NZ TRANSPORT AGENCY
WAKA KOTAHI

Roads of national significance

Ara Tūhono – Pūhoi to Wellsford

This document records technical and factual information used to support the NZTA's Assessment of Environmental Effects for the Pūhoi to Warkworth Project. It has been supplied to the Environmental Protection Authority by the NZTA in response to a section 149(2) Resource Management Act 1991 request. This document did not form part of the NZTA's application for the Project, which was lodged on 30 August 2013.

FURTHER NORTH

Pūhoi to Warkworth

Water Assessment Factual Report 6

Stormwater Design Philosophy Report

August 2013

Pūhoi to Warkworth

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Glossary of abbreviations

Abbreviation	Definition
ARC	Auckland Regional Council (legacy Council 08 the Auckland Council)
ARI	Average Recurrence Interval
ARP: ALW	Auckland Regional Plan: Air, Land and Water
BPO	Best Practicable Option
HEC-14	Federal Highway Administration Hydraulic Engineering Circular No. 14 Hydraulic Design of Energy Dissipaters for Culverts and Channels
m	Metres
NGTR	Northern Gateway Toll Road
NZTA	NZ Transport Agency
OWAR	Operational Water Assessment Report
RDC	Rodney District Council (legacy Council 08 Auckland Council)
RMA	Resource Management Act 1991
RoNS	Roads of National Significance
TP10	ARC Technical Publication Number 10: Stormwater Management Devices Design Guideline Manual
TP108	ARC Technical Publication 108: Guidelines for Stormwater Runoff Modelling in the Auckland Region
TSS	Total Suspended Solids

Glossary of defined terms

Term	Definition
Alignment	The route or position of a proposed motorway or state highway.
Average Recurrence Interval	The average time period between rainfall or flow events which equal or exceed a given magnitude. Similar to return period.
Bathymetry	The measurement of the depths of bodies of water.
Culvert	A pipe with an inlet from a watercourse and outlet to a watercourse, designed to convey water under a specific structure (such as a road).
Diversion of stormwater	The turning aside of stormwater from its natural course of flow; causing it to flow by a different route.
Erosion Control	Methods to prevent or minimise the erosion of soil, in order to minimise the adverse effects that land disturbing activities may have on a receiving environment.
Fish Passage	The movement of fish between the sea and any river, including up-stream or downstream in that river.
Heading up	Heading up is the term used to denote the condition when the water surface immediately upstream of the culvert rises to an elevation greater than the soffit of the culvert inlet.
Headwater	The water depth from the culvert invert at the inlet, to the water surface of the pool that forms as a result of heading up, is called the headwater.
Indicative Alignment	A route and designation footprint selected after short-list and long-list development to enable consultation with the community. This development involved specialist work assessing environmental, social and engineering inputs.
Intermittent Stream	Any stream or part of a stream that is not a Permanent stream.
Motorway	Motorway means a motorway declared as such by the Governor-General in Council under section 138 of the Public Works Act 1981 or under section 71 of the Government Roading Powers Act 1989.
Overland Flow Path	The flow path of stormwater over the ground.

Permanent Stream	Downstream of the uppermost reach of a river or stream which meets either of the following criteria: (a) has continual flow; or (b) has natural pools having a depth at their deepest point of not less than 150 millimetres and a total pool surface area that is $10m^2$ or more per 100m of river or stream bed length. The boundary between Permanent and Intermittent river or stream reaches is the uppermost qualifying pool in the uppermost qualifying reach.
The Project	Pūhoi to Warkworth section of the Pūhoi to Wellsford Road of National Significance Project.
Project area	From the Johnstone's Hill portals in south to Kaipara Flats Road in the north.
Sediment Control	Capturing sediment that has been eroded and entrained in overland flow before it enters the receiving environment.
Wetland	Vegetated stormwater treatment device designed to remove a range of contaminants.

Contents

1. Introduction and background

This report provides a factual basis for the Operational Water Assessment Report (OWAR) prepared for the New Zealand Transport Agency (NZTA). The OWAR provides an assessment of the environmental effects associated with water, arising from the operational aspects of the Ara Tūhono Pūhoi to Wellsford Road of National Significance (RoNS) Pūhoi to Warkworth section (the Project). The OWAR supports the Assessment of Environmental Effects, resource consent applications and Notices of Requirement for the Project.

This report is for the operational water systems proposed for the Project. The Project's operational water systems include permanent stormwater management systems and modifications to streams/flood plains which will be in place during operation of the motorway. It records the design criteria used in the consenting phase of the Project and will be used to inform designers in future stages.

1.1 Stormwater design philosophy

The two key objectives for the operational water systems are as follows:

- To ensure the performance of the motorway to NZTA standards; and
- To avoid, remedy or mitigate adverse environmental effects.

In summary, we have adopted the following design principles for the operational water systems:

- The design will provide a best practicable option to avoid, remedy or mitigate adverse environmental effects, determined through a robust evaluation of options;
- The design will integrate the total operational water system (collection and conveyance network; treatment devices; culverts and diversions and consideration of the floodplain);
- The design will include full consideration of stormwater operational implications throughout the design life of the asset;
- The design will best practicably mimic the existing hydrologic regime and setting, to deliver outcomes that avoid, remedy or mitigate adverse environmental effects;
- The design will avoid or mitigate changes that might make the current flood issues in the catchment worse;
- The design will provide for habitats in stream diversions where they existed prior to the Project. The designs will restore streams and recreate habitats to replicate the natural state and habitats that existing prior to the Project; and
- The design will provide where possible for fish passage in culverts for all permanent streams with future upstream habitats, and for intermittent streams where there is potential for fish habitat upstream.

1.2 Overview of operational water systems

Figure 1 provides a pictorial overview of how water is managed in the operational phase of the Project. Rainfall onto cuts and the motorway is collected and conveyed via stormwater treatment devices prior to discharge to streams which then drain to the estuary and harbours. Runoff from adjacent areas is diverted away from cuts and the motorway. Meanwhile streams that cross the motorway alignment are crossed by culverts or bridges. Culverts often require stream diversions to facilitate their construction. In some circumstances the motorway fills occupy floodplains.

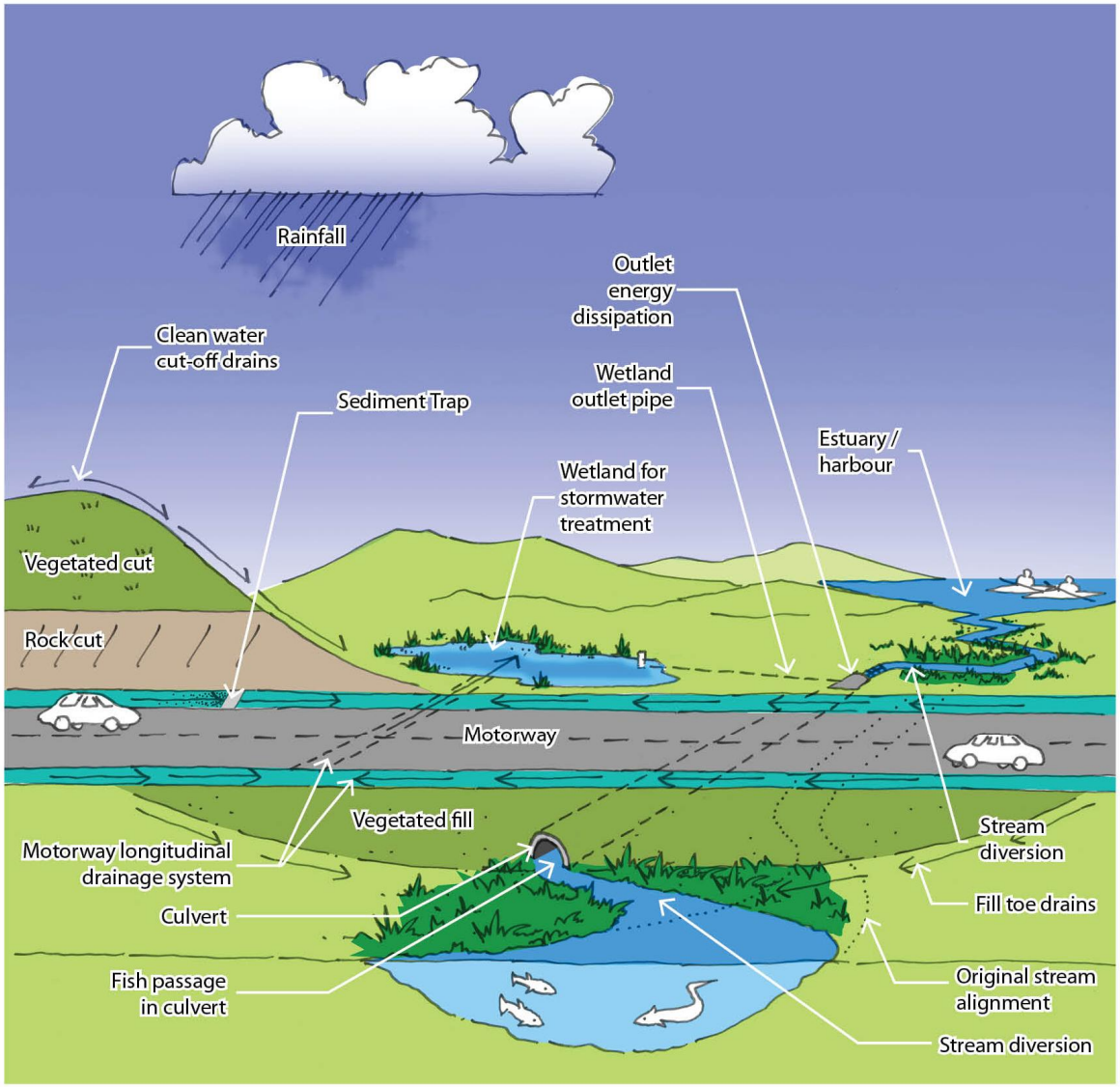

Figure 1: Motorway Operational Water Systems and the environment.

2. Basis for design

2.1 Performance of the motorway

The performance of the stormwater systems for safe operation of the motorway is a key design objective. The design criteria related to performance (other than environmental) have not been a focus to date as the Project is at the consent stage. The design criteria for performance of the motorway as they relate to safety, durability, maintenance, etc. will need to be added to the design philosophy at a later stage.

2.2 Minimise environmental effects

The stormwater management philosophy for the Project has been developed in conjunction with the assessment criteria described in Section 5 of the OWAR. These criteria have been developed from the Resource Management Act (RMA), ARP:ALW and Auckland District Plan: Operative Rodney Section, and establish the framework for the assessment of effects and environmental mitigation. The key assessment criteria matters concern stormwater quantity, stormwater quality, human impacts, ecological impacts and flooding.

The design criteria of the operational water systems for the Project is to satisfy the assessment criteria and mitigation requirements described in Section 5 of the OWAR.

The design philosophy and design criteria may need to be updated to reflect conditions of consent when consents are granted.

2.3 Relevant experience

The design philosophy for the Project is also based on the design and construction of the Northern Gateway Toll Road (NGTR) project, operational since February 2009. The Project team, comprising a range of experts with experience in similar projects including the NGTR, have developed the design philosophy and the OWAR. We consulted as-built drawings and carried out site visits to the NGTR.

To understand the operation and maintenance requirements of different stormwater management devices, we sought feedback from Peter Mitchell of the Auckland Motorway Alliance.

2.4 Existing environment

The Project traverses the Pūhoi and Mahurangi catchments. The Project area is largely characterised by steeper rolling hill country with interconnected ridge and valley systems in the south and central sectors. The terrain changes to low undulating country in the northern parts of the Mahurangi catchment.

The geology of the Project area consists of predominantly Pakiri Formation with some areas of Northern Allochthon, and alluvium in the northern sectors.

In the Pūhoi catchment the receiving environments are the tributaries and main streams of the Hikauae Creek and Pūhoi River, and ultimately the Pūhoi Estuary. In the Mahurangi catchment the receiving environments are the tributaries and main streams of the Mahurangi River left and right branches and ultimately the Mahurangi Harbour. The indicative alignment crosses a mixture of permanent and intermittent streams and rivers. The streams vary from natural streams with good riparian vegetation to farm drains. The streams have rock outcrops in places, but also consist of soft bottom streams.

A comprehensive description of the existing environment is provided in Section 3 of the OWAR. These environments have been considered in the development of the design philosophy and the OWAR.

3. Stormwater management

3.1 Water quality treatment

The primary water quality objective of permanent stormwater treatment devices is to remove suspended solids.

The proposed requirements for water quality treatment are summarised below:

- Water quality treatment is proposed for all new impervious areas, which include the motorway surface and rock cuts;
- Removal of 75% total suspended solids (TSS) on a long term average basis (in accordance with Auckland Regional Plan: Air, Land and Water (ARP: ALW) requirements);
- Treatment of many contaminants such as particulate trace metals, particulate nutrients, oil, grease and bacteria on sediments; and
- Treatment of gross litter and floatables such as oil and volatile hydrocarbons.

3.2 Water quantity treatment

The proposed requirements for water quantity treatment are summarised below:

- Flow conveyance for 100 year Average Recurrence Interval (ARI) flow by bypass or emergency overflow from to minimise erosion; and
- Minimise erosion of streams by providing 'extended detention' and controlled release of runoff generated in a rainfall event of 34.5mm over a 24 hour period. Exceptions are where discharges are in close proximity to the Pūhoi Estuary.

3.3 Wetlands

Constructed wetlands are the preferred stormwater treatment device for the Project, an outcome of the best practicable option (BPO) assessment described in Section 7 of the OWAR. This BPO approach is based on the ARP: ALW requirement to minimise the effects of operational water management and stormwater discharges.

3.3.1 Locations

Wetland locations will be refined with consideration given to landscape, constructability, maintenance and ecological values at the detailed design stage. At this stage the key considerations for wetland locations are:

- Located out of the post-development 100 year ARI floodplain;
- Located close to the indicative alignment to provide convenient and safe access for maintenance; and
- Located to reduce conveyance of water across bridges and viaducts.

3.3.2 Design criteria

The Wetland design requirements for the Project are detailed in Table 1.

Table 1: Wetland design criteria.

Criteria	Source
Design in accordance with TP10	ARP:ALW Industry best practice in Auckland region. ARC's preferred design approach for stormwater management devices. TP10
Provide treatment for; • All new motorway surfaces which include the pavement, median and shoulder, drainage channels, rock trap channels, and longitudinal swales; and • Rock cuts and re-vegetated areas above rock cuts where they cannot be readily separated.	Table 7, OWAR
Remove at least 75% TSS on a long-term average basis	ARP:ALW TP10
Densely plant to maximise the treatment effectiveness. Planting to be maintained in operation. A banded bathymetry (i.e. staggered series of depths) will be used to increase the wetland vegetation as shown, and planting will be in accordance with Auckland Council and NZTA standards	TP10 NZTA standards OWAR
Be constructed and located off-line, i.e. not constructed in or on the bed of an existing stream	TP10
Wetland volume = 50% water quality volume + extended detention volume. 500mm freeboard.	TP10
Wetland footprint = 3:1 length to width ratio	TP10
Energy dissipation are to be used where required to minimise erosion from all wetland and culvert outlets	ARP:ALW OWAR
Local overland flow to be diverted away from the wetland	TP10
Include a forebay	TP10
Include a submerged outlet (discharge manhole at wetland)	TP10
Outfalls are to be sized to convey the 100 year ARI flow rate. These flows will be piped to the adjacent stream.	OWAR
Less than 3m deep to crest of …….? and less than 20,000m^3	NZSOLD (2000)

3.3.3 Wetland inlet

Stormwater collected in motorway drainage systems will be conveyed by roadside drains, swales or pipes to wetlands for treatment prior to discharge to the natural environment. Discharge to the wetlands will be as follows:

- Stormwater flow from the motorway drainage system conveyed to wetland via inlet pipe;
- In general flow to the pond will be piped only with no overland flow (to limit pond spillway requirements);
- Inlet pipe discharges to wetland forebay, with wingwall and energy dissipation as required; and
- Flow will discharge evenly out into the forebay.

3.3.4 Wetland outlet

Primary outlet

Discharge from the wetland will be as follows:

- Flow will exit the wetland through a discharge manhole with low flow and slotted outlets to control extended detention discharge rates;
- The top of the discharge manhole will be the service spillway (secondary outlet);
- Treated flow from the wetland is conveyed by pipe to discharge to the natural environment; and
- The outfall shall have energy dissipation and erosion protection to minimise erosion.

Secondary outlet / overflow

In addition to the primary outlet all ponds shall have a secondary or emergency spillway. The spillway shall discharge in a manner that does not generate excessive erosion.

3.4 Sediment traps

Sediment traps are proposed for the Project in drains at the base of rock cut faces. These sediment traps are bespoke treatment devices that will capture sediment generated from rock cuts close to the source and protect the downstream wetlands from excess sediment.

3.4.1 Design requirements

The design requirements for the sediment traps are detailed in Table 2.

Table 2: Sediment trap design requirements.

Criteria	Source
Sediment traps to be used at the base of all rock cuts required for the Project	Table 7, OWAR
Refine sediment trap spacing matrix to suit rock cut heights and longitudinal slopes at the base of the rock cuts as detailed design develops.	Table 7, OWAR
Provide safe maintenance access with consideration given to how sediment will be removed from the sediment traps during the operational phase of the Project	Table 7, OWAR

The sediment trap baffle spacing matrix in Table 3 has been developed based on a 2 year maintenance interval. The sediment traps should not compromise the function and performance of the rock fall traps.

The methodology used to develop the sediment trap baffle spacing matrix is described in the Water Assessment Factual Report 8: Cross Drainage and Stream Diversion Design Memo (2013).

Table 3: Sediment trap baffle spacing.

	Baffle Spacing (m)	Rock Cut Height (m)			
		5 to 10	10 to 20	20 to 30	30 to 40
Swale Slope	0 to 1%	100	100	100	100
	1 to 3%	100	45	25	25
	3 to 5%	60	20	15	15

3.5 Vegetated roadside drains

A number of ancillary roads will be constructed or upgraded as part of the Project. Conveyance of water runoff from these ancillary roads constructed or upgraded as part of the Project will be via vegetated roadside drains that will discharge to existing streams. These drains are commonly "U" shape in profile and quite deep. They do not conform with TP10 requirements for swales.

The detailed design phase will consider the hydraulic sizing of the vegetated roadside drains to ensure that any risk of overtopping the road surface is mitigated. The detailed design phase will also select vegetation that will provide water quality benefits through filtration and infiltration.

3.6 Stormwater reticulation

Stormwater reticulation has not been designed for this consenting phase of the Project but will be undertaken during detailed design phase. Stormwater reticulation conveys stormwater from the

Project carriageway and from the toe of cut (and fill) slopes to stormwater treatment devices and may include the following types:

- Kerb / channel / catchpit / pipe;
- Drainage channels including vegetated roadside drains / swales;
- Rock trap drainage channels; and
- Drop structures.

There are opportunities for additional treatment devices such as swales and catchpit sumps to be incorporated into the stormwater reticulation to increase the stormwater treatment as well as provide conveyance.

3.7 Overland flow paths

Overland flow paths are to be provided and maintained for flows in excess of the primary drainage network capacity to accommodate flows up to and including the 100 year ARI storm event.

3.8 Other areas

Stormwater outcomes are dependent on the maintenance of cleanwater outside the Project and stabilisation of vegetated areas of the Project such as cuts and fills. To achieve these outcomes the following criteria should be met:

- Cleanwater from outside the Project shall be diverted so not to mix with stormwater from the motorway;
- Cleanwater diversions shall be sized for 100 year ARI;
- Cleanwater diversions to have erosion control as required to minimise scour; and
- Vegetated areas to have adequate ground cover and/or stabilisation measures to minimise sediment generation.

4. Cross drainage

Where the Project crosses existing streams (permanent and intermittent) we propose bridges and culverts for conveyance of normal flows and flood waters from one side of the motorway to the other, whilst minimising the effect on the existing flow and the ecological condition of the waterways.

4.1 Bridges

The design requirements for bridges are detailed in Table 4.

Table 4: Bridge Sizing Criteria for the Motorway (Hydraulic Criteria Only).

Criteria	Source
Accommodate a 100 year ARI with a minimum freeboard to the edge of the motorway of 600mm in non-forested areas and 1200mm in forested areas.	NZTA RoNS Design Standards & Guidance Document (2009) NZTA Bridge Design Manual
Effects of bridges on flood levels are to be minimised beyond the designation	OWAR Recommendations
Flooding effects from predicted afflux (rise in water level on the upstream side of a bridge / culvert) is less than 100mm in Carran Road Sector	OWAR Recommendations

4.2 Culverts

The design of the culverts for the Project is based on a range of hydraulic requirements and additional considerations for safety and maintenance. The design criteria for the culverts are detailed in Table 5.

Table 5: Culvert design criteria for the motorway.

Criteria	Source
Hydraulic capacity: • Pass a 10 year ARI without heading up • Minimum freeboard of 500mm during 100 year ARI to edge of carriageway • Accommodate 100 year ARI with Headwater Depth ÷ Culvert Diameter < 2	NZTA RoNS Design Standard & Guidance Document 2009, Rodney District Council (RDC) Standard for Engineering Design (2009) Previous NZTA minimum requirements
Debris blockage: • High risk catchments increase the culvert size to accommodate a 100 year ARI without heading up plus provide upstream debris rack. • Moderate risk catchments provide a relief inlet • Debris hazard framework to be reassessed at detailed design stage	OWAR Section 7

Criteria	Source
Minimum diameter for safety and maintenance purposes: • Culvert < 30m length = Culvert to be 600mm minimum diameter • Culvert 30 – 100m length = Culvert to be 1200mm minimum diameter • Culvert > 100m length = Culvert to be 1600mm minimum diameter	Scheme Assessment Report: Stormwater
Minimum cover: • Culverts shall be provided with not less than 600mm of cover	NZTA RoNS Standard, Austroads Guide to Road Design part 5 Drainage Design
All culverts shall have headwalls and hand rails	Industry safety practice, Building Code
Vertical and horizontal alignment of culvert to be constant from inlet to outlet i.e. no change in direction or grade	Industry practice
Effects of culverts on flood levels are to be minimised beyond the designation	OWAR Recommendations
Energy dissipation is to be used where required to minimise erosion from all culvert outlets.	OWAR Recommendations
Fish passage is to be provided at all culverts where the freshwater ecologist has identified permanent streams with upstream habitats, and intermittent streams where there is potential for fish habitat upstream.	Freshwater Ecology Assessment Report OWAR Recommendations

For culverts located in new or upgraded ancillary roads,(SH1, Moirs Mill Road and roads associated with underpasses) the motorway hydraulic criteria will apply.

For culverts located in new private roads (such as the property access road off Wyllie Road), we propose hydraulic design criteria that is less onerous than for the motorway, refer Table 6.

Table 6: Culvert design criteria for ancillary road upgrades or renewal.

Criteria	Source
Hydraulic capacity: • Pass a 10 year ARI without heading up.	NZTA RoNS Standard, RDC Standard for Engineering Design (2009)
Minimum cover: • Culverts shall be provided with not less than 600mm of cover	NZTA RoNS Standard, Austroads Guide to Road Design part 5 Drainage Design
Overland flow paths are to accommodate flows exceeding the 10 year ARI	

5. Stream diversions

Permanent diversions and flow channels are required to manage surface water for the Project. The design principle is to minimise adverse environmental effects by recreating habitats for stream diversions that restore streams to a natural state.

A flow chart that selects the most suitable type of stream diversion based on fish passage criteria is shown in Figure 2.

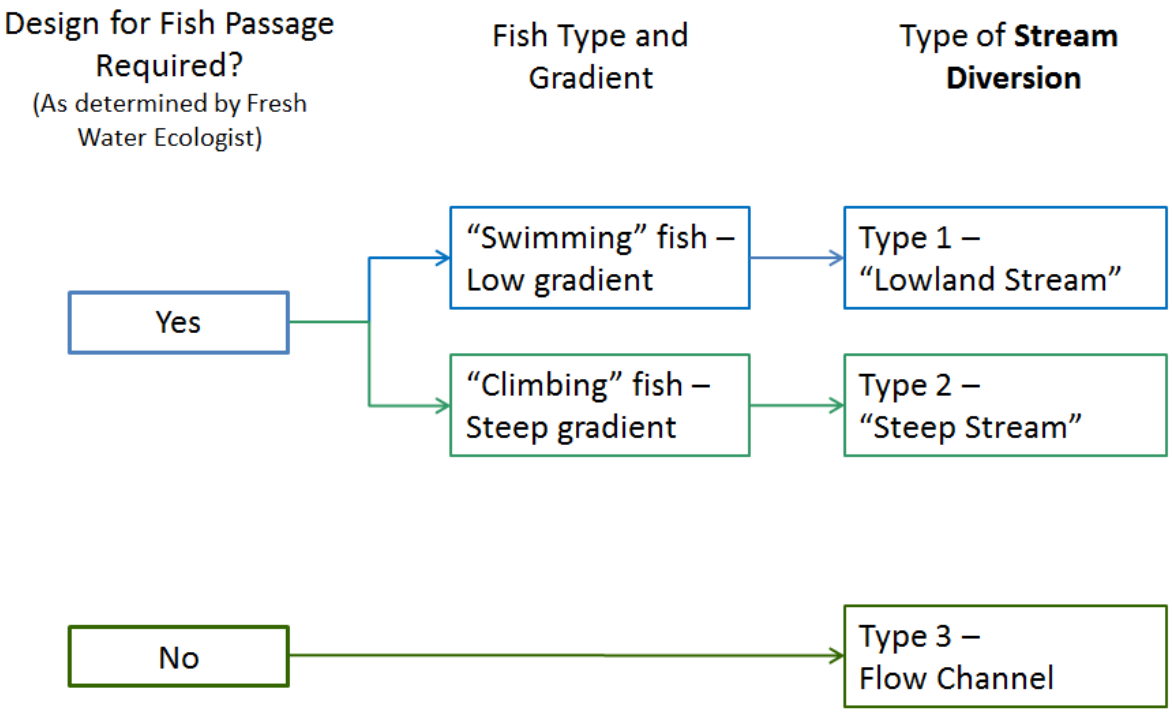

Figure 2: Flow chart for stream diversion type.

Table 7 describes stream diversion requirements for each of the three stream/channel types. These design requirements were developed in collaboration with the Project's freshwater ecologists together with input provided by Hōkai Nuku. Figure 3, Figure 4 and Figure 5 provide typical cross sections of the three types of stream diversions.

Table 7: Stream diversion requirements.

	STREAM DIVERSION TYPE		
Requirement	**1** **Lowland Stream**	**2** **Steep Stream**	**3** **Flow Channel**
Flow	• Flood conveyance of 100 year ARI rainfall event with stop bank if required; • Low flow channel; • Main channel for the 2 year ARI event; • Flood berm for larger events; and • Maintain velocity to mitigate ponding and stagnant water.	• Flood conveyance of 100 year ARI rainfall event; • Low flow channel; • Main channel for the 2 year ARI event; and • Flood berm for larger events.	Flood conveyance of 100 year ARI rainfall event.
Channel Stability	Stable for 2-year ARI floods.	Stable for 2-year ARI floods.	Stable for 100-year ARI floods, lined as appropriate to achieve stability (e.g. grass or rock lined).
In-stream Habitat	• Low continuous gradient; • Meanders; • Complexity (variety of logs and rocks that change flow patterns and provide resting places); and • Continuous low flow channel.	• Steep gradients; • Pools and cascade sequences; • Complexity (variety of logs and rocks that change flow patterns and provide resting places); and • Continuous wetted surface for climbing species.	No requirement for in-stream habitat.

	STREAM DIVERSION TYPE		
Requirement	**1 Lowland Stream**	**2 Steep Stream**	**3 Flow Channel**
Riparian	• Replicate the existing environment as much as possible; • Riparian zone to be 10-20m on either side of the stream edge. Riparian zone to be a heterogeneous planting regime, which reflects what is existing. Planting to be species found in the Rodney Ecological District. Planting to replicate lowland and Steep streams in accordance with Drawings SW-401, SW-402 and SW-403 respectively; • Recovery of plants and re-planting is encouraged; • Provide a bat-friendly corridor by inclusion of puriri and taraire trees; and • Establish a closed canopy cover early.		No requirement for riparian planting.

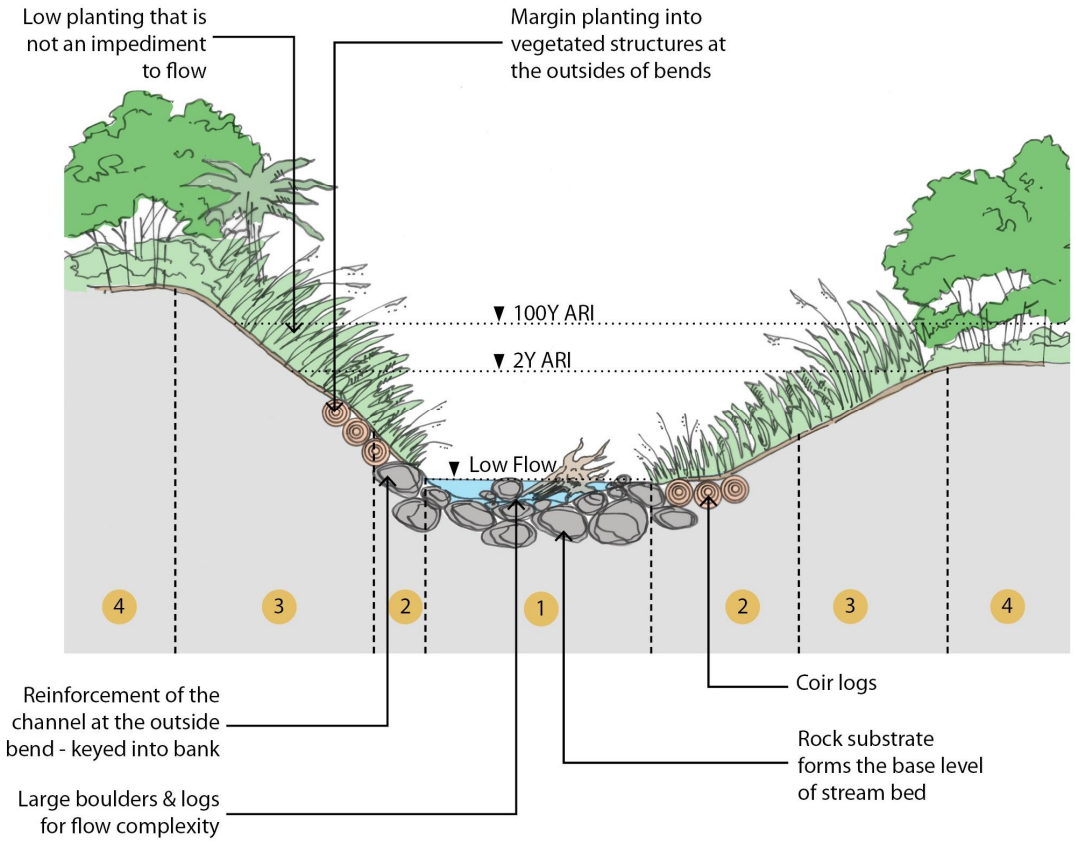

Figure 3: Stream diversion Type 1 – Lowland stream cross section (extract from Drawing SW-401).

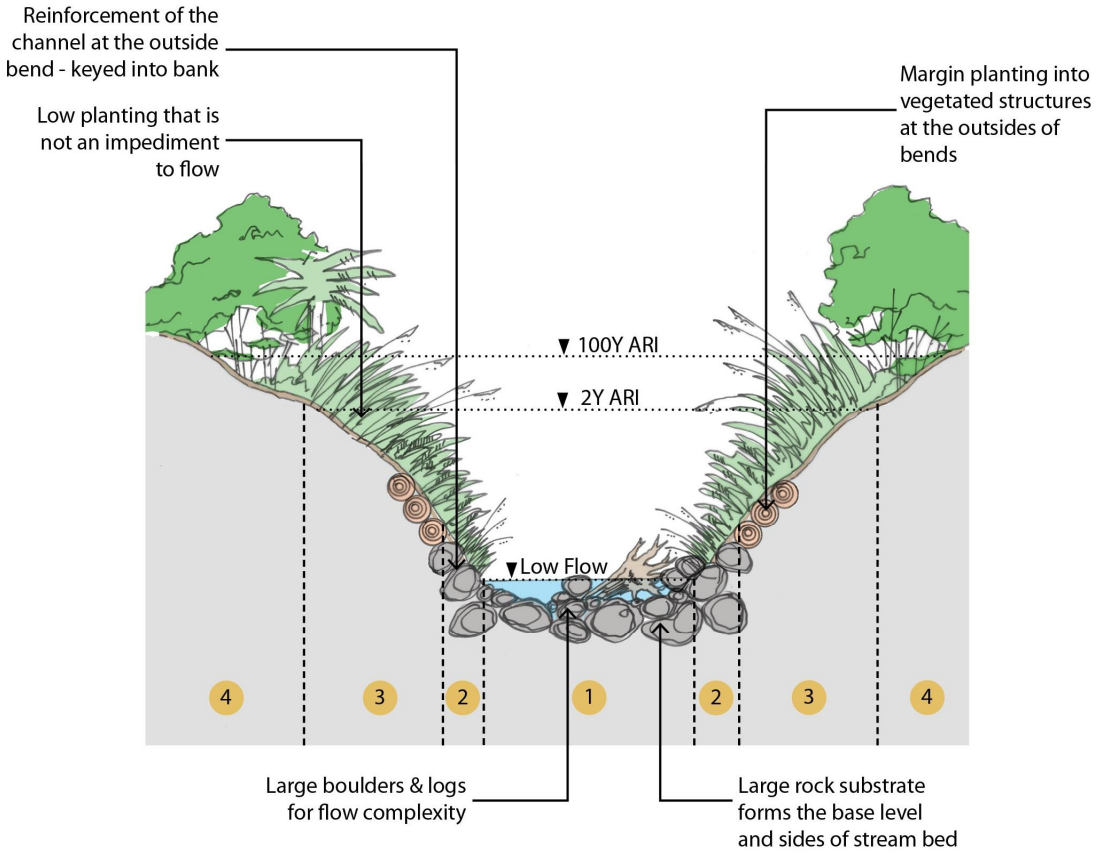

Figure 4: Stream diversion Type 2 – Steep stream cross section (extract from Drawing SW-402).

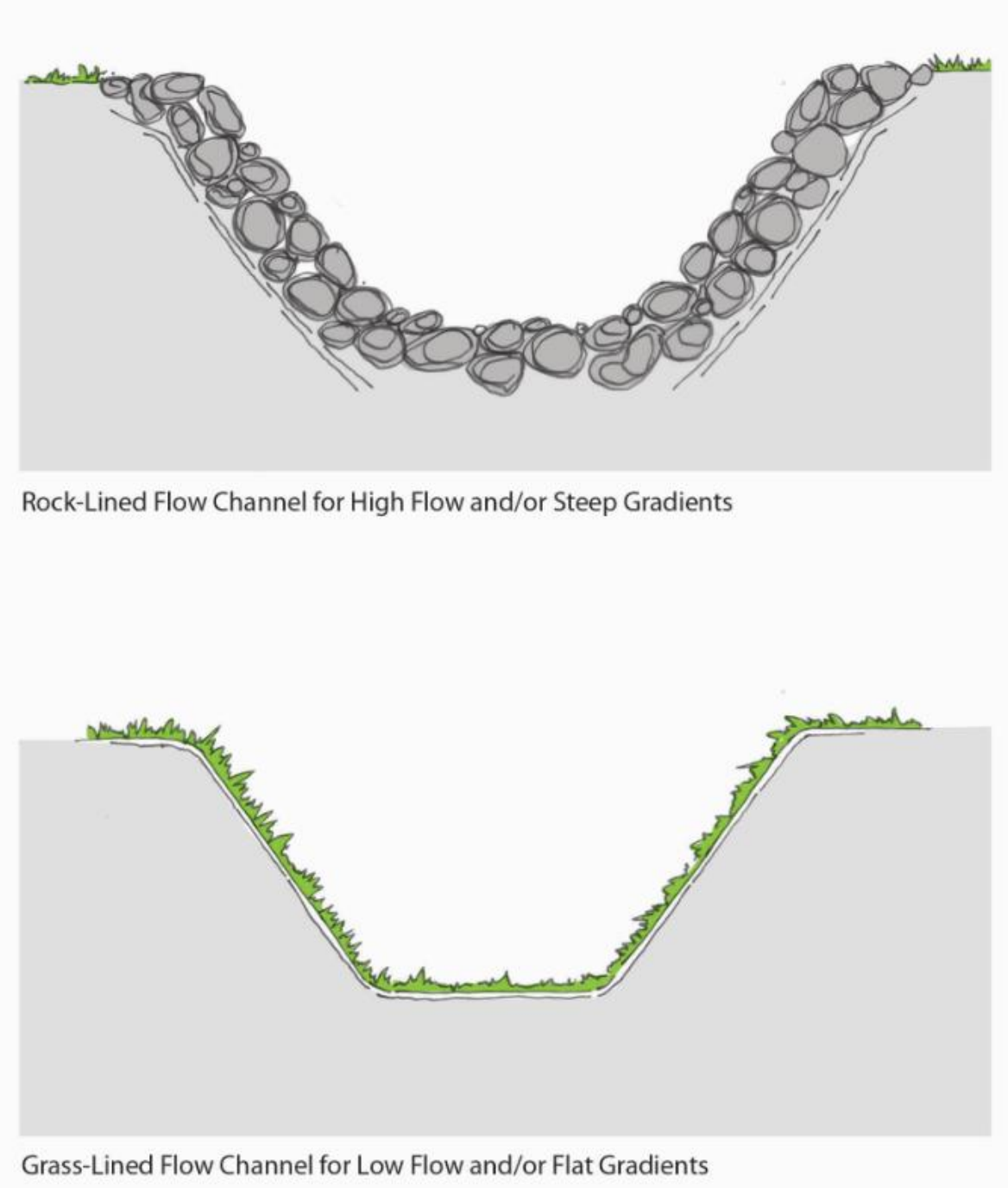

Figure 5: Stream diversion Type 3 – Flow channel cross section (extract from Drawing SW-403).

6. References

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