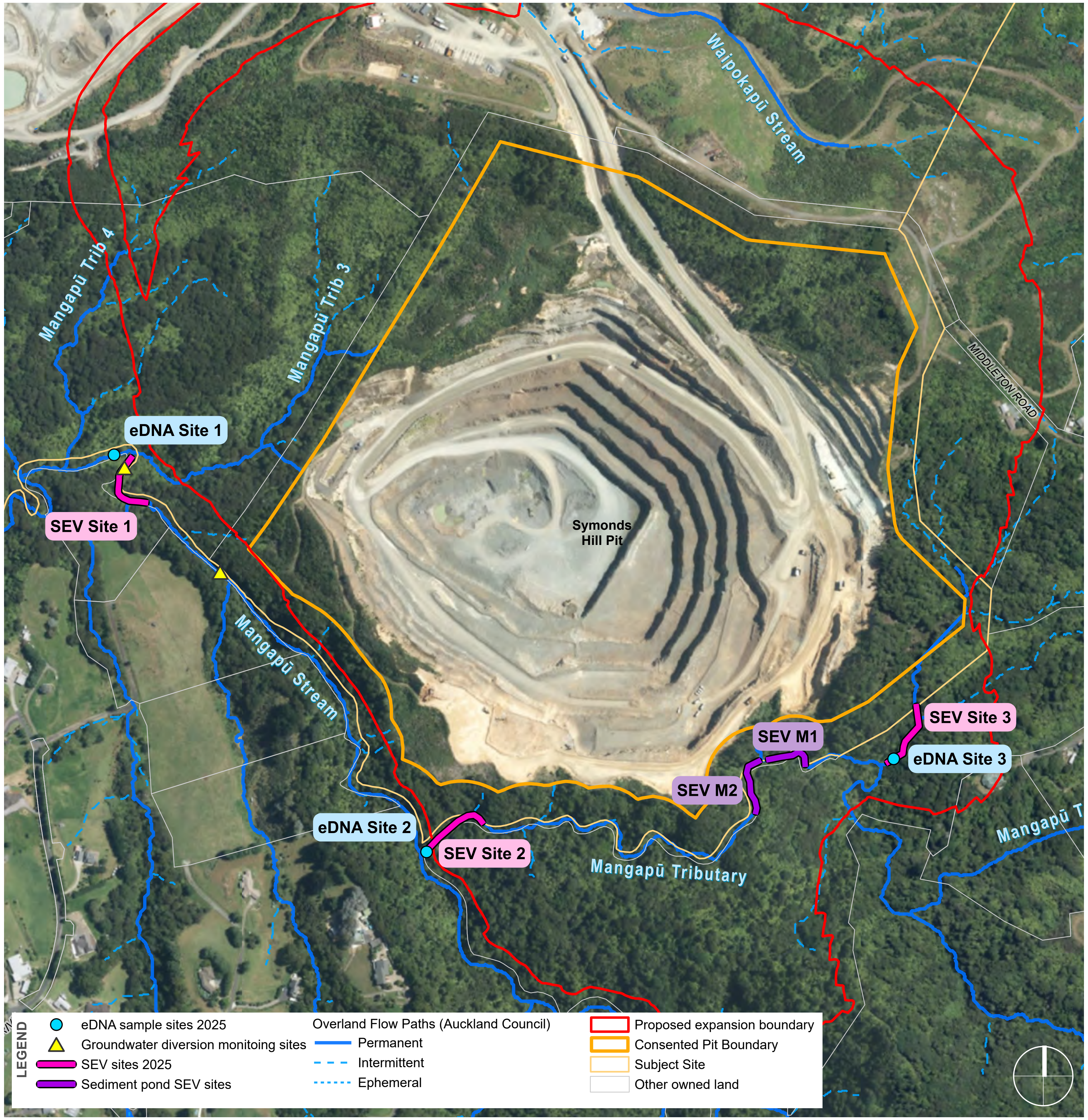


Figure 4: Freshwater Sample Sites, BML.

2.0 EXISTING ENVIRONMENT

ECOLOGICAL CONDITION AND VALUES

MACROINVERTEBRATES

Macroinvertebrate communities in the headwaters had low diversity (15 taxa) and were dominated by the mud snail Potamopyrgus (42%), followed by Diptera (21%). The EPT taxa mayflies accounted for 7.3% and caddisflies 2.1% of the community. The MCI-sb score of 113 is considered 'good' (Stark and Maxted, 2007). The eDNA sampling did not detect koura from our uppermost sampling point (Site 3, Figure 4).

FISH COMMUNITIES

No specific fish sampling was carried out in the Mangapū Stream tributary. Rather, we relied on the results of the eDNA sampling, as set out above. The eDNA results confirmed the presence of climbing fish species (eels and banded kokopu), including longfin eel (At Risk declining) but also confirmed the absence of swimming species. There are a number of significant waterfalls located within the Mangapū Stream that are likely to restrict upstream fish passage to all species except those with good climbing ability (i.e., eels and kokopu).

Detection strength of eels was greatest in the lower-mid-reaches of the tributary (Sites 2 and 3, Figure 4), and detection strength for banded kokopu was greatest in the upper reaches (Site 1, Figure 4). No introduced or pest fish were detected in the tributary. The ecological values of the Mangapū Stream tributary for native fish are high.

FROGS

Surveys were undertaken to assess suitable habitat and the presence of Hochstetter's frogs along the length of the current Mangapū Stream Tributary to be realigned. Habitat for Hochstetter's frogs was limited due to the incised nature of the stream and the sedimentation creating an embedded substrate (i.e., sediments surrounding and underneath the substrate rocks and cobbles meant little refuge available for frogs). Despite searches for Hochstetter's frogs, none were found. Overall, it is considered unlikely that Hochstetter frogs are present along the Mangapū Stream Tributary.

RIPARIAN VEGETATION

The vegetation surrounding the streams and rivers within the proposed expansion area were observed throughout both the stream and vegetation surveys. The immediate riparian species, those generally of low stature and providing direct stream shade and inputs, included parataniwha (*Elatostema rugosum*), kiokio (*Parablechnum novae-zelandiae*), hangehange (*Geniostoma ligustrifolium*), kanono (*Coprosma grandifolia*), wheki / rough tree fern (*Dicksonia squarrosa*), and kiekie (*Freycinetia banksii*). Vegetation within the riparian margin up to approximately 5 m away from the water's edge included some small shrubs and trees of larger stature. These included ponga / silver fern (*Alsophila dealbata*), nīkau (*Rhopalostylis sapida*), pāte (*Schefflera digitata*), heketara (*Olearia rani*), māhoe / whiteywood (*Melicytus ramiflorus*), mamaku / black tree fern (*Sphaeropteris medullaris*), tawa (*Beilschmiedia tawa*), and taraire (*Beilschmiedia taraire*).

SUMMARY OF THE ECOLOGICAL VALUES OF TRIBUTARY 1

The freshwater ecological value of the Mangapū Stream tributary is assessed as High, due to the high habitat quality and diversity with a natural channel, a forested catchment in native vegetation and an SEA), high shading, a diverse macroinvertebrate community with MCI scores ranging from 113 to 125. Stream function was also high with SEV scores from 0.8 to 0.91, and the presence of climbing native fish (including one classified as At Risk), and an absence of invasive or pest fish.

2.0 EXISTING ENVIRONMENT

LANDSCAPE CHARACTER AND VALUES

NATURAL CHARACTER OF THE MANGAPŪ TRIBUTARY

Mangapū Stream runs along the western boundary of the existing quarry, and several of its tributaries flow into it from the south to south-east. A series of character photographs of the Mangapū Stream Tributary within Stage 1 are included to the right.

The following key characteristics relating to the lower reach of the Mangapū Stream Tributary were identified during the Site visit. Based on these observations, the tributary is assessed as having a natural character rating of **High to Very High**.

- The lower reach of the Mangapū Stream Tributary displays a diverse range of natural features, including incised channel sections, waterfalls, and a sinuous, meandering path within a corridor that reflects natural fluvial processes rather than engineered modification.
- Hydrological heterogeneity is high along the reach with a mix of runs, riffles and deep and shallow pools present. Large boulders and bedrock are abundant, with cobbles and gravels common.
- The lower reach of the Mangapū Stream Tributary, its margins and wider landscape context exhibit a high degree of natural character, evidenced by the presence of mature indigenous vegetation, located within SEA_T_5323, (and limited exotic weed species) providing extensive and continuous canopy cover. This vegetation contributes to shading, bank stability, and habitat connectivity.
- Riparian vegetation is well established with a thick canopy and abundant understorey, providing shade to over 90% of the stream surface. The riparian community consists of abundant nikau, ponga and abundant parataniwha (*Elatostema rugosum*) along the stream banks. Bryophytes are abundant on large boulders and bedrock banks.
- The form and behaviour of the Mangapū Stream Tributary are strongly influenced by the surrounding landform, with geomorphology and surface topography guiding channel alignment, gradient, and flow dynamics.
- The tributary and Mangapū Stream are partly located within an ONL, which also reinforces its high natural character.

Figure 5: Character images of the Mangapū Stream Tributary.

OUTSTANDING NATURAL LANDSCAPE OVERLAY

Underlying values (ID60, Ponga Road) relate to the following:

- Extensive sequence of mature and regenerating native forest, combined with strongly articulated stream corridors that reinforce the natural qualities of this rolling to dissected hill country landscape
- Interplay of indigenous forest remnants and pasture, reinforcing topography
- Strong elevated relief as part of the wider hill sequence
- Extensive areas of native forest, native shrubland and stream corridors
- Very marked naturalness values and strong interplay of underlying topography with areas of bush and more peripheral pockets of pasture
- Strong sense of naturalness evident in the forest and shrubland areas, together with the terrain
- Very apparent greywacke hill landform overlain with shrubland/forest/stream corridor sequence

2.0 EXISTING ENVIRONMENT

GROUND MODEL AND INVESTIGATIONS

Ground conditions of this area are summarised on Geological Cross Section 4 (**Figure 7)** and Geological Long Section 8 (**Figure 8**). The location of the section lines and the geotechnical investigation sites are shown on the Investigation Location Plan, **Figure 6**.

Additional investigations in this area were undertaken for this study to provided subsurface geology control for assessment and design purposes. This included:

- Borehole HUN25/2 was completed near the crest of the Mangapū Tributary realignment cut (191m RL) to a depth of 80m below ground level (bgl). A typical greywacke profile was observed, becoming slightly weathered at 30m bgl and then into fresh/unweathered greywacke at 37m bgl.
- Borehole HUN25/3 was located midway up the slope (150m RL) and was drilled to a depth of 35m bgl. Residual and completely weathered soils were identified to a depth of 12m bgl, highly weathered greywacke to 20m bgl, and then becoming moderately weathered to the end of the hole.
- Four test pits were completed at the northern end of the proposed alignment at lower elevations (141m to 144m RL) and encountered completely to highly weathered greywacke at their final depth (4m to 5m bgl).

The information gathered indicated moderately to highly weathered greywacke was mapped at the northern (upstream) end of the proposed alignment in the existing Mangapū Tributary. Slightly weathered greywacke was observed at the southern (downstream) end of the proposed realignment of the Mangapū Tributary. Completely and highly weathered greywacke exposures were evident adjacent to walking tracks along the northern slopes, which is consistent with what was observed in the borehole investigations. Highly fractured highly weathered exposures were identified between the crest of the stream realignment section and the southern section of Mangapū Stream.

The greywacke in this area is dominated by sandstone sequence with lesser siltstone beds.

There are no known major faults within the proposed Mangapū Tributary realignment route. The subsurface investigations did not identify faulting in the boreholes or test pits. However, this will need to be monitored as excavations are carried out into this area and the geology is exposed. The potential for conjugate faults related to Faults A and B cannot be discounted (the spacing of faults A and B would imply the potential for a third fault in the vicinity of the tributary gully, and the presence of the waterfall in the Mangapū stream may align with this hypothesis. However, this is conjecture at this stage, as no physical evidence of a fault has yet to be exposed and if present the consequences of such a fault cannot be assessed until its nature and orientation can be confirmed).

Jointing is well developed in the greywacke rock. Joint spacing, persistence, orientation and joint wall condition are highly variable across the quarry and between weathering grades. Most of the joint defects have limited persistence and do not influence the kinematic stability of the cut faces and the general blocky jointed nature of the joint rock mass is accommodated within the rock strength assessments. One persistent joint set (Joint Set A) was identified within the Symonds Hill Pit (with a dip direction of 250° and dipping 60°) and was considered in our stability assessment.

Perched groundwater levels were measured in the piezometers installed in HUN25/2 and HUN25/3 at 172 to 167m RL and 143m RL respectively. Perched groundwater levels are also assumed to be controlled by the level of the nearby adjacent streams/tributaries. The investigations holes were terminated well above the regional groundwater table.

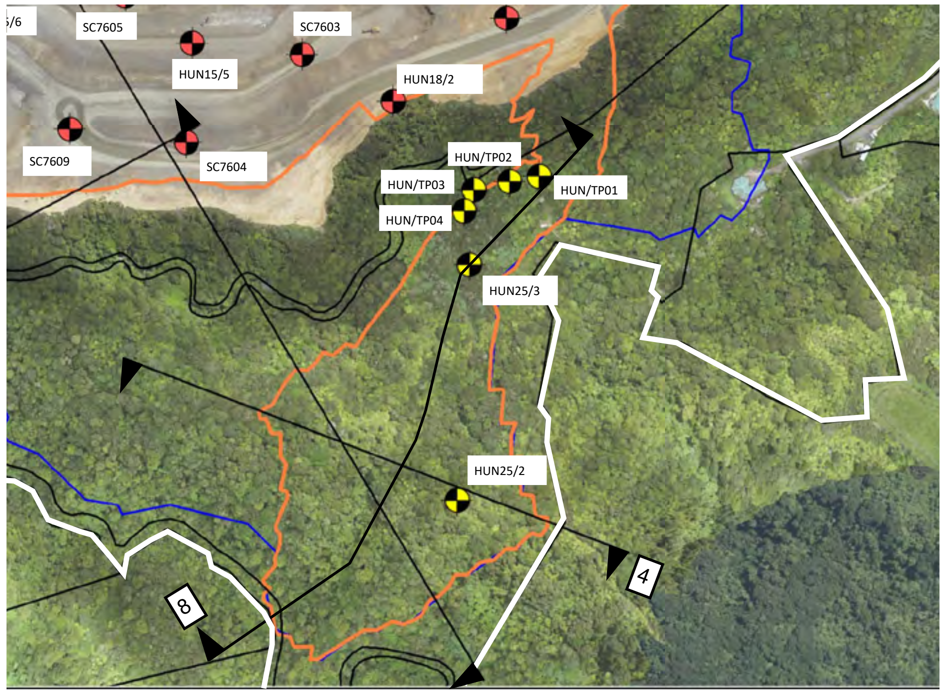


Figure 6: Investigation Location Plan, T&T.

2.0 EXISTING ENVIRONMENT

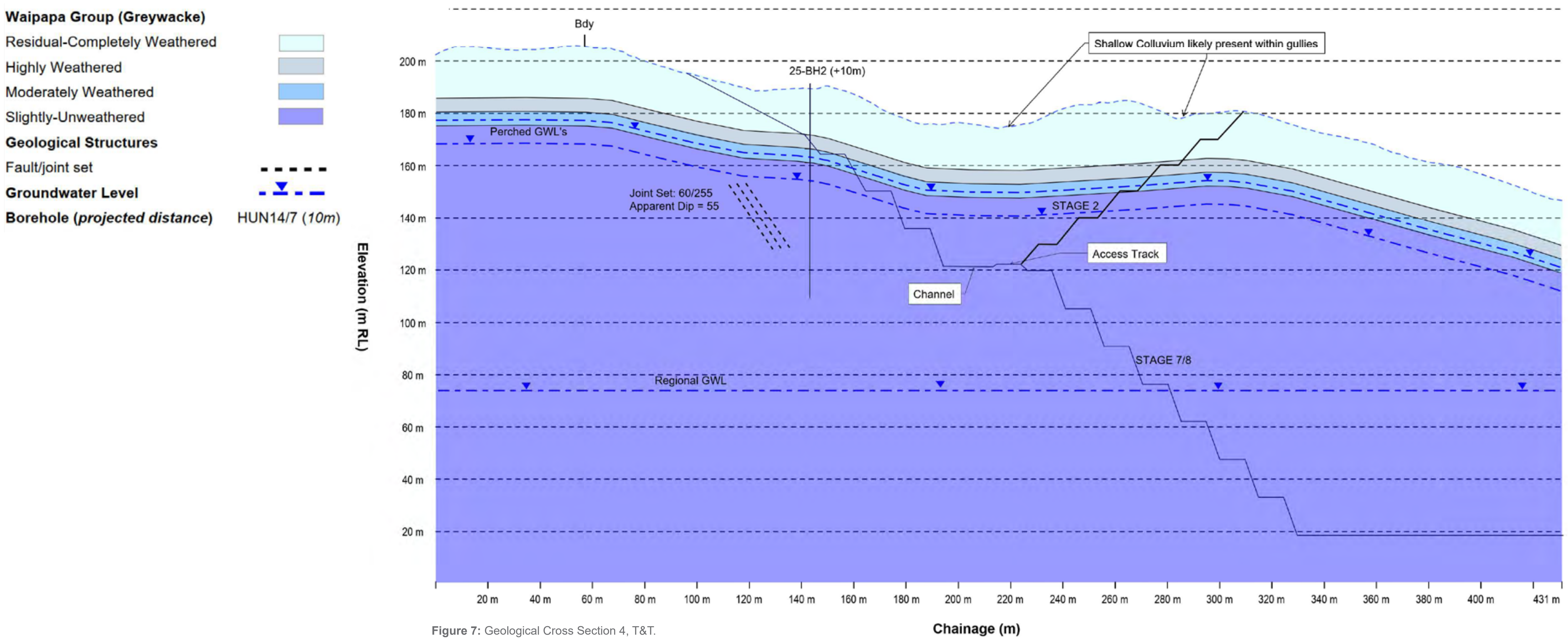


Figure 7: Geological Cross Section 4, T&T.

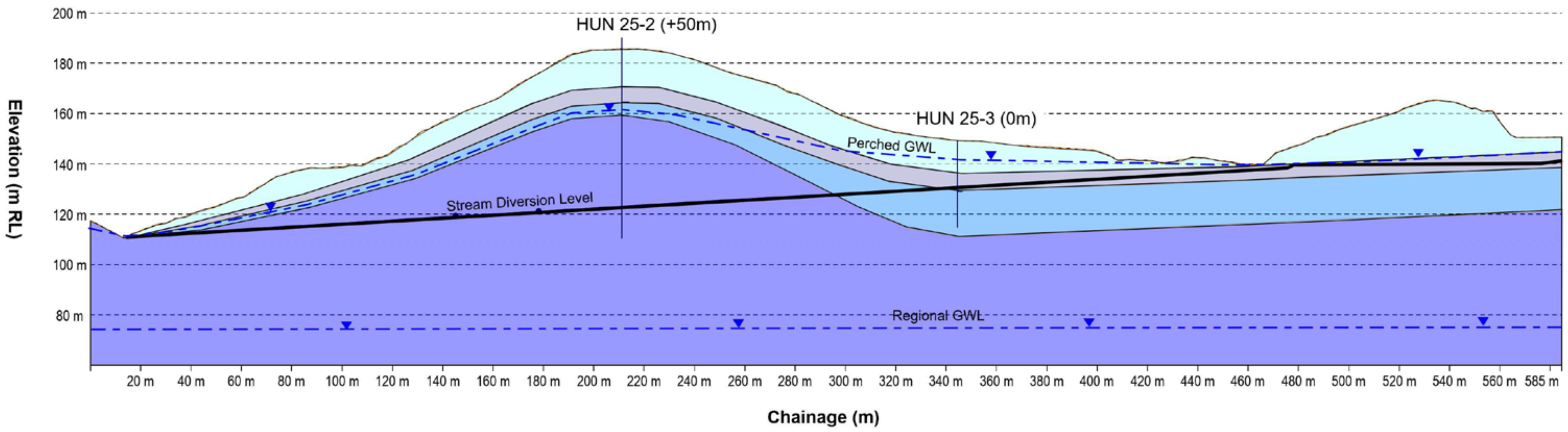


Figure 8: Geological Cross Section 8, T&T.

2.0 EXISTING ENVIRONMENT

MANGAPŪ TRIBUTARY BASE FLOW

The Mangapū Tributary (Southern Tributary) and the Mangapū Main Stream at US2 (above RL75m) are positioned above the regional groundwater table and are fed by discharge from the shallow groundwater system (PDP 2026).

The Southern Tributary is referred to a reach of a Mangapū Tributary between US1 stream flow gauging station and the main Mangapū stream (**Figure 9**).

The effects of the proposed quarry expansion on the Southern Tributary and the Mangapū Stream at US2, are assessed using the correlated MALF based on the stream flow gauging data. The Mean Annual Low Flow (MALF) is adopted as a reasonable and conservative proxy for estimating the average annual recharge to the shallow groundwater. This approach is based on the principle of baseflow-recharge equilibrium, where, during sustained dry periods, streamflow is dominated by baseflow discharge from the shallow aquifer.

The MALF is estimated based on the Streams low flow data collected since 2010 and its correlation with the flow data from the closest catchment to the site with long-term stream flow data and a similar geology. The Auckland Council operates a stream flow monitoring station (8529) at the Mangawheau catchment which has an area of 30.4 km^2. This station has been monitored since 1988 and has been used for the stream flow correlations. Based on the Auckland Council stream flow data, the MALF for the Mangawheau Stream is 2.51 L/s/km^2.

The correlation result for these two stations is shown in the Groundwater Effects Assessment (PDP 2026). The correlation accuracy (R2) and the resulting MALF estimates for the above gauging stations are given in **Table 2**. With an R^2 above 0.90, the model demonstrates an excellent fit to the observed data.

Table 2: Specific Discharge MALF for US1 and US2

Gauging Station	R^2	MALF Low Flow L/s/km^2	Catchment Area (km^2)	Elevation (m, RL)
Upstream Bridge (US1)	0.96	4.25	1.77	141
Upstream Fork (US2)	0.91	1.91	2.30	108

PREDICTED BASEFLOW LOSS FOR PROPOSED QUARRY STAGES

The effects of the proposed quarry expansion on the Southern Tributary and the Mangapū Stream (above RL75m) are assessed using the correlated MALF (discussed above) and the calculated reductions in the contributing catchment area for each quarry stage. The results are summarised in **Tables 3 and 4**.

Based on the results, the effects on the Mangapū Stream (above RL75m) are less than minor (0 to 1%; **Table 3**). Flow loss as a result of the realignment of the Southern Tributary (**Table 4**) is also less than minor (0 to 1%) for Stages 0 to 2 but increases to 5% for Stages 3 to 6 and 10% for Stages 7 to 8. This is caused by realignment of the shallow groundwater, especially within the Southern Tributary catchment area to the future pit.

The low flow reductions of more than 5% exceeds the natural variability. Therefore, if low flow reductions of more than 5% is confirmed via the proposed stream low flow monitoring (at the proposed Realignment 1 gauging station), a mitigation plan will be implemented before commencing Stage 3.

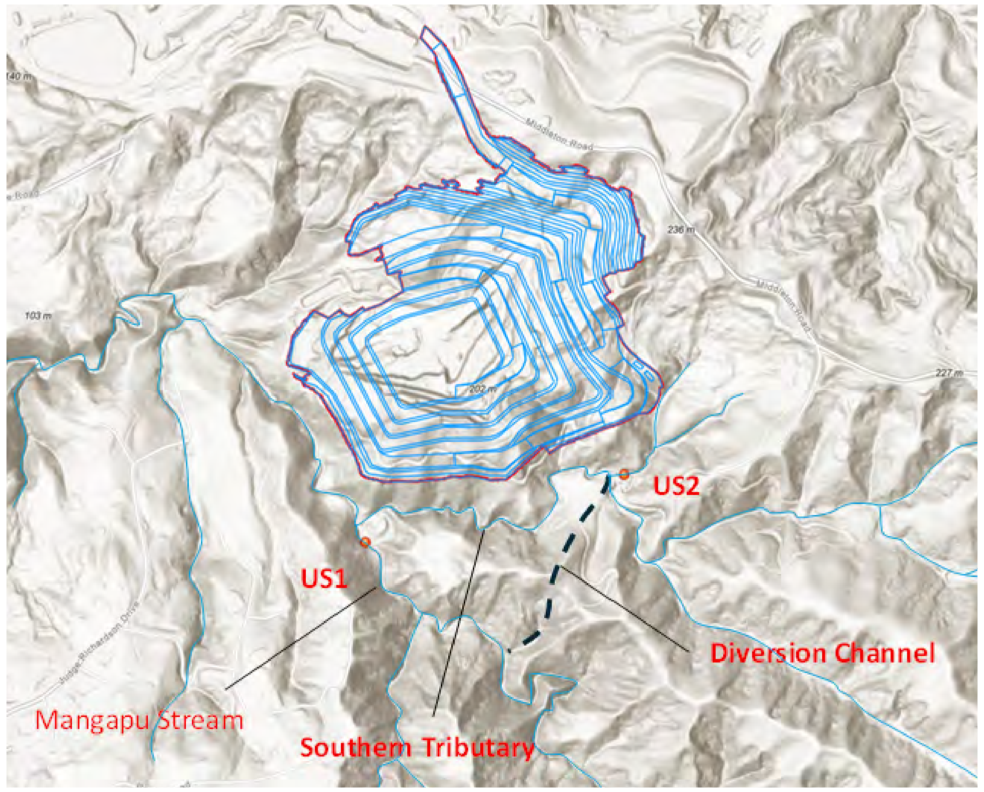


Figure 9: Existing gauging Stations US1 and US2, PDP.

Table 3: Main Mangapū Stream at US1

Stage	Area (km^2)	Existing MALF (L/s/km2)	Existing MALF (L/s)	Remaining Low Flow (L/s)	Flow Reduction (L/s)	Reduction %
Existing Conditions	2.30	4.25	9.77	-	-	-
Stages 0 to 3	2.30			9.77	0	0
Stages 4 to 8	2.27			9.66	0.11	1

Table 4: Southern Tributary (proposed tributary to be diverted)

Stage	Area (km^2)	Existing MALF (L/s/km2)	Existing MALF (L/s)	Remaining Low Flow (L/s)	Flow Reduction (L/s)	Reduction %
Existing Conditions	1.77	1.91	3.37	-	-	-
Stage 0	1.77			3.37	0	0
Stages 1 to 2	1.75			3.33	0.04	1
Stages 3 to 6	1.67			3.19	0.18	5
Stage 7 to 8	1.60			3.05	0.32	10

2.0 EXISTING ENVIRONMENT

CATCHMENT HYDROLOGY

Two catchment areas have been considered to assess the hydrology of the study area, as shown in **Figure 10**. The combined overall catchment area will reduce in size once the Mangapū tributary is removed as a result of the quarry pit development.

A hydrological assessment, using a synthetic flow record to replicate the Mangapū Stream and the Mangapū Tributary, was completed to estimate the flows for a range of return periods for the streams. Table 6 below shows the calculated estimated flows for a mean annual flood through to a 1000-year flood. A climate change adjustment of 3.8 degrees of warming was applied (RPC8.5 2120), as shown in column four of **Table 5.**

Table 5: 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
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

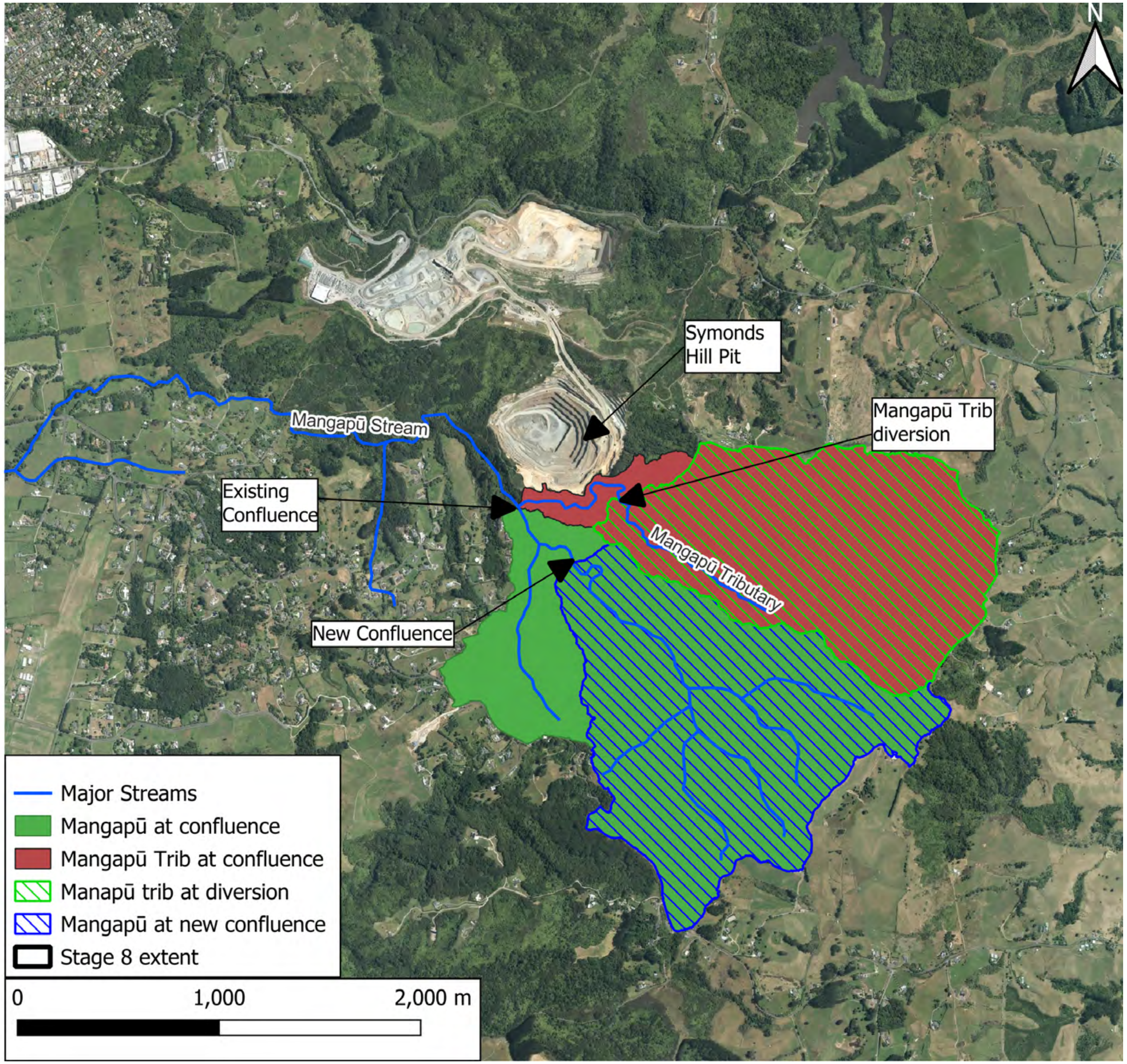


Figure 10: Catchment Map, PDP.

3.0 DESIGN OF MANGAPŪ TRIBUTARY REALIGNMENT

APPROACH

The design of the Mangapū Stream Tributary realignment has considered a high level conceptual, cultural and cultivated approach, including:

- The realignment design accommodates Stage 8 of the Quarry expansion (i.e., including loss of minor headwater channels of the tributary and the anticipated Stage 8 flow / quantity of the Mangapū Stream).
- The design incorporates equivalent stream habitat characteristics to provide for equivalent aquatic and riparian ecological values.
- The design incorporates variation in habitat types from upper to lower portions of realignment reflecting transitions as they occur moving downstream along the existing Mangapū Stream tributary.
- A waterfall is incorporated at the lowest end of the realignment, helpful for providing for climbing fish and preventing non-climbing fish from entering the realignment (reflecting the existing Mangapū Stream tributary).
- Compensation is provided for any calculated loss of ecological values.

These concepts have been incorporated into a series of design principles as setout below.

Figure 11: Photo of upper Mangapū Tributary, large meander, slow flow pool

DESIGN PRINCIPLES

The following high-level design principles are applied to the realignment of the Mangapū Stream Tributary:

- The realignment will achieve an average width of no less than 0.6m, with a maximum width of up to 6m.
- The channel design will replicate the form of the channel of the Mangapū Stream tributary but incorporate a low-flow (or baseflow) channel, a bank full channel and where practicable, small streamside gravel bars.
- Water flow will allow for the hydrology of the existing Mangapū Stream tributary (i.e., flows intermittently or permanently like the existing channel).
- The channel will accommodate, as much as practicable, natural meanders (or otherwise) like the stream to be reclaimed.
- The instream habitat will reflect a level of complexity and hydrologic heterogeneity through the creation of natural features such as cascades, runs, riffles, gravel bars, and small and large pools.
- The final substrate will reflect that naturally occurring in the Mangapū Stream tributary, including any changes that occur longitudinally upstream to downstream.
- The stream profile will allow the planting of riparian vegetation close to and extending over and into the water surface at the margins to create ample stream edge habitat. This can be low stature planting that provides vegetation overhang over and into the watercourse and to enhance habitat for the aquatic ecosystem.
- Riparian vegetation is to be planted along the length of the stream realignment, to the extent practicable. Appropriate riparian species selection will enhance stream ecology through providing shade to the stream, reducing water temperature, producing habitat and providing a food source. As much as possible, riparian vegetation will extend along either side of the realignment channel.

When implemented, the recommended principles and actions will provide acceptable remediation for the loss of the extent and values of Mangapū Stream Tributary.

Figure 12: Mangapū Tributary

Figure 13: Waterfall within the Mangapū Tributary

3.0 DESIGN OF MANGAPŪ TRIBUTARY REALIGNMENT

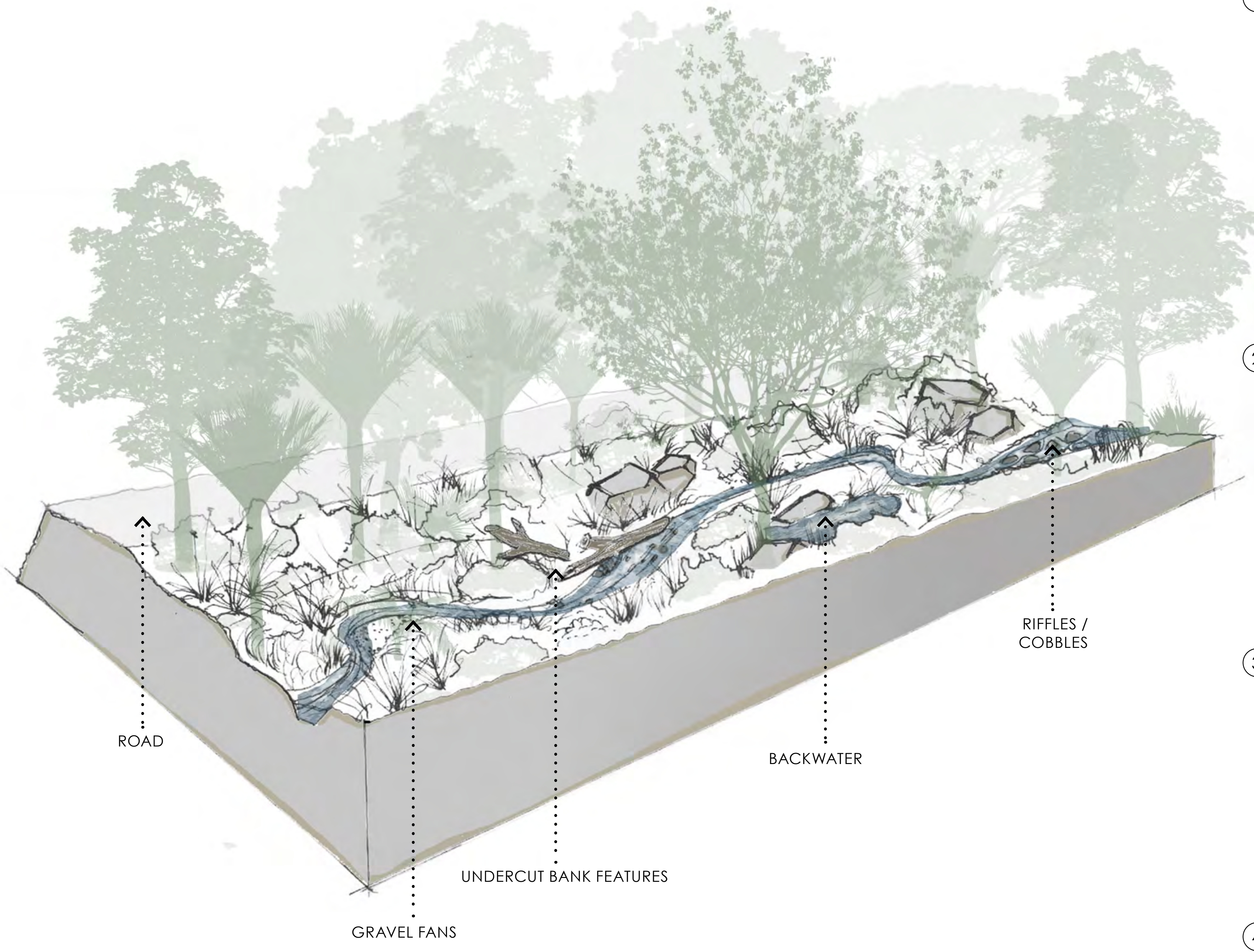
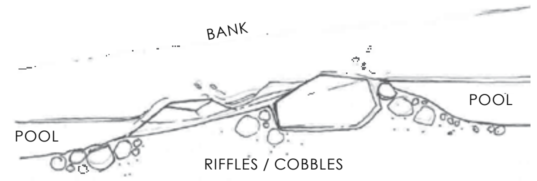
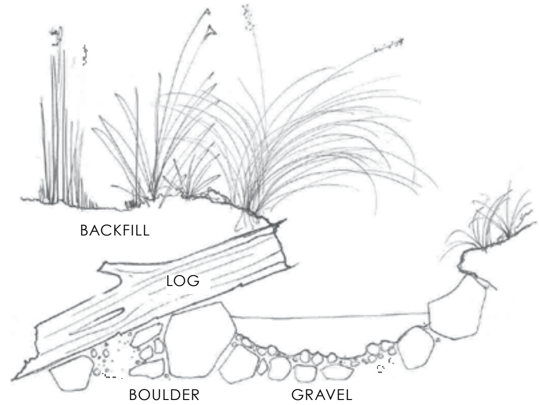


Figure 14: Cobble dominated typology, BML.



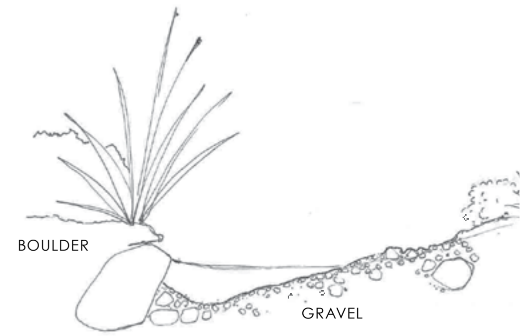
1 RIFFLES / COBBLES

Medium sized substrate mobilised in moderate to high flows. Habitat on surface and below the cobbles create habitat for different algae and invertebrates.



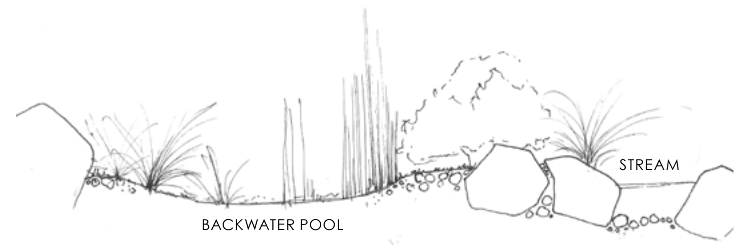
2 UNDERCUT BANK FEATURES

To create refuge for fish during daytime and periods of high flow.



3 GRAVEL FANS

Potential habitat for Hochstetter's frogs, and additional refuge for fish in higher flows.



4 BACKWATER

Refuge for fish in times of high flow and source of colonisers as flood waters recede.

3.0 DESIGN OF MANGAPŪ TRIBUTARY REALIGNMENT

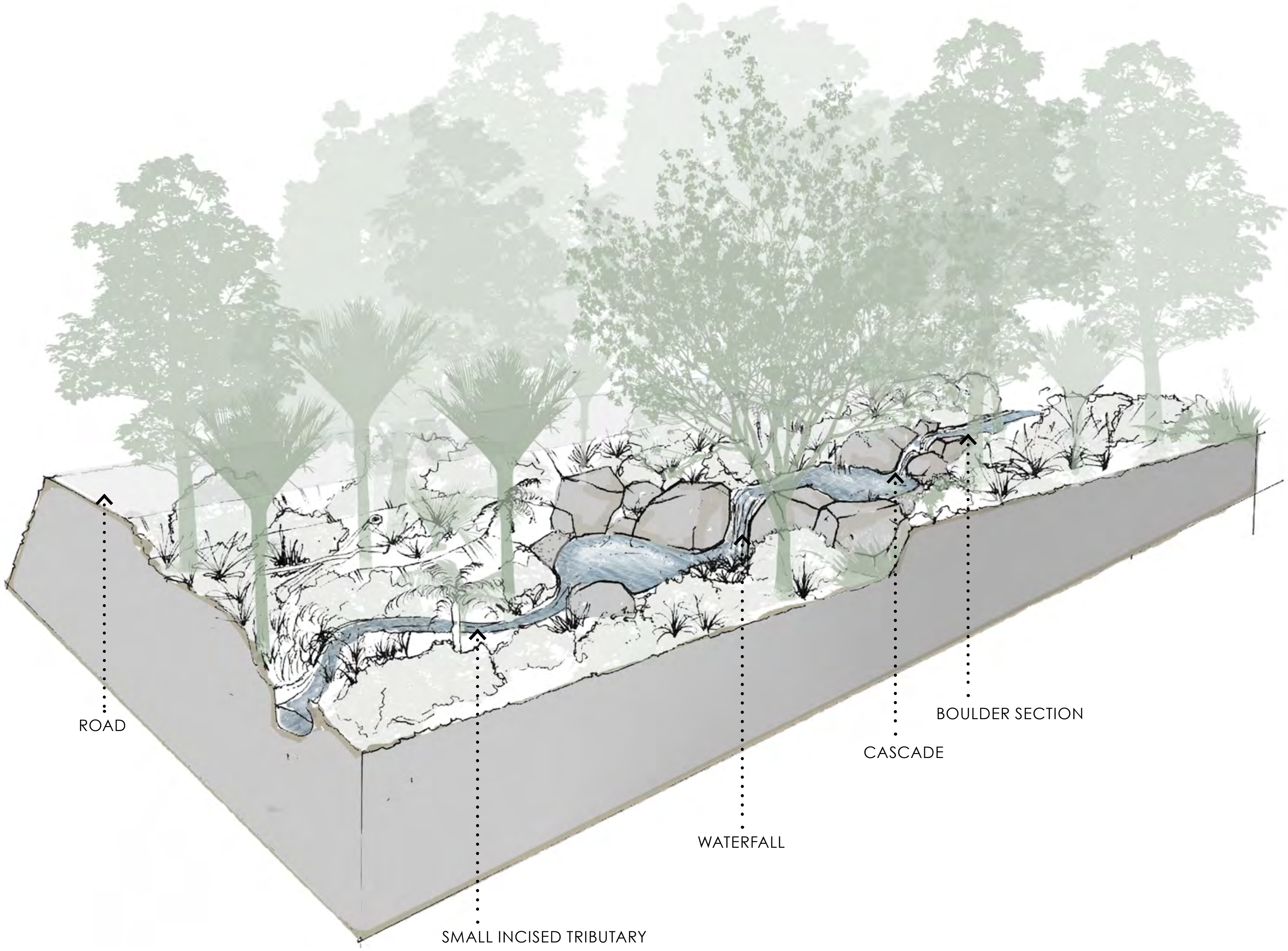
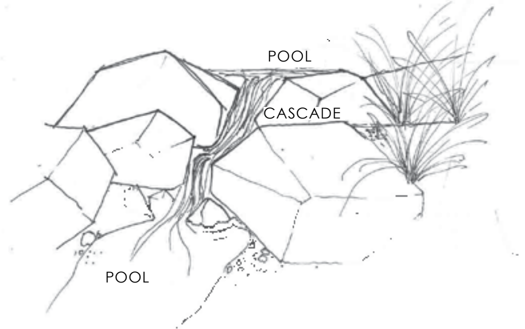
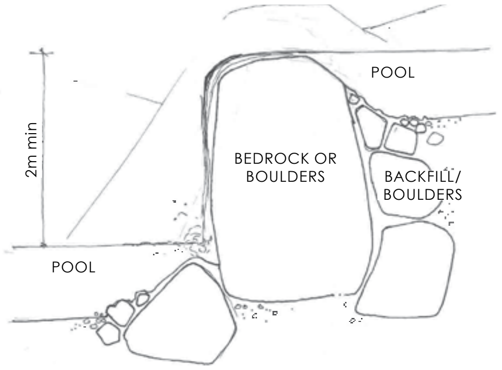


Figure 15: Boulder dominated typology, BML.



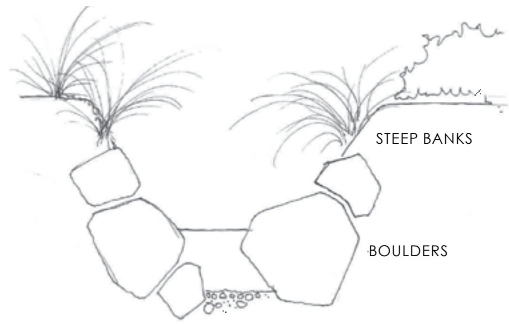
1 CASCADE

Series of rapid falls and small pools with variety of habitats and refuge for aquatic organisms in steeper channel gradients.



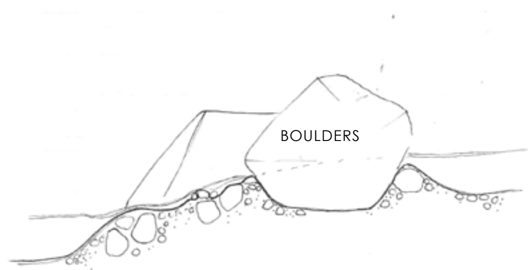
2 WATERFALL

Steep fall and plunge pool but available for passage of fish with ability to climb.



3 SMALL INCISED TRIBUTARY

Swift and shallow run section with steeper banks that help create shade.



4 BOULDER SECTION

Large permanent substrate features creating stable microhabitats for algal films and micro-flow variation for habitat.

3.0 DESIGN OF MANGAPŪ TRIBUTARY REALIGNMENT

DESIGN GUIDELINES

CHANNEL DESIGN CHARACTERISTICS

The following design parameters have been used to develop the design for the stream realignment channel. Refer to **Figures 14 – 15**.

- Broad flood channel for conveyance of a 1% AEP (1-in-100-year ARI) event with climate change adjustment and provide 500 mm freeboard to the proposed quarry haulage road.
- The design incorporates a climate change adjustment of 3.8 degrees of warming (based on the RCP8.5 to 2120 scenario).
- A meandering channel within the flood channel with capacity to convey the present day Mean Annual Flood (MAF).
- A low flow channel incorporated into the meandering channel to contain expected minimum flows needed for sustaining ecological life.
- An impermeable liner placed beneath the stream bed to prevent seepage into the cut rock.
- Inclusion of equivalent features as the existing stream corridor – cascades, riffle / runs, pools and waterfalls, providing for in-stream ecology and hydraulic performance.
- In-stream features such as waterfalls and cascades to manage the overall grade of the realignment channel and add diversity to the channel morphology.
- Incorporation of rock and plant debris to provide variable flow conditions, act as energy dissipators and provide a heterogeneous flow channel.

HABITAT DIVERSITY AND CHANNEL COMPLEXITY

Hydrologic heterogeneity and instream habitat complexity can be improved through the creation of natural features such as cascades, runs, riffles, gravel bars, and small and large pools. These features can be created utilising natural substrates such as rocks, logs and large boulders. Gravels, cobbles and boulders will be used to increase stream heterogeneity and stability.

The outcome will reflect the equivalent characteristics and be consistent with the habitat present in the Mangapū Stream tributary. The channel complexity and availability will 'naturalise' over time as the new realignment channel becomes established. Refer to **Figure 16**.

The inclusion of a shallow low-flow channel is to be included in the initial channel design. The purpose of a low-flow channel is to provide flow when climate conditions typically result in low rainfall conditions. The low-flow channel extends the period of habitat availability, should dry conditions persist.

RIPARIAN VEGETATION

Riparian vegetation is to be planted along the length of the stream realignment. Riparian vegetation plays an important role in the ecological success of a stream realignment. Appropriate riparian species selection will enhance stream ecology by providing shade to the stream, reducing water temperature, and providing habitat and a food source. Riparian vegetation should mimic the local vegetation and be appropriate for the local bioclimatic conditions.

The stream profile should allow the planting of riparian vegetation close to and extending over the water surface to create ample stream edge habitat. This will provide shading to the water surface, detritus in the form of fallen leaves and potential habitat for macroinvertebrate species.

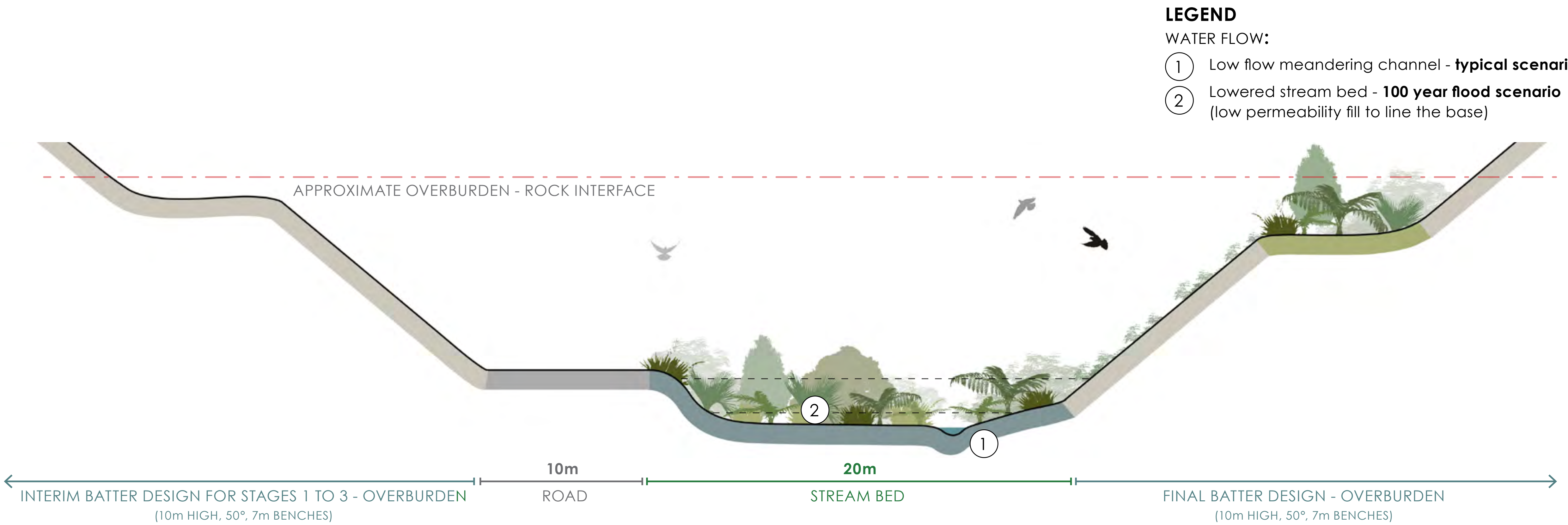


Figure 16: Typical section at completion of Stage 2, BML.

3.0 DESIGN OF MANGAPŪ TRIBUTARY REALIGNMENT

DESIGN GUIDELINES

STREAM CHANNEL METRICS

The stream channel is designed to be varied in form, so that there are sections of different depth and width which will create variations in flow velocities.

The 1% AEP (1-in-100-yr ARI) flood channel has a fixed width of 14 – 15 m. Within this channel the meandering flow channel which conveys the mean annual flood is typically 7 – 8 m wide but has varied widths created by the in-stream features. The in-stream features do not have prescriptively designed dimensions but follow a general approach as shown in **Table 6** below. Also shown are the estimated water depths and velocities encountered when the flow is low across the various in-stream features. Both water depth and velocity will vary depending on the flow encountered, with increases as the flow of the stream intensifies. It is estimated that for a 1% AEP flood event, the average velocity will be about 2 m/s within the realignment channel.

Table 6: Channel 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	0.049 – 0.069
Waterfall	0.8 – 1.3	0.1 – 0.2	0.067 - 0.075
Note: Low flow range 3.4 – 15 l/s			

FISH PASSAGE

Ecological surveys, including the collection of eDNA, have been undertaken to inform which fish species are present in the stream currently. Investigations suggest that long-fin and short fin eels and banded kokopu are present.

These fish species are known to climb as they navigate upstream. With that in mind, many of the in-stream features are suitable for these species; for example, waterfalls will be kept to a maximum height of 1 m. Cascade sections will include resting areas, particularly the longer cascade sections, allowing fish to break up their upstream traverse.

Conversely, as the stream and the upper catchment are home to native fish and invertebrate species, it is important to prevent predatory exotic species such as trout from entering the stream. The existing Mangapū Tributary has waterfalls, which act as natural barriers for exotic fish trying to move upstream. These features are to be replicated in the realignment channel to continue to prevent these species from entering the stream and the upper catchments.

CUT SLOPE STABILITY[1]

GENERAL

The primary geotechnical risks associated with the stream realignment relate to slope stability and potential rockfall. Some degree of rockfall is expected, and the design will ensure that such events do not adversely affect the realignment flow or operational performance of the channel.

The realignment design will incorporate rockfall catch capacity between the base of the slope and the stream channel. Occasional rockfall may occur from cut faces during excavation and over time as the slopes weather/degrade. While not considered a stability concern, this potential will be accounted for in the bench configuration and revegetation/rehabilitation design.

Surface water management on the overburden slopes will be important to reduce the risk of upper slope erosion, and the final design should specifically address scour protection to support long-term vegetation establishment. To reduce the risk of rock fall for permanent cut slopes, pre-splitting is recommended to minimise structural damage, which involves drilling a single row of closely spaced, lightly charged holes along the designed perimeter, which are detonated simultaneously or in close succession to shear the rock between them.

CUT SLOPE DESIGN GEOMETRY

Cut slope design geometries for the Mangapū Tributary realignment and the Symonds Hill Pit are presented in **Table 7.** The proposed rock cuts are the same as were adopted and used for the recently closed Hunua Quarry pit and Symonds Hill Pit operations to date. Based on current face mapping the rock mass at Symonds Hill Pit is less fractured and has a lower frequency of persistent joint sets than at the Hunua Pit. As a result, the pit slope design for Symonds Hill is potentially slightly more conservative than that used in the Hunua Pit. Over its approximately 10 years of operation, the Symonds Hill Pit has only experienced minor, localised slope failures confined to individual benches.

The design geometry shown in **Table 7** is based on full height slope stability assessment using SLIDE2 (limit equilibrium slope stability software), while individual rock cut bench faces are based on kinematic design using measured rock mass defects.

The proposed cut slopes in overburden soils are based on SLIDE2 analysis and previous experience within the wider Hunua Quarry site.

KINEMATIC ANALYSIS

Defects in rock mass influence stability subject to the orientation and persistence of the intersection defects to the face orientation. A given combinations of joints may be stable in one face orientation but unfavourable to stability in another.

A kinematic analysis was carried out for individual defects within the proposed greywacke rock for a range of cut faces orientations.

1 REFER TO TONKIN+TAYLOR GEOTECHNICAL ASSESSMENT REPORT.

Table 7: Cut slope design

Material	Batter Angle (degrees)	Batter Height (m)	Bench Width (m)	Overall Slope Angle (degrees)
Residual soil and completely weathered Waitemata Group and Waipapa Group (Overburden)	N/A	N/A	N/A	27 [1(V):2(H) slope]
Waitemata Group weathered rock and highly weathered Waipapa Group greywacke	50	15	9	35
Moderately weathered Waipapa Group greywacke	60	15	10	38
Slightly to unweathered Waipapa Group greywacke	70	15	10	43

The stability of specific rock defects was assessed for potential planar, toppling and wedge failures using stereographic projection methods within Rocscience DIPs software.

These analyses have conservatively assumed (worst case) that joints are persistent enough to form wedges and planes in the rock mass. It is noted from field observations that the joints in the Symonds Hill greywacke rock mass are generally not very persistent (i.e., less than 5 m), hence the kinematic stability analyses are likely to be conservative. It will be important to calibrate the results of the kinematic analyses with field observations as part of ongoing operations and operational cut design

3.0 DESIGN OF MANGAPŪ TRIBUTARY REALIGNMENT

DESIGN GUIDELINES

(refer to the Trigger Action Response Plan as discussed in Section 17.2 in the T+T Geotechnical Assessment Report).

The Mangapū Tributary realignment will comprise west to northwest facing slopes (270°–330°), and temporary east to southeast (90°–120°) facing slopes during Stage 1. The southeast facing slopes are later removed in Stage 4.

Based on the assumption that the defects measured in the nearby pit remains common, slope performance is expected to be similar to faces in the existing Symonds Hill Pit. The assessed risk is considered acceptable.

SOIL AND ROCK MASS STABILITY

General soil and rock mass stability analyses were undertaken on critical and representative sections using Rocscience SLIDE2 software. The analyses were carried out using limit equilibrium methods (Morgenstern–Price), with a half-sine inter-slice force function to satisfy both force and moment equilibrium.

The minimum factor of safety (FoS) was determined by automatically searching for potential circular failure surfaces and by manually assessing a range of fully defined failure surfaces. In all cases, optimisation was undertaken to identify the most critical failure surface.

The slope stability was assessed in SLIDE2 for Geological Cross Section 4 (Figure 6 above) for the proposed cut slopes in Stage 2 and Stage 8. Critical sections for the Stage 2 cut slope are included in Appendix G in the T+T Geotechnical Assessment Report . In all stability cases the target FoS was achieved. The resultant risk in all cases is considered acceptable (R1 to R2, refer to Appendix H in the T+T Geotechnical Assessment Report).

OTHER DESIGN CONSIDERATIONS

Once the quarry is cut down along the western edge of the stream diversion, where the channel crosses over moderately or slightly weather rock, the stream channel could leak to the nearby Symonds Hill Pit. Unmitigated, our assessment is the leakage from the stream channel, especially at low conditions, is likely to result in a R3 or even R4 risk (Refer to Appendix H in the T+T Geotechnical Assessment Report). A low permeability stream liner is proposed to minimise this risk, and to help maintain water in the stream during low flow periods. Erosion protection and naturalised stream features would be built over the top of the liner, as detailed in the PDP tributary preliminary design report. The assessed mitigated design is R1.

The proposed liner will comprise compacted low permeability fill, likely suitable clay rich overburden sourced from within the quarry site.

Hydrological design of the stream is detailed in the PDP tributary preliminary design report. The stream diversion has also been assessed against potential future over-design events, which could cause over-topping of the channel. This will be managed by constructing a bund on the channel bank or the outer edge of the haul road, to ensure that flood flows do not spill into the pit.

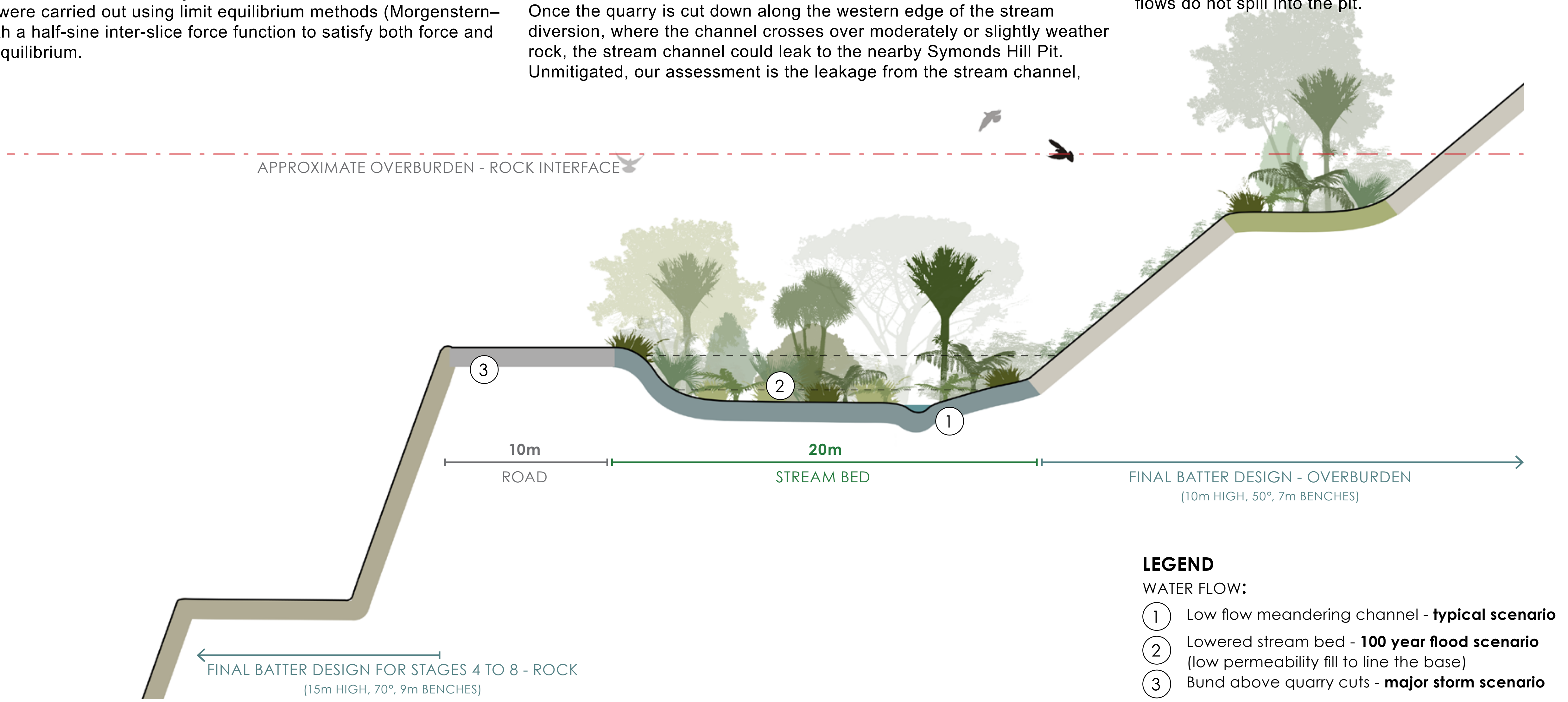
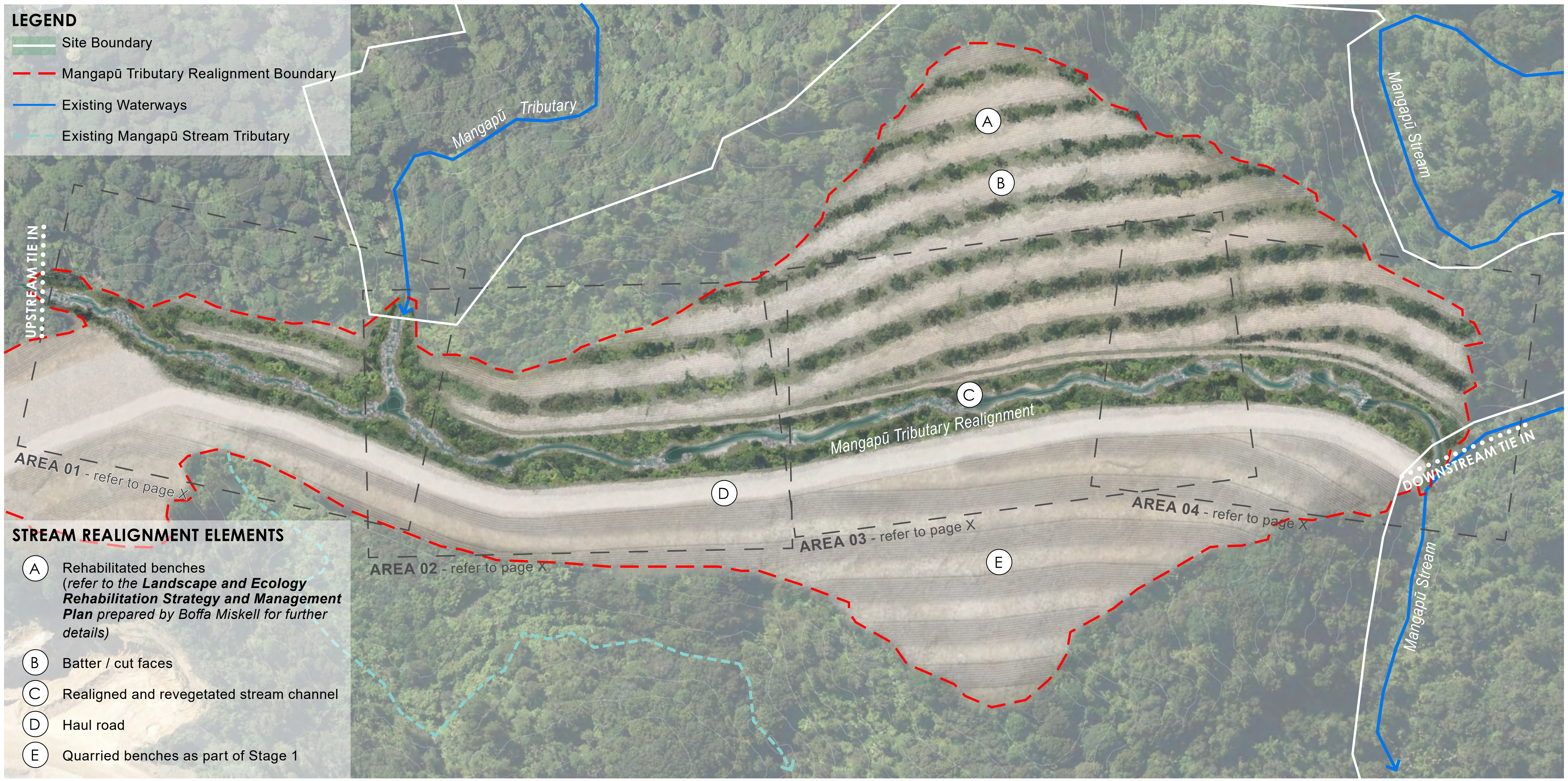


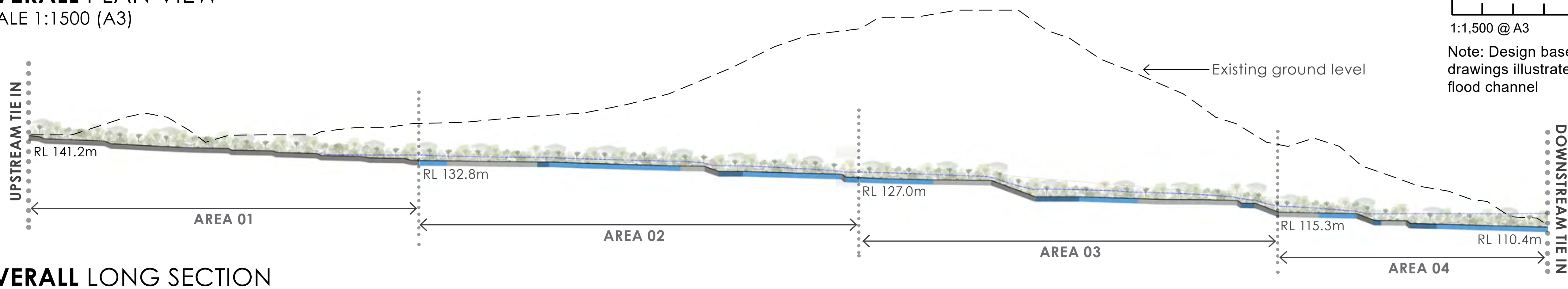
Figure 17: Typical section at completion of Stage 8, BML.

3.0 DESIGN OF MANGAPŪ TRIBUTARY REALIGNMENT



OVERALL PLAN VIEW
SCALE 1:1500 (A3)

Note: Design based on PDP technical drawings illustrated as the mean annual flood channel



OVERALL LONG SECTION
SCALE 1:500 (A3)

3.0 DESIGN OF MANGAPŪ TRIBUTARY REALIGNMENT

AREA 01 PLAN VIEW
SCALE 1:500 (A3)

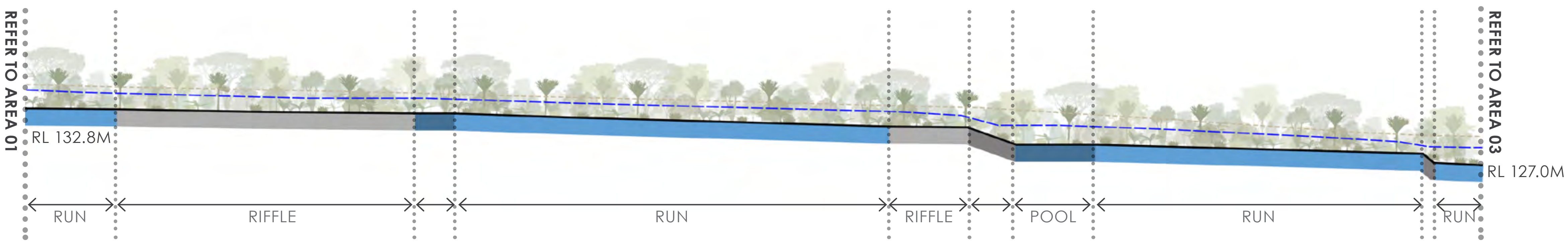
Note: Design based on PDP technical drawings illustrated as the mean annual flood channel.

AREA 01 LONG SECTION
SCALE 1:500 (A3)

3.0 DESIGN OF MANGAPŪ TRIBUTARY REALIGNMENT

AREA 02 PLAN VIEW
SCALE 1:500 (A3)

Note: Design based on PDP technical drawings illustrated as the mean annual flood channel.



AREA 02 LONG SECTION
SCALE 1:500 (A3)

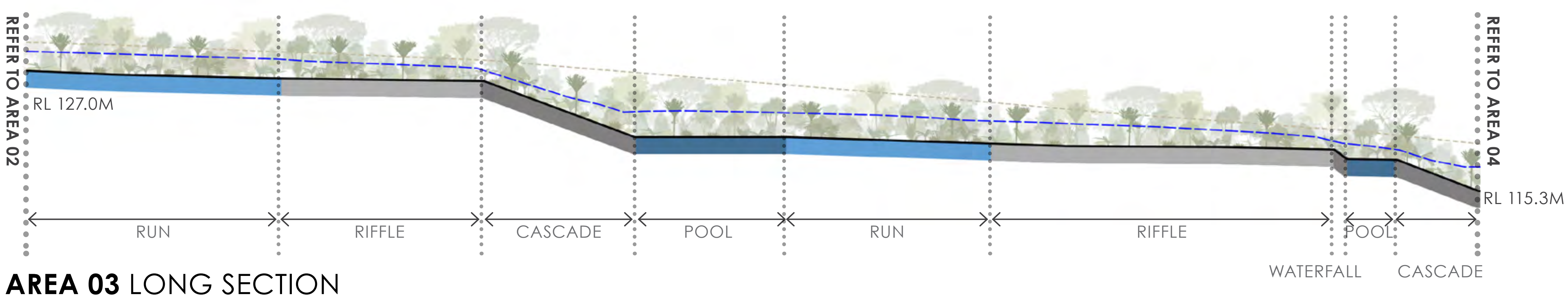
SECTION KEY
- Proposed Invert Level
- Proposed Haul Road Level
- 100yr Flood Model Level

DESIGN FEATURES
- Run
- Pool
- Riffle
- Cascade/Waterfall

3.0 DESIGN OF MANGAPŪ TRIBUTARY REALIGNMENT

AREA 03 PLAN VIEW
SCALE 1:500 (A3)

Note: Design based on PDP technical drawings illustrated as the mean annual flood channel



AREA 03 LONG SECTION
SCALE 1:500 (A3)

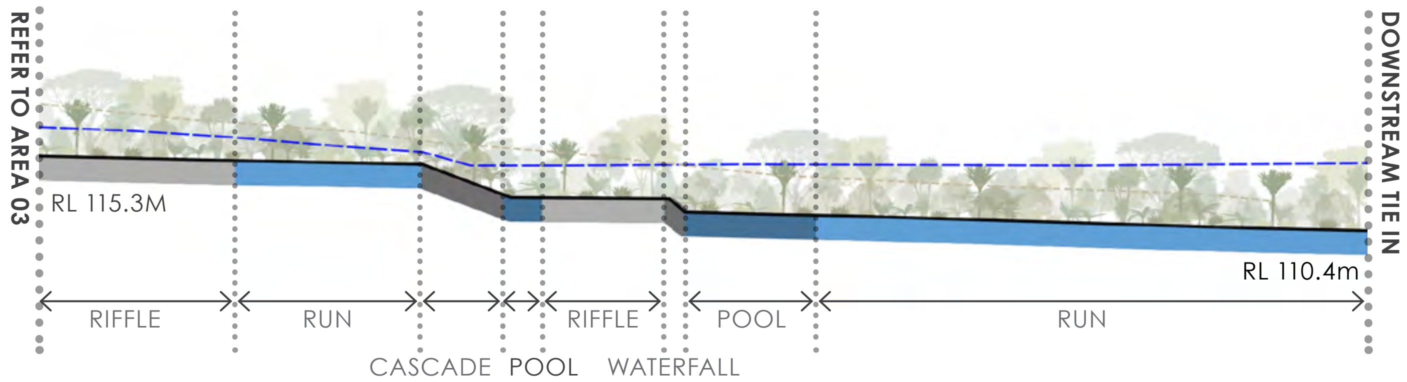
SECTION KEY
- Proposed Invert Level
- Proposed Haul Road Level
- 100yr Flood Model Level

DESIGN FEATURES
- Run
- Pool
- Riffle
- Cascade/Waterfall

3.0 DESIGN OF MANGAPŪ TRIBUTARY REALIGNMENT

AREA 04 PLAN VIEW
SCALE 1:500 (A3)

Note: Design based on PDP technical drawings illustrated as the mean annual flood channel.

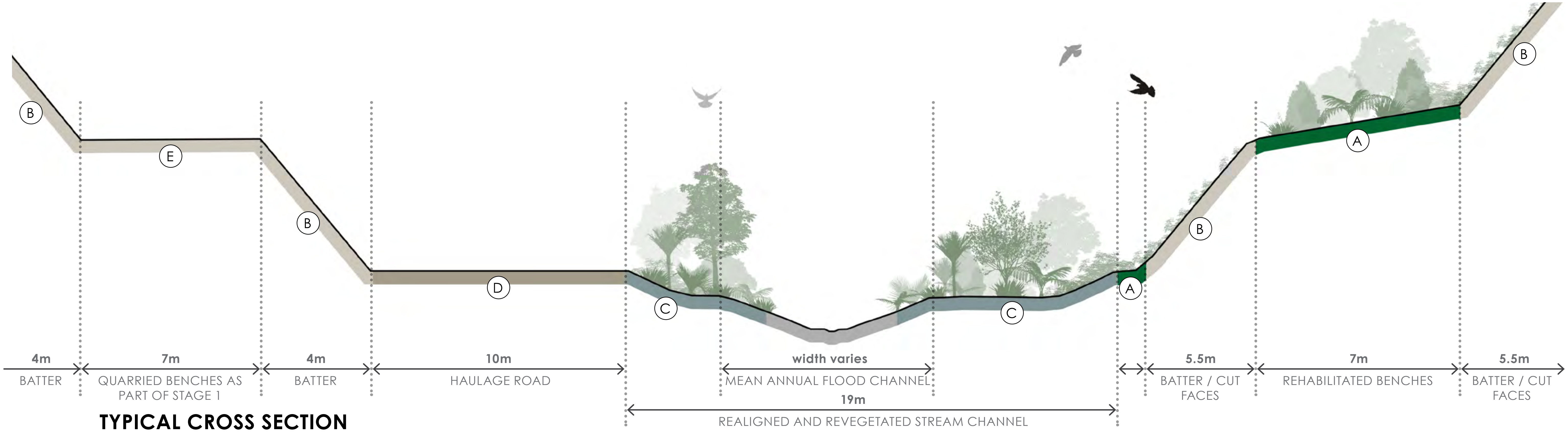


AREA 04 LONG SECTION
SCALE 1:500 (A3)

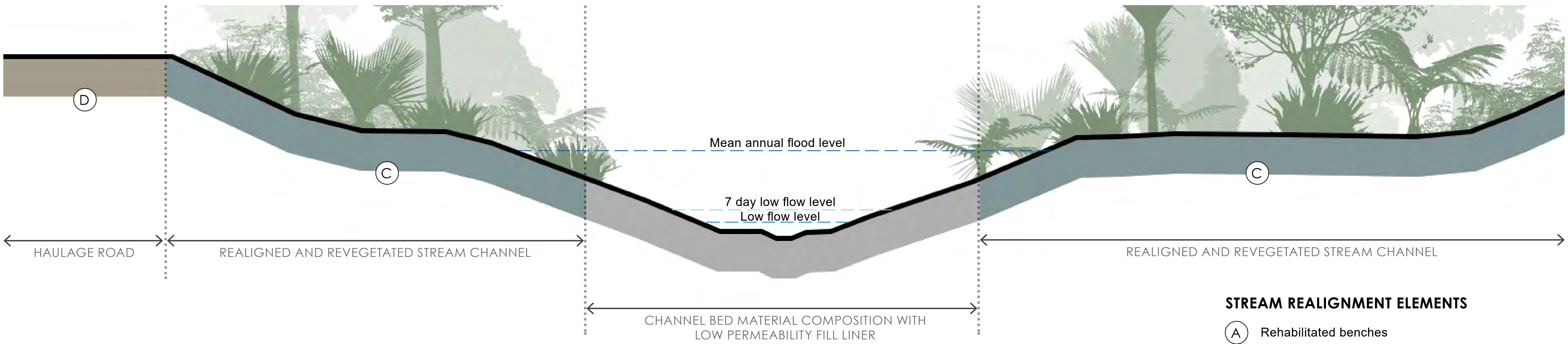
SECTION KEY
- Proposed Invert Level
- Proposed Haul Road Level
- 100yr Flood Model Level

DESIGN FEATURES
- Run
- Pool
- Riffle
- Cascade/Waterfall

3.0 DESIGN OF MANGAPŪ TRIBUTARY REALIGNMENT



TYPICAL CROSS SECTION
SCALE 1:150 (A3)



TYPICAL LOW FLOW CROSS SECTION
SCALE 1:50 (A3)

STREAM REALIGNMENT ELEMENTS

- (A) Rehabilitated benches
- (B) Batter / cut faces
- (C) Realigned and revegetated stream channel
- (D) Haul road
- (E) Quarried benches as part of Stage 1

4.0 IMPLEMENTATION OF THE MANGAPŪ TRIBUTARY REALIGNMENT

CONSTRUCTION METHODOLOGY

During construction and at completion of the realigned channel, an inspection by a Freshwater Ecologist will be undertaken to ensure ecological principles have been integrated. The following provides an overview of an indicative construction methodology:

1. Vegetation clearance to enable access to the Mangapū Tributary crossing location, following gecko salvage.
2. Construction of bridge over the Mangapū Tributary to enable ongoing access for heavy machinery to the realignment channel works area.
3. Site clearance and stripping over the entire works area – vegetation clearance and stockpiling of reusable materials.
4. Conduct topographical surveys to set out earthwork requirements.
5. Construct the 10m wide access road on the western side of the proposed stream channel and install the sediment control infrastructure.
6. Strip loose overburden material from the stream works area using a 100t excavator and 100t ridged axel trucks. Material will be removed to the Hunua OBDA.
7. A series of benches will be created following standard quarrying practices (drill and blast) to dig and cart the rock to the processing facility. The final bench will be the surface for the construction of the haul road and stream channel.
8. The stream channel will be created using a bulldozer and excavator, excavating the channel lower than the design bed level.
9. The design bed level will be built up with the placement of the liner (compacted site-won clay fill) and the placement of channel bed substrate (rock of various sizes and gravels).
10. Strategic rock placement will create the in-stream features such as waterfalls, cascades and riffles.
11. Topsoil and bedding material will be added to the stream banks and stream planting will commence.
12. Following a period of vegetation establishment, the channel will be 'livened' with phased realignment of water from the Mangapū Tributary. This will be achieved by placement within the Mangapū Tributary of a combination of rock, gravels, sandbags and geotextile fabric.
13. Following a period of phased flow transfer leading to a complete realignment of flow, the Mangapū Tributary will be permanently blocked.

EROSION AND SEDIMENT CONTROL

All erosion and sediment control measures associated with the stream realignment will be be undertaken in accordance with the Erosion and Sediment Control Plan (ESCP)[1] prepared for the wider quarry operations. In addition, instream works will follow best practice methodologies relevant to working within and adjacent to flowing water, including measures to minimise sediment mobilisation, protect water quality, and maintain aquatic habitat during construction. The instream erosion and sediment controls outlined in this report will be applied alongside the broader ESCP to ensure an integrated and consistent approach across the site.

Collectively, these controls are intended to avoid or minimise adverse effects on the Mangapū Stream Tributary, support compliance with freshwater management requirements, and protect ecosystem values throughout the realignment works.

STAGING OF REALIGNMENT

A staged approach to introduce water to the newly constructed stream channel is proposed. The channel will be constructed entirely 'off-line' and once sufficiently established will be connected to the flow of the Mangapū Tributary.

The staged approach will involve the placement of material on the Mangapū Tributary just downstream of the connection with the new stream channel. The materials will be readily available within the quarry including rock, gravels, sandbags and geotextile fabric. Materials will need to be adjusted (added / removed) to stage flow but will maintain a height that enables climbing fish passage to continue along the Tributary until necessary.

As detailed in section 5.0 below, initially a portion of the flow will be diverted into the new channel for a time. The hydraulic and ecological performance will be monitored so that adjustments can be made. When deemed appropriate more water will be diverted by adding materials. This adjustment in flow volumes and monitoring will continue until the full flow can be diverted into the new channel. Once the full realignment of water has happened, the Mangapū Tributary will be permanently blocked.

As the amount of water is reduced in the Mangapū Tributary, fish salvage operations will be undertaken, with rescued fish either being placed in the new channel or downstream into the main Mangapū Stream. All fish salvage shall be undertaken in accordance with the Aqua Fauna Salvage and Relocation Plan.

1 REFER TO THE EROSION AND SEDIMENT CONTROL ASSESSMENT REPORT, PREPARED BY MPD ENVIRONMENTAL LIMITED, DATED MARCH 2026.

HYDROLOGICAL FLOW REGIME

As discussed above, there is an overall reduction in ground and surface water once the stream realignment is complete, which may affect base flows within the new channel and further downstream within the Mangapū Stream.

It is proposed that flow gauges[2] be installed on the Southern Tributary (Mangapū Tributary) (upstream of the realignment (at US2) and downstream of the realignment (Realignment 1) and on the Mangapū Stream (downstream of the new channel confluence and downstream of the existing Mangapū Tributary confluence (at US1). The location of the proposed gauging station is shown in **Figure 9**. By monitoring the base flows near the downstream new confluence, assessments can be made on whether any mitigation measures are required.

Conversely to low flows, the hydraulic assessment has shown that the realignment channel will contain the 1% AEP flood. The velocity of the water exiting the realignment channel into the Mangapū Stream will increase, due to the increased grade of the realignment channel comparable to the current Mangapū tributary and the shorter travel distance. There will be an increase in flood depth for larger flood events (1% AEP) on the Mangapū Stream within the Hunua Quarry property, however this depth reduces further downstream outside of the quarry property boundary.

2 USING THE SAME APPROACH AS OTHER STREAMS (TWICE GAUGING IN SUMMER AND COMPARING THE LOW FLOWS WITH MALF)

4.0 IMPLEMENTATION OF THE MANGAPŪ TRIBUTARY REALIGNMENT

FISH PASSAGE VELOCITIES

Native (climbing) fish have been detected in the Mangapū Stream tributary. Accordingly, it is essential that provision for the migration and passage of these native fish is formed in the realigned channel.

Fish swimming capabilities and instream water velocity, as well as climbing ability are essential to understanding the ability for fish species to migrate. Guidance on fish passage is provided in the Fish Passage Guidelines (NIWA 2024). These guidelines are generally aimed at constructed features (e.g., culverts, weirs) and less attention is given to realignment of stream channels, especially those with well-formed natural substrates. Nevertheless, the commentary and advice in the fish passage guidelines is helpful in providing advice on fish swimming speeds required within the proposed realignment channel.

Fish have three basic categories of swimming speed – sustained, prolonged, and burst. Sustained swimming occurs aerobically and can be maintained indefinitely without muscle fatigue. Experimentally, it is typically defined by a swimming speed that a fish can maintain for greater than 200 minutes[1].

NIWA (2024) explain that fish use sustained swimming for activities like migration and foraging. Burst swimming is an anaerobically-fuelled process that leads to muscle fatigue over a period of less than 20–30 seconds. Fish typically use burst (20-30 seconds) swimming for prey capture and predator avoidance.

1 THE MAXIMUM SUSTAINED SWIMMING SPEED IS TYPICALLY APPROXIMATED USING A CRITICAL SWIMMING SPEED TEST. MORE RECENT RESEARCH SUGGESTS THAT THE MAXIMUM SUSTAINED SWIMMING SPEED IS ONLY 60–80% OF THE CRITICAL SWIMMING SPEED. FOR DESIGN PURPOSES, THE MAXIMUM SUSTAINED SWIMMING SPEED SHOULD BE ASSUMED TO BE AROUND 70% OF A MEASURED CRITICAL SWIMMING SPEED (NIWA 2024).

Critical swimming speeds for relevant native species in the Mangapū Stream are provided in **Table 8**. For design purposes, sustained swimming should be the focus.

Noting that the indicative swimming speeds detailed from the guidelines are mean values, the banded kokopu is in the moderate range of swimming speed for galaxiids (mean 0.36, min 0.07, max 0.81, all m/s), and for elvers the mean critical swimming speed is slightly higher. At 70% of these measured swimming speeds, the mean velocities would be in the order of 0.25 m/s up to 0.41 m/s. This range of velocity would be indicative as averaged for run/riffle habitat arrangements within the stream realignment, acknowledging that cascades would have faster velocities over much shorter distances.

Table 8: Mean critical swimming speeds for a range of native fishes during their primary upstream migratory life stage

Native Fish	Mean maximum sustained swimming speed (m/s)	Mean critical swimming speed (m/s)	Mean size (cm)
Banded Kokopu	0.25	0.36	4.2
Longfin elver	0.22	0.41	4.1

4.0 IMPLEMENTATION OF THE MANGAPŪ TRIBUTARY REALIGNMENT

CREATING SUITABLE ENVIRONMENTAL CONDITIONS

Existing vegetation remnants play a critical role in rehabilitation by providing seed sources, shelter, and habitat for native fauna, which in turn support natural seed dispersal. Prior to the commencement of each extraction stage, the extent of quarry activities will be clearly defined, potentially including on-ground marking, to avoid accidental removal of vegetation intended to be retained.

Where practicable, vegetation stripped from the Site will be mulched and stockpiled for later use. The upper soil layers (generally the top 200 mm) will also be carefully stripped and stockpiled separately from underlying subsoils and overburden to preserve their value as growth media. These materials provide essential nutrients, organic matter, and seed banks for establishing vegetation cover during rehabilitation. Mulch may be blended with topsoil to enhance substrate quality for planting and natural regeneration.

Stockpiles will be located where they will not be compacted by machinery, kept to a maximum height of 1.5m to avoid anaerobic conditions that reduce soil quality, and grassed to provide stability and reduce dust. Storage duration will be limited to a maximum of two years to maintain soil health.

Because benches can direct and concentrate water flow, drainage design is essential to prevent scouring and erosion that could damage plantings. Cut-off drains or berms will be installed on benches to protect replaced soils, create stable platforms for plant establishment, and facilitate safe maintenance access. These drains and berms will be designed to retain water on benches and release it slowly to the surrounding environment. Given that rehabilitation substrates will generally be free-draining aggregates, retaining moisture will be important for the successful establishment and progressive development of vegetation communities.

Soil preparation is a critical component of successful rehabilitation, both for areas that will be left to regenerate naturally and for areas intended for planting. With appropriate planning, much of the required soil material can be sourced onsite through mulching vegetation, stockpiling topsoil, and incorporating suitable quarry by-products. While imported topsoil may be required in some situations, the strategy does not rely on it as a primary source.

The appropriate blend of rubble, fill, and topsoil will be determined on a Site-specific basis, depending on substrate characteristics and the planting requirements of each area. Fertiliser needs will also be considered as part of developing the final soil mix. As extraction progressively concludes, soils will be stabilised to minimise erosion and dust. Where practicable benches will be ripped to a depth of approximately 500 mm before the placement of coarse aggregates, overburden, and surface soils as part of the rehabilitation process.

PLANTING AND REVEGETATION TECHNIQUES

Progressive rehabilitation of the exposed benches and faces and riparian planting along the realigned Mangapū Tributary is integral to restoring landscape and ecological values and the natural character condition of the stream corridor.

This will include ongoing monitoring and adaptive management to refine species selection, adjust planting and revegetation techniques, implement additional erosion and sediment control measures to improve rehabilitation outcomes. Where required growing conditions will be enhanced through ripping, mulching, and fertilising, along with weed and pest control measures.

Engineered landforms typically presents harsh and highly variable conditions, ranging from exposed edges and limited soil depths to rapidly draining substrates, meaning that only certain native species are well adapted to establishing and thriving in these environments.

Revegetation, therefore, relies on species that can tolerate these conditions while progressively improving soil structure, shading substrates, and facilitating natural regeneration processes.

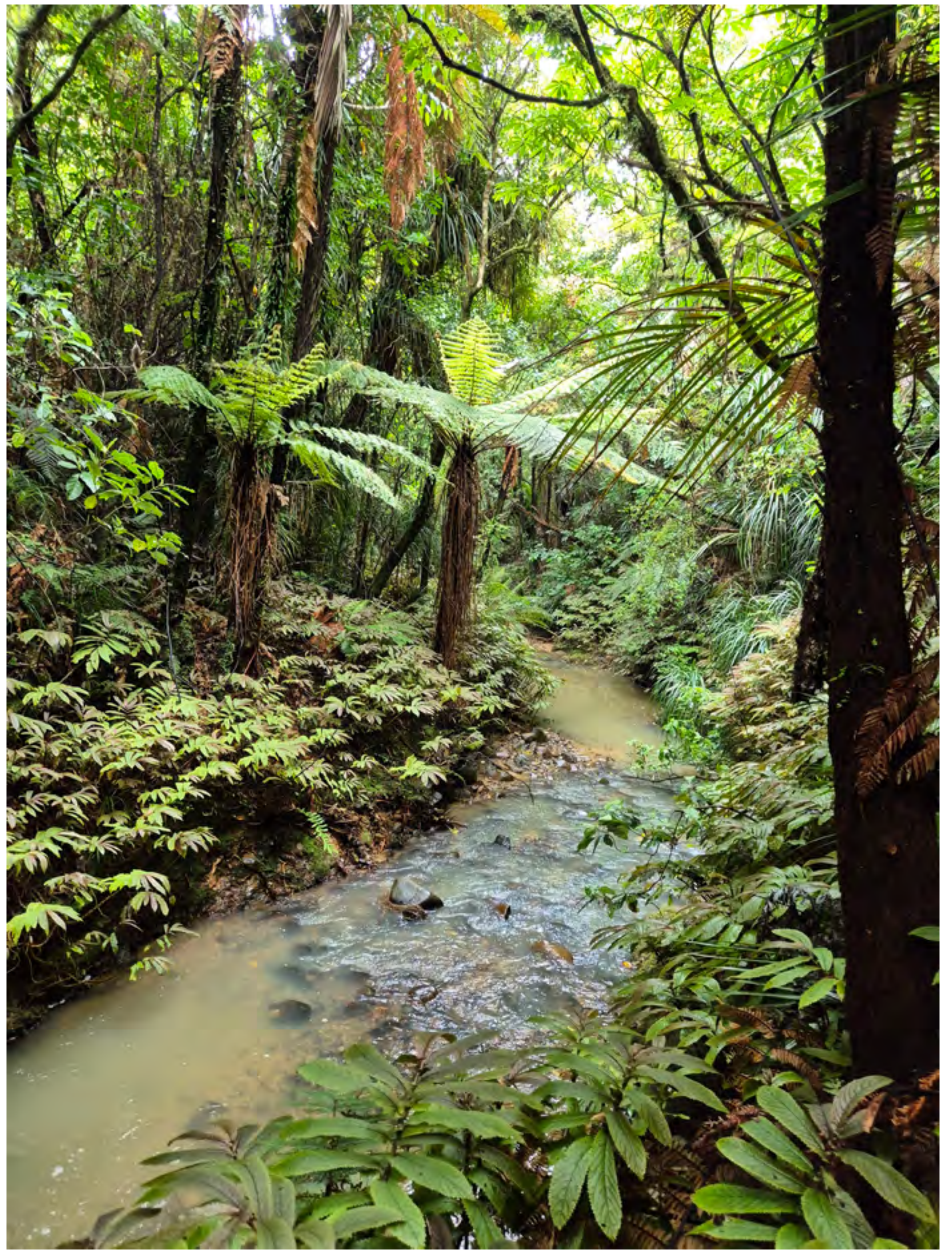
Species selection is guided by characteristics that support successful revegetation outcomes, including:

- High survival rates under planted conditions;
- Tolerance to environmental extremes, such as persistently wet or seasonally dry microsites and areas exposed to wind;
- Fast early growth combined with the ability to persist and suppress weeds;
- Branching growth forms that provide early shade to the realigned watercourse corridor and visual screening of cut faces;
- Attributes that attract birds, such as seed or nectar, to encourage natural dispersal and recruitment of additional native species; and
- Relatively long lifespans, ensuring vegetation stability and minimising opportunities for invasive species to colonise.

Through this approach, revegetation will act as a primary driver for ecological recovery, restored natural character and visual integration of the realigned Mangapū Tributary, enabling natural succession processes to take hold while ensuring that early and effective establishment is achieved.

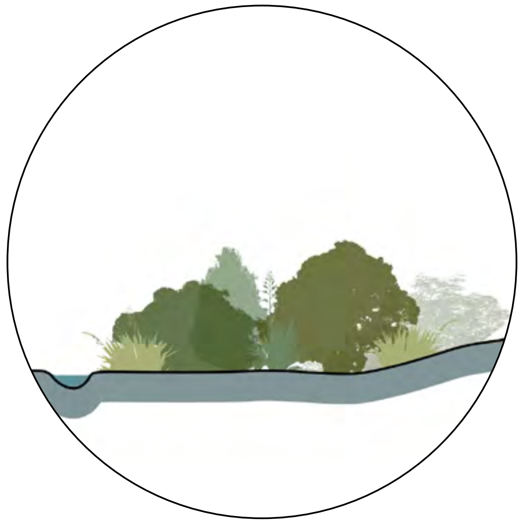
PLANT TYPOLOGIES

The following plant lists illustrate a range of species proposed for the stream corridor. These lists demonstrate typical plants selected for their specific functions and intended purposes. They are not exhaustive but provide an indication of the types of species that may be expected within these areas.



4.0 IMPLEMENTATION OF THE MANGAPŪ TRIBUTARY REALIGNMENT

STAGES OF PLANTING



STAGE 1

IMPLEMENTATION PLANTING

The first stage will occur within the next planting season following the construction of the stream diversion. The primary objective is to establish groundcover for soil stabilisation and introduce shrub cover to support early ecological development. Restoration tree planting will also be incorporated as part of the overall planting scheme to ensure long-term structural integrity and habitat creation.

Toe Toe
Austroderia fulvida

Flat Leaved Sedge
Carex dissita

Rautahi
Carex geminata

Pūrei
Carex secta

Pūkio
Carex virgata

Ti Kouka
Cordyline australis

Giant umbrella sedge
Cyperus ustulatus

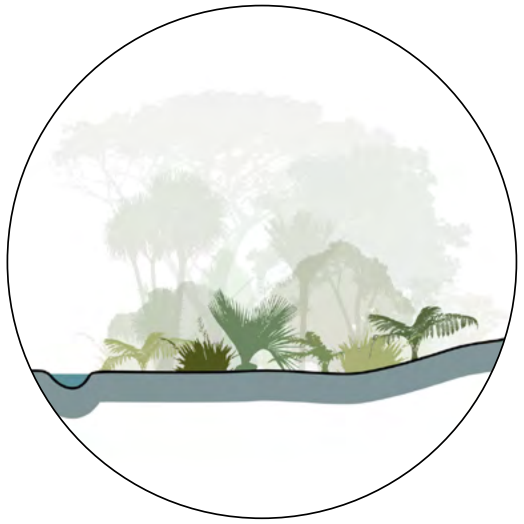
Kiokio
Parablechnum novae-zelandia

Karamū
Coprosma robusta

Tutu
Coriaria arborea

Wheki
Dicksonia squarrosa

Kiekie
Freycinetia banksii



STAGE 2

SUPPLEMENTARY PLANTING

Second stage selective tree planting to create a canopy layer that provides shade and improves microclimatic conditions. This canopy development is essential for preparing the site for the eventual removal of the quarry batter, ensuring stability and ecological resilience during the transition.

Silver Fern
Alsophila dealbata

Nīkau
Rhopalostylus sapida

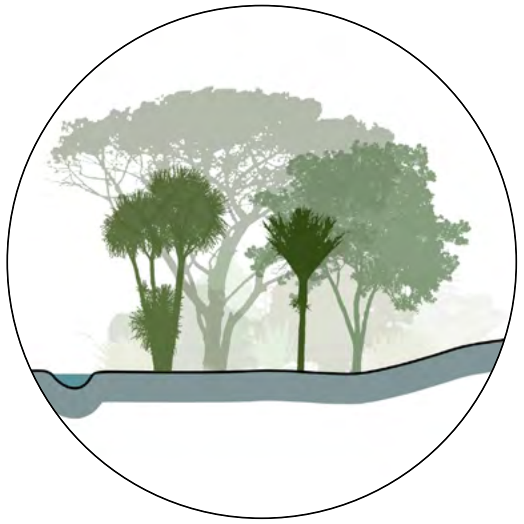
Pāte
Schefflera digitata

Mamaku
Sphaeropteris medullaris

Kiokio
Parablechnum novae-zelandia

Bamboo Orchid
Earina mucronata

Easter Orchid
Earina autumnalis



STAGE 3

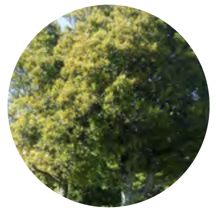
CANOPY ESTABLISHMENT

Supplementary ecological planting on establishment of canopy cover to enhance species diversity and habitat complexity. This stage aims to enable succession planting, improve biodiversity, and support the long-term ecological health of the site.

Pukatea
Laurelia novae-zelandiae

Māhoe
Melicytus ramiflorus

Kanono
Coprosma grandifolia



Tawa
Beilschmiedia tawa

Taraire
Beilschmiedia taraire

Putaputaweta
Carpodetus serratus

Mānuka
Leptospermum scoparium

4.0 IMPLEMENTATION OF THE MANGAPŪ TRIBUTARY REALIGNMENT

PLANTINGS

Winstone Aggregates will oversee the implementation of this plan and ensure the intended outcomes for the Site are achieved. Planting and aftercare are expected to be carried out by contractors with proven experience and capacity to deliver high-quality, consistent work across the project.

All planting layouts will be confirmed on Site with the approval of Winstone Aggregates or its nominated representative to ensure that the intended landscape, ecological and natural character outcomes are achieved.

Planting work will generally be undertaken between April and September when weather conditions are mild, damp, and conducive to planting, and when the ground is workable. Operations will be suspended during periods of severe cold or sun exposure, waterlogging, drought, or persistent drying winds.

The genetic source of all New Zealand native plant material will be from the Auckland Ecological Region, preferably the Hunua Ecological District. No plant material is to be sourced from outside this area without prior approval of Winstone Aggregates or its nominated representative.

Plant material refers to all plants required for the project, as shown on the plans and detailed in the plant schedules.

All plants will be high-quality nursery stock, true to name and type, with well-shaped trunk or stem and head. Stock will be well hardened to suit local site conditions and free from pests, diseases, and physical defects.

Root systems will be healthy and fibrous, with roots just reaching the container edge. Plants showing root circling or poor structure should be rejected.

Plants will also be free from damage such as knots, bark abrasions, wind, or frost injury, and should show evidence of correct pruning.

All plant material will be made available for inspection by Winstone Aggregates or its nominated representative, prior to planting.

Each plant, or bundle of plants, will carry a legible label showing the approved botanical name, quantity, and any other required identified details. Plant sizes are to be specified by root trainer or litre container size.

No plant species will be substituted without prior approval of Winstone Aggregates or its nominated representative. If specified species are unavailable at the time of planting, substitute alternatives may be proposed and approved by a qualified landscape architect or ecologist.

Ongoing monitoring is essential to the success of rehabilitation, enabling early identification of trends, issues, and opportunities. Annual monitoring will allow favourable micro-sites and high-performing plant species to be recognised and prioritised, while also enabling prompt response to emerging pest plant or animal issues. Monitoring will also help manage the effects of variable climatic conditions, such as adjusting planting schedules during drought years. In addition, trial plots can be established and monitored to test and refine new approaches that may improve revegetation outcomes over time.

Maintenance and monitoring is covered in more detail in Section 6.5 below.

HYDROLOGY AND ENGINEERING

As the construction of the new realignment channel will be 'offline', high flows following heavy rain events will continue to be conveyed by the existing Mangapū Tributary. The critical period for manging flood flows is when the phased transition of flow from the Mangapū Tributary into the new channel is happening.

Monitoring of local rainfall and stream responses will be crucial to manage the flows between the two channels, to ensure that large volume and fast flows are not directed down the newly constructed channel before sufficient establishment of features and planting has occurred.

Table 9: Implementation Stages

Development Stage	Spring / Summer Season	Autumn/Winter Season
Plant Supply	• Obtain seed and propagate plants • Purchase plants as required • Grow on plants during summer	• Grow on and harden off plants and deliver to the site nursery/holding area as required
Site Preparation	• Review site-wide boundary fences and upgrade where required. • Assess site for weeds and control as required. • Undertake soil samples • Prepare planting zones. • Undertake fencing upgrades and pest management	• Continue pest management
Planting	• Commence proposed planting. • Continue weed control.	• Continue planting of wetland and riparian zones.
Weed and Pest Control	• Control all weed infestations within planting zones. • Continue pest management.	• Undertake weed surveys over the entire site and control as necessary. Continue pest management as required.
Monitoring and Maintenance	• Monitor and replace dead wetland, riparian, and other vegetation. • Ongoing maintenance.	• Monitor and replace dead wetland, riparian, and other vegetation. Continue maintenance.
Project Completion	• Monitoring and maintenance period completed. Assess the need for further weed and pest control.	• Final monitoring and replacement of dead plants as required.

4.0 IMPLEMENTATION OF THE MANGAPŪ TRIBUTARY REALIGNMENT

GEOTECHNICAL CONSIDERATIONS DURING CONSTRUCTION

During ongoing quarry development, there remains the potential for encountering unforeseen geological structures such as previously unmapped faults, shear zones, or persistent orthogonal joint sets. This is the main geotechnical risk to the site. These features can locally alter rock mass strength, slope instability, and groundwater conditions and may locally increase the likelihood and scale (hence consequence) of any resultant instability. This has the potential to elevate the assessed risk rating from R1 or R2 to R3 or above (refer to Appendix H in the T+T Geotechnical Assessment Report) and would, if encountered, necessitate a design change. As excavation progresses to greater depths, continuous geological mapping and geotechnical inspections should be implemented to identify any such structures early.

If a new fault or other significant structural feature is encountered, the associated geotechnical risk can be assessed at that stage. This would typically include an evaluation of its orientation relative to the excavation faces, continuity, potential to form release or wedge planes, and any influence on local groundwater flow or pressure conditions. Depending on findings, slope designs or drainage provisions may require refinement to maintain long-term stability and operational safety.

Additionally, monitoring of groundwater inflows and piezometric responses during excavation should continue as proposed as part of the consent conditions, as newly exposed pathways or fault zones may locally increase permeability and lead to changes in water pressure. If elevated inflows are detected, targeted dewatering or slope drainage measures can be implemented to mitigate any adverse effects on slope stability or working conditions, such as horizonal directionally drilled drainage.

A Trigger Action Response Plan (TARP) will guide appropriate responses if conditions differ from those anticipated. Targeted investigations within the Mangapū Tributary realignment should also be undertaken as the quarry advances.

A careful approach will be required when reaching the final face positions in Stage 8 to minimise the risk of back-break, leading to unnecessarily broken rock in the final face and any temporary faces. Pre-splitting is recommended to minimise structural damage to the final batter profiles, which involves drilling a single row of closely spaced, lightly charged holes along the designed perimeter, which are detonated simultaneously or in close succession to shear the rock between them. At the end of the 50-80-year cycle, the final faces should be subject to inspection by a geotechnical professional familiar with the contents of the T+T Geotechnical Assessment Report.

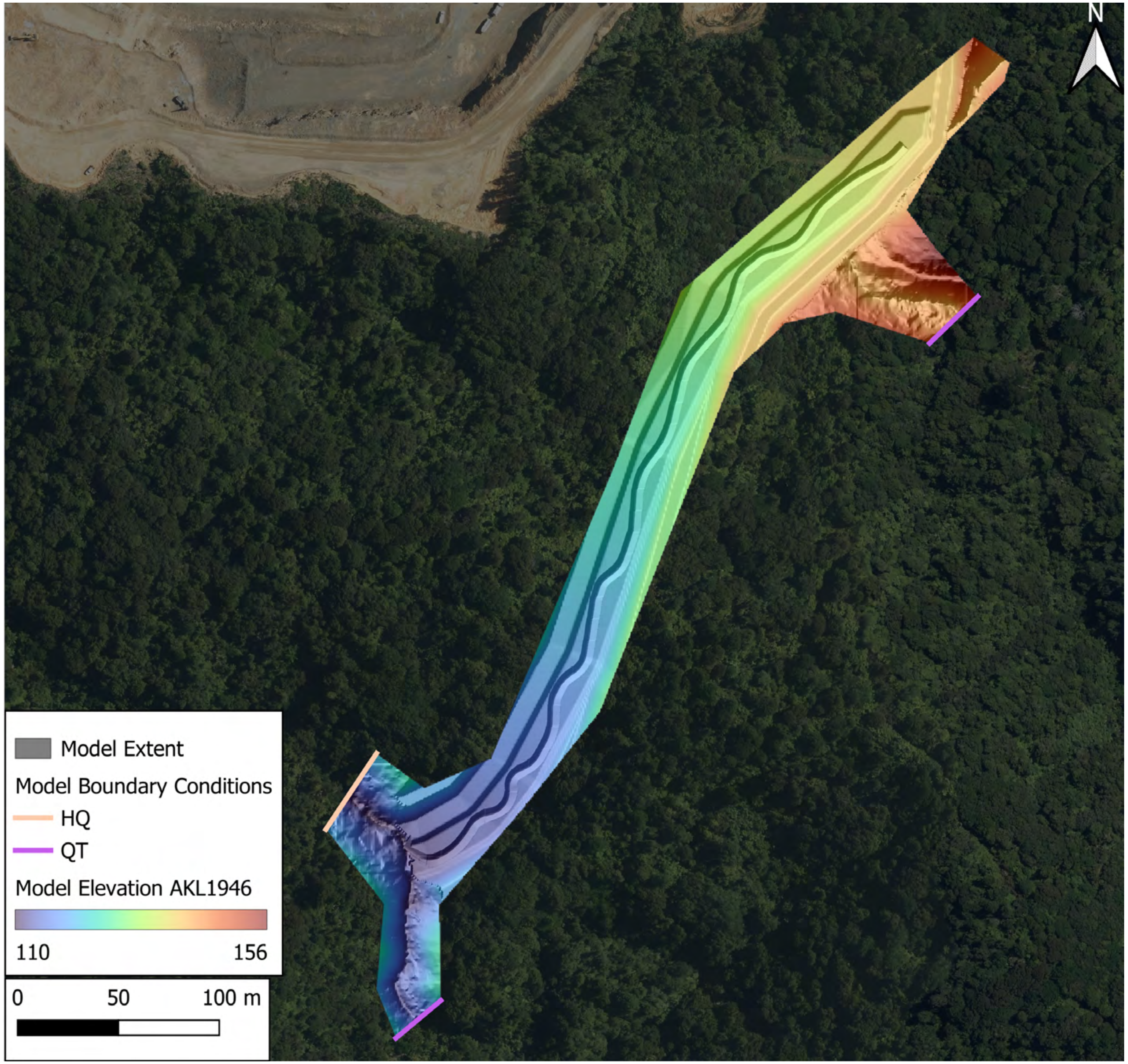


Figure 18: LiDAR of the proposed realigned Mangapū Stream Tributary, PDP.

5.0 LIVENING THE MANGAPŪ STREAM TRIBUTARY

PHASING THE TRANSITION BETWEEN WATERWAYS

It is intended that the realignment channel will progressively become live, with a phased realignment of the stream flows over time as set out in section 4.3 above. It is recommended that the tributary channel remains viable to convey flows, particularly more extreme flows, to prevent flood flows entering the realignment channel before vegetation and sediment accumulation have established enough to withstand larger flows.

Because the construction and development of the realigned channel is expected to occur in advance of the stages of expansion, there is an opportunity for the livening of the channel to be expanded over a period of time, rather than a sudden 'switch over'. This in turn provides the opportunity for a transition of ecological values from one channel to another, rather than the more typical abrupt stop-start in one single moment in time.

The livening will occur through a staged transition of flows from the Mangapū Stream tributary to the realigned tributary over some 18-24 months as suggested in **Table 10**.

Table 10: Example phases of livening of Mangapū Stream tributary, Hunua Quarry Development

Phase of livening	Mangapū Stream tributary	Realigned channel	Ecological Actions
Pre-livening	100% flow	Channel construction	Construction of instream channel habitat features Vegetation clearance and fauna salvage and relocation (as required).
Phase 1	66% flow	34% flow	Monitoring aquatic colonisation and values
Phase 2	34% flow	66% flow	Monitoring aquatic colonisation and values Aquatic fauna salvage and relocation
Phase 3	Flow ceases	100% flow	Outcome monitoring commences

We emphasise that livening will only occur once the instream habitat features have been designed and built into the realigned channel. The phased livening provides opportunity for monitoring the colonisation and advancement of aquatic ecological values, allowing for modifications prior to full livening at Phase 3. The transitioning of the ecological values from the Mangapū Stream tributary to the realigned channel is an important factor in the management of effects of the project.

The phased livening means that for a period of time there is additional (temporary) stream extent, with differing aquatic ecological values (one mature channel and one developing channel). The mature aquatic ecological values will persist in the Mangapū Stream tributary channel but will likely diminish as flows are reduced as the phases progress. However, it is expected that the aquatic ecological values of the realigned channel will improve as flows increase and the habitat settles, biofilms and algal food sources mature, and invertebrates and fish colonise the channel. Thus, the aquatic ecological values transition over the period of livening. As applicable, when salvage and relocation of aquatic fauna (fish and koura) from the Mangapū Stream tributary is implemented, the realigned channel becomes a realistic option for relocation.

NATURAL COLONISATION OF THE REALIGNED CHANNEL

Colonisation occurs as aquatic species not initially present at a location occupy new or available habitat. Freshwater organisms colonise aquatic habitats through many avenues including:

- Drift from upstream populations.
- Migration from downstream sources.
- Egg laying from adult (insects) direct into the stream.

Invertebrate and algal drift from upstream is a well know phenomenon in aquatic ecology and is the most likely source of colonists in the initial phases of the realigned stream. Although the headwater streams had a lower diversity of macroinvertebrates, the eDNA detections confirm a diverse fauna and flora upstream of the realignment suggesting a substantive source of colonists for the realigned channel.

The benefit of the phased livening of the realigned channel means that:

- Organic layers of bacteria and algae will form in the habitat prior to the removal of the current stream.
- The organic layers provide a food source for invertebrates that colonise the formed channel.
- Variation in natural (but not full volume capacity) flows enables the formed habitat to adjust to flowing water.

Further colonisation will be aided by the relocation of fish and koura (and associated invertebrates) from planned salvage from the current Mangapū Stream tributary.

The phased livening of the realigned channel means that a staged reduction in flow within the Mangapū Stream tributary will make the salvage of aquatic fauna less challenging but also means that salvage will need to be efficient and timely as flows recede. Details of aquatic fauna salvage and relocation are outlined below and in more detail in the Aquatic Fauna Salvage and Relocation Plan.

Monitoring of the colonisation and the progression of aquatic values is proposed thus providing for adaptive responses as required and as detailed in the Stream Realignment Management Plan.

6.0 POST CONSTRUCTION MONITORING

RESPONSIBILITIES AND COMPETENCIES

6.1 Key personnel (SQEP)

This management plan, is required to be prepared and implemented by a SQEP (Suitably Qualified and Experienced Person(s)), in close coordination with Winstone. As at 2026, the following technical leads are identified as responsible for the implementation of this management plan are:

Ecology	Ian Boothroyd
Landscape Architect	Amanda Anthony
River Engineering	Verity Kirstein
Water Resource	Parviz Namjou
Engineering Geology	Phil Mathewson
Cultural Integration	Jade Wikaira

6.2 Staff induction procedures

Prior to the commencement of any works associated with the realignment of the Mangapū Stream Tributary, all SQEP (listed in section 6.1 above) and any personnel working or assisting with the management of activities in accordance with this Plan, shall hold a prestart meeting to discuss the location and extent of any works required, the required management actions in accordance with actions identified in this Plan, any lead in times required to complete enabling works.

CHANNEL CONVEYANCE MONITORING AND MAINTENANCE

Monitoring and maintenance of the 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.

As set out in section 4.4 above, gauging stations will be established to monitor flows to assess the performance of the channel and inform high flow inspections and follow-up maintenance. Gauging should be established on the Mangapū Tributary upstream of the realigned channel intake confluence, downstream of the realigned channel connection on the Mangapū Stream and further down the Mangapū Stream downstream of the existing tributary confluence.

Based on information from the flow gauges, an inspection programme should be developed which should be activated when flows of a certain magnitude are experienced. By compiling flow and inspections data, maintenance needs can become more predictive, i.e. by recording any damage that occurred on a defined flow, predictions on future damage and maintenance needs can be made.

Maintenance activities within the active channel will likely 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 might include placement of rock to protect banks, placement of rock to divert flows back onto an appropriate route or additional planting to provide more buffer protection. Areas of sedimentation which pose an outflanking or overtopping risk should be addressed by removal or redistribution of the material.

As part of operating and maintaining the realigned stream channel, an operational maintenance plan will be prepared to align with this 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 to maintain the design intent and mitigate adverse effects.

INSTREAM MONITORING

Immediately following the livening of the realignment channel and inspection will be undertaken by a suitably qualified Freshwater Ecologist. The objective of monitoring is to ensure that the realigned channel is functioning as intended.

To measure the overall success of the realignment channel ongoing monitoring is required. The success is to be measured using habitat and macroinvertebrate community composition metrics. The following monitoring parameters and methods will be undertaken as set out in **Table 11**.

Table 11: Monitoring parameters and methods for the realigned Mangapū Stream Tributary

Monitoring attribute	Method	Metrics	Protocol (where appropriate)
Habitat	Rapid Habitat Assessment (RHA)	HQS	Clapcott et al. (2020)
Settled sediment	In-stream visual estimate of % sediment cover	Fine sediment cover (%)	Sediment Assessment Method 2 (Clapcott et al. 2011)
Algal cover	Periphyton cover (%)	No algae (bare substrate), Films, Mats, Filaments.	National Environmental Monitoring Standards for Periphyton (NEMS 2022a)
Macroinvertebrates	Benthic macroinvertebrates	Taxa number, MCI, EPT, % EPT	National Environmental Monitoring Standards for Macroinvertebrates (NEMS 2022b)
Riparian planting	Cover% Planted success%	Cover% Planted success%	

6.0 POST CONSTRUCTION MONITORING

FREQUENCY OF MONITORING

Ecological Monitoring of the stream channel will be undertaken annually for five years post-livening, and again at Year 10 to ensure the realigned channel is meeting ecological objectives and function. If the objectives and functions are being met then no further monitoring is required.

MONITORING AND 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.

Monitoring will address all aspects of rehabilitation, not only plant survival. Key elements include:

- Observing the stability of finished landforms, including any small-scale slumping or rockfalls that may influence revegetation success
- Assessing erosion control performance, including surface erosion on benches, batters, slopes, and scree areas.
- Monitoring water quality within the realigned Mangapū Tributary, drainage channels, bench runoff paths, and receiving environments for signs of sedimentation or contamination.
- Evaluating soil fertility, particularly where plant survival is patchy or growth rates are below expectations; soil testing may be used to determine nutrient or amendment needs.
- Reviewing drainage performance, including the function of cut-off drains and berms, to ensure water is retained and released appropriately without scouring or undermining planting.
- Identifying animal pest damage (e.g., browsing, digging, or trampling) as a trigger for pest-control actions.
- Monitoring the incidence and persistence of invasive plant species.
- Recording the survival and growth of planted shrubs and trees to guide infill planting and refine future species selection and planting programmes.
- Evaluating fire risk within rehabilitated and regenerating areas.
- Establishing and monitoring trial or experimental plots to test alternative rehabilitation techniques and inform adaptive management

These monitoring requirements will form part of the rehabilitation documentation. Some management measures will be implemented from the outset, but many will rely on ongoing monitoring to determine what actions are required and when. Responses may be as simple as refining existing methods or as significant as altering the timing and techniques used. Management practices will therefore be adapted year by year based on monitoring insights.

Comprehensive record-keeping will support the accumulation of site-specific knowledge, leading to increased efficiency and reduced costs over the life of the project. Photographic records, including fixed-point photos, aerial imagery, and views from key vantage points, will be valuable tools for tracking change and confirming progress.

Initial monitoring and maintenance by Winstone or their nominated representative will occur at least every two months for the first year following each new planting, and again in spring, early summer, and late summer during the first two years. Monitoring each season and stage will enable timely supplementary planting or management actions to ensure plant establishment and survival.

Independent monitoring by a suitably qualified ecologist will also be undertaken to assess the success of restoration planting and habitat condition to determine whether additional management is required. Ecological monitoring will occur every three months in the first year following planting, and then annually thereafter.

Extended maintenance will continue for at least five years after each planting is completed. During this period, site inspections will occur at least once every three months, and any planting failures will be replaced to maintain full cover. By the end of this period, at least 90% of plants must be well established and demonstrating strong growth, with compliance confirmed by a suitably qualified and experienced practitioner.

Pest plants shall be assessed within the riparian planting. Where pest plants are considered to be dominating the vegetation and/or smothering desired plants, then control activities shall be undertaken as soon as is practicable.

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.

Table 12: Indicative thresholds for the realigned Mangapū Stream Tributary

Realignment	Realigned Mangapū Stream tributary
Metric	
Habitat Quality Score band	Good
Deposited fine sediments NOF Table 16	= or > Band B
MCI Band NOF Table 14	= or > Band C

INDICATIVE PERFORMANCE TARGETS

The indicative targets for the performance of the realignments are set out in **Table 12**. These performance targets have been drawn from the existing ecological values as assessed above, NOF from the NPS-FM, and related metrics (i.e., RHA). The indicative performance indicators focus on condition of habitat (including deposited sediments) and reference to NOF bands for macroinvertebrates.

REPORTING

A brief Monitoring Report for Winstone Aggregates will be prepared each year until the completion targets are met. Monitoring Report Content should include:

- Dates of visits
- Photographs as appropriate
- Hydrological flows
- Water quality
- Condition of the vegetation and plant health
- Record of instream species and habitat condition
- Number of plants replaced during the year
- Stages of implementation completed
- Pest and weed status
- Identification of any arising issues that require special monitoring
- Actions required

At the end of the realignment cut, and again before the opening of the realignment to stream flows, the final faces should be subject to inspection by a geotechnical professional familiar with the contents of the T+T Geotechnical Assessment report .

ONGOING MANAGEMENT

Ongoing management is intended to be addressed through site-wide management plans.

7.0 REFERENCES

Cultural Values and Consultation Summary Report, prepared by Wikaira Consulting, dated March 2026.

Assessment of Ecological Effects, prepared by Boffa Miskell, dated 18 March 2026.

Mangapū Tributary Realignment - Preliminary Design and Effects Technical Report, prepared by PDP, dated 19 March 2026.

Erosion and Sediment Control Assessment Report, prepared by MPD Environment Limited, dated March 2026.

Technical Report – Geotechnical Assessment, prepared by Tonkin & Taylor Ltd, dated March 2026.

Groundwater Effects Assessment, prepared by PDP, dated March 2026.

Landscape Effects Assessment, prepared by Boffa Miskell, dated 23 March 2026.

Landscape Rehabilitation Strategy and Management Plan, prepared by Boffa Miskell, dated 17 March 2026.

Pest Management Plan, prepared by Boffa Miskell, dated March 2026.

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Boffa Miskell is a leading New Zealand environmental consultancy with nine offices throughout Aotearoa. We work with a wide range of local, international private and public sector clients in the areas of planning, urban design, landscape architecture, landscape planning, ecology, biosecurity, Te Hihiri (cultural advisory), engagement, transport advisory, climate change, graphics and mapping. Over the past five decades we have built a reputation for creativity, professionalism, innovation and excellence by understanding each project's interconnections with the wider environmental, social, cultural and economic context.

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Whangarei 09 358 2526
Auckland 09 358 2526
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Wellington 04 385 9315
Nelson 03 548 8551
Christchurch 03 366 8891
Queenstown 03 441 1670
Dunedin 03 470 0460