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Kings Quarry Stage 2 Expansion

Freshwater Ecology Residual Effects Analysis Report

for: Kings Quarry Limited

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Cover Illustration: Central Lower stream reach at 158 Hellyer Road.

1 EXECUTIVE SUMMARY

Kings Quarry Limited is proposing to expand its existing Kings Quarry operation with a Stage 2 pit and fill development. This will require removal of 2,439 linear metres of stream length. The Stage 2 area (Project area) is zoned 'Special Purpose Zone: Quarry' (SPQZ) under the Auckland Unitary Plan – Operative in Part (AUP) and the streams within the Project Area were classified as intermittent, modified intermittent and permanent streams. The Assessment of Ecological Effects identified that the reclamation of the streams would represent a 'very high' level of effect (Bioresearches, 2025), and these significant residual adverse effects would require biodiversity offset or compensation.

This report describes the proposed biodiversity offset plan, using the Environmental Compensation Ratio (ECR), to assess the level of offset actions required to ensure a no net loss, and preferably a net gain of freshwater habitat values. The loss of stream extent cannot be practicably offset; therefore, this loss is proposed to be compensated. These offset actions need to be sufficient to outweigh the impact from the proposed quarry pit Stage 2.

To offset these losses in stream value, it is proposed to carry out a total of 2,893 linear metres of stream restoration through riparian planting and the removal of barriers to fish passage. To compensate for the loss of 1,119 m^2 of stream bed area, 6,400 m^2 of degraded wetland habitat is proposed to undergo restoration through wetland and buffer planting, and fencing; and a weir currently situated in the Waitoki Stream will be removed in addition to the wetland restoration. The offset and compensation sites selected are within the same ecological district (Rodney district) located approximately 1.5 km and 26 km north of the Project area.

Details for ongoing monitoring are provided with specified targets and contingency plans for each of the offset sites. It is anticipated that a net gain in biodiversity values should occur following the completion of all offset and compensation actions.

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2 INTRODUCTION

Kings Quarry Limited (KQL) is proposing to expand its existing quarry operation, known as 'Kings Quarry', to develop a Stage 2 pit and associated fill areas. Collectively, the Stage 2 pit and fill areas, and associated infrastructure are hereafter referred to as the 'Project area' (Figure 1). The ecological habitats, including aquatic habitats, within the Project area have been assessed and recommendations for the mitigation, offset and compensation of ecological effects of the proposed expansion have been made in the Ecological Impact Assessment (EcIA) report (Bioresearches, 2025). The expansion of the quarry will include the loss of all streams within the Project Area (Figure 1). The loss of the streams was assessed as a significant residual adverse effect requiring offset and compensation.

This report provides a summary of the approach, methodologies and analysis used to determine the stream ecological offset requirements for the expansion of Kings Quarry.

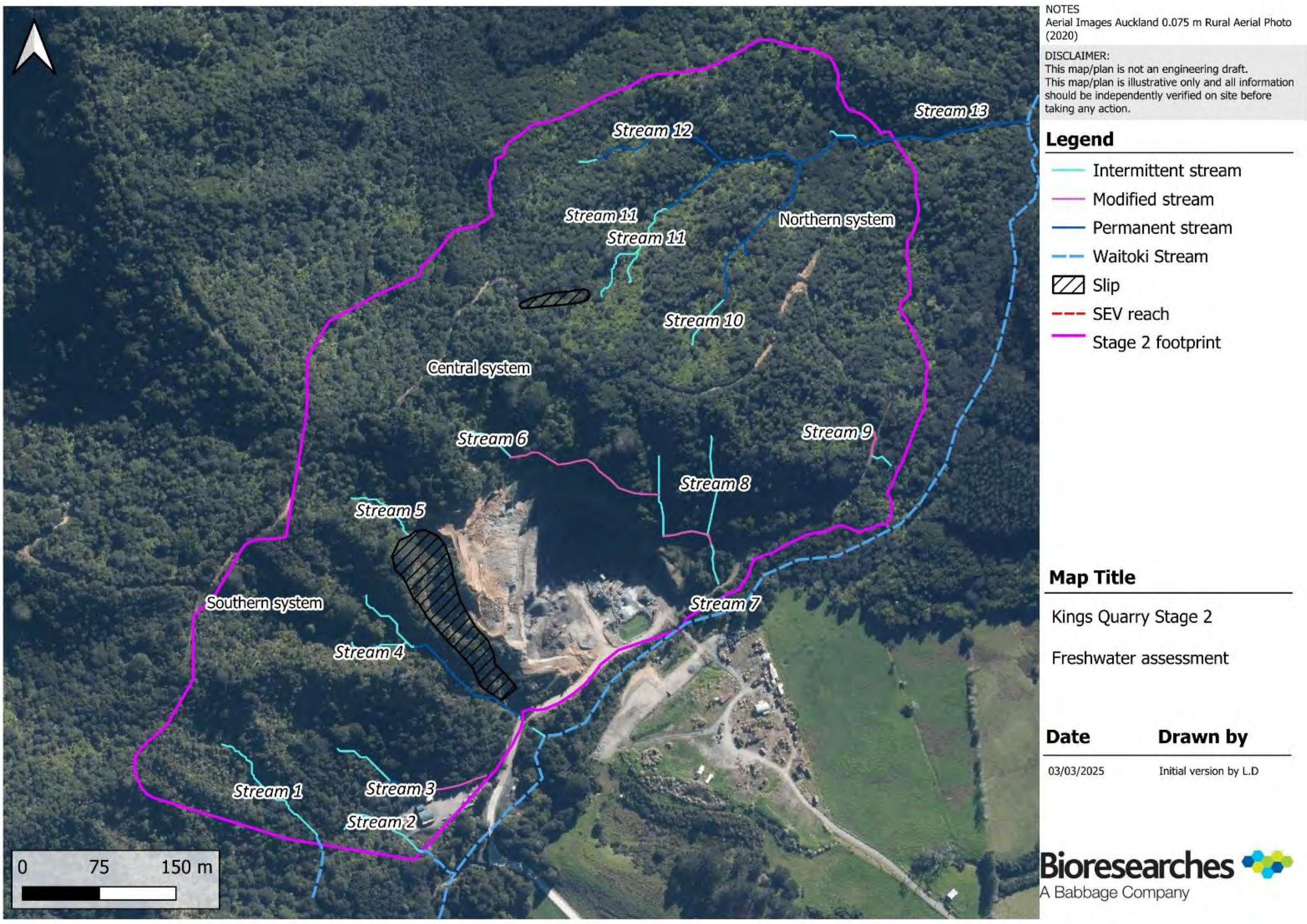

Figure 1. Kings Quarry Project Area and Stream Locations

3 STATUTORY CONTEXT

This section summarises the legislation, policy, plans and strategies relevant to the protection, conservation and enhancement of nature conservation interests associated with the Kings Quarry Project Area. The ecological values described in this report allow significant ecological issues and adverse effects to be identified as they relate the Resource Management Act 1991 (RMA). The identification of significant values and subsequent management recommendations to mitigate adverse effects are consistent with standards and objectives of the following legislative, policy statement and regional plan documents.

3.1 Legislation

3.1.1 Resource Management Act 1991 (RMA)

The purpose of the RMA is to promote the sustainable management of natural and physical resources. An important element of this is the protection of areas of significant indigenous vegetation and significant habitats of indigenous fauna. The RMA requires that adverse effects of activities on the environment be avoided, remedied, or mitigated. These elements are given effect in Sections 5, 6 and 7, and Schedule 4 sets out the requirements for effects assessments.

3.1.2 National Environmental Standards for Freshwater (NES-F, 2020)

The National Environmental Standards for Freshwater 2020 (NES-F) set requirements and regulations for carrying out certain activities that pose risks to freshwater and freshwater ecosystems.

Reclamation of wetlands is a Discretionary Activity under Regulation 45A of the NES-F ('Quarrying activities'), provided that there is a functional need for the reclamation in that location; and the effects management hierarchy is applied.

3.2 National Policy Statements

3.2.1 Freshwater Management

The National Policy Statement for Freshwater Management 2020 (NPS-FM) provides direction under the RMA to local authorities on managing activities that affect the health of freshwater, provides for the protection of freshwater bodies, including natural inland wetlands, includes provisions for monitoring and reporting on freshwater quality and quantity, as well as provisions providing for addressing the impacts of land use activities on freshwater resources.

3.3 Regional Plans and Policies

Auckland Council (AC) is the principal statutory planning document for the Auckland Region. It was prepared by Auckland Council for the purpose of giving effect to the RMA as a territorial authority. Regional planning documents relevant to this report include the Auckland Unitary Plan – Operative in Part, Regional Pest Management Plan

4 CURRENT STREAM HABITATS AND PROPOSED LOSS

Due to the topography and characteristics of streams within the Project area, representative aquatic habitats within the Project area were assessed. These comprised thirteen un-named intermittent and permanent streams, all tributaries to the Waitoki Stream. The location and description of each stream and the five representative sections of the streams where more detailed assessments were carried out are presented in Table 1 and Figure 1. No natural inland wetlands were identified throughout the Project area, and none were expected due to the topography and steepness of the Project area.

Table 1. Waitoki Stream Tributaries and their locations within the Project Area

Site Name	Location	Map Reference NZTM*
Stream 1	Intermittent stream to the Waitoki Stream on the southern side	E 1739298 N 5947767
Stream 2	Intermittent and permanent stream to the Waitoki Stream on the southern side	E 1739403 N 5947738
Stream 3	Intermittent and permanent stream to the Waitoki Stream on the southern side	E 1739382 N 5947803
Stream 4	Intermittent and permanent stream to the Waitoki Stream on the southern side	E 1739490 N 5947868
Stream 5	Intermittent stream to the Waitoki Stream on the southern side	E 1739401 N 5948049
Stream 6	Intermittent stream to the Waitoki Stream within the centre. Contains modified reaches	E 1739530 N 5948096
Stream 7	Intermittent stream to the Waitoki Stream within the centre. Contains modified reaches	E 1739682 N 5948034
Stream 8	Intermittent stream to the Waitoki Stream within the centre. Contains modified reaches	E 1739733 N 5948082
Stream 9	Intermittent stream to the Waitoki Stream within the centre. Contains modified reaches	E 1739843 N 5948117
Stream 10	Intermittent and permanent tributary to Stream 13 on the northern side	E 1739758 N 5948295
Stream 11	Intermittent and permanent tributary to Stream 13 on the northern side	E 1739669 N 5948306
Stream 12	Intermittent and permanent tributary to Stream 13 on the northern side	E 1739706 N 5948408
Stream 13	Permanent stream and tributary to the Waitoki Stream, northern most watercourse in the expansion footprint.	E 1739873 N5948404

*to approximate mid-point of watercourse

The results of the detailed stream assessments and site characteristics are summarised in Appendix 1 and briefly described below. More detailed descriptions are provided in the EcIA report (Bioresearches, 2025).

Eight streams (Stream 1 – 5 and Stream 10 - 12) were assessed as having 'High' freshwater ecological values, four streams (Stream 6- 9) were assessed as being of 'Low' ecological value, and one (Stream 13) was assessed as having 'Very High' ecological value. The riparian vegetation cover was good to excellent along many of the stream reaches, however four stream reaches (Streams 6, 7, 8 and 9) have been subject to historic modification through diversion.

The streams were dominantly soft clay bottomed with some hard substrate habitat; with the degree hydraulic variation variable between each reach, ranging from shallow, steep runs to scour pools, to shoots, runs, waterfalls, riffles and pools within the stream channel. There was evidence of slipping and erosion throughout the catchment, including a major hillside slip destroying a large proportion of an intermittent stream; and sediment affecting the movement of water throughout most stream reaches. Water quality parameters showed temperatures and dissolved oxygen concentrations were well within the range that is considered suitable for most benthic invertebrates and conductivity levels were moderate to low, showing minimal signs of nutrient enrichment.

Macroinvertebrate communities in all the unmodified tributaries were found to be dominated by taxa indicative of good habitat quality. The macroinvertebrate sample from Stream 7, a modified intermittent stream, was dominated by Chironomid flies, and indicated lower habitat quality than that of the other streams. A low to moderate range of taxa was recorded (8 to 16 taxa), including 12 EPT taxa and 6 taxa with individual MCI scores >8, which are typically sensitive to reduced water quality. The overall MCI scores indicated 'good' to 'excellent' instream habitat quality and, with the exception of the sample from the modified stream (Stream 7), SQMCI scores indicated 'good' and 'excellent' quality. (Stark & Maxted, 2007a, b)

The smaller tributaries (Stream 1 – Stream 10) provided limited habitat for native freshwater fish due to the shallow water and steep flow paths, including the permanent reaches. Although, longfin eel (*Anguilla dieffenbachii*) was detected through eDNA in the intermittent tributaries, the depth and availability of water would limit their presence to juveniles, and likely transitory juveniles. The permanent stream provided a good variety of habitats for both longfin eel *(Anguilla dieffenbachii)* and shortfin eel (*A. australis)*, bullies (*Gobiomorphus* spp.), and galaxiids (*Galaxias* spp.), however a significant barrier to fish passage is present in the Waitoki Stream, prohibiting access to swimming fish. The freshwater fish Index of Biotic Integrity (IBI) indicated that stream habitats had a 'Good' diversity of fish in comparison to other Auckland streams (Joy & Henderson, 2004). The presence of longfin eel (rated as 'at risk; declining') elevated the value of the lower tributaries as habitat for aquatic fauna.

The Stream Ecological Valuation (SEV) scores for the entire Project Area were moderate to high, with the highest score (0.83) attributed to the highly forested watercourses (Streams 10 to 12) and the lowest score (0.64) to the stream reaches which have been historically modified through diversion i.e. the smaller tributary watercourses at the base of the very steep gully system in the north-west of the catchment

(Streams 6 to 9). The good riparian cover and hilly landscape throughout the Project Area provide high shading to support sensitive invertebrate taxa and has resulted in largely unmodified high-quality streams.

The aquatic habitat within the Project Area that will be impacted by the Stage 2 expansion comprises an estimated 2,439 linear metres of low to high value streams (permanent and intermittent), resulting in the overall loss of stream values and extent.

5 AQUATIC OFFSETTING AND COMPENSATION

5.1 Freshwater Habitat Loss

Thirteen streams, all tributaries to the Waitoki Stream, were assessed within in the Project area. The proposed use of the Project area for quarrying aggregate will result in the total loss of the tributary streams. There will be no direct effects on freshwater habitats in the Waitoki Stream.

5.2 Principles of Stream Offsetting

The loss of the 2,439 m (1,119 m²) of aquatic habitat in the Project area is considered a significant residual adverse effect under the AUP, and a Very High Level of effect under the EcIA guidelines (Roper-Lindsay *et al.*, 2018), and would require aquatic offset and/or aquatic compensation.

Guidance on, and the Principles for, good practice aquatic biodiversity offsetting is provided in the AUP, Ministry for the Environment *et al.* (2014), and in Appendix 6 of the National Policy Statement for Freshwater Management (NPS-FM). In summary, the offsetting restoration and enhancement documents recommend:

a) The site be located as close as possible to the subject site;
b) Be 'like-for-like';
c) Preferably achieve no net loss;
d) Consideration of the use of biodiversity offsetting; and
e) The use of Storey *et al.* (2011), Appendix 8 of the AUP (Operative in part, 2016), and Ministry for the Environment *et al.* (2014) for guidance.

With the eleven principles for aquatic offsetting being (NPS-FM):

1. Adherence to effects management hierarchy;
2. When aquatic offsetting is not appropriate;
3. No net loss and preferably a net gain;
4. Additionality;
5. Leakage;
6. Long-term outcomes;
7. Landscape context;
8. Time lags;
9. Science and mātaurana Māori;
10. Tangata whenua or stakeholder participation; and
11. Transparency.

Under the effects management hierarchy, were adverse effects cannot be offset, they must be compensated for.

The thirteen principles for aquatic compensation being (NPS-FM):

1. Adherence to effects management hierarchy;
2. When aquatic compensation is not appropriate;
3. Scale of aquatic compensation;
4. Additionality;
5. Leakage;
6. Long-term outcomes;
7. Landscape context;
8. Time lags;
9. Trading up;
10. Financial contribution;
11. Science and mātauranga Māori
12. Tangata whenua or stakeholder participation
13. Transparency.

5.3 Environmental Compensation Ratio (ECR)

The Stream Ecological Valuation (SEV) methodology combined with the calculation of the Environmental Compensation Ratio (ECR) is a transparent, well-recognised methodology for calculating the quantum of offset required for stream loss, and is the preferred method of stream offset under the AUP (Storey *et al.,* 2011). Although the methodology was originally developed in Auckland, it has been reviewed by NIWA for use in Wellington, Hawke's Bay and Southland, and is considered applicable without modification to most stream and river types in those regions. (Storey *et al.,* 2011).

For permanent and intermittent streams, SEV scores can be utilised to calculate environmental compensation for any loss or modification to natural stream habitat by using the Environmental Compensation Ratio (ECR; Storey *et al.*, 2011). The ECR considers the SEV values of both the affected or impacted stream/s and the proposed restoration site stream/s, and determines any differential between the scores to provide a ratio for compensation which will result in "no net loss of area weighted stream function" (Storey *et al.*, 2011). The SEV score used in the ECR calculation does not include two biotic functions relating to fish and macroinvertebrates due to the difficulty of predicting changes to these communities (Storey *et al.*, 2011).

The ECR equation is calculated as follows:

$$ECR = [\ (SEVi\text{-}P - SEVi\text{-}I) \ / \ (SEVm\text{-}P - SEVm\text{-}C)\ ] \times 1.5$$

Where:

- SEVi-P and SEVi-I are the potential SEV value and SEV value after impact, respectively, for the site to be impacted.

- SEVm-C and SEVm-P are the current and potential SEV values, respectively, for the site where the environmental compensation (mitigation) works are to be applied.
- 1.5 is a multiplier that allows for the delay in achieving compensation benefits.

The ECR calculations are, unavoidably, carried out using a number of assumptions. The 'Potential' SEV scores are calculated by altering parameter scores assuming best practice riparian restoration of the stream has taken place and is well established to a level providing at least 70% shade to the stream bed. As most of the streams within the Project Area have full riparian cover, no additional 'potential' will be added to the SEV scores for Streams 1-5, and Stream 10 – 13. The potential for the Central Streams has assumed planting of the 10 m riparian yard has been provided.

Calculation of the 'Impact' SEV scores would assume an outcome as proposed, with the full length of the stream being lost. Calculation of the 'Potential' score for a restoration site will assume native riparian restoration of a 20m margin (10m to 10m either side of the watercourse) and the removal of barriers to fish passage.

Following calculation of the ECR, the area of stream impacted (based on length and width of the stream) is multiplied by this value to determine the stream area required for restoration works.

A detailed Restoration Planting Plan and Weed Management Plan has been prepared for the stream offset sites by a qualified plant ecologist, ensuring good quality native habitat is created (Bioresearches, 2025b). A minimum of a five-year defects and maintenance contract would be required for the restoration planting to ensure cover is achieved, weed control is maintained and to ensure the proposed biodiversity offset is achieved over the medium term.

5.4 Offset and Compensation Site

Two offset and compensation sites have been selected as they meet the recommended attributes.

147 Oldfield Road, Wellsford, is located 26 km north of the Project area. The stream habitats are located within farmland with stock able to access the streams. The site has an elevation of 80 – 190 m above sea level, and is topographically steep and hilly resulting in a greater proportion of intermittent headwater streams, with a pastoral catchment. This is similar to Kings Quarry, (Stage 2 is approximately 70 m to 170 m above sea level), with streams within the Stage 2 area consisting of small intermittent headwater streams.

158 Hellyer Road is located 1.5 km north-west of the Project Area. The site is less topographically steep and hilly than Kings Quarry, with lower topography resulting in a greater proportion of permanent streams with the historic land use pastoral farming.

Figure 2. Offset site locations, 142 Old Field Road (yellow polygon) and 158 Hellyer Road (orange polygon) and their proximity to Kings Quarry (pink polygon)

5.5 Stream and Wetland Assessment Methodology

Following a high-level constraints analysis, detailed assessments were undertaken on the proposed stream offset sites in 2023, 2024 and 2025. Hellyer Road steams were assessed on the 6th September, 2024, streams on the 142 Old Field Road were assessed on 26 June 2024, and wetlands on the 3rd February, 2025.

The SEV methodology (Storey *et al.*, 2011) enables the overall function of the streams to be assessed and compared to the quality of other streams in the Auckland Region. The SEV procedure involves the collection of habitat data (e.g. stream depth, substrate type, riparian cover), and sampling of fish communities and macroinvertebrates (e.g. insect larvae, snails), with the latter being recognised indicators of habitat quality. SEV data is then entered into a SEV calculator to calculate an averaged SEV value.

Potential wetland areas were assessed following the Ministry for the Environment's (MfE) wetland delineation protocols (MfE, 2020a), to ascertain if the area presented with the physical characteristics to be considered a Natural Inland Wetland. Consequently, the first step in delineating a Natural Inland Wetland is to ensure it meets the definition of a wetland under the Resource Management Act (RMA), referred to as 'the Act'. If the potential wetland met the definition of an RMA wetland, it was then under the NPSFM also checked to see if any of the exclusions in the Natural Inland Wetland Definition applied to the area. Finally, if the potential wetland did not meet any of the NPSFM exclusions, the remainder of the MfE wetland delineation process was carried out to determine if the area was a natural inland wetland. (MfE, 2020b)

When following the MfE wetland delineation process, if the rapid test was not appropriate for determining if an area was an RMA wetland, vegetation assessment in accordance with Clarkson (2013) was undertaken; based on the dominance and prevalence of plant species assigned the following 'wetland plant indicator ratings' within a vegetation plot:

- Obligate wetland vegetation (OBL) – almost always a hydrophyte, rarely in uplands;
- Facultative wetland (FACW) – usually a hydrophyte but occasionally found in uplands;
- Facultative (FAC) – commonly occurs as either a hydrophyte or non-hydrophyte;
- Facultative upland (FACU) – occasionally a hydrophyte by usually occurs in uplands; and
- Upland (UPL) – rarely a hydrophyte, almost always in uplands.

6 FRESHWATER VALUES OFFSET AND COMPENSATION

6.1 142 Oldfield Road

The streams on 142 Old Field Road were assessed on 26 June 2024 and 3 February, 2025 (Figure 3)

Four stream sections and four natural inland wetlands were assessed. Two stream types, and two wetlands were considered appropriate as shown in Figure 3.

- Stream 1a and 1b – SEV Reach 1
- Stream 4 – SEV Reach 4
- Wetland 1
- Wetland 2

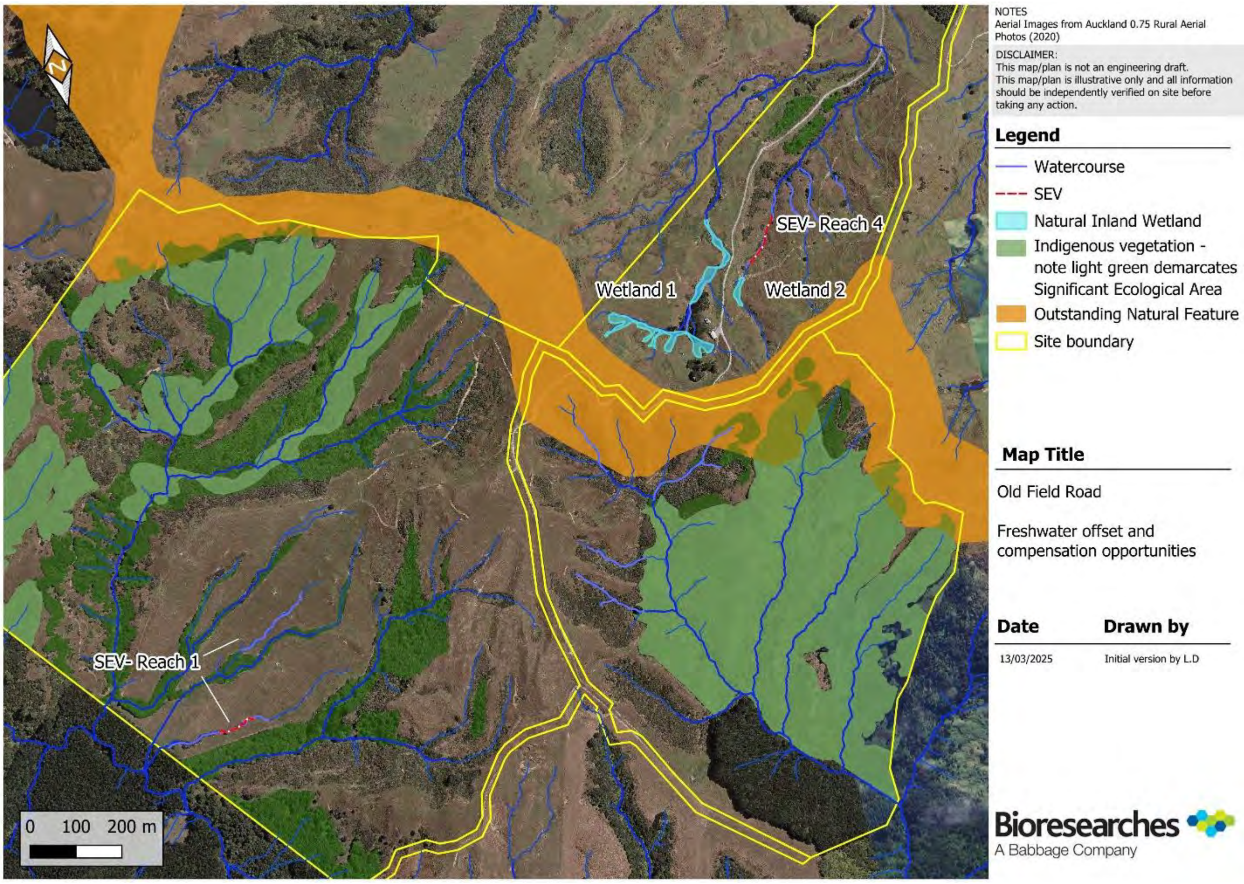

Figure 3. Freshwater offset locations within Old Field Road. Note terrestrial offset planting not shown for clarity.

6.1.1 Stream 1a and 1b – SEV INT-OFR

Stream 1a and Stream 1b were located on the western portion of the site, and flowed in an east to west direction, draining into areas of indigenous bush. An SEV (SEV1) was undertaken on Stream 1a, and is representative of Stream 1b as the watercourses were similar in regard to the channel characteristics, stream classification and land use practices (Photo 1 to Photo 4).

Photo 1. Stream 1a

Photo 2. Stream 1b

Photo 3. Stream 1a

Photo 4. Stream 1b

The intermittent streams had an average width of 0.57m (0.24 m – 0.83 m) and an average depth of 0.08 m (0.01 m – 0.17m), with water slow flowing. The banks were highly incised throughout the entirety of both reaches restricting connectivity to the floodplain, with the exception of the headwaters which showed evidence of bank collapse due to stock access.

Hydrological heterogeneity was considered to be low and consisted of a slow run with the occasional shallow pool. Oxygen reducing process were sub-optimal. The dominant substrate throughout the reaches were silts, with occasional small gravels present and a high loading of fine sediment. Organic matter observed included woody debris, leaf litter and some root mats with the macrophytes watercress (*Nasturtium officinale*), starwort (*Callitriche stagnalis*) and water forget-me-not (*Myosotis laxa* subsp. *caespitosa*) present (Photo 5).

The riparian yard of Stream 1a and 1b was poor, and consisted of rank pasture grasses, and gorse (*Ulex europaeus*) with a small stand of native trees present on the downstream reach. This low-quality riparian yard provided very low riparian yard functions such as filtration and bank stability. However, the topography of the site and channel incision provided good shade to the length of the reach (Photo 6).

Aquatic habitat and diversity was considered to be moderate to low, with available habitat for indigenous fauna limited to patchy areas of woody debris, gravels, pools and rooted macrophytes. It is likely shortfin eel (*Anguilla australis*) and banded kōkopu (*Galaxias fasciatus*) would be able to access and reside within the reach.

Photo 5. Macrophyte cover

Photo 6. Topography and bank incision provided good shade.

Stream 1a and Stream 1b had a SEV score of 0.46 and were considered to be of low ecological value due to the lack of good quality aquatic habitat and diversity, and likely low diversity of in-stream fauna. The streams were highly channelised and impacted through livestock with a lacking riparian yard.

6.1.2 Stream 4 – SEV P-OFR

Stream 4 was located on the northern portion of the site and flows in a south to north direction, where it flows for 190 m before entering a planted wetland. The stream had an average width of 0.6 m (0.34 m – 1.52 m), and an average depth of 0.08 m (0.01 – 0.28 m). Stream 4 was classified as a permanent stream, and was flowing well at the time of assessment, with a variety of hydrology including runs, pools, chutes and waterfalls, however areas of still pools were present.

Photo 7. Incised channel

Photo 8. Waterfall system.

Substrate throughout the reach was bedrock covered by an unnatural loading of fine sediment with some gravels present throughout. Organic matter included leaf litter, woody debris and some macrophyte growth. The banks of the stream were variable, with the lower reaches incised with some bank slumping, and the upper reaches containing some connectivity to the floodplain but limited due to the naturally steep gully. Macrophyte cover was moderate to high throughout the reach, and included watercress, forget-me-not and reed sweet grass. The high macrophyte biomass in winter indicated the oxygen reducing processes were low, additional factors included a sulphuric odour, sediment bubbling and infestation of reed-sweet grass present within sections of the channel.

Riparian vegetation throughout Stream 4 predominantly consisted of grazed grasses with discrete patches of indigenous vegetation such as red matipo (*Myrsine australis*), kānuka, and ponga. Whilst canopy cover through the reach was low, shade was high due to the topography of the area (Photo 9 and Photo 10). Riparian yard functions such as filtration and bank stability were considered to be low due to the prevalence of grazed pasture grasses.

Photo 9. Upper portion riparian yard.

Photo 10. Lower portion with banks.

Aquatic habitat abundance and diversity was low to moderate, with habitat available for indigenous freshwater fauna including pools, woody debris, cobbles and undercut banks. There were no records from the FFDB for the stream catchment, however nearby catchments show shortfin eel, īnanga (*Galaxias maculata*), and bullies *(Gobiomrophus sp.*) to be nearby. It is likely shortfin eel and potentially bullies would access and reside within Stream 4.

Stream 4 had an SEV score of 0.46 was considered to be of low ecological value. The stream provided some variety in terms of aquatic habitat; however, the stream channel was incised with some areas of anaerobic sediment and a low-quality riparian yard.

6.1.3 Wetland 1

Wetland 1 was located within the central northern portion of the site, forming the headwaters and upper reaches of a catchment draining in a northern direction. The wetland is a low value palustrine swamp, cumulatively 5,850 m^2 in size and formed two distinct portions which are hydrologically connected by 100 m of permanent stream.

The upper headwaters portion of the wetland was 3,783 m^2 in size and contained within a wide vale. The vegetation consisted of mixed exotic and indigenous wetland plants including; sharp-spike sedge (*Eleocharis acuta*), tall fescue (*Lolium arundinaceum*), lotus (*Lotus pedunculatus*), jointed rush (*Juncus articulatus*), soft rush (*Juncus effusus*) and fan-flowered rush (*Juncus sarophorus*) (Photo 11). The lower portion of Wetland 1 was 2,067m^2 in size and laid within wide gully floor with steeper sloping banks. The vegetation within this lower portion was largely a reed-sweet grass monoculture with some water cress and water pepper (Photo 13).

The entirety of Wetland 1 was unfenced and severely impacted by stock access, with extensive pugging and grazing observed, especially throughout the lower portion. The wetland was permanently saturated with one hydrological unit, where non-channelised water flows through vegetation (Photo 12). No open water or areas of pools were present, with the exception of the pugging holes (Photo 14). The wetland buffer is limited in how it can form protective services to the wetland, with the vegetation consisting of rank pasture grasses or gorse.

Photo 11. Upper portion of Wetland 1 vegetation

Photo 12. Bed conditions in upper portion

Photo 13. Monoculture in lower portion

Photo 14. Bed condition in lower portion.

6.1.4 Wetland 2

Wetland 2 is a small wetland located at the headwaters of Stream 4, and is a palustrine swamp of low ecological value. The wetland is hydrologically connected to Stream 4 and its downstream reach. Wetland 2 was located within a vale with steep gully's immediately upstream and downstream of the wetland, which was 570 m^2 in size. Wetland 2 consists of a monoculture of grazed reed-sweet grass with sparse fan-flowered rush, lotus and buttercup (*Ranunculus sp.*) present (Photo 15).

The wetland was not fenced and impacted by livestock through pugging and grazing. Standing water and saturated soils were present throughout the wetland, however the bed damage from livestock has likely restricted water flows through the wetland to be still or very slow flowing (Photo 16). Like Wetland 1, the wetland buffers were poor and did not provide any protective services and consisted of grazed pasture grasses.

Photo 15. Wetland 2 vegetation.

Photo 16. Bed condition of Wetland 2.

6.2 158 Hellyer Road

This streams on the 158 Hellyer Road proposed offset site were ground truthed on 6 June 2023.

Three stream sections were assessed, as illustrated in Figure 4.

- Central Upper – SEV Reach 1
- Central Lower – SEV Reach 2
- Tributary 1 – SEV Reach 3

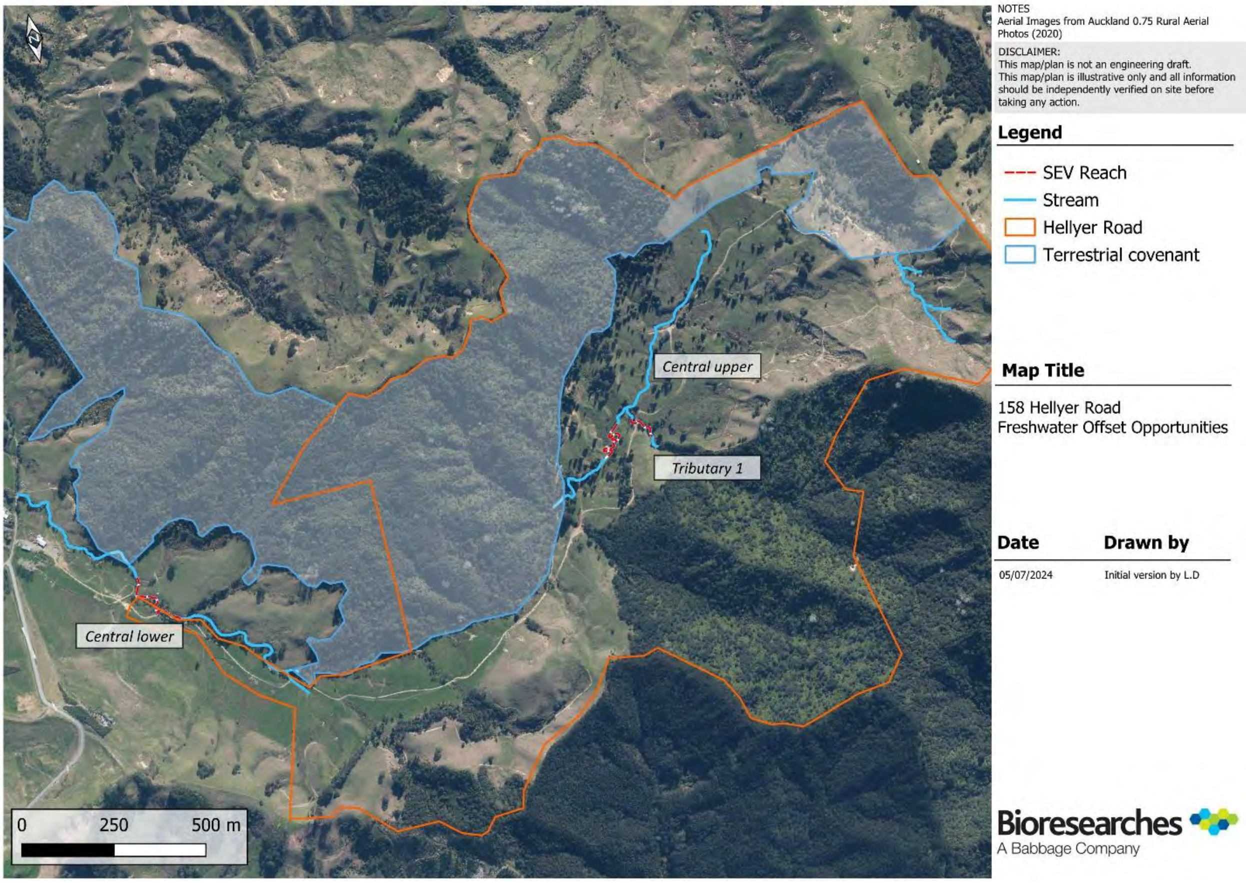

Figure 4. Freshwater offset locations available at 158 Hellyer Road.

6.2.1 Central Upper – SEV-CU

The Central Upper reach originated within the property, within the eastern side, forming the headwaters or the Te Kuru Stream and Kaukapakapa River. The stream reach had an average width of 2.29 m (1.89m-3.27m) and an average water depth of 0.09 m (0.02 m – 0.31 m), however significant deep pools between 0.6 m to 0.8 m were common throughout the reach (Photo 17). Hydrological heterogeneity of the stream was considered to be low with pools and runs present throughout the reach. Water was slow flowing throughout the assessed reach, however no areas of still water were observed. The banks of the stream were highly incised with some portions of the bank slumping into the stream resulting in a high proportion of fine sediment within the watercourse. This bank incision was severe in some locations, over 1.5 m in height, and largely restricted the connectivity to the floodplain (Photo 18).

Substrate within the watercourses predominantly consisted of gravel with an unnatural loading of fine sediment present. Organic matter present within the stream was low with some woody debris, bankside macrophytes and thin brown matting periphyton coating the hard substrates. These bankside macrophytes consisted of water celery (*Apium nodiflorum*), red ludwigia (*Ludwigia repens*), willow weed (*Persicaria maculosa*) and some lotus.

The riparian yard largely consisted of grazed pasture and wetland vegetation with areas of bare ground. Some mature deciduous trees were present; a patch of mature kānuka, and kahikatea (*Dacrycarpus dacrydioides*) with no understory (just pasture grass) (Photo 19 and Photo 20). Due to the lack of sufficient riparian yard, shading provisions bank stability and ground filtration function to the stream were considered to be low. It is likely that macrophyte growth during the summer months would be high due to the low shading provided for by the riparian yard.

Photo 17. The Central Upper reach contained deep and flow flowing water.

Photo 18. Riffle habitat with significant scour on the banks

Photo 19 The riparian yard was largely limited to grasses and few mature trees.

Photo 20. Some riparian yard provided very low functions to the stream.

There was a moderate abundance and diversity of fish cover and macroinvertebrate habitat that would be suitable for a diverse range of aquatic fauna. Habitat available included sparse woody debris, riffles, undercut banks and hard substrates. While no macroinvertebrate community samples were collected, mayfly were observed on the underside of cobbles. Native fish surveys above and below the site and records from the New Zealand Freshwater Fish Database show a diverse range of indigenous fish in the upper Te Kuru Stream (Table 2). It is highly likely that all species listed below would access and reside within the site providing no barriers to fish passage are present on the downstream reach. Additionally, while not recorded, it is expected additional species such as banded kōkopu (*Galaxias fasciatus*), redfin bully (*Gobiomorphus huttoni*), and common bully (*Gobiomorphus cotidianus*), would find suitable habitat within the Upper Central reach

Table 2. Fish species records from Bioresearches freshwater surveys and the New Zealand Freshwater Fish Database within the upper catchment of the Te Kuru Stream.

Species Name	Common Name	Classification
Anguilla australis	Shortfin eel	Native – Not Threatened
Anguilla dieffenbachii	Longfin eel	Native – At Risk
Galaxias maculosa	Īnanga	Native – Not Threatened
Paranephrops planifrons	Koura	Native – Not Threatened

The freshwater ecological value of the Upper Central Stream reach was assessed to be moderate due to the permanent presence of moderate quality aquatic habitat and potential presence of a diverse range of indigneous fauna, however the riparian yard integrity is considered to be very low due to the dominance of pasture grass, slumping and erosion of banks and paucity of mature trees to provide shading and organic inputs to the stream.

6.3 Central Lower – SEV-CL

The Central Lower was the lower section of the Te Kuru Stream tributary draining from the west of the property. The Lower Tributary SEV reach was assessed between two tributaries to the Te Kuru Stream. The Lower Tributary reach flowed from the east to west direction. The Lower Tributary had an average water depth of 0.14 m (0.03m – 0.47 m) and an average width of 2.09 m (0.99 m – 2.54 m). One farm crossing intersects the stream with an undersized and perched culvert, acting as a total barrier to fish passage (Photo 21). Much the stream channel is modified through bank incision restricting the connectivity to the floodplain.

Photo 21. A perched culvert was located on the Central Lower Reach

Photo 22. Bank incision was severe throughout the Central Lower Reach

Hydrological heterogeneity was considered to be low with the reach largely consisting of a single run and small pools, with water slowly flowing through the reach. The dominant substrate throughout the Lower Tributary consisted of an unnatural loading of fine sediments. Organic matter present included leaf litter, woody debris and thin brown mat periphytons.

Riparian vegetation largely consisted of pasture grass, with sparse grazed wetland vegetation contributing the ground cover. Tall trees present within the riparian yard largely consisted of mature exotic trees such as macrocarpa (*Cupressus macrocarpa*), kānuka, and kahikateas (Photo 23) Shade and organic matter input were considered to be low-moderate due to the occasional presence of mature exotic trees, however as the riparian yard predominantly consisted of pasture grass, filtration function and bank stability were considered to be low.

Aquatic habitat and diversity throughout Lower Tributary were considered to be low with habitat available for indigenous fish and macroinvertebrates consisting of woody debris, riffles and undercut banks (Photo 24). Furthermore, the undersized culvert within the reach would act as a total barrier to fish passage, and restrict species moving upstream.

Photo 23. The riparian yard was restricted to grass with small bands of evergreen vegetation

Photo 24. Aquatic habitat within Central Lower was low.

The lower tributary was considered to be of moderate ecological value due to the presence of permanent aquatic habitat which could utilised by a range of indigenous freshwater fauna. The reach currently contains a total barrier to fish migration to the upstream catchment and lacks sufficient riparian yard integrity, reducing riparian yard functions such as bank stability and filtration.

6.3.1 Tributary 1 - SEV - T

Tributary 1 originated within the property on the southern side of the side flowed in a northern direction before joining the Central Upper reach. The stream reach had an average width of 1.93 m (0.75 m - 3.07 m) and an average water depth of 0.09 m (0.03 m – 0.19 m). The banks of the stream were highly incised and scoured with some bankside vegetation flattened from high flows. Within the centre of Tributary 1, a ford road crossing is present, however this was not considered to be a barrier to fish passage (Photo 25).

Hydrological heterogeneity of the stream was considered to be moderate with pools, runs and riffles present throughout the reach. Water flow was good with no areas of still or slow flowing water observed. Substrate within the watercourse predominantly consisted of gravel and cobbles with an unnatural loading of fine sediment present. Organic matter present within the stream was low and consisted of sparse woody debris.

The riparian yard largely consisted of grazed and sparse soft rush (*Juncus effusus*) pasture and some mature deciduous trees such as kānuka, kahikatea and tōtara No understory was present with groundcover solely consisting of pasture and bare ground (Photo 26). Due to the lack of established riparian vegetation, the riparian yard services such as shading, bank stability and ground filtration function to the stream were considered to be low, however oxygen reducing process were considered to be optimal due to the lack of macrophyte growth, and no anaerobic sediments or bubbling was observed.

Photo 25. Low profile ford crossing in the centre of Tributary 1.

Photo 26. The riparian yard was restricted to short grasses with some mature trees.

There was a moderate abundance and diversity of fish cover and macroinvertebrate habitat that would be suitable for a diverse range of aquatic fauna. Habitat available included woody debris, macrophyte cover, riffles and pools, and hard substrates.

The SEV score of the Tributary 1 reach was 0.41, with a potential score of 0.60.

The freshwater ecological value of the Tributary 1 reach was assessed to be moderate due to the permanent presence of moderate quality aquatic habitat and potential presence of a diverse range of indigenous fauna, however the riparian yard integrity is considered to be very low due to the dominance of pasture grass, slumping and erosion of banks and low density of mature trees to provide riparian yard services to the stream.

7 FRESHWATER OFFSET

The loss of stream *values* will be offset through the restoration of the aforementioned streams at Old Field Road and Hellyer Road to ensure no-net-loss of biodiversity values. The proposed loss of stream values cannot be avoided, minimised or remedied, therefore offset through the enhancement of lower quality streams is proposed.

The project will result in an overall net loss of stream *extent*, which cannot be reasonably offset. The proposed measures and justifications for the compensation of stream extent is described in Section 8 - .Freshwater Compensation.

7.1 Environmental Compensation Ratio for loss of stream values

The current SEV score for the Project Area streams ranged between 0.64 and 0.83 (Table 4). The potential for these streams is assessed as equivalent to the current SEV values, as the potential of the SEV reflects land use practices that include riparian planting, with the Project Area being fully vegetated. Potential for riparian planting of Central System streams was considered low, due to the roading directly adjacent to the modified reaches, achieving a potential SEV score of 0.66. Loss of the stream reaches, as proposed, would produce an impact SEV of 0.0.

The current SEV score of the proposed restoration streams at 158 Hellyer Road range between 0.39 and 0.49, with the potential score for the site streams following restoration and enhancement of riparian vegetation, removal of fish barriers and with some instream enhancements, assessed to range between 0.70and 0.74.

The current SEV score of the proposed restoration streams at 142 Old Field Road is 0.47, with the potential score for the site stream following restoration and enhancement of riparian vegetation, and with some instream enhancements, assessed to be 0.74.

Table 3 presents a summary of the SEV inputs to the ECR, including the areas of loss and the parameters of at the offset site, with further summary data presented in B.

Table 4 provides the range of offset site data for the ECR and Table 5 presents the offset SEV, stream length and stream width data for the ECR calculations, with further detail presented in the Appendices.

Table 3. Estimation of area of compensation and ECR Inputs

ECR Inputs and Calculation	
Impact Streams	
SEVi-Current (range)	0.66-0.84
SEVi-Potential (range)	0.66-0.84
SEVi-Impact	0.0
Stream bed area loss m²	1,119
Stream length loss m	2,439
Average stream width (range) m	0.22 – 0.93
158 Hellyer Road Offset Streams	
SEVm-Current (range)	0.39 – 0.49
SEVm-Potential (range)	0.70 – 0.72
Average stream width (range) m	1.4 – 2.29
142 Old Field Road	
SEVm-Current (range)	0.46-0.47
SEVm-Potential (range)	0.70 – 0.74
Average stream width (range) m	0.57 – 0.60

Table 4. Summary SEV, stream length and stream width data from Offset Sites for ECR

	SEV Current	SEV Potential	Length (m) available	Stream Width (m)
158 Hellyer Road				
Central upper	0.49	0.72	1,125	2.29
Central lower	0.39	0.70	969	2.09
Tributary 1	0.47	0.74	170	1.93
142 Old Field Road				
SEV - INT	0.46	0.70	439	0.57
SEV- P	0.47	0.74	190	0.60

The ECR calculations area presented as a rolling calculation table in Appendix C, and in summary as Table 5.

Table 5. Summary of Results of ECR calculations location of offset for each Impact Stream reach (refer Appendix C).

Impact Stream ID	Offset Stream/s	ECR	Compensation method
Stream 1	SEV-P, SEV-INT and Tributary 1	4.50 & 5.25 & 4.67	Enhancement
Stream 2	Tributary 1	4.67	Enhancement
Stream 3	Tributary 1 & Central Upper	4.67 & 5.48	Enhancement
Stream 4	Central Upper	5.48	Enhancement
Stream 5	Central Upper	5.48	Enhancement
Stream 6	Central Upper	4.30	Enhancement
Stream 7	Central Upper	4.30	Enhancement
Stream 8	Central Upper	4.30	Enhancement
Stream 9	Central Upper	4.30	Enhancement
Stream 10	Central Upper	5.48 & 4.06	Enhancement
Stream 11	Central Upper	4.06	Enhancement
Stream 12	Central Lower	4.06	Enhancement
Stream 13	Central Lower	3.77	Enhancement

The quantum of offset for the stream length that will be lost to Stage 2 works at Kings Quarry, using the SEV /ECR methodology and enhancement at 158 Hellyer Road and 142 Old Field Road, is 2,893 linear metres of stream length requiring to 5,509 m² of bed area enhancement. Of this, a total of 629 linear metres and 795 m² of stream bed is available at Old Field Road, and 2,264 linear metres and 4,929 m² of stream bed on the Te Kuru Stream permanent tributaries is available at Hellyer Road. The ECR methodology recognises that there are values associated with edge habitat and the proximity to banks and requires that the minimum replacement length must at least be equal to stream length lost. Consequently, the total stream length lost at Kings Stage 2 is 2,439 m.

7.2 Biodiversity Gains and Habitat Enhancement

Biodiversity gains at the offset site would be achieved through the enhancement of the existing habitat to improve its condition; through the restoration of the 10 m riparian yard of the streams, fencing the area from stock; and ongoing weed control of the restoration plantings (Figure 5 and Figure 6).

At 153 Hellyer Road, the removal and replacement of fish barriers, including the perched culverts will be undertaken, restoring fish passage through the reach.

Combined with these enhancement activities, habitat creation is proposed, involving restoration planting of species that form the early stages in a succession towards a native forest habitat. The restoration planting provides aquatic ecological benefits provided by replacing pasture grass and/or weed species with native shrubs and trees in the riparian zone (providing temperature control and reduction of nuisance growth of aquatic vegetation through shading); woody debris in the stream (increasing habitat and refuges for invertebrates and fish); stabilisation of channel banks and channel shape; and reduction of nutrient and sediment inputs into the streams.

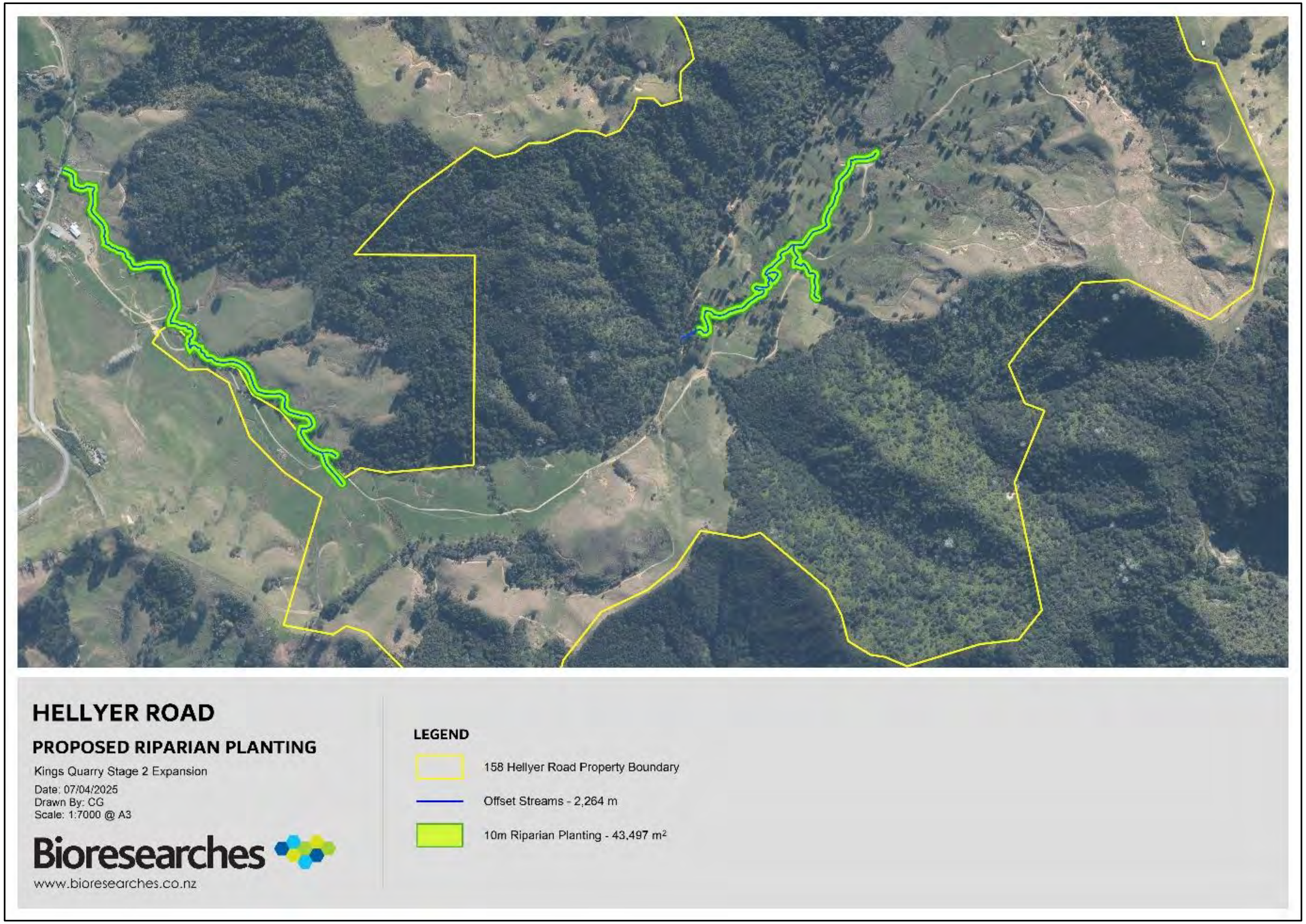

Figure 5. Proposed freshwater offset measures to be undertaken at 158 Hellyer Road.

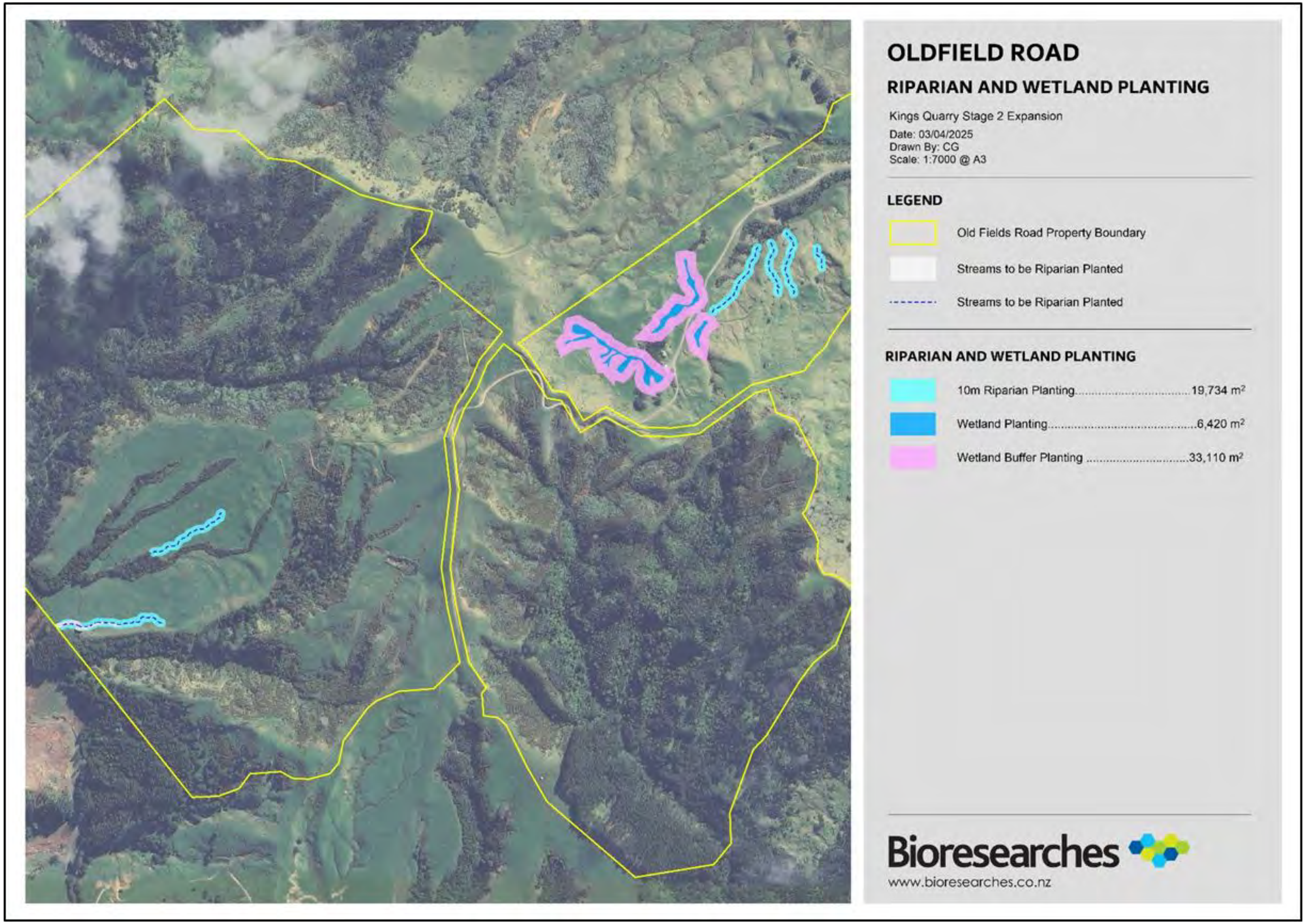

Figure 6. Proposed freshwater offset (riparian planting) and compensation (wetland planting) measures to be undertaken at Oldfield Road

8 .FRESHWATER COMPENSATION

8.1 No-Net-Loss of Stream Extent

When referring to stream loss the NPS-FM refers to extent and values. It is acknowledged the above SEV and ECR calculations account for the loss of stream values, and the project will result in the net-loss of stream extent, as the overall length of stream loss cannot be practicably offset. In order to adequately offset this loss of stream extent, a minimum of 2.4 km of stream creation is required; through the construction of new channels or the daylighting of urban streams.

Daylighting would be impracticable due to the sheer extent of piped stream length that would be required for this, with piped reaches typically associated with the urban environment. Daylighting would not achieve a like-for-like offset, as the recreated streams would be located within an urban setting with the extents and integrity of riparian buffers able to implemented dissimilar to those buffers in the Project Area. Urban environments typically receive high inputs of pollutants from roading run-off, diffuse source pollution, rubbish and refuse, and potentially wastewater overflow (Chakravarthy *et al.*, 2019), compromising water quality where sensitive organisms, such as spiny gilled mayfly (*Coloburiscus humeralis*), present in the Project Area which would be unlikely to colonise (Gadd *et al.*, 2020). Additionally, there would likely be restrictions on the continual length of pipe able to be daylighted, with the proposed offset being fractured into multiple sections, rather than a continuous stream channel. This would therefore result in sections of piped reach throughout the offset that may not be possible to daylight with possible barriers to fish passage associated with these piped sections. Considering these constraints and limitations in the urban environment, it is unlikely a greater than 'Moderate' ecological value would be achieved

In addition to daylighting, the creation of stream length, likely within the rural setting due to space requirements, is considered to be inappropriate. It may be possible to achieve 'Moderate' to 'High' ecological values through careful design and accounting for the natural movement of sediments (being dependant on the underlying geologies and landform of the area), connectivity to the wider environment, in-stream structures and habitats, and riparian planting. If the system of channels at the extent required to appropriately offset the Stage 2 expansion were to be constructed to replace the lost stream extent and achieve no -net-loss, adverse effects to the immediate catchment will likely occur. This may result in the permanent diversion of water (and to an extent, groundwater) likely resulting in adjacent stream reaches and/or wetlands drying out or experiencing reductions in hydrological inputs, such as water flow and level, which would in turn lead to increased temperatures and nutrient/contaminant concentrations, reduced aquatic habitat and aquatic connectivity (Ministry for the Environment, 2020c). This reduction in contributing catchment is observable through the historic implementation of farm drains, throughout rural New Zealand leading to a reduction in wetland extent.

Putting aside the impracticality of daylighting and/or creating 2.4 km of stream reach, these restoration activities would result in a more perverse ecological outcome as they would result in streams which are not ecologically feasible or of 'High' or greater ecological value to adequately replace those streams lost in the expansion, or may result in adverse effects to adjacent waterbodies, leading to an overall poor ecological outcome.

Whilst we acknowledge daylighting streams in the urban setting can be highly beneficial, it is not appropriate for offset in this scenario. As the loss of stream extent cannot be reasonably offset, the loss of stream extent is proposed to be compensated for through wetland restoration.

8.2 Wetland Restoration

The project will result in an overall loss of stream extent, which is proposed to be compensated for through the restoration of wetlands (Wetland 1 and Wetland 2) at Old Fields Road., which would provide significant biodiversity gains with enhancement and buffer of 6,400m ^{2} of degraded headwater wetlands. The stream compensation will replace the loss of stream with a rare and threatened ecosystem type of wetland. There is insufficient wetland area for compensations at both Kings Quarry and within Hellyer Road to provide this uplift in a closer local. The wetlands at Old Fields Road are located approximately 36 km from the marine environment at the Kaipara Harbour, with an elevation of 120 – 180 m above sea level, within the upper portions of hilly land with a pastoral catchment. This is similar to Kings Quarry, where Stage 2 is approximately 70 m to 170 m above sea level and drains into the Kaipara Harbour 29 km downstream.

The enhancement vegetation will be complex with multiple structural tiers and appropriately designed for the Rodney Ecological District. The planting will create an indigenous wetland ecosystem and buffers while also providing for green corridors up the site, into the terrestrial offset planting, resulting in an increase in ecological linkages and steeping stones to indigenous forest within the local area. This planting will also consolidate a large portion of both the freshwater and terrestrial offset and compensation planting to one area, rather than establishing discreet and isolated patches of restoration throughout the Rodney Ecological District. Additionally, the removal of reed-sweet grass from the upper reaches will then minimise the spread of seeds and rhizomes to the lower reaches.

Fauna habitat will be greatly improved through animal pest control, planting and weed control and buffer enhancements to create a high-quality ecosystem which will increase in habitat for At Risk fauna throughout the wetland, including fish and avifauna. The wetlands currently contain one hydrological unit which will be enhanced and diversified through wetland planting and restoration. This will likely result in a more naturalized hydrological regime and increase the wetlands ability to act as a filter for nutrients and sediment, and a regulator of water flows.

The restoration of headwater wetlands will benefit lower reaches through reducing the levels of contaminants and sediments transported downstream through the natural wetland filtration process (Uuemaa *et al*., 2018). This would particularly benefit the offset gains on Stream 4, with the quality of water being discharged into the downstream receiving environment being of higher water quality following fencing and planting of the wetland and its margins (Brydon *et al*., 2006). This higher water quality will likely result in the colonisation of more sensitive taxa, such as the spiny-gilled mayfly to the offset stream habitats. Plant diversity, biomass and rarity will be improved upon through the wetland planting, which will become a regenerating ecosystem over time.

All proposed restoration activities will have their methodologies detailed in a Wetland Restoration Planting Plan, for the wetland and riparian buffers. Due to the extent of the wetland, the restoration activities will likely be undertaken in staggered blocks, to allow for a comprehensive restoration.

- The enhancement/restoration wetland will be divided into bands, in which the restoration activities will be staggered. This will allow for the intensive works associated with the restoration to be comprehensively carried out.
- Vegetation removal of pest vegetation, namely willow and reed-sweet grass. Vegetation removal will ideally be undertaken within the warmer summer months, where water levels are lowest. This will also be aided by the canopy cover of the willows providing shade to the wetland. Reed-sweet grass is intolerant of full shade (Weedbusters, 2024).
- Replanting of the currently 'Exotic wetland' portion of the restoration wetland with indigenous wetland species, allowing it to develop the characteristics for an indigenous wetland ecosystem. Due to the hydrology of the wetland, multiple planting zones are available, with the planting of obligate wetland species used.
- Fencing of the restoration wetland and its 20 m buffer (as prescribed in the AUP OP E3), using a combination of new and existing fencing.
- Carrying out ongoing weed control, and if needed, replacement planting to ensure at least a 90% coverage is maintained in the wetland and replanted buffer areas.
- Carrying out pest control within the wetlands and 20 m buffers to reduce pest animal densities. Monitoring of pest control success should be undertaken.
- Monitoring of planting success, to be undertaken at year 1, 2, 3, 4, 5 post planting for each restoration block.
- Annual wetland monitoring should be undertaken in general accordance with Clarkson *et al.* (2004). This monitoring should include sufficient measures to assess of the expected uplift in ecological value is occurring, and if not, recommended additional measures to ensure this occurs.

8.3 Additional Stream Extent Compensation

In addition to the wetland enhancement actions, it is proposed to remove an instream structure within Waitoki Stream to provide further compensation for the loss of stream extent.

Instream structures typically result in modified habitats through changes in water depth, water velocities, alterations to sediment distribution and deposits and erosion, and stream fragmentation and species loss/biodiversity reductions (Poff and Hart 2002; Jellyman and Harding 2012; Birnie-Gauvin et al. 2017). The Waitoki Stream weir currently restricts freshwater connectivity through altering flow regimes and the movement and flows of sediments and aquatic fauna with increases in water depth, proportions of fine sediments, and decreases in water velocity, all of which is observable upstream of weir, indicating alteration through backwatering is present. The weir acts as a barrier to fish passage, with only those species with very strong climbing ability, such as juvenile eels (*Anguilla* sp.) and juvenile banded kōkopu (*Galaxias fasciatus*), likely to navigate the structure, resulting in a reduction in the dispersal of freshwater fish through the Waitoki Stream. While common bully (*Gobiomorphus cotidianus*), were detected upstream of the weir, it is likely a population was present upstream prior to the installation of the weir, and established a "landlocked" breeding population following the weir installation.

The removal of the weir will result in the restoration in connectivity to 3,468 m linear metres of stream extent in the upper Waitoki Stream. The removal of the weir will enable the movement of a diverse range of fish populations, through all life stages, to the upstream environment and provide access to a variety of high value aquatic habitats. Additionally, there may be an increase in the genetic diversity of common bully, if the population above the weir have been "landlocked" for a period of time.

The removal of the weir will improve connectivity and movement of particles, such as natural sediments and substrates, leaf litter and wood, throughout the Waitoki Stream. Backwatering effects of the weir in the upstream reach are present, with much of the upper catchment consisting of slow flowing runs over fine sediments. The removal of the weir will remove the backwater effects, and restore the hydrological variation throughout the upper Waitoki. It is likely that within a short-term scale, run-pool-riffle sequences will be restored throughout the upstream reach as hydrology and sediment transportation are naturalised, increasing the degree of bully habitat and variety of other native fish habitats throughout the reach.

The primary adverse effect of the removal of the weir is the release of fine sediments to the downstream receiving environment during the streamworks phase. An Erosion and Sediment Control Plan should be prepared and implemented during the removal of the weir to minimise the degree of disturbance to the watercourse, including specific measures to avoid localised sedimentation and the release of fine sediments to the downstream receiving environment. The affected bed and banks of the Waitoki should be stabilised through rock armaments or a similar structure, replicating the existing stream substrates and minimising erosion and scour.

9 PRINCIPLES OF AQUATIC OFFSET AND COMPENSATION

Because the stream reclamation results in the permanent loss of open, natural stream habitat, it is not possible to address all the adverse effects via mitigation. The NPS-FM sets out eleven principles that underpin the concept of aquatic biodiversity offsetting and compensation. These principles are identified in Table 6Table 7**Error! Reference source not found.** with a brief explanation of how the proposed aquatic habitat offset for the site will appropriately implement or satisfy them.

Table 6. Principles of Aquatic Offsetting from the NPS-FM, and how these will be achieved for the proposed works.

Offsetting principle	How this will be achieved
Adherence to effects management hierarchy	Ecological values and effects assessments prior to works. Avoidance/ minimisation of ecological effects through design. Mitigation of potential adverse effects on freshwater fauna with a Native Fish Recovery and Relocation Plan. Identification of residual adverse effects, after avoid, remedy and mitigate measures, and where significant, calculate offset to provide no net loss, and preferentially a net biodiversity gain.
When aquatic offsetting is not appropriate	Assessments prior to offset. The ecological values of the habitats proposed for offset are assessed as High, but the streams and stream type is well represented in the local area.
No net loss and preferably a net gain	Accounting using the SEV and ECR methodology for stream loss. The proposal will not result in a measurable reduction in the population size, range or long-term viability of indigenous species. The restoration of streams will result in a net gain in stream area quality and biodiversity values.
Additionality	There are no current or future plans to undertake any of the proposed revegetation and restoration actions.
Leakage	The aquatic offset design and implementation will avoid displacing harm to this location, and will ensure that potential harm to existing biodiversity will be mitigated and temporary.
Long term outcomes	All restoration actions will be legally protected in perpetuity, and monitored for a minimum 5 years to ensure offset targets are achieved.
Landscape context	Restoration and offsets, including habitat creation, will be carried out within 1.5 km and 26 km from the Project Area. The lengths of streams will be planted with riparian vegetation to create ecological linkages and green corridors through the intermittent headwater streams, and create buffered areas that provide habitat for fauna to access both the permanent streams and its tributaries will be subject to offset planting.
Time lags	The SEV/ECR model has a time lag component incorporated within the methodology and improvements at the offset site will be effective immediately upon restoration and planting of the offset streams as minimal trees or shrubs are currently present, with canopy closure resulting in at least 70% shading to the streams predicted well within the five-year maintenance period.

Science and mātauranga Māori	The design of the biodiversity offset will be based on established and proven methods for fauna and flora management and restoration. The biodiversity offset will provide careful consideration to opportunities for maximising ecological outcomes as well as providing for interests of the landowners and including tangata whenua.
Tangata whenua or stakeholder participation	Ngāti Whātua o Kaipara have been consulted through this process and have visited the Project Area, including a number of the watercourses to be removed and provided input via their CIA. Auckland Council has been consulted via an application review process.
Transparency	The Stream Ecological Valuation (SEV) methodology combined with the calculation of the Environmental Compensation Ratio (ECR) is a transparent, well-recognised methodology for calculating the quantum of offset required for stream loss. (Storey e*t al.*, 2011). Although the methodology was originally developed in Auckland, it has been reviewed by NIWA for use in Wellington, Hawke's Bay and Southland, and is considered applicable without modification to most stream and river types in those regions. (Storey *et al.*, 2011). Accounting using the SEV and ECR methodology for stream loss, are tabulated in the report with additional data provided in the Appendices.

Table 7. Principles of aquatic biodiversity compensations outlined in the NPS-FM, and how these will be achieved for the proposed works.

Compensation principle	How this will be achieved
Adherence to effects management hierarchy	An Ecological Effects Assessment has been completed (Bioresearches, 2025), and through this process the effects management hierarchy has been applied. Avoidance/ minimisation of ecological effects through design has been proposed where-ever this has been practicable/possible. Mitigation of potential adverse effects on freshwater with a Native Fish Recovery and Relocation Plan has been undertaken for other aspects of the project. The loss of stream extent cannot be reasonably offset through the construction and/or daylighting of 2.4 km of new stream length. Therefore, the loss of stream extent must be compensated for. Identification of residual adverse effects, after undertaking all feasible avoidance, remediation and/or mitigation measures, has identified stream loss.
When aquatic compensation is not appropriate	Compensation can achieve the conservation outcomes specified in the NPS FM. There is no net loss of irreplaceable habitat; there is adequate certainty about the success of the proposed compensation measures; and it is the most technically feasible option to address the residual effects after application of the initial steps of the effect's management hierarchy.
Scale of aquatic compensation	The proposed expansion will result in a loss in stream extent. The proposal will result in 6,400 m^2 of wetland restoration from exotic, unbuffered wetlands to indigenous wetlands with native buffer planting. Downstream effects of the quarry will be avoided through hydrological mitigation and management where required. Effects to fauna utilising the streams are adequately managed as described above.

	It is expected that the uplift in ecological value and consequently the ecosystem services provided by the restoration of a of wetland will adequately compensate for the loss in stream bed area; and will lead to a net positive outcome for biodiversity values, including wetland function and habitat availability for fauna (such as wetland birds) within the wider ecological area.
Additionality	There are no current or future plans to undertake any of the proposed revegetation and restoration actions.
Leakage	The aquatic compensation design and implementation will avoid displacing harm to the restoration wetland location; and will ensure that potential harm to existing biodiversity will be mitigated and temporary.
Long term outcomes	All restoration actions will be legally protected in perpetuity and monitored for a minimum 5 years to ensure compensation targets are achieved.
Landscape context	The proposed compensation wetland is located 26 km from the impact area. They are within the same ecological region and ecological district; and are all considered to be a very similar wetland type. This is discussed further in Section 6.2 Both wetlands, and impact streams drain into the Kaipara Harbour, within a similar landscape, elevation and distance prior to entering the marine environment.
Time lags	Within the restoration wetland, a herbaceous wetland planting tier will establish within a season, and will be replacing dominantly exotic species; with the shrub and tree-tiers taking longer to establish. This is time lag is assessed as temporary and short term. Monitoring of the plantings will be undertaken in general accordance with the Clarkson et al., 2003 'Handbook for Monitoring Wetland Condition'. A five-year period for monitoring is considered adequate.
Trading up	When trading up forms part of aquatic compensation, the proposal demonstrates that the aquatic extent gained are demonstrably of greater or higher value than those lost. The loss of intermittent and permanent stream extent, considering values will be offset, will be replaced with the restoration of indigenous wetlands, a recognised rare and threatened ecosystem type (Dymond *et al.*, 2021). The proposal also shows the values lost are not comprised of Threatened or At Risk/Declining flora or fauna species or species considered vulnerable or irreplaceable. The compensation wetland replacing the stream extents will be of higher ecological value and ecosystem rarity.
Financial contribution	This is not a consideration at this site.
Science and mātauranga Māori	The design of the biodiversity compensation will be based on established and proven methods for fauna and flora management and restoration. The compensation will provide careful consideration to opportunities for maximising ecological outcomes as well as providing for interests of the landowners and including tangata whenua.
Tangata whenua or	Ngāti Whātua o Kaipara have been consulted through this process and have visited the Project Area, including a number of the watercourses to be removed and provided input via their CIA. Auckland Council has been consulted via an application review process.

stakeholder participation	
Transparency	The wetland compensation calculations are based on the primary attributes of the wetlands, which have been assigned in accordance with nationally and regionally accepted reference documents, including Johnson and Gerbeaux (2004) as published by the Department of Conservation and the Ministry for the Environment; as well as the EIANZ guidelines for assigning ecological values. Detailed mapping of the existing condition of the restoration wetlands and their existing riparian buffer zones was also undertaken. These maps are provided within this report. A site-specific planting plan will be developed, and success monitoring of the restoration activities is recommended; and regular maintenance and monitoring reports will be provided to Council and (where appropriate) other stakeholders.

10 CONCLUSION

The expansion of Kings Quarry will result in the permanent loss of 2,439 linear metres of stream. Offset compensation for the loss of aquatic habitat is proposed, using the SEV / ECR methodology for streams approximately 1.5 km and 26 km north of the quarry. The stream enhancements, including riparian planting are proposed as part of the offset package. 2,893 linear metres of stream will be enhanced with 10 m of riparian planting, and fencing at 158 Hellyer Road and 142 Old Field Road. The loss of stream extent is proposed to be compensated through the restoration of currently degraded wetland habitat to indigenous wetlands and associated 20 m buffer. Additional ecological gains will be procured through the removal of a weir, acting as a barrier to fish passage within the Waitoki Stream, restoring the connectivity of approximately 3.468 km of stream extent. This will result in the restoration of stream hydrology, sediment transportation and the movement of aquatic fauna through all life stages. This will increase fish biodiversity, and restore habitats and natural stream processes through the upper Waitoki Catchment.

The restoration and enhancement of degraded aquatic habitats will provide for a positive aquatic ecological benefit, biodiversity gains and restore connectivity to existing habitats.

11 REFERENCES

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Appendix A

Kings Quarry Stage 2 Stream Summary

Appendix 1. Stream characteristics within the Kings Quarry Stage 2 Footprint.

	Southern System	Central System	Northern System	Stream 13
Representative Stream	Stream 4	Stream 7	Stream 10	-
Habitat Features				
Average width (m)	0.64	0.47	0.37	0.93
Average depth (m)	0.05	0.04	0.04	0.11
Dominant substrate	Gravels and bedrock	Gravels	Silt/clay	Gravels
Macrophyte abundance	Nil	Nil	Nil	Nil
Riparian vegetation	Mature indigenous vegetation	Regenerating indigenous vegetation, long grasses, exotic shrubs	Mature indigenous forest	Mature indigenous forest
Water Quality				
Date	08/09/2023	08/09/2023	07/09/2023	07/09/2023
Time	13:55	11:25	13:00	
Temperature (°C)	12.1	11.5	13.2	12.6
Oxygen Saturation (%)	89.1	89	89	93
Dissolved Oxygen (mg/L)	9.7	9.8	9.3	10.0
Conductivity (µS/cm)	103.1	54.3	93.6	140.7
Macroinvertebrates				
Sampling protocol	Hard bottomed	Hard bottomed	Soft bottomed	Hard bottomed
No. of taxa	10	8	11	16
Dominant taxon	*Potamopyrgus* snail	Orthcladiinae	*Potamopyrgus* snail	*Coloburiscus*
EPT	5	3	4	9
%EPT*	46	17	22	92
MCI	102 'Good'	103 'Good'	139 'Excellent'	139 'Excellent'
SQMCI	6.00 'Good'	2.93 'Poor'	5.78 'Good'	7.62 'Excellent'
Fish				
Species Recorded	*Kōura*	Nil	Longfin eel	*Kōura*
Number of Fish	-		1	-
Fish IBI score**	-		30 'Fair'	-
Stream Ecological Valuation	SEV2*	SEV 3	SEV2	SEV1
SEV score	0.73	0.47	0.79	0.62

Appendix 2. Impact stream locations in relation of the wider catchment

Site Name	Location
Stream 1	Intermittent and stream to the Waitoki Stream on the southern side
Stream 2	Intermittent stream to the Waitoki Stream on the southern side
Stream 3	Intermittent and permanent stream to the Waitoki Stream on the southern side
Stream 4	Intermittent stream to the Waitoki Stream on the southern side
Stream 5	Intermittent stream to the Waitoki Stream on the southern side
Stream 6	Intermittent stream to the Waitoki Stream within the centre. Contains modified reaches
Stream 7	Intermittent stream to the Waitoki Stream within the centre. Contains modified reaches
Stream 8	Intermittent stream to the Waitoki Stream within the centre. Contains modified reaches
Stream 9	Intermittent stream to the Waitoki Stream within the centre. Contains modified reaches
Stream 10	Intermittent and permanent tributary to Stream 13 on the northern side
Stream 11	Intermittent and permanent tributary to Stream 13 on the northern side
Stream 12	Intermittent and permanent tributary to Stream 13 on the northern side
Stream 13	Permanent stream and tributary to the Waitoki Stream, northern most watercourse in the expansion footprint.

Appendix 3. Impacts stream extents

Stream	Classification	Length (m)	Width (m)	Stream bed area (m^2)
Stream 1	Intermittent	204	0.41	59
Stream 2	Intermittent	136	0.3	26
Stream 3	Modified Intermittent	70	0.22	15
	Intermittent	65	0.22	14
	Permanent	30	0.22	7
Stream 4	Intermittent	153	0.22	89
	Permanent	132	0.64	84
Stream 5	Intermittent	78	0.49	38
Stream 6	Intermittent	55	0.29	16
	Modified intermittent	161	0.35	56
Stream 7	Intermittent	153	0.47	52
	Modified intermittent	54	0.35	19
Stream 8	Intermittent	53	0.31	16
Stream 9	Intermittent	131	0.27	27
	Modified intermittent	23	0.35	8
Stream 10	Intermittent	58	0.37	21
	Permanent	187	0.37	69
Stream 11	Intermittent	166	0.38	63
	Permanent	77	0.38	29
Stream 12	Intermittent	19	0.4	8
	Permanent	150	0.4	60
Stream 13	Permanent	284	0.93	169
Total	**-**	**2,439**	**-**	**1,119**
Total Modified		**308**	**-**	**99**
Total Intermittent		**1,271**	**-**	**507**
Total Permanent		**860**	**-**	**514**

Appendix B

Current and potential SEV scores of the impact and offset streams

Table 8. Summary Current SEV data from impact streams

Function Category	Report Section	Function	Stream 4	Stream 7	Stream 10	Stream 13
Hydraulic	4.1	NFR	0.93	0.80	0.93	0.83
Hydraulic	4.2	FLE	0.68	0.05	0.68	0.16
Hydraulic	4.3	CSM	1.00	1.00	1.00	1.00
Hydraulic	4.4	CGW	0.90	0.90	0.96	0.92
Biogeochemical	4.5	WTC	0.92	0.68	0.92	0.90
Biogeochemical	4.6	DOM	1.00	1.00	1.00	1.00
Biogeochemical	4.7	OMI	0.95	0.67	0.95	1.00
Biogeochemical	4.8	IPR	0.96	0.76	0.96	0.90
Biogeochemical	4.9	DOP	0.69	0.42	0.69	0.63
Habitat provision	4.10	FSH	0.12	0.10	0.12	0.17
Habitat provision	4.11	HAF	0.99	0.86	0.99	0.56
Biodiversity	4.12	FFI	-	-	0.63	0.80
Biodiversity	4.13	IFI	0.77	0.55	0.87	0.61
Biodiversity	4.14	RVI	0.90	0.50	0.90	0.90
Overall mean SEV score			**0.83**	**0.64**	**0.79**	**0.62**

Table 9. Summary Current SEV data from offset streams

Function Category	Report Section	Function	Old Field Road		Hellyer Road		
			SEV-int	SEV-p	Tributary 1	Central Upper	Central Lower
Hydraulic	4.1	NFR	0.60	0.61	0.63	0.64	0.65
Hydraulic	4.2	FLE	0.06	0.38	0.31	0.16	0.09
Hydraulic	4.3	CSM	1.00	1.00	0.30	1.00	0.00
Hydraulic	4.4	CGW	0.73	0.86	0.87	0.81	0.84
Biogeochemical	4.5	WTC	0.56	0.68	0.26	0.28	0.40
Biogeochemical	4.6	DOM	0.60	0.40	1.00	1.00	0.68
Biogeochemical	4.7	OMI	0.06	0.11	0.79	0.08	0.12
Biogeochemical	4.8	IPR	0.80	0.52	0.90	0.80	0.80
Biogeochemical	4.9	DOP	0.47	0.52	0.86	0.34	0.34
Habitat provision	4.10	FSH	0.05	0.05	0.72	0.13	0.05
Habitat provision	4.11	HAF	0.51	0.65	0.76	0.63	0.66
Biodiversity	4.12	FFI					
Biodiversity	4.13	IFI					
Biodiversity	4.14	RVI	0.09	0.01	0.50	0.06	0.06
Overall mean SEV score			**0.46**	**0.48**	**0.66**	**0.49**	**0.39**

Table 10. Summary Potential SEV data from impact sites

Function Category	Report Section	Function	Stream 4	Stream 7	Stream 10	Stream 13
Hydraulic	4.1	NFR	0.93	0.80	0.93	0.83
Hydraulic	4.2	FLE	0.68	0.05	0.68	0.16
Hydraulic	4.3	CSM	1.00	1.00	1.00	1.00
Hydraulic	4.4	CGW	0.90	0.90	0.96	0.92
Biogeochemical	4.5	WTC	0.92	0.68	0.92	0.90
Biogeochemical	4.6	DOM	1.00	1.00	1.00	1.00
Biogeochemical	4.7	OMI	0.95	0.67	0.95	1.00
Biogeochemical	4.8	IPR	0.96	0.76	0.96	0.90
Biogeochemical	4.9	DOP	0.69	0.42	0.69	0.63
Habitat provision	4.10	FSH	0.12	0.10	0.12	0.17
Habitat provision	4.11	HAF	0.99	0.86	0.99	0.56
Biodiversity	4.12	FFI	-	-	0.63	0.80
Biodiversity	4.13	IFI	0.77	0.55	0.87	0.61
Biodiversity	4.14	RVI	0.90	0.50	0.90	0.90
Overall mean SEV score			**0.74**	**0.64**	**0.83**	**0.64**

Table 11. Summary Potential SEV data from offset sites

Function Category	Report Section	Function	Old Field Road		Hellyer Road		
			SEV-int	SEV-P	Tributary 1	Central Upper	Central Lower
Hydraulic	4.1	NFR	0.63	0.63	0.63	0.76	0.76
Hydraulic	4.2	FLE	0.44	0.44	0.44	0.36	0.20
Hydraulic	4.3	CSM	0.87	0.87	0.87	0.79	0.78
Hydraulic	4.4	CGW	0.38	0.38	0.38	0.28	0.16
Biogeochemical	4.5	WTC	1.00	1.00	1.00	1.00	1.00
Biogeochemical	4.6	DOM	1.00	1.00	1.00	1.00	1.00
Biogeochemical	4.7	OMI	0.79	0.79	0.79	0.72	0.72
Biogeochemical	4.8	IPR	0.90	0.90	0.90	0.98	0.98
Biogeochemical	4.9	DOP	0.86	0.86	0.86	0.89	0.89
Habitat provision	4.10	FSH	0.72	0.72	0.72	0.73	0.70
Habitat provision	4.11	HAF	0.76	0.76	0.76	0.68	0.70
Biodiversity	4.12	FFI					
Biodiversity	4.13	IFI					
Biodiversity	4.14	RVI	0.50	0.50	0.50	0.50	0.50
Overall mean SEV score			**0.74**	**0.74**	**0.74**	**0.72**	**0.70**

Assumptions:

1. Riparian planting of 10 m either side of the stream
2. Removal of all total and partial barriers to fish passage i.e. undersized and perched culverts
3. Small areas of natural instream enhancements (natural rock, large wood) where erosion or bank slumping is identified as a risk to property or riparian planting
4. Increase in ecosystem functions associated with established riparian planting, i.e. up to 70%

shade, increase in organic matter inputs, increase in filtration.

Appendix 4. Potential SEV score assumptions

Function and Variable	Impact Streams	Off-set Streams
Hydraulic		
Vchann	No change.	Some naturalisation with increase in roughness (addition of rock) and riparian vegetation.
Vlining	No change.	Some decrease in heavy load of silt.
Vpipe	No change.	No change.
Vbank	No change.	No change.
Vrough	No change.	Changed to reflect riparian margins, with regenerating indigenous vegetation and fenced, to 20m on both banks.
Vbarr	No change.	Removal of hanging culverts where applicable
Vchanshape	No data entry required.	No data entry required.
Biogeochemical	No change.	
Vshade	No change.	Increased to reflect change in riparian margins.
Vdod	No change.	Increase with stock restricted and reduction in macrophytes.
Vveloc	No change.	Reduction in stagnant areas with reduction in macrophytes.
Vdepth	No change.	No change.
Vripar	No change.	Changed to reflect riparian margins 20 m on each bank.
Vdecid	No change.	No change, no deciduous
Vmacro	No change.	Reduction in macrophytes with increased shading
Vretain	No data entry required.	No data entry required.
Vsurf	No change..	Increase in wood component but reduction of macrophytes.
Vripfilt	No change.	Changed to reflect riparian margins.
Habitat provision	No change	
Vgalspwn	No change.	No change due to topography.
Vgalqual	No change.	Increase with shading.
Vgobspawn	No data entry required	No data entry required
Vphyshab	No change.	Increase in parameters associated with riparian planting.
Vwatqual	No change.	No change.
Vimperv	No change.	No change.
Biodiversity		
Vfish	Removed for ECR.	Removed for ECR.
Vmci	Removed for ECR.	Removed for ECR.
Vept	Removed for ECR.	Removed for ECR.
Vripcond	No data entry required.	No data entry required
Vinvert	Removed for ECR.	Removed for ECR.
Vripconn	No change.	Changed to reflect riparian margins.

Appendix C

Rolling ECR Calculations

		Impact					Compensation/Offset							ECR		Compensated	Residual
Stream ID	Impact type	SEVi-P	SEVi-I	Length (m)	Average width (m)	Streambed area (m2)	Stream ID	Compensaton method *	SEVm-P	SEVm-C	Average width (m)	Length available (m)	Steambed area available (m2)	ECR	Strembed area compensation required (,m2)	Proportion of impact reach compendated	Compensation stream bed area still available (m2)
Stream 1	Reclamation	0.84	0	204	0.41	84	SEV Reach 4	Enhancement	0.74	0.46	0.6	190	*114*	4.50	376.38	0.30	0.0
		0.84	0		0.41	*58*	SEV-Reach 1	Enhancement	0.74	0.46	0.57	439	*250.23*	4.50	262.38	0.95	0.0
		0.84	0		0.41	*3*	SEV-T	Enhancement	0.74	0.47	1.93	170	*328.1*	4.67	12.60	26.04	315.5
Stream 2	Reclamation	0.84	0	136	0.3	41	SEV-T	Enhancement	0.74	0.47	1.93		315.5	4.67	190.40	1.66	125.1
Stream 3	Reclamation	0.84	0	165	0.22	36	SEV-T	Enhancement	0.74	0.47	1.93		125.1	4.67	169.40	0.74	0.0
		0.84	0		0.22	*9*	SEV-CU	Enhancement	0.72	0.49	2.29	1125	*2576.25*	5.48	52.00	49.54	2524.2
Stream 4	Reclamation	0.84	0	285	0.64	182	SEV-CU	Enhancement	0.72	0.49	2.29		2524.2	5.48	999.23	2.53	1525.0
Stream 5	Reclamation	0.84	0	78	0.49	38	SEV-CU	Enhancement	0.72	0.49	2.29		1525.0	5.48	209.38	7.28	1315.6
Stream 6	Reclamation	0.66	0	216	0.32	69	SEV-CU	Enhancement	0.72	0.49	2.29		*1315.6*	4.30	297.52	4.42	1018.1
Stream 7	Reclamation	0.66	0	202	0.41	83	SEV-CU	Enhancement	0.72	0.49	2.29		*1018.1*	4.30	356.49	2.86	661.6
Stream 8	Reclamation	0.66	0	53	0.31	16	SEV-CU	Enhancement	0.72	0.49	2.29		*661.6*	4.30	70.72	9.36	590.9
Stream 9	Reclamation	0.66	0	154	0.31	48	SEV-CU	Enhancement	0.72	0.49	2.29		590.9	4.30	205.49	2.88	385.4
Stream 10	Reclamation	0.84	0	245	0.37	91	SEV-CU	Enhancement	0.72	0.49	2.29		385.4	5.48	496.60	0.78	0.0
		0.84	0			*20*	SEV-CL	Enhancement	0.7	0.39	2.09	969	*2025.21*	4.06	82.49	24.55	1942.7
Stream 11	Reclamation	0.84	0	242	0.38	92	SEV-CL	Enhancement	0.7	0.49	2.29		1942.7	6.00	551.76	3.52	1391.0
		0.84															
Stream 12	Reclamation	0.84	0	127	0.4	51	SEV-CL	Enhancement	0.7	0.39	2.09		1391.0	4.06	206.48	6.74	1184.5
Stream 13	Reclamation	0.78	0	284	0.93	264	SEV-CL	Enhancement	0.7	0.39	2.09		1184.5	3.77	996.84	1.19	187.6

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