REPORT

Tonkin+Taylor

Stream Ecological Effects Assessment

Beachlands South Private Plan Change

Prepared for
Beachlands South Limited Partnership
Prepared by
Tonkin & Taylor Ltd
Date
March 2022
Job Number
1014358.4000.v4

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Document Control

Title: Stream Ecological Effects Assessment					
Date	**Version**	**Description**	**Prepared by:**	**Reviewed by:**	**Authorised by:**
August 2021	1	Preliminary draft for client review	S Pratt	D C Miller	P Millar
October 2021	2	Draft for client review	S Pratt	D C Miller	P Millar
January 2022	3	Final draft for client review	S Pratt	D C Miller	P Millar
March 2022	4	Final report	S Pratt	D C Miller	P Millar
March 2022	5	Final report with minor amendments	S Pratt	D C Miller	P Millar

Distribution:

Beachlands South Limited Partnership	1 electronic copy
Tonkin & Taylor Ltd (FILE)	1 electronic copy

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Glossary

Area of impact	Those sections of stream indicated to be potentially directly impacted by stream reclamation or culvert installation.
Avoid	Ways in which the project might be modified to avoid effects on areas or features of ecological value.
Best Practicable Option (BPO)	Defined in section 2(1) of the Resource Management Act 1991 (RMA), as: *"in relation to a discharge of a practicable contaminant or an emission of noise, means the best method for option preventing or minimising the adverse effects on the environment having regard, among other things, to —* *(a) the nature of the discharge or emission and the sensitivity of the receiving environment to adverse effects; and* *(b) the financial implications, and the effects on the environment, of that option when compared with other options; and* *(c) the current state of technical knowledge and the likelihood that the option can be successfully applied.*
Compensation	Compensation is any measure proposed or agreed to by the applicant for the purpose of ensuring positive effects on the environment to compensate for any adverse effects on the environment that will or may result from allowing the activity.
Council	Auckland Council
Cumulative effects	Changes to the environment that are caused by an action in combination with other past, present and future human actions.
ECR	Ecological Compensation Ratio (ECR) is a calculation based on SEV values. The ECR determines the amount of stream restored relative to the amount of stream degraded.
eDNA	Environmental DNA (eDNA) able to be sampled from water and filtered for laboratory analysis. Laboratory analysis
EFM	Electric Fishing Machine (EFM) survey utilises electricity to temporarily stun fish for the purposes of capture, measurement, and identification to characterise fish communities within a section of stream.
E-MBR	Enhanced Membrane Bioreactor
Mitigate	Refers to any action that alleviates or moderates the severity of an impact caused by something. Actions that mitigate impacts may also minimise those effects.
No Net Loss/Net Gain	The values that are adversely affected by an activity are addressed through compensation that seeks to achieve a No Net Loss / Net Gain outcome as assessed using an Ecological Compensation Ratio (ECR) approach.
Offset	a 'measurable conservation outcome' that meets certain principles and balances adverse residual effects that cannot reasonably be avoided, remedied or mitigated, to a No Net Loss / Net Gain standard.
Remedy	Refers to any action that rehabilitate, restore, reinstate conditions following an impact.
Residual effect	Effects on biodiversity or ecological values that cannot be avoided, remedied or mitigated.
SEV	Stream Ecological Valuation (SEV) is a standardised methodology for attributing "value" to freshwater streams on the basis of habitat quality and ecological function. SEV values are utilised for the ECR calculations below.

SEA	Significant Ecological Areas (SEAs) are identified by the Auckland Council to maintain and protect indigenous biodiversity. These areas are recorded in the Auckland Unitary Plan – Schedule 4.
Total suspended solids (TSS)	The total amount of particulate matter that is suspended in the water column, that are not dissolved, that can be trapped by a filter.
Turbidity	A measure of the clarity of water. Turbidity is the measurement of the amount of light scattered by suspended particulates present in the water when a light is shined through the water. The more total suspended particulates in the water, the murkier it can appear and the higher the turbidity.

Executive summary

Beachlands South Limited Partnership (BSLP) is seeking a Private Plan Change (PPC) to re-zone the Formosa Golf Course and an adjacent area of currently rural and private property land in Beachlands, Auckland to facilitate urban development of that area.

The properties included in this PPC process and associated Beachlands South Structure Plan (herein 'Structure Plan') include the Formosa Golf Resort (approximately 170 ha), a farm at 620 Whitford-Maraetai Road (approximately 80 ha) and various smaller land parcels totalling 57 ha.

The PPC area is currently zoned Rural – Countryside Living under the Auckland Unitary Plan – Operative in Part (AUP-OP). Through the Structure Plan, the BSLP are seeking to rezone the land to a combination of Business (Mixed Use, Local Centre and Neighbourhood Centre), Open Spaces, various residential zones and Future Urban zone.

A key focus of the Structure Plan is to enable the urbanisation of the land whilst protecting and enhancing ecologically significant values. To this end, the proposed PPC area includes an Ecological Protected Area Network (EPAN) covering 88.7 hectares. This EPAN includes the most significant existing and potential ecological values, which will be protected from development and enhanced.

Initially it is proposed to 'Live Zone' the northern portion of the PPC area (the 170 ha Formosa Golf Course) via a plan change. It is also proposed to rezone the southern portion of the PPC area as Future Urban Zone. This Future Urban Zone will then be the subject of a further plan change application in due course.

Report scope and methods

BSLP has requested that Tonkin & Taylor Ltd (T+T) prepare a stream ecological effects assessment (this report) for the PPC. This report sits alongside terrestrial, wetland and marine ecology assessment reports to inform the assessment of environmental effects of the project prepared to support the PPC application.

This report presents an assessment of stream ecological effects for the land use change associated with the proposed PPC and potential subsequent development. Our assessment has been undertaken in general accordance with the Ecological Impact Assessment (EcIA) guidelines (vs.2) produced by the Environmental Institute of Australia and New Zealand (Roper-Lindsay et al., 2018). The work has included a desktop review of existing relevant ecological data, site specific field surveys to assess stream classification, habitat and fauna values. The EcIA guidelines ascribe an overall level of ecological effect (from **Very Low** to **Very High**) that is determined using a matrix based on ecological values and the magnitude of effect on those values.

The Stream Ecological Valuation (SEV) and Environmental Compensation Ratio (ECR) methodologies have been used to determine the quantum of stream restoration and enhancement measures needed to offset the potential habitat loss (residual) effects within the Live Zone and based on the proposed Structure Plan and Precinct Plan.

Site description and stream values

Four main stream catchments are present within and/or adjacent to the Formosa Golf Resort along with a number of smaller tributaries not connected to the larger stream catchments. All of the stream catchments are modified to some degree, either through the historic construction works on the golf course, creation of on-line ponds, culvert works, wastewater discharge or general land-use and riparian zone modification. Two fenced Significant Ecological Areas (SEA-T's) are located in forested gully systems on the 620 site. The largest stream catchment on the 620 site coincides with the larger of the two SEA's and is a mostly unmodified watercourse.

Stream ecological values vary across the site from **Low** to **High** based on the extent of modification, water quality, the macroinvertebrate and fish communities present and habitat quality and function as assessed using the Stream Ecological Valuation methodology. The highest stream ecology values present on the overall site are associated with the SEA-T's on the 620 site.

Assessment of ecological effects

Our assessment of stream ecological effects is based on the Structure Plan that supports the PPC application and by undertaking the following measures to avoid, remedy and mitigate effects from the proposed PPC. The stream ecology effects management approach has been developed through the Structure Plan and PPC preparation process and has included:

- Site optimisation during the master-planning phase to avoid direct impacts on streams as far as practicable through the proposed 88.7 ha EPAN within the Live Zone and wider PPC area;
- Development of construction staging and erosion and sediment control protocols for the development in line with best practice;
- Implementation of best practice measures to avoid and minimise impacts on freshwater fauna such as avoiding important spawning and migration periods as appropriate, fish rescue protocols for any culvert works and consideration of fish passage at any stream crossings (bridges or fish friendly culverts);
- Development of a water sensitive design approach and a stormwater management plan in line with best practice; and
- Development of a preferred solution for wastewater management comprising treatment through a E-MBR system to achieve a high level of contaminant removal followed by either polishing wetland treatment or disposal of the treated effluent to land.

Table ES.1 provides a high-level summary of the overall level of stream ecological effects associated with the proposed PPC. We have taken a catchment-by-catchment approach to presenting the assessment of ecological effects and considered intermittent and permanent streams separately depending on the effect being considered. We note that impacts on smaller intermittent stream catchments (outside of the main catchments) have also been captured in terms of any loss of stream habitat. The range in the overall level of effects provided in Table ES.1 reflects the catchment-by-catchment and intermittent-permanent stream approach. The detail is provided in Section 4.

Table ES.1: Summary of the level stream ecological effects on ecological values on the Beachlands South site

Potential effects associated with the proposed land-use change	Level of effects category
Stream water quality effects due to construction related discharges	Very Low to Low
Construction related effects on native fish	Very Low to Low
Effects on native fish passage	Very Low to Low
Loss of stream habitat (intermittent streams only)	Moderate to High
Effects due to modified stream hydrology	Very Low to Low
Effects due to stormwater discharge	Very Low to Low
Effects due to the discharge of treated wastewater	Very Low to Low

Our assessment is that most residual effects due to the PPC and associated land use change and development on stream habitats and receiving environments will be **Very Low** to **Low**. However, our assessment also indicates that level of residual effects due to intermittent stream reclamation (stream loss) will be **Moderate to High**. With reference to the EIANZ framework, further effects

management to reduce the overall effects due to intermittent stream habitat loss and wastewater discharge is warranted.

Residual effects management

The SEV/ECR methodology has been used to determine the quantum of stream restoration and enhancement work needed to offset the potential habitat loss effects within the Live Zone and based on the Structure Plan and Precinct Plans included in the PPC. Our calculations have been based on restoration primarily by way of riparian planting. We note there is further scope for stream restoration involving culvert removal (stream daylighting) and fish passage improvement. Proposed offset measures will be further developed through the resource consenting phase and following further consultation.

Our calculations indicate that a total stream habitat area of 1,083 m^2 is required to be subject to riparian restoration to achieve no-net-loss of ecological function. Based on ECR calculations, the effects of stream bed area being lost within the Live Zone can be offset in full using the stream restoration sites available within the Live Zone area. The required restoration for stream reclamation will be secured by the existing AUP planning framework in which any new reclamation is a non-complying activity; and under the National Policy Statement for Freshwater Management (NPS FM) regulation in which reclamation is a discretionary activity. This existing planning framework provides scope and discretion to assess the effects and to require the necessary mitigation and/or offsetting as identified in this report.

Conclusion

In conclusion, our assessment is that most effects due to the PPC, associated land use change and subsequent development on stream habitats and receiving environments will be **Very Low** to **Low** provided the measures to avoid remedy or mitigate effects are implemented as set out in this report. However, our assessment also indicates that the level of residual effects due to intermittent stream reclamation (stream loss) with subsequent development of the Live Zone will be **Moderate to High**.

Residual stream habitat loss effects associated with development of the Live Zone can be addressed by way of stream offset work comprising riparian zone restoration and enhancement of the specific permanent and intermittent stream reaches identified within the EPAN as shown on the compensation plan (Figure 2 in Volume 2, Appendix A). Based on preliminary ECR modelling we consider a No Net Loss outcome for stream ecological values can be achieved.

We therefore consider that adverse ecological effects on streams due to the PPC and subsequent development can be adequately addressed through the effects management measures outlined in this report.

The above outcomes for stream ecology will be achieved through the adoption of the Auckland wide and proposed provisions developed for Beachlands South (as set out in the Planning Report that accompanies the PPC application) and through subsequent resource consent processes.

1 Introduction

This Stream Ecological Effects Assessment report has been prepared to inform the Structure Plan and a proposed Private Plan Change (PPC) being sought by Beachlands South Limited Partnership (BSLP) across multiple contiguous properties in Beachlands, Auckland.

1.1 Overview

BSLP is seeking a PPC across multiple contiguous properties in Beachlands, Auckland (approximately 307 ha) to expand the existing Beachlands Maraetai coastal town.

The PPC area is bound by Jack Lachlan Drive to the north, the Pine Harbour Marina and ferry terminal directly to the northwest, a coastal edge and the coastal marine area along the west, Whitford-Maraetai Road to the east and rural-residential properties to the south. The properties included in this PPC process and associated Beachlands South Structure Plan (herein 'Structure Plan') include the Formosa Golf Resort (approximately 170 ha), a farm at 620 Whitford-Maraetai Road (approximately 80 ha) and various smaller land parcels (see Table 1.1).

The PPC area is currently zoned Rural – Countryside Living under the AUP-OP. Through the Structure Plan, the BSLP are seeking to rezone the land to a combination of Business (Mixed Use, Local Centre and Neighbourhood Centre), Open Spaces, various residential zonings and Future Urban zone.

A key focus of the Structure Plan is to enable the urbanisation of the land whilst protecting and enhancing the significant ecological values. To this end, the proposed PPC area includes an Ecological Protected Area Network (EPAN) covering 88.7 hectares and including the most significant existing and potential ecological values, which will be protected from development and enhanced.

Table 1.1: Complete Structure Plan area (properties owned by BSLP shaded)

Address	Lot and DP number	Area (Hectares)
110 Jack Lachlan Drive Beachlands	LOT 2 DP 501271	170.475
620 Whitford-Maraetai Road	LOT 100 DP 504488	79.944
770 Whitford-Maraetai Road	LOT 10 DP 54105	6.867
758 Whitford-Maraetai Road	LOT 9 DP 54105	6.140
746 Whitford-Maraetai Road	LOT 8 DP 54105	5.800
740 Whitford-Maraetai Road	LOT 7 DP 54105	5.145
732 Whitford-Maraetai Road	LOT 6 DP 54105	5.094
722 Whitford-Maraetai Road	LOT 5 DP 54105	4.923
712 Whitford-Maraetai Road	LOT 4 DP 54105	4.752
702 Whitford-Maraetai Road	LOT 1 DP 208997	2.134
692 Whitford-Maraetai Road	LOT 1 DP 197719	1.774
682 Whitford-Maraetai Road	LOT 1 DP 187934	1.258
680 Whitford-Maraetai Road	LOT 26 DP 504488	12.813
Total		**307.119**

Initially it is proposed to 'Live Zone' the proposed development footprint within the northern portion of the PPC area (the 170 ha Formosa Golf Course at 110 Jack Lachlan Drive, Beachlands) via a plan change. It is proposed to rezone the remaining development footprint within the southern portion of the PPC area as Future Urban Zone. This includes the proposed development footprint within the farm at 620 Whitford-Maraetai Road and various smaller land parcels. These Future Urban Zone

areas will be the subject of a further plan change application in due course. The site location and proposed zoning is shown in Figure 1.1.

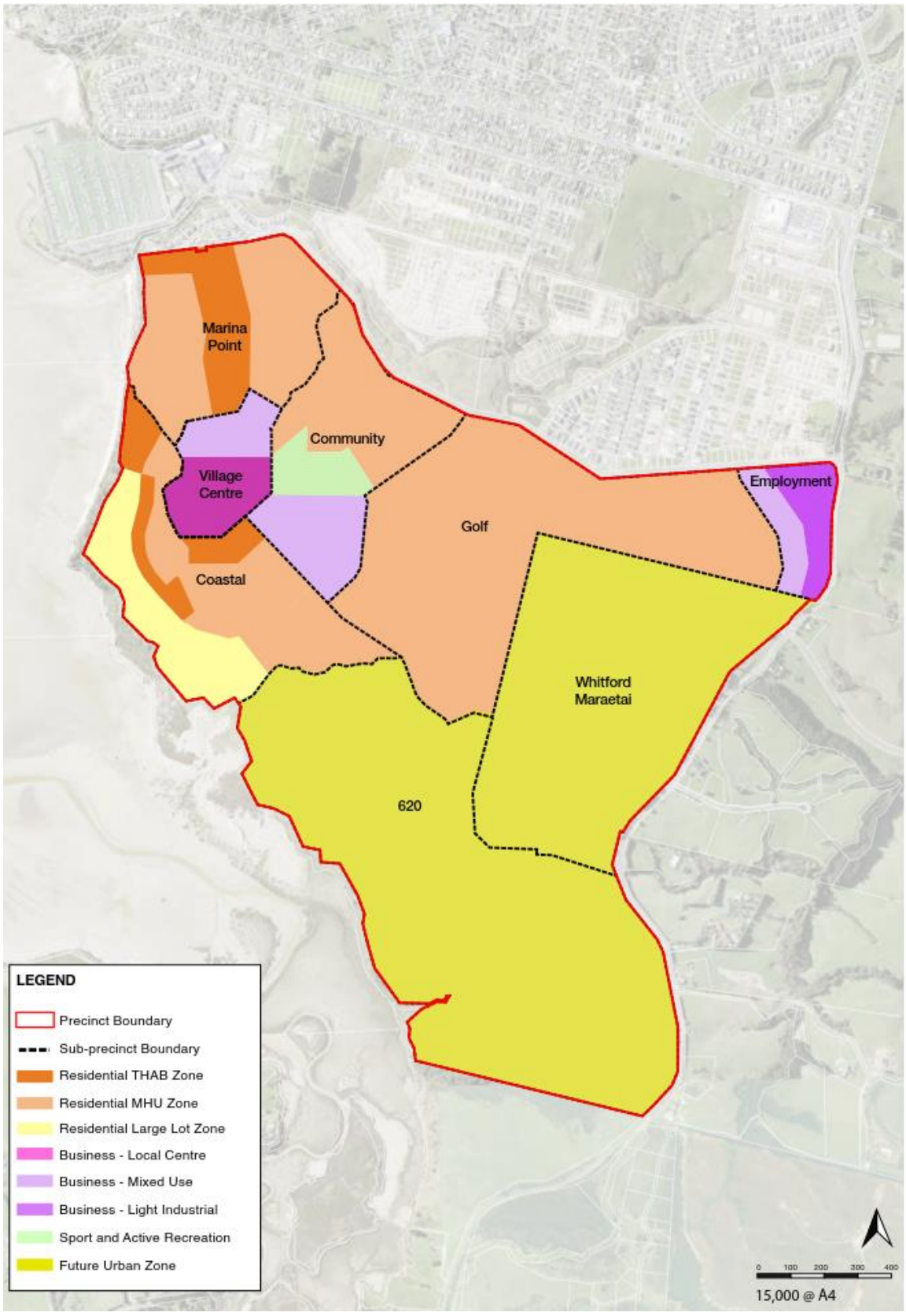

Figure 1.1: Beachlands South site location and proposed zoning

BSLP has commissioned a series of technical reports as part of the planning process for the Beachlands South Structure Plan and subsequent private plan change (the Project).

This report assesses the potential effects of the Project on stream ecological values. It also provides recommendations to avoid, remedy or mitigate adverse effects within the structure plan and plan change area and matters to be considered in the development of potential precinct provisions over the plan change area to guide and manage future development activities.

1.2 Report scope

BSLP has requested that Tonkin & Taylor Ltd (T+T) prepare a stream ecological effects assessment (this report) to inform the Section 32 report and accompanying Assessment of Environmental Effects (AEE) that will support the Private Plan Change (PPC) application[1]. The report assesses the stream ecological effects associated with the land use change due to the proposed PPC and subsequent development, including construction phases.

This ecology assessment focusses on stream environments on the site. Several on-line ponds are also present on the site and the ecological values of these are described in the Wetland ecological effects assessment. This stream effects assessment report includes:

- A description of stream ecological values of the site, based on desktop review and field surveys;
- An assessment of effects of the PPC proposal on those stream ecology values;
- Recommended measures to avoid, remedy or mitigate adverse effects on stream ecology; and
- Recommendations for addressing anticipated residual adverse effects on stream ecology that cannot be avoided, remedied or mitigated, through restoration and enhancement.

This Stream Ecological Effects Assessment sits within a suite of ecological assessment reports and associated information as set out below:

- Volume 1: Ecology Technical Reports
  - Ecological Assessment of Effects Report: Executive Overview
  - Terrestrial Ecology Effects Assessment (this report)
  - Wetland Ecology Effects Assessment
  - Stream Ecology Effects Assessment
  - Marine Ecology Effects Assessment
  - Biodiversity Compensation Modelling Report
- Volume 2: Appendices
  - Appendix A: Combined Ecology Tables and Figures
  - Appendix B: Terrestrial Ecology Tables and Figures
  - Appendix C: Wetland Ecology Tables and Figures
  - Appendix D: Stream Ecology Table and Figures
  - Appendix E: Marine Ecology Tables and Figures
  - Appendix F: Biodiversity Compensation Modelling Tables

[1] This work has been undertaken in accordance with our letter of engagement dated 11 December 2020.

1.3 Statutory context

The statutory and planning documents that provide the framework for this stream ecology effects assessment are detailed in the Section 32 Evaluation for the proposal. In brief, these include:

- Part 2 of the Resource Management Act 1991
- The National Policy Statement for Freshwater Management 2020 (NPS-FM).
  - Policy 3 of the NPS-FM requires that *"freshwater is managed in an integrated way that considers the effects of the use and development of land on a whole-of-catchment basis, including the effects on receiving environments."*
  - Policy 7 of NPS-FM requires that *"the loss of river extent and values is avoided to the extent practicable."*
- The Resource Management (National Environmental Standards for Freshwater) Regulations 2020 (NES-FW). Notably, the proposal does not involve any activity prohibited by the NES-FW in relation to streams. Subpart 2 Rule 57 states that *"Reclamation of the bed of any river is a discretionary activity."*
- The Auckland Unitary Plan (Operative in Part) (AUP-OP). Intermittent and permanent streams are protected under the AUP-OP, and reclamation (filling) of these is a Non-Complying Activity.
  - The Policies and Objectives in Chapter E3 of the AUP OP direct that reclamation of streams is avoided in the first instance and that streams are retained and enhanced.
  - Where reclamation cannot be practicably avoided, mitigation or offset is required to address adverse effects.
- Conservation (Indigenous Freshwater Fish) Amendment Act 2019 provides for the protection of indigenous freshwater fish and management of key threats such as barriers to fish passage and loss of spawning sites.

The following non-statutory documents are also relevant to this assessment:

- Auckland Unitary Plan Practice and Guidance note on River/ Stream Classification. RC 3.3.17 (V2) dated July 2021.
- Storey, R G, Neale, M W, Rowe, D K, Collier, K J, Hatton, C, Joy, M K, Maxted, J R, Moore, S, Parkyn, S M, Phillips, N and Quinn, J M (2011). Stream Ecological Valuation: a method for assessing the ecological function of Auckland streams. Auckland Council Technical Report 2011/009.
- Roper-Lindsay, J., Fuller S.A., Hooson, S., Sanders, M.D., Ussher, G.T. (2018). Ecological impact assessment Guidelines (EcIAG). EIANZ guidelines for use in New Zealand: terrestrial and freshwater ecosystems. 2nd edition.

2 Methods

A desktop investigation and field surveys were used to identify the stream ecological characteristics and values onsite, using the methods described in the following sections. Field investigations were undertaken across the site including:

- Stream classification according the AUP-OP definitions and guidance
- Water quality sampling
- Macroinvertebrate community sampling
- Freshwater fish surveys
- Environmental DNA (eDNA) sampling
- Stream ecological valuations (SEV)

This report includes an assessment of effects on stream ecology based on the known or likely ecological values on site and the expected magnitude of effects on those values due to the PPC proposal. We have used the Ecological Impact Assessment Guidelines (EcIAG) produced by the Environmental Institute of Australia and New Zealand (EIANZ) to frame our assessment of ecological effects (EIANZ, 2018).

Our assessment covers potential direct impacts of the PPC proposal on stream habitats, proposed stormwater discharges during construction and finished development stages and the point source discharge of treated wastewater from a proposed on-site Wastewater Treatment Plant (WWTP).

SEV and Ecological Compensation Ratio (ECR) modelling was used to assist in determining the type and magnitude of offsetting or compensation measures needed to address potential residual adverse effects that could not be avoided, remedied or mitigated (e.g. stream reclamation).

2.1 Description of ecological characteristics and values

2.1.1 Desktop assessment

A desktop assessment was undertaken to compile information and data relating to the ecology of the stream environments on site. This included the following key sources of information and additional references therein. A full list of information sources is provided in the Section 8.

- New Zealand Freshwater Fish Database
- Wildland Consultants Ecological opportunities and constraints report for part of the 620 site.

2.1.2 Catchment and survey site naming conventions

The stream networks on the site are generally unnamed tributaries draining to the Waikopua Creek intertidal area. For the purposes of this report, we have named the main catchments as the “Northern (N)”, “Eastern (E)”, “Southern (S)” and “Western (W)” Catchments on the Formosa site and private properties. We refer to the catchments on the large 620 Whitford-Maraetai Road part of the site as “620 Catchments (620)”. Catchment/stream and survey site locations are shown in Volume 2, Appendix D; Figure 2.

2.1.3 Stream classification

Stream classification is an important component of the field investigations. The classification of a watercourse as permanent, intermittent, or ephemeral has implications with respect to the objectives, policies and rules in the Auckland Unitary Plan (AUP) and the National Environmental Standard for Freshwater (NES-F). We have used the framework set out in Auckland Unitary Plan

Practice and Guidance note[2] for the purposes of clearly and transparently classifying streams for this study.

Stream classification work utilised the Auckland Council (AC) overland flow path (>4,000 m^2) layer as the starting point for identifying potential stream alignments. Initial stream classification was undertaken by T+T staff in 2020[3,4] as part of Opportunities and Constraints investigations. This comprised desktop review of aerial photographs and field assessments and was for the purposes of categorising watercourse types present on the property and refining the modelled AC overland flow path layer. The 2020 inspections documented observed intermittent or permanent stream but did not differentiate between intermittent or permanent stream.

Field investigations for the PPC project comprised multiple field visits between March and October 2021 and a review of historic aerial photographs. This was undertaken for the purposes of refining the initial watercourse classifications and collecting information on permanent stream and intermittent stream ecological values. The 2021 field investigations covered both the Live Zone and Future Urban Zone parts of the overall PPC area.

- The field investigations undertaken between March and May 2021 were used to refine the extent of permanent stream within the catchments present on the site.
- The field investigations undertaken during the months of July and October 2021 were used to refine the transition between intermittent stream and ephemeral stream on the site. This focussed entirely on those upper tributaries of these catchments that were indicated as being potentially within the "Developable Footprint" through the Master Plan development process.

Using the Auckland Unitary Plan Practice and Guidance note on stream classification we have identified instances where key intermittent stream characteristics were indeterminant. In these instances, we have taken a precautionary approach and have classified these as intermittent (as opposed to ephemeral). We have also taken into consideration the "very dry" to "extremely dry"[5] conditions experienced in the Auckland region over 2020 and 2021.

2.1.4 Permanent and intermittent stream values

Permanent and intermittent stream ecological values were assessed during summer and winter conditions respectively with the detail provided in the following sections.

2.1.4.1 Permanent stream survey

Stream ecological surveys and water quality sampling were conducted at permanent stream sites between March and May 2021 to characterise the existing ecological values. This work covered a range of methods with a focus on these streams being potential receiving environments for any future stormwater and/or wastewater discharges with a change to urban land use, and as potential ecological offset sites.

[2] Auckland Unitary Plan. Practice and Guidance note: River/Stream classification. 24 May 2021. RC 3.3.17 (V1).
[3] T+T, 2020a. Beachlands Ecological Opportunities and Constraints Due Diligence Report. Technical report prepared for Piritahi, February 2020.
[4] T+T, 220b. Assessment of ecological values at 620 Whitford-Maraetai Road. Technical report prepared for Beachlands South Limited Partnership, July 2020.
[5] New Zealand Drought Index (NZDI) indicator categories calculated and administered by the National Institute of Weather and Atmosphere (NIWA)

A total of 14 survey locations for permanent streams were selected across the site, four in the Northern Catchment, one in the Eastern Catchment[6], two in the Southern Catchment, three in the Western Catchment, and three on the property at 620 Whitford-Maraetai Road.

The types of ecological surveys conducted at each site (SEV, water quality, macroinvertebrate, freshwater fish) varied depending on site characteristics and the proximity to other sampling sites in each catchment. eDNA samples were collected from the most downstream survey location on each stream system to characterise freshwater fish communities within each catchment.

The sampling locations and the types of ecological surveys conducted at each site are summarised below in Table 2.1 and shown on Volume 2, Appendix D; Figure 2.

Table 2.1: Ecological survey site locations and the surveys conducted at each permanent stream site. Coordinates are New Zealand Transverse Mercator 2000

Catchment	Site	Easting*	Northing*	Stream classification (date surveyed)	Surveys conducted
Northern	N1[+]	1777819	5915220	Permanent stream (March 2021)	SEV, water quality, macroinvertebrates, eDNA
	N2	1777765	5915096	(March 2021)	SEV, water quality, macroinvertebrates
	N2-2	1777719	5914974	(March 2021)	SEV, water quality, macroinvertebrates, EFM fish survey
	N4[+]	1777652	5914814	(March 2021)	Macroinvertebrate survey
	N5[+]	1777629	5914659	(March 2021)	SEV, water quality, macroinvertebrates
Eastern	E1	1778289	5914842	(March 2021)	SEV, water quality, macroinvertebrates, eDNA
Southern	S1	1777570	5914071	(March 2021)	SEV, water quality, macroinvertebrates, EFM fish survey, eDNA
	S2	1777720	5914091	(March 2021)	SEV, water quality, macroinvertebrates, EFM fish survey
Western	W1	1777227	5914940	(March 2021)	SEV, water quality, macroinvertebrates, EFM fish survey, eDNA
	W2	1777344	5914714	(March 2021)	SEV, water quality, macroinvertebrates, EFM fish survey
	W3	1777369	5914455	(March 2021)	SEV, water quality, macroinvertebrates
620 Catchments	620-1	1778110	5913132	(May 2021)	SEV, water quality, macroinvertebrates, EFM fish survey, eDNA

[6] For the eastern catchment, permanent watercourse was restricted to the lower 120 m of the catchment within the Formosa property at the time of permanent stream survey. This was confirmed to still be the situation when the catchment was re-visited in May 2021.

Catchment	Site	Easting*	Northing*	Stream classification (date surveyed)	Surveys conducted
	620-2	1778282	5913169	(May 2021)	SEV, water quality, macroinvertebrates, EFM fish survey
	620-3	1778134	5913111	(May 2021)	SEV, water quality, macroinvertebrates, EFM fish survey

*Co-ordinate provided are for the downstream location for SEV survey undertaken at each location.

+Constructed pond site

2.1.4.2 Intermittent stream survey

Ecological surveys were conducted in intermittent streams in July and October 2021, within the accepted period for intermittent stream survey, to characterise the existing ecological values. The intermittent stream survey focussed on sites that were within the identified "developable footprint" and potentially directly impacted by reclamation. A total of 33 locations were inspected within both the Live Zone and Future Urban Zone parts of the PPC area having been identified as potentially directly impacted. Due to the small size and nature of these upper headwater tributaries only SEV and macroinvertebrate sampling were undertaken to characterise stream values.

Surveyed locations were first confirmed to be intermittent using the approach outlined in Section 2.1.3. The sampling locations and the types of ecological surveys conducted at each site are summarised below in Table 2.2 and shown on Volume 2, Appendix D; Figure 2. SEV assessments were undertaken at representative intermittent stream sites only. We have indicated in Table 2.2 where SEV scores from neighbouring tributaries have been applied.

Table 2.2: Ecological survey site locations and the surveys conducted at each intermittent stream site. Coordinates are New Zealand Transverse Mercator 2000

Catchment	Site	Easting*	Northing*	Date surveyed	Surveys conducted
Northern	N-UT1	1777680	5914827	July 2021	Inspection only - ephemeral
	N-UT2	1777833	5914962	July 2021	Inspection only - ephemeral
	N-UT3	1777641	5914771	July 2021	SEV, macroinvertebrates
	N-UT4	1777588	5915359	July 2021	SEV
Eastern	E-UT1	1778312	5914761	July 2021	Inspection only - ephemeral
	E-UT2	1779014	5914566	July 2021	SEV, macroinvertebrates
	E-UT3	1779203	5914593	July 2021	Inspection only - ephemeral
	E-UT4	1779214	5914623	July 2021	Inspection only - ephemeral
	E-UT5	1779193	5914645	July 2021	Inspection only
	E-UT6	1779088	5914354	July 2021	Inspection only - ephemeral
	E-UT7	1778993	5914422	July 2021	SEV, macroinvertebrates
	E-UT8	1778952	5914534	July 2021	SEV, macroinvertebrates
	E-UT9	1778954	5914553	July 2021	Inspection only - ephemeral
	E-UT10	1778081	5914720	July 2021	Inspection only - ephemeral
	E-UT11	1779199	5914656	July 2021	Inspection only - ephemeral
	E-UT12	1779131	5914652	July 2021	Inspection only - ephemeral
	E-UT13	1779107	5914620	July 2021	Inspection only - ephemeral

Catchment	Site	Easting*	Northing*	Date surveyed	Surveys conducted
	E-UT14	1778352	5914565	July 2021	SEV
	E-UT15	1778395	5914528	July 2021	Inspection only - ephemeral
	E-UT16	1778305	5914600	July 2021	SEV
	E-UT17	1778414	5914447	October 2021#	SEV, macroinvertebrates
	E-UT18	1778412	5914058	October 2021#	SEV
	E-UT19	1778667	5914417	October 2021#	SEV
Southern	S-UT1	1778212	5913795	July 2021	Inspection only - ephemeral
	S-UT2	1778054	5914061	July 2021	SEV, macroinvertebrates
	S-UT3	1778019	5914080	July 2021	Not surveyed - apply S-UT2 SEV values
	S-UT4	1778067	5914104	July 2021	SEV, macroinvertebrates
	S-UT5*	1777925	5914158	July 2021	Not surveyed - apply S-UT6 SEV values
	S-UT6*	1777925	5914158	July 2021	SEV, macroinvertebrates
Western	W-UT1	1777337	5914810	July 2021	Not surveyed - apply W-UT3 SEV values
	W-UT2	1777381	5914838	July 2021	Not surveyed - apply W-UT3 SEV values
	W-UT3	1777381	5914838	July 2021	SEV, macroinvertebrates
	W-UT4	1777440	5914761	July 2021	Ephemeral above track
	W-UT5	1777459	5914663	July 2021	Not surveyed - apply W-UT3 SEV values
	W-UT6	1777404	5914590	July 2021	Not surveyed - apply W-UT3 SEV values
	W-UT7	1777424	5914484	July 2021	Inspection only - ephemeral above existing track
	W-UT8	1777451	5914440	July 2021	Inspection only - ephemeral above existing track
	W-UT9	1777495	5914323	July 2021	SEV, macroinvertebrates
	W-UT10	1777436	5914382	July 2021	Not surveyed - apply UT9 SEV values
620 Catchment	620-UT1	1778428	5913379	July 2021	SEV, macroinvertebrates
	620-UT2	1778417	5913413	July 2021	Not surveyed - apply 620-UT1 SEV values
	620-UT3	1778392	5913545	July 2021	SEV, macroinvertebrates
	620-UT4	1778352	5913535	July 2021	Inspection only - ephemeral
	620-UT5	1778640	5913312	July 2021	Not surveyed - 620-UT1 SEV values

*S-UT5 and S-UT6 have the same starting location. S-UT5 is a tributary entering from the east and S-UT6 is a tributary entering from the north.

Survey undertaken 1st of October 2021 due to Covid-19 related delays

2.1.5 Water quality

Spot *in situ* water quality measurements of temperature, dissolved oxygen, pH, and conductivity were collected at each permanent stream survey site at the time of conducting surveys using calibrated YSI Pro-ODO and Eutech PCSTestr35 hand-held meters. Spot water quality measurements are used to provide an understanding of the water quality conditions at time of sampling.

Grab water quality samples were also collected at each SEV site at the time of survey. Samples were placed on ice as soon as possible after collection and delivered to an accredited laboratory (Hill Laboratories in Hamilton) for testing. Water samples were tested for the following parameters as required:

- Turbidity
- pH
- Total hardness
- Electrical conductivity (EC)
- Total Suspended Solids
- Total nitrogen (TN)
- Total Ammonical-N (TAN)
- Nitrite-N
- Nitrate-N
- Nitrate-N + Nitrite-N
- Dissolved calcium
- Dissolved and total copper
- Dissolved lead
- Dissolved magnesium
- Dissolved and total zinc
- Total Kjeldahl Nitrogen (TKN)
- Dissolved Reactive Phosphorus (DRP)
- Total Phosphorus
- Chemical Oxygen Demand (COD)
- Faecal coliforms
- *Escherichia coli (E. coli)*

2.1.6 Freshwater macroinvertebrates

A single macroinvertebrate sample was collected at each SEV site. Macroinvertebrate samples were collected in accordance with National Protocols C1 (hard bottom semi-quantitative) and C2 (soft bottom semi-quantitative) as appropriate for macroinvertebrate sampling in wadeable streams (Stark et al., 2001). Samples were collected at both permanent and intermittent stream survey locations.

Samples were preserved in ethanol and sent to Stark Environmental Limited for sorting and identification using Protocol P2 (200 fixed-count with scan for rare taxa). Macroinvertebrate samples were also analysed for counts of Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa (pollution-sensitive species), the presence of which can indicate good water and habitat quality.

The results of the macroinvertebrate samples were used to calculate the Macroinvertebrate community Index (MCI) and Quantitative Macroinvertebrate Community Index (QMCI) scores for each site. An interpretation of MCI and QMCI scores is presented below in Table 2.3.

Table 2.3: Interpretation of macroinvertebrate community index values (Stark & Maxted, 2007)

Quality Class	MCI score	QMCI score
Excellent	> 119	> 5.99
Good	100 -119	5.00 – 5.99
Fair	80 – 99	4.00 – 4.99
Poor	< 80	< 4.00

2.1.7 Freshwater fish survey

Freshwater fish in the streams within the site were surveyed using two different methods, electric fishing using an Electric Fishing Machine (EFM) and eDNA sampling and processing. Electric fishing provided an estimate of the relative abundance of freshwater fish present which could then be compared to the results of eDNA samples taken within each catchment system. Fish surveys were only conducted at permanent stream survey locations.

2.1.7.1 Electric fishing survey

Electric fishing was the chosen method for completing freshwater fish surveys as appropriate to water depth and flow characteristics. Freshwater fish surveys were undertaken between March and May 2021 inclusive in general accordance with New Zealand freshwater fish sampling protocols (Joy

et al., 2013). All captured fish were identified, counted and measured before being returned to the stream.

The only catchment where an EFM survey was not undertaken was the eastern catchment. In this instance the nature of the stream was such that turbidity, depth, and depth of detritus/soft sediment meant that EFM was inappropriate as a survey method. However, at the time of survey, flow conditions were such that flows did not extend through the culvert located at the upstream end of this survey reach effectively isolating this section of stream. On this basis eDNA was relied on as the primary means of fish survey, and more detail on this method is provided below.

2.1.7.2 eDNA sampling

Three replicate Environmental DNA (eDNA) water samples were collected at the lowest survey location within each catchment (N1, E1, S1, W1 and 620-1). Samples were collected following detailed instructions from the supplier and sent to Wilderlab NZ Ltd in Wellington for analysis.

eDNA is the genetic material that is obtained from environmental samples, in this case, water. This method allows for a rapid assessment of the biodiversity present at a site and record a high percentage of animal (including fish) trace DNA present within the environmental sample. The samples were specifically collected to determine which fish species were present.

This method provides information on presence/absence information only as the number of positive DNA reads (identification) is not directly correlated to species density. This method also provides an advantage over traditional methods in that EFM survey, net survey, and spot lighting all have inherent bias due to species behaviour and avoidance. This is avoided in that the water filtered to make up the eDNA sample should in theory contain shed DNA of all species upstream of that location. The accuracy of this is further improved through collection of three replicates at separate locations within the lower catchment.

2.1.8 Stream ecological valuation

The SEV surveys on permanent streams (between March and May 2021) were conducted in accordance with the methods set out in the Auckland Council Technical Report 2011/009 (Storey *et al.,* 2011). Further SEVs were conducted on intermittent streams (in July and October 2021) in accordance with the adapted method for intermittent streams set out in Auckland Technical Report 2016/023 (Neale *et al.,* 2016).

The SEV assessment determines habitat quality and ecological function of a stream reach (including assessment of bed type, channel shape average depth, sediment coverage, shade and the presence/absence of any aquatic vegetation). Site specific macroinvertebrate and freshwater fish data were also included in the SEV assessment. An overall SEV score was calculated for each site (out of a possible 1), with higher scores indicating higher quality habitats.

The SEV score for each permanent stream site was calculated using the SEV Data Analysis Spreadsheet Version 2.3 (October 2017). The SEV score for intermittent sites were calculated using the intermittent SEV Data Analysis Spreadsheet (June 2016).

2.2 Assessment of effects methodology

An assessment of effects on stream ecology was carried out on the basis of the information on site ecology values as outlined above and the details of the PPC. Our assessment covers the effects of land-use change, future reclamation of streams within the development footprint and associated stormwater and wastewater discharges. Our assessment covers the whole of the PPC area but with a focus on direct stream impacts on the Live Zone.

Our assessment was undertaken in general accordance with the Ecological Impact Assessment Guidelines (EcIAG) (Roper-Lindsay et al., 2018). These guidelines provide a systematic, consistent and transparent framework for undertaking assessments of potential effects, while also providing for professional judgement and flexibility where appropriate.

As outlined in the following sections, the guidelines have been used to determine:

- **Step 1**: Identifying the 'ecological value' of the existing environment (Volume 2, Appendix A, Table 7);
- **Step 2**: The 'Magnitude of Effect' on the environment (Volume 2, Appendix A, Tables 4 and 5); and
- **Step 3**: The overall 'Level of Effect' after recommended measures have been taken to further avoid, remedy or mitigate for effects (Volume 2, Appendix A, Table 6).

2.2.1 Step one: Assigning ecological value

'Ecological values' were assigned on a scale of 'Negligible' to 'Very High' based on species and habitat values, using criteria in the EcIAG (Roper-Lindsay et al., 2018) and adapted for stream systems. The ecological values assigned are guided by the descriptors provided in (Volume 2, Appendix A, Table 7 which assist in providing a transparent means of arriving at a given ecological value based on available data.

2.2.2 Step two: Assessing the magnitude of effects

The 'Magnitude of Effect' is a measure of the extent or scale of the effect of an activity and the degree of change that it will cause after measures to avoid, remedy or mitigate for effects have been applied.

The 'Magnitude of Effect' after measures to avoid, remedy or mitigate for effects, was scored on a scale of 'Negligible' to 'Very High' (Volume 2, Tables 4 and 5) and was generally assessed in terms of:

- Spatial scale of the effect;
- The relative permanence of the effect;
- The intensity of the effect within the impact footprint;
- Timing of the effect in respect of key ecological factors; and
- Level of confidence in understanding the expected effect.

2.2.3 Step three: Assessing the level of effects

An overall 'Level of Effect' on each value (after measures to avoid, remedy or mitigate for effects) was identified for each activity or habitat/fauna type using a matrix approach. This approach combines the ecological values (described in Section 2.2.1) with the magnitude of effects (Section 2.2.2) resulting from the activity (Volume 2, Appendix A, Table 6).

The matrix describes an overall 'Level of Effect', after measures to avoid, remedy or mitigate effects, on a scale from 'Very Low' to 'Very High'. The 'Level of Effect' is then used to guide the extent and nature of measures to demonstrably offset and/or compensate for these residual effects.

It is considered necessary to address any 'Level of effect' associated with the proposed land-use change that is assessed as being 'Moderate' or higher through offsetting or compensation measures. However, any 'Level of Effect' deemed to be 'Moderate' or higher should also be assessed against the 'Limits to offsetting' principle to determine if that effect can be adequately addressed through offsetting or compensation.

2.2.4 Determining residual effects management requirements

The type and magnitude of proposed compensation measures will be guided by the application of a SEV and ECR model approach. The ECR approach provides for additional objective transparency, process and justification for the overall compensation package.

ECRs were calculated following the methods outlined in Auckland Council Technical Report 2011/009. Calculation of the ECR involves the assessment of 'potential' and 'predicted' SEV values and comparison of these values with 'current' SEV values. For the purposes of calculating the ECR, biotic functions 'intactness of fish fauna' and 'invertebrate fauna' are not included in the calculation of SEV values due to the difficulty in predicting these outcomes. The ECR calculations were based on ecological compensation comprising good practice stream restoration work (riparian planting) being undertaken on the streams within the "ecological areas" (EPAN) shown in the Master Plan drawings.

The following formula was used to determine the amount that the impacted stream habitat area should be multiplied by to achieve equivalent replacement of stream function at the given compensation sites. The area of compensation is based on 'no net loss', and is dependent on the value of both the impacted stream, and the compensation stream:

$$ECR = [(SEVi\_P - SEVi\_I) \div (SEVm\_P - SEVm\_C)] \times 1.5$$

Where:

- SEVi-P is the potential SEV value for the sites to be impacted;
- SEVm-C and SEVm-P are the current and potential SEV values respectively for the site where environmental compensation is to be applied; and
- SEVi-I is the predicted SEV value of the stream to be impacted, after impact.

3 Stream Ecology Characteristics and Values

3.1 Site description

The PPC's 307 ha site consists primarily of two properties, Formosa Golf Resort and 620 Maraetai-Whitford Road. Several smaller lots between 678 and 770 Whitford-Maraetai Road are also included in the PPC for the site location.

Formosa Golf Resort makes up the bulk of the proposed Live Zone and consists of open grass fields maintained for golfing purposes, interspersed with rank grass, exotic forest and exotic shrublands. Patches of regenerating native bush occur, and mature native vegetation is present only on the western edge of the course where small areas of remnant pōhutukawa, pūriri, broadleaved forest and pōhutukawa treeland/flaxland /rockland remain on steep cliffs. A developed area of approximately 5 ha is present at the centre of the course area consisting of buildings and carparks.

Four main-stream catchments are present within and/or adjacent to the Formosa Golf Resort (hereafter referred to as the Northern, Eastern, Southern, and Western Catchments respectively). The main stream catchments are shown on Figure 1 included in Volume 2, Appendix D. A number of smaller tributaries are also present but not connected to the larger stream catchments. Of the four large catchments, two (Northern and Eastern) are heavily modified with a number of on-line constructed ponds associated with the golf course (being water hazards, or landscape features). The Western Catchment is modified also, albeit without constructed on-line ponds, but having been the receiving environment for the resort's wastewater discharge. The Southern Catchment is arguably the least modified of the large catchments on the Formosa Golf Resort site.

The 620 Maraetai-Whitford Road site makes up the bulk of the Future Urban Zone and is dominated by pasture grass having been recently retired from farming. Two fenced Significant Ecological Areas (SEA's) are located in forested gully systems across this site which consist of regenerating native forest (mānuka, kānuka forest) and mature native forest (taraire, tawa podocarp forest and tawa, kohekohe, rewarewa, hīnau, podocarp forest). Native plantings have been undertaken along riparian margins at the headwaters of these catchments. Weed invasions and pest mammals have impacted some of the native-dominated forest fragments.

The largest stream catchment on the 620 site coincides with the larger of the two terrestrial SEA's and is a mostly unmodified watercourse. The stream largely consists of bedrock substrate with steeply incised stream channels along much of its length. In addition to the main catchment present, a number of smaller intermittent streams are present discharging directly to the coast.

Catchments on site all drain to Waikopua Creek, an important wading bird area with areas designated as marine Significant Ecological Areas (SEA_M2_43a, SEA_M2_43w1, SEA_M1_43c, SEA_M1_43w4, SEA_M2_43a).

3.2 Catchment descriptions

3.2.1 Northern Catchment

The Northern Catchment is situated within the northern part of the Formosa Golf Resort with the upper tributaries of the catchment nearby the course club house. The catchment has been subject to extensive historic modification through the installation of culverts and construction of on-line ponds providing golf course "water hazards" or landscape features (see Photograph 3.1). The number and size of these constructed ponds as well as associated landscape modification is such that there is a limited length of watercourse within this catchment that could be classified as "stream". The catchment is also sparsely vegetated with only the lower half of the catchment having sections of riparian vegetation of any note.

In summary there are six modified sections of the catchment which should be classified as constructed ponds. Five culverts associated with the constructed ponds which are moderately-significantly perched provided a barrier to fish passage within the catchment (see Photograph 3.2). We do note however, that given the modified nature of the catchment downstream and outside of the property footprint it is likely that more barriers to fish passage are present.

Photograph 3.1: Online pond in the Northern Stream Catchment (refer to site N4 on Figure 1)

Photograph 3.2: Perched culvert (indicated by the red arrow) is located at the downstream end of the catchment (refer Site N1 on Figure 2) and would limit fish movement into the Northern Stream system.

3.2.2 Eastern Catchment

The Eastern Catchment is situated within the eastern half of the Formosa Golf Resort with the upper tributaries of the catchment extending to the north-eastern boundary of the property footprint and a separate arm extending into and across private property lots to the south. The lower section of the main stream comprises a well shaded natural channel for around 100 m upstream of Jack Lachlan Drive to the first of a series of culverts on site (Photograph 3.3). This catchment has a comparatively larger number of smaller tributaries connected to the main stream throughout its length. Sections of this catchment have been subject to extensive historic modification through the construction of on-line ponds providing golf course "water hazards" and landscape features. There are also constructed on-line pond features in the tributaries draining the private properties. Much of the catchment is intermittent stream habitat based on observations made during field surveys (Photograph 3.4).

The catchment has a high number of installed culverts both on the golf course property and throughout the private property lots. The bulk of these are located on the subcatchment extending to the north-eastern corner of the property with the subcatchment extending to the southeast through private property. Similar to the Northern Catchment, there are a number of sections of the catchment which have limited riparian cover with other sections having relatively complete and dense riparian margins.

In summary there are at least six modified sections of the catchment which should be classified as constructed ponds. Six culverts within the Golf Resort property are moderately-significantly perched and provided a barrier to fish passage within the catchment. In addition to this, 6 culverts within the adjacent private property lots within the PPC area are also perched to varying degrees based on limited survey conducted to date.

Photograph 3.3: Typical habitat in the main stem of the Eastern Stream (Site E1 on Figure 2).

Photograph 3.4: Intermittent stream habitat in the upper Eastern Catchment on the golf course (Site E-UT2 on Figure 2)

3.2.3 Southern Catchment

The Southern Catchment is located on the southern boundary of the Formosa Golf Resort with the upper tributaries of the catchment extending eastward inland. This catchment does not have online ponds on the main-stream but does have one located on a true right tributary within the lower catchment. Many of the small tributaries entering into the main-stream are intermittent streams.

Although there were no culverts observed within the main-stream of the catchment a number of natural features were observed which would compromise fish passage within the catchment (Photograph 3.5). A series of knickpoints within the lower third of the catchment would limit passage for fish species with poorer climbing ability. Barriers of varying degrees were also observed within the mid catchment in the form of steep sections of bedrock. Lastly, a notable natural barrier was observed to have formed immediately downstream of the confluence of two major headwater tributaries with the main-stream approximately three quarters of the way up the catchment. This barrier potential formed through a knickpoint migrating upstream before interception dense roots within the stream channel.

Photograph 3.5: Natural fish passage barrier on the main Southern Catchment tributary near Site S2 on Figure 2.

Photograph 3.6: Typical upper tributary habitat at Site S-UT2 on Figure 2, near the edge of the Live Zone boundary.

Contrary to the previous catchments described, the lower third of this catchment had a low proportion of riparian vegetation which became progressively denser within the mid catchment. The riparian zone again became sparse within some of the upper headwater tributaries of the catchment which have been subject to grazing historically (Photograph 3.6).

3.2.4 Western Catchment

The Western Catchment is situated within the southwestern corner of the Formosa Golf Resort with the upper tributaries of the catchment extending to the south. This catchment receives the wastewater discharge for the Golf Resort in its mid-reach which is relatively open (Photograph 3.7). Many of the small tributaries entering into the main stream are intermittent streams.

No culverts were observed within the broader catchment however a series of natural barriers to fish passage were observed in the form of steep sections of bedrock. A single culvert at the bottom of the catchment near the discharge point to the ocean was observed to be perched and presenting a barrier to fish passage into the wider catchment. This observation was made at approximately high tide on the day of survey and therefore this observation can be relied on confidently. However, this may present a part barrier in that short periods of connectivity may be achieved during king tides.

The lower third of this catchment had a low proportion of riparian vegetation which became progressively denser within the mid catchment. The riparian zone again became sparsely vegetated within some of the upper headwater tributaries of the catchment (Photograph 3.8).

Photograph 3.7: Typical Western main stream habitat upstream of Site W2 on Figure 2.

Photograph 3.8: Typical upper intermittent tributary habitat in the Western Catchment (Site W-UT8 on Figure 2)

3.2.5 620 site and associated catchments

The 620 site catchment is situated to the south of the Southern Catchment described above. This catchment is the least modified catchment on the overall PPC area, with much of the catchment in a natural state except for a handful of upper headwater tributaries which may have some minor historic modification. Many of the small tributaries entering into the main stream are intermittent streams (Photograph 3.9). The catchment is situated within a Significant Ecological Area (SEA; described in more detail in the terrestrial ecology report) with extensive coverage of dense riparian vegetation which provides high shading and filtering throughout the catchment (Photograph 3.10).

No culverts were observed in the catchment. However, a series of natural barriers in the form of steep sections of bedrock potentially present a barrier to species with poor climbing ability.

Photograph 3.9: Upper tributary habitat in the main 620 catchment. Locates outside of the SEA boundary at Site 620-UT1 on Figure 2.

Photograph 3.10: 620 Tributary within the SEA and at the bottom of the catchment, just upstream of the site boundary.

3.3 Stream classification

Initial stream classifications were undertaken in 2020[3,4] using the AUC overland flow path layer as a starting point of reference for ground truthing the presence of permanent and intermittent watercourse within the project footprint. The result of this earlier investigation was a high-level figure detailing the location of intermittent/permanent stream on site based on the AUC overland flow path layer.

These stream classifications were revisited during the more detailed data collection conducted in 2021. The purpose of this was to focus specifically on those upper tributaries that were identified as being potentially directly impacted by the proposed PPC. We sought to confirm the stream classification specifically for each section of watercourse within the "developable footprint" and potentially impacted by future development. If confirmed to be intermittent, the existing map layers were updated with the intermittent stream extent (e.g. where the intermittent stream terminates). The permanent and intermittent stream map is provided in Volume 2, Appendix D; Figure 1. The rationale for the classification of assessed watercourse is detailed in Volume 2, Appendix D, Table D1.

3.4 Water quality

Field measurements of dissolved oxygen indicate sites are of varying quality (range 6.9 % - 154.6 %) and spot water temperature measurements ranged from 11.8 to 30.2 °C (Volume 2, Appendix D, Table D2). Both dissolved oxygen and temperature will be influenced by the time of day measurements were taken, as well as factors affecting temperature control such as stream shading and ponding. Spot water quality measurements are indicative of water quality conditions at the time of survey.

Water grab samples were analysed for key nutrients, metals and biological parameters to inform baseline water quality across the site. All laboratory results are presented in Volume 2, Appendix D Tables D3 and D4, and some summary points are provided below:

- Turbidity ranged from 0.79 NTU to 165 NTU. Highest readings were from sites W3 and N5, both of which are the most upstream sites sampled within those respective catchments;
- pH ranged from 6.6 to 7.3, except for Site N2 (pH = 3.6);

- Faecal coliforms showed high variation across sampled sites (60 – 11,000 cfu/100 mL), as did *Escherichia coli* (60 – 11,000 cfu/100 mL). Highest concentration was recorded for N4 though concentrations >1,000 cfu/100 mL were recorded in the Eastern, Southern, and Western catchments;
- Total hardness ranged from 28 – 168 g/m^3 as $CaCO_3$, generally the higher the hardness, the lower the toxicity of other metals to aquatic life (e.g. copper and zinc). Total hardness was typically higher at downstream sites;
- Dissolved calcium and dissolved magnesium, concentrations were generally lower at upstream sites (N5, S2 and 620-3) when compared to samples taken further downstream;
- Dissolved and total copper were below detection limit for 8 of 13 and 6 of 13 sites respectively. The highest concentration was recorded at W3 within the Western Catchment;
- Dissolved and total zinc was considerably higher at N2 (0.33 g/m^3) than all other sites (dissolved zinc < 0.023 g/m^3, total zinc < 0.0131 g/m^3). Site N2 is located within the lower Northern Catchment;
- Soluble inorganic nitrogen (SIN) (calculated by the addition of total ammoniacal-N, Nitrate-N and Nitrite-N) ranged from 0.012 to 0.316 g/m^3, highest concentrations were recorded at E1 followed by S2 (0.275 g/m^3); and
- Dissolved reactive phosphorus (DRP) was below laboratory detection levels at all northern catchment sites. DRP concentrations at remaining sites ranged from 0.013 to 0.134 g/m^3 with the highest concentrations recorded in the 620 catchment.

The water quality data collected for permanent stream survey locations generally reflect the modified nature of the Northern, Eastern, Western and Southern Catchments. The 620 catchment also shows influence of land use on water quality having the highest concentration of DRP recorded from all catchments and likely linked to recent farming practices within the upper catchment.

3.5 Aquatic macroinvertebrate community

The composition of macroinvertebrate communities and associated metrics are provided in Table 3.1 below and full analysis sheets are available in Volume 2, Appendix D, Table D5.

In summary, the macroinvertebrate community samples can generally be classed as fair or poor (refer to Table 3.1) being characterised by poorer scoring, less sensitive taxa. The fair and poor-quality classes typically reflect degraded habitat quality and the modified nature of the catchments. In the case of the main 620 watercourse scores reflect a lack of stable high-quality habitat (e.g. large woody debris, cobbles, large gravels) with in-stream habitat limited to bedrock crevasses.

Mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Trichoptera) are highly sensitive and samples with high numbers of these “EPT” taxa present indicate high water and habitat quality conditions. No sensitive EPT taxa were identified in northern, southern or western catchment samples, with low percentages of EPT taxa (6.7 – 15.4 %) identified in eastern and 620 catchment samples.

Average score per metric (ASPM) is another means of characterising a macroinvertebrate community using a score derived from multiple metrics as a means of providing an “average” as opposed to simply considering these metrics in isolation. ASPM scores for permanent streams ranged from 0.12 to 0.22. All but one of the sampling locations (620-3; 0.22 ASPM) had ASPM scores corresponding to the “Very Low” ASPM quality class.

Table 3.1: Macroinvertebrate summary results collected from permanent stream ecology assessment sites during March and April 2021

Site	Number of individuals	Number of taxa	%EPT Richness	MCI	QMCI	ASPM
N1*	207	20	0.0	63	1.94	0.13
N2*	174	21	0.0	79	4.95	0.14
N2-2*	235	15	0.0	69	2.11	0.12
N4*	207	20	0.0	66	3.08	0.13
E1	210	30	6.7	86	4.02	0.17
S1*	214	19	0.0	74	2.76	0.13
S2	209	16	0.0	76	3.80	0.13
W1*	206	19	0.0	77	3.87	0.12
W2*	132	10	0.0	98	4.66	0.12
W3*	208	13	0.0	59	2.12	0.12
620-1	213	22	13.6	83	3.52	0.18
620-2	210	20	10.0	82	4.36	0.17
620-3	209	26	15.4	94	3.97	0.22

* Soft bottom sites have MCI-sb and QMCI-sb scores

MCI and QMCI metrics have been attributed a quality class based on Stark and Maxted 2007[7] with Red text denoting "poor" quality and Orange text denoting "fair" quality.

Macroinvertebrate samples were also collected from intermittent stream survey locations where possible. For some reaches the depths and/or width of the intermittent stream meant that a macroinvertebrate sample was not able to be collected and in these instances a nearby intermittent location has been used as a reference.

The intermittent stream samples are typically less diverse communities reflecting the transient nature of available habitat for macroinvertebrates. The intermittent stream samples typically had higher MCI scores than those collected from permanent streams on site. Similarly, the intermittent streams also had a higher proportion of samples corresponding to the 'good' quality class for QMCI.

Given that the purpose of the intermittent stream samples was for inclusion of the metric into the SEV calculation we have not calculated ASPM for these samples.

[7] Stark, J.D. and Maxted, J. R. (2007) A user guide for the Macroinvertebrate Community Index. Prepared for the Ministry for the Environment. Cawthron Report No. 1166.

Table 3.2: Macroinvertebrate summary results collected from intermittent stream ecology assessment sites during July 2021 and October 2021

Site	Number of individuals	Number of taxa	% EPT Richness	MCI-sb	QMCI-sb
E-UT2	210	14	7.14	96	3.19
E-UT	252	13	0	86	5.37
E-UT10	202	14	0	75	2.63
E-UT14	249	5	0	86	5.42
E-UT16	250	12	0	81	5.12
E-UT17	217	30	6.67	97	4.14
S-UT3	33	5	0	117	5.58
S-UT4	211	8	0	83	5.22
S-UT6	222	7	0	107	5.25
W-UT9	107	10	0	56	1.68
620-UT1	216	7	0	102	4.55
620-UT3	294	14	0	80	2.36

MCI and QMCI metrics have been attributed a quality class based on Stark and Maxted 2007 with Red text denoting "poor" quality, Orange text denoting "fair" quality, and Blue text denoting "good" quality.

3.6 Freshwater fish communities

The results from both electric fishing survey and eDNA sampling within each catchment are provided below in Table 3.3 and Table 3.4, respectively. EFM surveys provide data regarding species presence, as well an indication of relative abundance. The use of eDNA sample collection and analysis provides an additional line of evidence regarding fish species presence or absence and has proven useful for identifying those species not picked up in the traditional survey methods (EFM and netting). We note that some of these data are indeterminant (e.g. "giant or shortjaw") or only identifiable to a higher taxonomic level (genus or family; not to species level).

On the whole, the results from the two methods used at the site are largely comparable. The following summarises the fish species present in each catchment. Threat classifications are provided:

- Northern Catchment: shortfin eel (*Anguilla australis,* Non-threatened),
- Eastern Catchment: shortfin eel, inanga (*Galaxias maculatus,* At Risk), banded kōkopu (*Galaxias fasciatus,* non-threatened), and giant kokopu (*Galaxias argenteus,* At Risk).
- Southern Catchment: shortfin eel, longfin eel (*Anguilla dieffenbachia,* At Risk), banded kōkopu.
- Western Catchment: shortfin eel and banded kōkopu.
- 620 catchment: shortfin eel, longfin eel, and banded kōkopu.

The on-site survey information (both eDNA and EFM) are in keeping with the broader fishing records for the area, albeit clearly influenced by barriers to fish passage in site streams (Table 3.5). Also of note in survey records for the area was the presence of NZ freshwater mussels (*Echyridella menziesii*) within the wider catchment (Table 3.5). NZ freshwater mussels were not present within the streams surveyed on-site based eDNA sampling.

Freshwater crayfish (koura) were captured in the main stream system on the 620 site.

Table 3.3: Freshwater fish survey (electric-fishing) results from March and April 2021.

Site	Date	Fish caught		
		Common name	**Scientific name**	**Number (size range in mm)**
N2-2	12/03/2021	Shortfin eel	*Anguilla australis*	3 (220-710)
S1	15/03/2021	-		
S2	16/03/2021	Shortfin eel	*Anguilla australis*	1 (220)
		Banded kōkopu	*Galaxias fasciatus*	5 (70-110)
W1	15/03/2021	Shortfin eel	*Anguilla australis*	3 (130-450)
W2	15/03/2021	-		
620-1	15/04/2021	Shortfin eel	*Anguilla australis*	2 (90-260)
		Longfin eel	*Anguilla dieffenbachii*	2 (90-700)
		Banded kōkopu	*Galaxias fasciatus*	3 (75-220)
		Missed eel	-	1
		Missed fish	-	1
620-3	15/04/2021	Shortfin eel	*Anguilla australis*	2 (220-315)
		Banded kōkopu	*Galaxias fasciatus*	1 (75)
		Koura	*Paranephrops*	3 (5-7)

Table 3.4: Environmental DNA (eDNA) results from samples taken from freshwater ecological assessment sites in March and April 2021.

Catchment	**Northern**			**Eastern**			**Southern**			**Western**			**620**		
Site	**N1**			**E1**			**S1**			**W1**			**620-1**		
Replicate	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
Shortfin eel	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Inanga	-	-	-	P	P	P	-	-	P	-	-	-	-	-	-
Banded kōkopu	-	-	-	P	P	P	-	-	-	P	P	P	-	P	P
Longfin eel	-	-	-	-	-	-	-	-	P	-	-	-	P	P	P
Giant / shortjaw kōkopu*	-	-	-	-	P	-	-	-	-	-	-	-	-	-	-
Galaxiids	-	-	-	-	P	P	-	-	-	-	-	-	-	-	P
Bullies	-	-	-	-	-	-	-	-	-	-	-	-	-	-	P
Galaxias and mudfish	-	-	-	-	-	-	-	-	-	-	P	-	-	-	-

*Species distribution records infer the species is likely giant kōkopu. No NZFFD records exist for either species for the local catchments.

Table 3.5: Freshwater fish species capture records downloaded from New Zealand Freshwater Fish Database for catchments in proximity to the site.

Date			2001	2001	2005	1992	2000	1990	1991	1996	1991
Location			Te Puru Stream	Te Puru [illegible]	Te Puru Stream	Waikopua Creek	Turanga Creek	Maraetai Beach	Maraetai Beach	Maraetai Beach	Waiomanu Beach
Native fish	**Scientific**	**Status**									
Banded kokopu	*Galaxias fasciatus*	Non-threatened		Y	Y		Y	Y	Y	Y	Y
Common bully	*Gobiomorphus cotidianus*	Non-threatened			Y		Y				
Inanga	*Galaxias maculatus*	At risk	Y	Y	Y		Y				Y
Giant bully	*Gobiomorphus gobioides*	Naturally uncommon							Y		
Longfin eel	*Anguilla dieffenbachii*	At risk			Y	Y					
Redfin bully	*Gobiomorphus huttoni*	Non-threatened			Y				Y		Y
Shortfin eel	*Anguilla australis*	Non-threatened			Y	Y	Y	Y		Y	
Torrentfish	*Cheimarrichthys fosteri*	At risk									Y
Exotic fish	**Scientific**	**Status**									
Brown trout	*Salmo trutta*	Protected game fish						Y			
Gambusia	*Gambusia affinis*	Pest fish		Y		Y	Y				
Silver carp	*Hypophthalmichthys molitrix*	Restricted fish									
Invertebrates	**Scientific**	**Status**									
Freshwater mussel	*Echyridella menziesii*	Declining			Y						
Freshwater shrimp	*Paratya curvirostris*	Non-threatened			Y	Y		Y	Y	Y	
Koura	*Paranephrops planifrons*	Declining			Y						

3.7 Stream ecological valuation

SEV surveys were undertaken at permanent stream survey locations for the purposes of characterising the receiving environment for potential stormwater discharges from the proposed plan change and to indicate restoration potential. SEV scores ranged between 0.349 and 0.706 and reflect the relative level of modification within the various catchments (Table 3.6). Generally, scores within all catchments were poorer with regard to habitat provision and biodiversity function types, with the hydraulic and biogeochemical function types typically scoring higher.

Stream ecological valuation surveys were also undertaken at selected intermittent stream survey locations for the purposes of characterising habitat quality and function for potential direct impacts arising from the proposed plan change and change in land-use. SEV scores ranged between 0.361

and 0.581 and also reflect the relative level of modification within the various catchments (Table 3.7). As per the permanent streams, scores for intermittent stream reaches were poorer with regard to habitat provision and biodiversity function types, with the hydraulic and biogeochemical function types typically scoring higher.

More detailed function data is available in Volume 2, Appendix D Tables D6 and D7 for both the permanent and intermittent SEV assessments respectively.

Table 3.6: Stream Ecological Valuation (SEV) summary table showing key function scores and overall current SEV score for each permanent stream ecology assessment sites

Catchment	Site	Function Type				Overall SEV score
		Hydraulic	Biogeochemical	Habitat provision	Biodiversity	
Northern	N1	0.70	0.33	0.2	0.17	**0.383**
	N2	0.88	0.69	0.55	0.36	**0.651**
	N2-2	0.85	0.69	0.4	0.29	**0.606**
Eastern	E1	0.74	0.6	0.59	0.43	**0.601**
Southern	S1	0.61	0.37	0.14	0.1	**0.349**
	S2	0.81	0.66	0.29	0.33	**0.580**
Western	W1	0.59	0.51	0.32	0.3	**0.464**
	W2	0.71	0.49	0.26	0.16	**0.449**
	W3	0.71	0.34	0.2	0.08	**0.370**
620	620-1	0.82	0.8	0.45	0.56	**0.705**
	620-2	0.79	0.82	0.43	0.5	**0.688**
	620-3	0.95	0.79	0.39	0.45	**0.706**

Table 3.7: Stream Ecological Valuation (SEV) summary table showing key function scores and overall SEV score for each intermittent stream ecology assessment sites

Catchment	Site	Function Type				Overall SEV score
		Hydraulic	Biogeochemical	Habitat provision	Biodiversity	
Northern	N_UT3	0.58	0.34	0.20	0.21	**0.361**
	N_UT4	0.66	0.40	0.17	0.17	**0.391**
Eastern	E_UT2	0.40	0.59	0.34	0.58	**0.498**
	E_UT7	0.71	0.45	0.22	0.55	**0.513**
	E_UT8	0.63	0.36	0.18	0.53	**0.447**
	E_UT10	0.57	0.29	0.18	0.40	**0.379**
	E_UT14	0.75	0.47	0.31	0.41	**0.513**
	E_UT16	0.66	0.40	0.42	0.32	**0.482**
	E_UT17	0.44	0.57	0.41	0.70	**0.538**
	E_UT18	0.64	0.23	0.49	0.64	**0.471**
	E_UT19	0.43	0.26	0.22	0.68	**0.392**
Southern	S_UT3	0.67	0.75	0.32	0.35	**0.581**

Catchment	Site	Function Type				Overall SEV score
		Hydraulic	Biogeochemical	Habitat provision	Biodiversity	
	S_UT4	0.66	0.54	0.25	0.31	**0.484**
	S_UT6	0.61	0.57	0.25	0.33	**0.485**
Western	W_UT3	0.75	0.68	0.31	0.07	**0.519**
	W_UT9	0.49	0.51	0.25	0.06	**0.369**
620	620_UT1	0.61	0.49	0.27	0.37	**0.468**
	620_UT3	0.61	0.27	0.13	0.42	**0.377**

4 Assessment of Ecological Effects

This section presents an assessment of ecological effects on streams within the PPC area due to the subsequent change in land-use enabled by the PPC. We have considered potential direct effects on intermittent streams in cases where the Structure Plan indicates a potential direct effect (i.e. stream reaches that extend outside of the "Ecological Areas" (EPAN) as shown on the Structure Plan and Precinct Plans included in the PPC). We have also considered effects on the streams as receiving environments for potential stormwater and wastewater discharges. The methodology used for undertaking the assessment of ecological effects is detailed in Section 2.2.

Our assessment covers the whole of the proposed PPC area but with a focus on stream impacts associated with the Live Zone. The Live Zone boundary is shown on Figures 1 and 2 (Volume 2, Appendix D).

4.1 Ecological values assessment

The framework provided in Volume 2, Appendix A, Table 7 has been used to assign ecological values for both permanent and intermittent streams on the site. The assessment draws holistically on the various water quality and ecological survey data collected during 2021 and described in Section 3.

Our assessment of ecological values is presented in Table 4.1 broken down by the main catchments on the site with an assessment made for both permanent and intermittent streams within those catchments.

Table 4.1: Ecological values assessment

Catchment		Assessment	Ecological value
Northern	Permanent streams	Highly modified catchment with multiple online constructed ponds, culverts and impacted water quality. SEV score ranging between 0.38 – 0.65. Fish community depauperate and limited to shortfin eel. Macroinvertebrate community typically characterised as Poor for MCI/QMCI and an absence of EPT taxa reflecting degraded habitat and water quality.	Low
	Intermittent streams	SEV score ranging between 0.36 – 0.39. Riparian cover limited to rank grass and shading if any provided through channel incision. Macroinvertebrate community samples were unable to be collected however samples from the permanent streams were typically characterised as Poor for MCI/QMCI and an absence of EPT taxa reflecting degraded habitat and water quality.	Low
Eastern	Permanent streams	Highly modified catchment with multiple online constructed ponds, culverts and impacted water quality. SEV score for permanent stream in the lower catchment was 0.60. Fish community comparatively diverse (based on eDNA) with positive DNA sequence for inanga and giant kokopu. Macroinvertebrate community characterised as Fair for MCI/QMCI. Sensitive EPT taxa were present but only represented 6.7 % of the sample's taxonomic diversity.	Moderate
	Intermittent streams	SEV score ranging between 0.38 – 0.54. Riparian cover was variable and ranged from being limited to rank grass to high levels of shade provided by exotic pine and/or native	Low-Moderate

Catchment		Assessment	Ecological value
		vegetation. Macroinvertebrate community samples were typically characterised as Poor/Fair for MCI and Poor or Good for QMCI. Sensitive EPT taxa were typically absent with the exception of a single sample.	
Southern	Permanent streams	Modified catchment with impacted water quality. SEV score ranging between 0.35 – 0.58. Fish community survey indicates low numbers of individuals comprising banded kokopu and shortfin eel. eDNA sampling did pick up a positive DNA sequence for longfin eel and inanga in one of the three replicates taken in the lower catchment. Macroinvertebrate community characterised as Poor for MCI/QMCI with all samples indicating an absence of sensitive EPT taxa.	Low-Moderate
	Intermittent streams	SEV score ranging between 0.48 – 0.58. Riparian cover was variable and typically limited to rank grass with sparse shrubs. Shading was typically provided through channel incision rather than riparian shading. Macroinvertebrate community samples were typically characterised as Good for MCI/QMCI however the number of taxa were limited to 5-8 taxa. Sensitive EPT taxa were typically absent from the samples.	Low
Western	Permanent streams	Modified catchment with multiple online constructed ponds and impacted water quality. This catchment receives treated wastewater discharges. SEV score ranging between 0.37 – 0.46. Fish community comparatively depauperate (based on eDNA) with positive DNA sequence limited to shortfin eel and banded kokopu. Macroinvertebrate community characterised as Fair or Poor for MCI/QMCI with all samples indicating an absence of sensitive EPT taxa.	Low
	Intermittent streams	SEV score ranging between 0.37– 0.52. Riparian cover was variable and typically limited to rank grass with sparse shrubs. Shading was typically provided through channel incision rather than riparian shading. The macroinvertebrate community was only able to be characterised from a single sample which indicated the community characterised as Poor for MCI/QMCI. Sensitive EPT taxa were absent from the samples.	Low
620	Permanent streams	Streams situated within SEA with diverse mature native vegetation providing high shading and runoff filtering. SEV score ranging between 0.69 – 0.71. More diverse fish community than other catchments, though influenced by natural fish barriers. Macroinvertebrate community typically scoring Fair or Poor for MCI/QMCI reflecting dominance of bedrock substrate and therefore a low abundance of macroinvertebrate refugia. Sensitive EPT taxa were present in all samples.	High
	Intermittent streams	Situated outside of the SEA and within grazed farmland. SEV score ranging between 0.38 – 0.47. Riparian cover was limited to rank grass. Shading, where present, was typically provided through channel incision rather than riparian shading. Macroinvertebrate community samples were typically characterised as Fair or Good for MCI and Poor or	Low

Catchment		Assessment	Ecological value
		Fair for QMCI. Sensitive EPT taxa were absent from the samples.	

4.2 Magnitude of effects assessment

Our assessment of the 'Magnitude of Effects' on stream ecological values is based on the likely extent, intensity, duration and timing of effects associated with the PPC and associated land use change and after measures have been undertaken to avoid, remedy or mitigate adverse effects.

An overview of the potential adverse effects associated with the PPC is provided in Section 4.2.1, and key measures to avoid, remedy or mitigate effects are outlined in Section 4.2.2. This is followed by an assessment of the magnitude of each identified effect (Section 4.2.3).

4.2.1 Overview of potential effects

The effects of the proposal on stream ecological values will be determined in further detail at the resource consents stage of the project when detailed design is available. Nevertheless, potential adverse effects on stream ecological values relating to the change in land use and associated activities may include:

- Effects on stream water quality due to construction related discharges;
- Effects on freshwater fish including direct mortality during instream works and disturbance to migration and/or spawning due to construction related discharges (particularly fine sediment);
- Effects on freshwater fish due to habitat loss and restrictions to fish passage; and
- Loss of stream habitat through earthworks diversion, reclamation, or installation of culverts. Loss of stream habitat will impact on intermittent stream habitats only, and no streams within the SEA-T areas will be reclaimed. Our assessment assumes that all intermittent streams indicated to extend outside of the "Ecological Protected Area Network" (EPAN) boundary on Figures 1 and 2 (Volume 2, Appendix D) will be reclaimed, other than some reaches on the part of the Formosa Golf Course that is to be retained.

Potential long-term ongoing adverse effects associated with the change in land-use activity status will include:

- Effects on stream ecology through changes to hydrology including altered base flows and or bank and bed erosion due to stormwater flows.
- Effects on stream ecology through urban stormwater and wastewater discharges that affect water quality within stream receiving environments.

Mitigation for these effects is discussed below.

4.2.2 Overview of proposed measures to avoid, remedy or mitigate effects

Measures to avoid or minimise the loss of stream habitat associated with the change in land-use activities were undertaken though the optioneering and concept design phases of the PPC, including refining the configuration of the Structure Plan (e.g. designing the developable footprint to avoid the main stream networks and as much as possible). Direct reclamation is only indicated for select upper headwater intermittent streams (reaches of intermittent streams indicated to extend outside of the EPAN boundary, refer to Figure 2 (Volume 2, Appendix D)).

Potential adverse effects associated with the proposed land-use change would be avoided, remedied or mitigated through:

Construction phase effects management measures

- Development and implementation of Erosion and Sediment Control Plans (ESCPs) for works within the PPC area on the basis of the "Erosion and Sediment Control Report" prepared by Harrison Grierson Ltd[8]. The "Erosion and Sediment Control Report" (ESC report) describes the methods and practices to be implemented to minimise the effects of sediment generation on stream (and marine) receiving environments. The ESC report provides standards for proposed controls with design undertaken according to Auckland Council Guidance Document 05, for Land Disturbing Activities in the Auckland Region (GD05).
- Development and implementation of a water quality monitoring and adaptive management programme for the construction phases of the project to document indicators of earthworks related discharges e.g. turbidity, total suspended solids, oil and grease;
- Seasonal avoidance of stream works during periods of peak spawning activity for the kōkopu species present (April – August[9]);
- Preparation and implementation of a fish relocation plan to remove and relocate fish from any impacted section of stream habitat prior to stream works;

Long-term effects management measures

- Use of bridges and or fish friendly culverts at any stream crossings. Culvert design will be in accordance with New Zealand Fish Passage Guidelines[10];
- Inclusion of industry good practice stormwater controls to manage stormwater quantity and quality from the future urban area. This should include "offline" storm water devices to manage discharges. Concept designs show that all devices are offline[11]; and
- Inclusion of an Enhanced Membrane Bioreactor (E-MBR) Wastewater Treatment Plant (WWTP) that provides a high level of treatment for wastewater outputs and disposal options to land and/or incorporating polishing treatment.

It is assumed all the above measures to avoid, remedy or mitigate potential adverse effects will be undertaken to reduce the severity of adverse ecological effects associated with the proposed land-use change should the PPC be approved. The above measures (with the exception of the WWTP) are standard considerations in resource consent processes involving streamwork activities and this existing framework will ensure the severity of adverse ecological effects associated with the proposed land-use change are reduced should the PPC be approved.

4.2.3 Magnitude of effects after measures to avoid, remedy or mitigate

The magnitude of effects on stream values is assessed based on the extent, intensity, duration and timing of effects associated with the project. Potential effects on stream values are set out below and in turn the magnitude of effects on each of these values are assessed after measures to avoid, remedy, or mitigate effects have been considered.

The magnitude of effects categories in ascending order include 'Negligible', 'Low', 'Moderate', 'High' or 'Very High' (Volume 2, Appendix A Table 4). The magnitude of effects is discussed in the following sections.

[8] Harrison Grierson Ltd, 2021. Beachlands South ESCP Report. Consultancy report prepared for Beachlands South Limited Partnership Ltd, August 2021.
[9] NIWA (2014). Freshwater Fish Spawning and Migration Periods. Technical report prepared for Ministry of Primary Industries.
[10] NIWA (2018). New Zealand Fish Passage Guidelines: For structures up to 4 metres. Technical Report 2018019HN.
[11] Harrison Grierson Ltd, 2021. Beachlands South Stormwater Management Plan Template – Ver 1.1 (DRAFT). Consultancy report prepared for Beachlands South Limited Partnership Ltd, August 2021.

4.2.3.1 Construction related discharge effects on stream water and habitat quality and macroinvertebrates

Potential effects on streams related to construction related activities are predominantly related to the potential for sediment discharge. Sediment discharges typically result in elevated instream turbidity and suspended sediment during and following rainfall events. Increases in sediment discharge therefore have the potential reduce water clarity and result in excess deposited sediment in the stream bed with subsequent effects on in-stream ecology.

High suspended and deposited sediment can affect macroinvertebrates in a variety of ways. An increase in suspended sediment can reduce photosynthesis of benthic plants affecting the food supply for some macroinvertebrates. High suspended solid levels may clog the food-filtering or trapping apparatus of stream insects[12].

Deposited fine sediment strongly affects stream ecosystem health by a range of mechanisms including inhibition of hyporheic exchange in the river-bed and degradation of micro-habitat and refugia for invertebrates. Studies have found macroinvertebrates predominantly show either increased drift or decreased abundance in response to experimental sedimentation depending on their habitat preference[13].

It is proposed that bulk earthworks will be staged over several earthworks seasons with open earthworks limited within each of the sub-catchments. To manage the effect of potential sediment discharge specific ESCP's will be developed at future resource consent application stage. Specific ESCP's will be guided by the principles of the ESC Report[8] which has been prepared in keeping with Auckland Council's GD05 guidelines. Erosion and sediment control devices are proposed to intercept and direct site runoff to treatment ponds to treat runoff from construction area's and reducing the suspended sediment load of discharged water.

NIWA has modelled 24-hour sediment loads for 2 year and 100-year rainfall events for the baseline (existing) condition and for the mid-construction condition, both with and without the proposed sediment and erosion controls in place[14]. The analysis is broken down by the main catchments on the site with predicted sediment loads to the various stream catchments relevant to the Live Zone for the 2-year event summarised in Table 4.2.

Table 4.2: Summary of predicted sediment loads for the 2-year event for the baseline and mid-construction scenarios

NIWA Catchment	Receiving environment /s	Sediment load (tonnes)			% reduction in construction phase sediment load due to treatment
		Baseline	Construction untreated	Construction treated	
2 &3	Eastern & Northern Catchments	10.4	163.7	30.3	81.1
1	Western Catchment	4.2	62.7	11.3	82.0
4	Southern Catchment	8.5	80.9	17.7	78.1

[12] Ryan, P.A. (1991). Environmental effects of sediment on New Zealand streams: A review, New Zealand Journal of Marine and Freshwater Research, 25:2, 207-221,

[13] Davies-Colley, R., Hicks, M., Hughe, A., Clapcott, J., Kelly, D., & Wagenhoff, A. (2015). Fine sediment effects on freshwaters, and the relationship of environmental state to sediment load: A literature review. NIWA Client Report: HAM2015-104. DHI Water & Environment Limited (20 February 2019).

[14] T+T, 2022. Beachlands South Structure Plan Change - Water Quality & Sedimentation Modelling Report.

In summary, the proposed treatment systems are predicted to reduce sediment loads from Live Zone catchments for the 2-year event by around 80 % for a mid-construction phase scenario.

The duration of sediment discharge effects will be short term and limited to the construction phase within each individual catchment. The Erosion and Sediment Control Report[8] sets out the need for device and discharge monitoring to provide for adaptive management to ensure that treatment is effective, which we support. The monitoring programme should also include stream receiving environment water quality and ecological monitoring, the detail of which can be developed further at resource consent stage.

With the proposed erosion and sediment control to intercept and treat construction related discharges and given the temporary nature of earthworks activities the magnitude of effect on stream receiving environments is considered to be **Low**.

4.2.3.2 Construction related effects on native fish

Increases in turbidity and suspended sediment associated with construction related discharges can have a range of potential effects on native fish. Deposited fine sediment reduces the amount of habitat (including spawning habitat) and cover available for juvenile and adult fish, particularly those, such as bullies, that prefer cobbled beds with large interstitial spaces for refugia[13].

An increase in suspended and deposited sediment due to sediment discharges has the potential to affect native fish populations through a reduction in habitat quality, food supply and feeding efficiency. High suspended sediment levels can cause a reduction in macroinvertebrate food supply for fish and suspended sediment can reduced fish feeding efficiency[15] . A reduction in food supply and feeding efficiency can lower fish growth rates over time. In a study by Rowe and Dean (1998)[16] banded kōkopu feeding was reduced by 36 % at a turbidity of 20 NTU.

The main potential for effects on native fish spawning activities in streams relates to the discharge of sediment during construction and therefore the duration of this effect will be temporary (limited to construction phase earthworks). Construction should be timed to avoid peak spawning periods in the first instance which will be different for each catchment based on species known to be present. If peak fish spawning periods cannot be avoided in any particular catchment then robust erosion and sediment control[8] will be the key measure to minimise the effect on native fish spawning (see Section 4.2.3.1).

Provided the above mitigation options can be implemented then we consider the potential magnitude of effect for sediment discharge effects on native fish can be managed to be to be **low.**

For the upper tributaries identified as being potentially reclaimed or where culvert installation is indicated then there is potential for injury or direct mortality to fish present during in-stream works. Without mitigation the direct magnitude of effects on native fish would be high due to the potential for mortality to native fish. However, preparation and implementation of a fish relocation plan to remove and relocate fish from any impacted section of stream habitat prior to stream works will substantially reduce the risk of mortality and therefore the magnitude of effect for direct mortality of fish due to instream construction works is considered to be **low.**

Effects on freshwater fish within intermittent stream sections can be avoided entirely if reclamation works are undertaken in late summer when many intermittent streams are naturally dry. In this instance magnitude of effect for direct mortality of fish due to instream construction works is considered to be **negligible.**

[15] Cavanagh, J.E., Hogsden, K.L., & Harding, J. S. (2014). Effects of suspended sediment on freshwater fish. Prepared for West Coast Regional Council.

[16] Rowe, D.K., Chisnall, B.L. & Dean, TL. (1998). Effects of land use on native fish communities in east coast streams of the North Island of New Zealand. New Zealand Journal of Marine and Freshwater Research, 33: 141–151.

4.2.3.3 Effects on native fish passage effects

The placement of instream culverts (and related structures) has the potential to impede fish passage and fish access to aquatic habitat upstream. Specifically, design elements of culverts such as vertical drops, velocity, structure length, presence or absence of resting pools (to list a few) have the potential to exclude or restrict passage for native fish species dependant on swimming and/or climbing ability.

To mitigate the potential for these structures to create barriers to fish passage, the design and construction of these structures will follow best practice guidance set out in NZ Fish Passage Guideline[10]. Work will also be undertaken to remove existing dilapidated and perched culverts within the catchments to reinstate fish passage or remediate fish passage as appropriate. By following industry best practice design and construction guidance as well as removing existing culvert related barriers within the site the magnitude of effect of the proposed plan change on fish passage is deemed to be **Low**.

4.2.3.4 Loss of stream habitat

Future development associated with the proposed plan change has the potential to result in loss of stream habitat through earthworks diversion, reclamation, or installation of culverts. Based on the current Structure Plan, potential direct effects through diversion or reclamation of stream habitat will be largely avoided and limited to upper intermittent tributaries of the stream catchments. Placement of culverts will also result in habitat loss albeit replaced by lower quality habitat (e.g. the attributable habitat provision from a well-designed culvert in accordance with the NZ Fish Passage Guidelines). The duration of these effects will be permanent.

A breakdown of intermittent stream habitat loss on a catchment-by-catchment basis for the Live Zone and the BSLP owned properties (620 and 712 Whitford Maraetai Road) in the Future Urban Zone is provided in Table 4.3 and is on the basis of the current Structure Plan. The locations of the impacted reaches referred to in Table 4.3 are shown on Figure 2 in Volume 2, Appendix D. In most cases the impacted reaches comprise upper extent of the various headwater tributaries. These reaches generally offer limited habitat opportunities for stream fauna which is reflected in poor habitat provision and current biodiversity function SEV scores. However, the impacted reaches of the headwater systems do provide important ecosystem services such as hydraulic and biogeochemical functions, particularly when considered across the whole of the site.

Table 4.3: Breakdown of intermittent stream habitat loss for the proposed Live and Future Urban Zones

Zone	Catchment	Impacted reaches	Ecological value	Stream length impacted (m)	Stream area impacted (m^2)
Live	Western	W-UT3, W-UT5, W-UT6, W-UT10	Low	258.6	80.2
	Southern	S-UT2, S-UT4, S-UT5, S-UT6, S-UT7	Low	211.9	52.5
	Northern	N-UT2, N-UT3, N-UT4	Low	599.1	79.7
	Eastern	E-UT2, E-UT5, E-UT11, E-UT12, E-UT13, E-UT20	Low - Moderate	285.0	74.2
Future Urban*	Eastern	E-UT18 (various tributaries)	Low	120.0	70.8
	620	620-UT1, 620-UT2, 620-UT3, 620-UT5	Low	291.0	89.8

*BSLP owned properties only – comprising 620 and 712 Whitford-Maraetai Rd.

An estimated total of 286.5 m^2 of intermittent stream habitat would be lost within the Live Zone and an estimated 160.6 m^2 of intermittent stream habitat would be lost from the BSLP owned properties in the Future Urban Zone.

The magnitude of effect for the reclamation of stream habitat associated with the aforementioned activities is **Very High** due to the direct loss of habitat and irreversible nature of the effect (Volume 2, Appendix A Table 4 and Table 5).

4.2.3.5 Effects due to modified stream hydrology

An increase in impermeable surfaces due to a change to urban land use and concentration of stormwater runoff into stormwater conveyance associated with the proposed plan change has the potential to result in alteration to stream hydrology. Specifically, concentration of this stormwater flow can result in higher magnitude and more rapid peak in flow within stream during significant rainfall events. This alteration has the potential to result in destabilisation of the stream channel through increased erosion of stream bed and banks. Stream baseflows can also be impacted (reduced) due to an increase in impervious area, potentially reducing the extent of both permanently and intermittently flowing stream reaches. The duration of effects due to modification of stream hydrology will be permanent.

The overall approach to stormwater management is set out in the Stormwater Management Plan (SMP)[11]. The general approach includes the use of bioretention rain gardens and swales providing first-flush treatment within the public road reserves. Hydrological mitigation and peak flow attenuation will also be provided within multi-purpose attenuation basins (ponds/wetlands) as a second line of defence.

The attenuation ponds as set out in the SMP[11] will act to intercept and retain peak flow from stormwater conveyance and discharge this flow at a lower velocity and over a longer duration. The indicative enhancement of the riparian zones through planting will also act to create improved resilience of streams to any erosion effects.

Then use of bioretention devices distributed throughout the site as the initial attenuation/treatment devices will assist in providing for stream baseflows by infiltrating runoff into the ground. With the proposed controls to intercept and retain peak stormwater flows and measures to maintain baseflows the magnitude of effect is deemed to be **Low**.

4.2.3.6 Effects on water and sediment quality due to stormwater discharges

The proposed plan change and associated future development will increase the loading of stormwater related contaminants (e.g. metals – copper, zinc; various hydrocarbons, and nutrients etc.) to the stream receiving environments due to a shift to more urbanised land use and increased road surface area and traffic. Mean annual TSS, zinc and copper loads to the various stream catchments on site were estimated by NIWA using a Contaminant Load Model for the existing and fully developed scenario as inputs to the marine contaminant modelling study[14]. In summary, sediment loads are likely to reduce for the fully developed vs existing scenario while copper and zinc loads will increase for all Live Zone catchments.

The effect of this if left unmitigated is further degradation of water and sediment quality conditions within the stream receiving environments. These changes to water and sediment quality can result in subsequent effects on aquatic species especially where discharge concentrations are in excess of Australian and New Zealand Water Quality Guidelines (ANZWQG, 2018) or relevant contaminant guidelines. The duration of effects on water and sediment quality will be permanent.

The details for stormwater management are provided in the SMP prepared by HG[11]. The SMP document provides guidance and the principals for stormwater management in subsequent developments within the plan change area. We understand that the information in the SMP

complies with the standards and procedures set out in the Auckland Council Stormwater Code of Practice v2 in terms of water quality treatment.

The SMP includes management options for stormwater discharges from roads including the construction of bioretention swales and bioretention rain gardens to intercept and retain contaminants. Several management options for are proposed for private lots including rain water tanks, permeable and porous paving slabs, small-scale bioretention systems, and living roofs.

At the communal stormwater treatment level stormwater discharges will be directed to attenuation basins (assumed to be wetlands) to provide a second stage of water quality treatment. In total, 15 attenuation and treatment basins are proposed to be constructed throughout the site. These will be located 'offline' and will discharge into existing streams within each of the five catchments. We understand that treatment device sizing for water quality treatment has assumed no upstream treatment (therefore conservative).

On the basis of the proposed stormwater quality management in accordance with best practice we consider the magnitude of effect due to stormwater discharges can be managed to be **Low.**

4.2.3.7 Effects due to the discharge of treated wastewater

Wastewater from the development will be treated on-site at a proposed wastewater treatment plant (WWTP). The indicative location of the WWTP is shown in the Concept Design Reticulation and WWTP report prepared by GWE.

Discharges from WWTPs typically contain residual levels of microbes (e.g. *Escherichia coli* or *Enterococci sp.*), nutrients, biological oxygen demand (BOD), heavy metals[17] and residual aluminium if flocculants are included in the treatment process. Treated wastewater discharged into stream receiving environments therefore has the potential to increase contaminant and nutrient loading to stream systems, reduce dissolved oxygen conditions, result in excess biological growths as well as alter the hydrological regime.

GWE has developed the concept design for on-site reticulation and wastewater treatment to service the proposed development (GWE, 2022)[18]. The options assessment identified an Enhanced Membrane Bioreactor (E-MBR) WWTP as the most suitable option to treat wastewater based on anticipated quantities and quality of influent and required effluent quality. Treated effluent concentrations are the product of several key units in the wastewater treatment process, including UV disinfection to removal faecal coliform bacteria and chemical dosing to aid dentifrication and phosphorus removal prior to discharge[18]. The anticipated effluent quality for key contaminants after E-MBR treatment based on advice by GWE[19] is present below (Table 4.4). We note that no information is available on potential concentrations of Emerging Organic Contaminants (EOCs)[20] .

[17] Noting that elevated heavy metals from wastewater treatment systems is dependent on the land use of the catchment being serviced; industrial catchments are more likely to contribute heavy metal loads to wastewater treatment systems via trade waste.

[18] GWE Consulting Engineers Ltd. (2022). Beachlands South – Concept Design Reticulation and WWTP. Consultancy report prepared for Beachlands South Limited Partnership Ltd, March 2022.

[19] Email from Gareth Williams (GWE) to John Dobrowolski (Russel Property Group) and Dean Miller (T+T) dated 3 February 2022.

[20] The effects on freshwater aquatic life from EOCs is an emerging area of science, and there is global concern that the presence of EOCs in the environment may lead to adverse effects on ecological health (Stewart *et al.*, 2016). Despite an increase in international studies, there is still a paucity of information on EOCs in the New Zealand receiving environment

Table 4.4: Beachlands South anticipated effluent quality requirements (as advised by GWE).

Parameter	Treated effluent – mean concentration	Treated effluent – 90th percentile concentration
5-Day Carbonaceous Biochemical Oxygen Demand (mg/L)	5	10
Total Suspended Solids (mg/L)	5	8
Total Nitrogen (mg/L)	5	8
Ammonia Nitrogen (NH_4-N) (mg/L)[1]	1	2
Nitrate/Nitrite Nitrogen (NOx-N)	4	6
Total Phosphorus (mg/L)	1	2
Soluble reactive Phosphorus (SRP) (mg/L)	1	2
E.Coli (cfu/100 ml)	5	10

1 – Assumed characterisation (by T+T) based on typical treated effluent N and P and existing MBR data supplied by GWE.

Further treated wastewater polishing and disposal options have been considered to address potential issues associated with a direct discharge to the streams on site during low flows, such as ammonium and nitrate toxicity and low dissolved oxygen. The options are described in GWE's Concept Design Reticulation and WWTP report[18]. GWE's recommended options are described briefly as follows, noting a combination of options may be implemented and scaled to the staging of future development.

1 Land disposal to FUZ land.

2 Tertiary polishing wetlands and land disposal to the golf course and FUZ land.

3 Tertiary polishing wetlands at the head of the western catchment gully with subsequent discharge into the existing constructed wetland and permanent stream sections of the western catchment (and subsequently to the marine environment).

Land disposal Options 1 and 2 above would include areas draining to the Eastern, Southern and 620 Catchment streams. Disposal would be to ground which would avoid issues with ammonia toxicity and biological oxygen demand (reduced dissolved oxygen) associated with direct discharges to streams. There may be some potential for nutrients to enter stream environments diffusely, however the high levels of stream shading due to existing and proposed planting in the EPAN will reduce the potential for in-stream eutrophication effects. It is therefore unlikely that there will be a response aquatic plant or algae growth in stream receiving environments relative to the current state.

Options 2 and 3 include tertiary polishing wetlands. While not required for land disposal, Option 2 would include polishing wetlands to achieve additional reductions in nutrients and would provide storage prior to irrigation of the golf course. The polishing wetland system would comprise vertical flow wetlands (VFW) for nitrification and potentially a surface flow wetland (SFW) for denitrification, noting that the discharge from an SFW would be low in dissolved oxygen. Indicative contaminant removal efficiencies for VFW are provided in Table 4.5. The nitrate removal efficiency in a well-constructed and maintained SFW should exceed 30 % in winter months and 70 % in summer months[21].

VFW polishing wetlands would reduce ammonia nitrogen concentrations to below concentrations of concern in terms of potential for aquatic toxicity effects. Biological oxygen demand would also be reduced to below freshwater guideline levels (2 mg/L). As discussed above the proposed riparian

[21] T+T, 2022. Stream Ecological Effects Assessment. Concultancy report prepared for Beachlands South Limited Partnership, March 2022. Appendix C to GWE's Concept Design Reticulation and WWTP report.

restoration and increased shading in the Western Catchment tributary would also manage eutrophication effects associated with residual concentrations of plant available nutrients. A SFW wetland could be used to reduce nitrate further, but this would need to be balanced against the potential for reduced oxygen in the stream receiving environment during low flow conditions.

Table 4.5: Indicative average removal efficiencies in Vertical Flow Wetlands

Water quality parameter	Average efficiency of removal
Carbonaceous Biological Oxygen Demand ($CBOD_5$)	85 %
Ammonia nitrogen (NH4-N)	75 %
Total nitrogen (TN)	45 %
Orthophosphate (OP)	58 %
Total phosphorus (TP)	63 %

On the basis of the proposed wastewater discharge management options described above we consider the magnitude of effect due to wastewater discharges on stream environments on site can be managed to be **Low.**

We note that a WWTP discharge and receiving environment water quality monitoring programme will likely be required covering the relevant freshwater (and marine) environments and will be addressed at the resource consent stage.

4.3 Overall level of effects

The potential overall level of each identified effect after measures to avoid, remedy or mitigate for effects are presented in Table 4.6 to Table 4.9 below. Separate tables (Table 4.2 to 4.5) are provided to account for the variable ecological value present in the individual catchments present within the project footprint which in turn creates the potential for differing overall levels of effect from catchment to catchment. We have also assessed values for permanent and intermittent streams separately.

Our assessment is that most residual effects due to the PPC and associated land use change and development on stream habitats and receiving environments will be **Very Low** to **Low**. However, our assessment also indicates that the level of residual effects (prior to offsetting) due to intermittent stream reclamation (stream loss) will be **Moderate to High**.

Recommendations for addressing residual effects are provided in Section 5 below and include riparian restoration and enhancement planting. Outside of restoration and enhancement planting (utilised for ECR calculations to address residual effects) further benefit to ecological value can be achieved through improving stream connectivity within the stream catchments, many of which have multiple barriers to fish passage.

Table 4.6: Level of effects associated with the proposed land-use change for the Northern and Western Catchments after proposed measures to avoid, remedy or mitigate for effects have been undertaken

Potential effects associated with the proposed land-use change	Ecological value category (applicable stream class)	Magnitude of effects category (after avoid, remedy, mitigate)	Level of effects category
Stream water quality effects due to construction related discharges	Low (permanent)	Low	Very low
Construction related effects on native fish	Low (permanent)	Low	Very low
Effects on native fish passage	Low (intermittent) Low (permanent)	Low	Very low
Loss of stream habitat	Low (intermittent)	Very High	Moderate
Effects due to modified stream hydrology	Low (permanent)	Low	Very low
Effects due to stormwater discharge	Low (permanent)	Low	Very low
Effects due to the discharge of treated wastewater*	Low (permanent)	Low	Very low

*The treated wastewater discharge is only relevant to the Western Catchment.

Table 4.7: Level of effects associated with the proposed land-use change for the Southern Catchment after proposed measures to avoid, remedy or mitigate for effects have been undertaken

Potential effects associated with the proposed land-use change	Ecological value category (applicable stream class)	Magnitude of effects category (after avoid, remedy, mitigate)	Level of effects category
Stream water quality effects due to construction related discharges	Low-Moderate (permanent)	Low	Very Low - Low
Construction related effects on native fish	Low-Moderate (permanent)	Low	Very Low - Low
Effects on native fish passage	Low (intermittent)	Low	Very Low - Low
Loss of stream habitat	Low (intermittent)	Very High	Moderate
Effects due to modified stream hydrology	Low-Moderate (permanent)	Low	Very Low - Low
Effects due to stormwater discharge	Low-Moderate (permanent)	Low	Very Low - Low
Effects due to the discharge of treated wastewater	Low (intermittent) Low-Moderate (permanent)	Low	Very Low - Low

Table 4.8: Level of effects associated with the proposed land-use change for the Eastern Catchment after proposed measures to avoid, remedy or mitigate for effects have been undertaken

Potential effects associated with the proposed land-use change	Ecological value category (applicable stream class)	Magnitude of effects category (after avoid, remedy, mitigate)	Level of effects category
Stream water quality effects due to construction related discharges	Moderate (permanent)	Low	Low
Construction related effects on native fish	Moderate (permanent)	Low	Low
Effects on native fish passage	Low-Moderate (intermittent) Moderate (permanent)	Low	Low
Loss of stream habitat	Low-Moderate (intermittent)	Very High	Moderate - High
Effects due to modified stream hydrology	Moderate (permanent)	Low	Low
Effects due to stormwater discharge	Moderate (permanent)	Low	Low
Effects due to the discharge of treated wastewater	Low-Moderate (intermittent) Moderate (permanent)	Low	Very Low - Low

Table 4.9: Level of effects associated with the proposed land-use change for the 620 Catchment after proposed measures to avoid, remedy or mitigate for effects have been undertaken

Potential effects associated with the proposed land-use change	Ecological value category (applicable stream class)	Magnitude of effects category (after avoid, remedy, mitigate)	Level of effects category
Stream water quality effects due to construction related discharges	High (permanent)	Low	Low
Construction related effects on native fish	High (permanent)	Low	Low
Effects on native fish passage	Low (intermittent)	Low	Very low
Loss of stream habitat	Low (intermittent)	Very High	Moderate
Effects due to modified stream hydrology	High (permanent)	Low	Low
Effects due to stormwater discharge	High (permanent)	Low	Low
Effects due to the discharge of treated wastewater	Low (intermittent) High (permanent)	Low	Very low to Low

5 Proposed Residual Effects Measures

This section focusses on residual stream habitat loss effects within the Live Zone part of the overall PPC area.

Based on the current Structure Plan there would be around 160 m^2 of stream habitat impacted within the BSLP owned areas of the FUZ. The FUZ will be the subject of a further plan change application in due course and stream loss and any ecological offset will be assessed at that time. There is potential opportunity for stream offset work to be undertaken in the Eastern Catchment tributaries located within the FUZ land currently in private ownership (not owned by BSLP). This area includes a gully network with intermittent streams and wetlands that generally lack riparian vegetation.

5.1 Residual effects management overview

The proposed plan change will result in the loss of approximately 1,355 lineal metres (286.5 m^2) of intermittent stream habitat within the Live Zone based on the Structure Plan and Precinct Plan. Stream loss is limited to upper catchment tributaries within the four stream catchments within the developable area footprint. No permanent stream length is indicated to be lost.

On a per catchment basis the following length of intermittent stream loss is indicated. Smaller intermittent tributary systems outside of the main catchments are captured within these figures:

- Northern Catchment: 79.7 m^2
- Eastern Catchment: 74.2 m^2
- Western Catchment: 80.2 m^2
- Southern Catchment: 52.5 m^2

Applying the EcIAG, the level of effect of stream loss, without offset or compensation, is assessed as being Moderate due to the length and ecological value of stream being lost and the irreversible nature of the effect (4.2.3.4). It is not possible to remediate or mitigate stream reclamation at the point of impact. To 'mitigate' means to alleviate, or moderate the severity of something[22]. This is not possible for stream reclamation as there is a complete and permanent loss of habitat.

While stream reclamation cannot be mitigated, it can be offset or compensated. Offsetting is 'a measurable conservation outcome resulting from actions designed to compensate for residual adverse biodiversity effects arising from activities after appropriate avoidance, remediation, and mitigation measures have been applied'[17]. To be considered an offset, the conservation outcomes resulting should be consistent with a set of offsetting principles, including the goal of 'no net loss'[17].

5.2 Residual effects management approach

The environmental compensation ratio (ECR) is a tool identified within the AUP to quantify the amount of streambed area that is required to be subject to restoration, depending on the extent and type of enhancement works proposed, relative to the amount lost to achieve a 'no-net-loss' in ecological function as a result of the activities. The ECR quantifies the likely loss in values and functions at an impact site and the increase in stream ecological values and functions at an offset site.

The streams utilised for offset in our calculations are a mixture of intermittent and permanent stream, and do not necessarily constitute "like for like" given the loss of stream is exclusively intermittent. However, we consider the use of permanent streams for offset is appropriate given the

[22] Maseyk, F, Ussher, G, Kessels, G, Christensen, M, and Brown, M (2018). Biodiversity offsetting under the Resource Management Act – A guidance document September 2018.

small size of the catchments and that the entirety of these catchments are situated within the proposed plan change footprint. It is also preferable that, although not “like for like”, stream enhancement for the purposes of offset is retained within the same catchment as the impact. In many cases will be in the immediate proximity to the point of impact.

Where wetlands or open water bodies are present within the stream catchment the loss of these or enhancement for the purposes of compensation are addressed in the Wetland Ecology Report. In keeping with this, any area identified as wetland within the catchments has not been included in the preliminary offsetting calculations for stream loss.

5.3 Stream offset

Presented below is the summary of preliminary ECR calculations undertaken on a catchment-by catchment-basis across the Live Zone. For the purposes of calculating ECR values an SEVm-P value of 0.7 has been selected. The rationale for this is based on comparable current state SEV scores (SEVc-C) being found on site within the modified Northern Catchment (e.g. N2 (0.72), N2-2 (0.67), as well as higher values detailed for the three survey locations in the nearby 620 catchment (0.73, 0.75, and 0.75, respectively), albeit an SEA and a more mature state forested habitat.

Table 5.1 presents a summary of the ECR calculations to determine the quantum of stream habitat to be restored to achieve no-net-loss. Detailed ECR and offset quantum calculations are provided in Volume 2 Appendix D.

We have assumed restoration will comprise riparian restoration within a 10 m strip on both banks at all offset sites along with daylighting of a short piped section (50 m) of the main Eastern catchment stream and a minor re-alignment and subsequent enhancement of tributary E-UT10. The offset solution on which the calculations are based is show on Figure 2 in Volume 2 Appendix A (refer to the areas shown as Stream Riparian Planting). This proposed solution provides for a net gain of around 90 m^2 of stream habitat.

Table 5.1: Preliminary assessment of the offset quantum for stream loss within the Live Zone due to the PPC and based on the current Structure Plan.

Catchment	Stream linear loss (m)	Stream area loss (m^2) (based on median stream width)	ECR ratios*	Stream area required (m^2)**
Western	258.6	80.2	3.86 – 6.89	442.8
Southern	211.9	52.5	2.85 – 11.10	224.0
Northern	599.1	79.7	2.32 – 4.52	242.6
Eastern	285.0	74.2	1.68 – 3.92	173.6
Total stream habitat area to be subject to restoration to achieve no-net-loss				**1,083.0**

*A range of ECR ratios are provided given losses within some catchments have utilised a number of offset reaches with different SEV scores.

** Stream area required is calculated on stream area loss multiplied by the applicable ECR ratio.

Based on ECR calculations, the effects of stream bed area being lost within the Live Zone can be offset in full using the streams available within the EPAN and Golf course areas of the Live Zone. These ECR calculations will need to be undertaken in more detail at the consenting stage to account for final design specifications and the potential for any deviation from the current Structure Plan.

Alongside the riparian enhancement being undertaken to offset stream loss, there is a much wider programme of restoration proposed (offset and compensation for Wetland and Terrestrial Ecology

effects) that will also result in benefits to stream ecology. In addition, there are numerous opportunities for further ecological enhancement available on site through the removal or remediation of deteriorated and perched culverts which currently impede fish passage. This provides a degree of certainty that changes in design that result in minor additional stream reclamation should also be able to be managed on site and within the Live Zone.

6 Conclusion

In conclusion, our assessment is that most effects due to rezoning from the PPC, associated land use change and subsequent development on stream habitats and receiving environments will be **Very Low** to **Low** provided the measures to avoid remedy or mitigate effects are implemented as set out in this report. However, our assessment also indicates that the level of residual effects due to intermittent stream reclamation (stream loss) with subsequent development of the Live Zone will be **Moderate to High**.

Residual stream habitat loss effects associated with development of the Live Zone can be addressed by way of stream offset work comprising riparian zone restoration and enhancement of the specific permanent and intermittent stream reaches identified within the EPAN as shown on the compensation plan (Figure 2 in Volume 2, Appendix A). Based on preliminary ECR modelling we consider a No Net Loss outcome for stream ecological values can be achieved.

The above outcomes for stream ecology will be achieved through the Auckland-wide provisions under the AUP and proposed precinct provisions developed for the proposed Beachlands South Precinct (as set out in the Planning Report that accompanies the PPC application) and through subsequent resource consent processes. The proposed precinct provisions will assist in the delivery of the stream ecological effects management measures discussed in this report by:

- ensuring the protection of the most significant stream ecology values onsite within the EPAN;
- ensuring that bulk earthworks and stormwater discharge activities are managed to minimise impacts on stream receiving environments;
- providing for stream habitat restoration and enhancement opportunities within the EPAN to be undertaken as offset for stream reclamation at the time of future consent applications; and
- requiring that all restoration and enhancement work in the EPAN is undertaken with a Biodiversity Management Plan.

We therefore consider that adverse ecological effects on streams due to the PPC and subsequent development can be adequately addressed through the effects management measures outlined in this report and as guided by the Auckland-wide and proposed precinct provisions.

7 Applicability

This report has been prepared for the exclusive use of our client Beachlands South Limited Partnership, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

We understand and agree that our client will submit this report as part of an application for a private plan change and that Auckland Council as the territorial authority will use this report for the purpose of assessing that application.

Tonkin & Taylor Ltd

Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
	
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