21. Operational water management

An Operational Water Assessment Report has been prepared for the Project, which provides an assessment of the environmental effects of the Project, specifically those effects arising from motorway stormwater management and stream works. Effects on water in relation to erosion and sediment control and the construction phase of the Project are the subject of a separate report and are summarised in Section 10 of this AEE. Other effects relating to water are also included in Sections 11 (Freshwater ecology) and 19 (Hydrogeology) of this AEE.

The Operational Water Assessment Report describes the Project's operational water systems, including the permanent stormwater management systems and modifications to streams and flood plains necessary for the operation of the motorway. The approach to operational water management has been to minimise effects by designing mitigation measures into the Project based on a BPO approach. The extent of the mitigation measures discussed in the Report is based on consideration of the sensitivity of the receiving environment and the assessment of any potential unmitigated effects.

The following is a summary of the issues and potential effects identified in the Operational Water Assessment Report. This summary and the Report subsequently inform the recommended mitigation contained in Section 28 and will inform the Project conditions.

21.1 Operational water systems

Figure 21-1 provides an overview of how water will be managed during throughout operation 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. Rainfall onto adjacent areas is diverted away from cuts and the motorway. Streams that intersect the motorway alignment are conveyed via a culvert or crossed by a bridge. In limited circumstances (not shown in Figure 21-1) the motorway fills occupy floodplains.

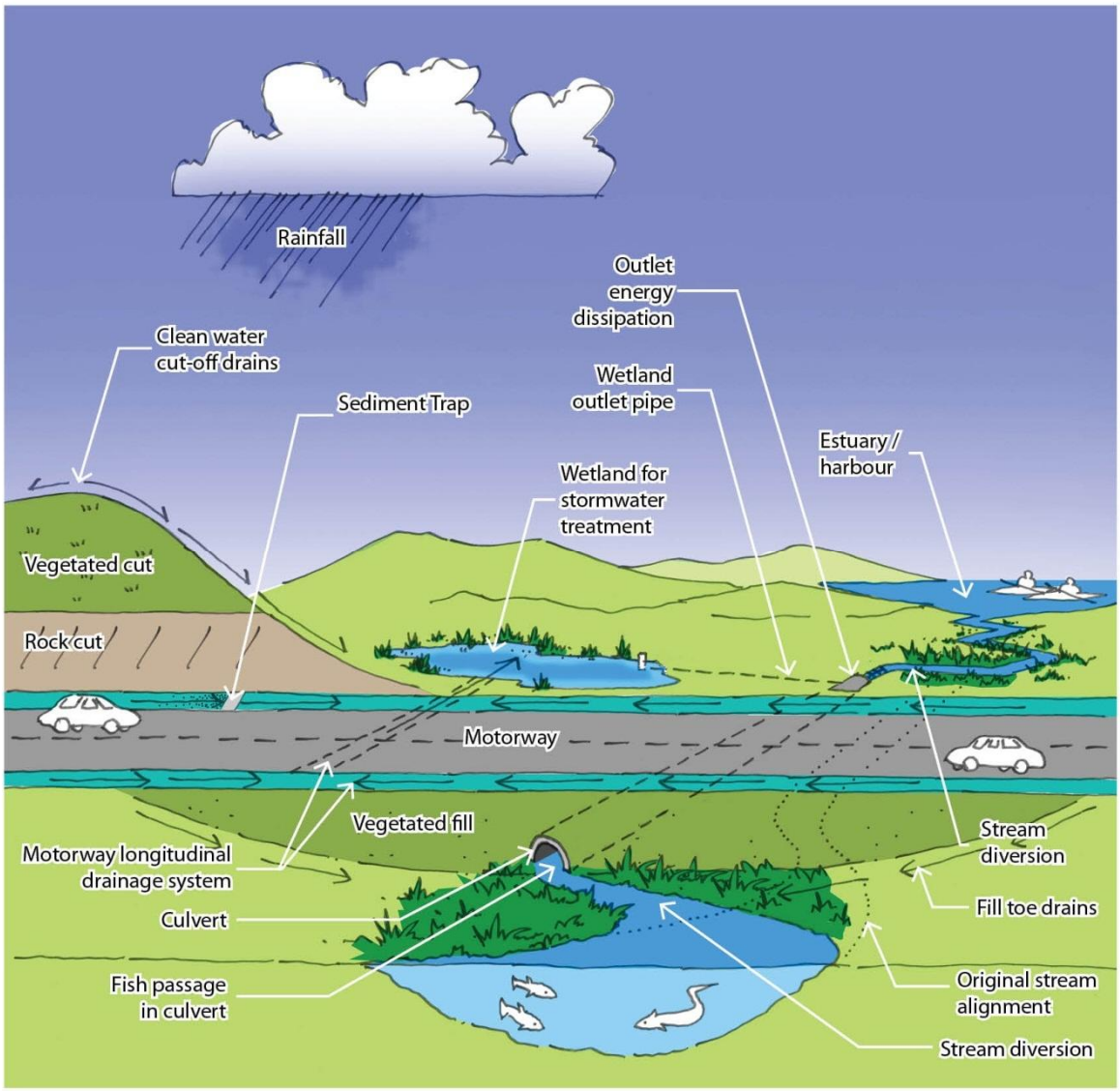

Figure 21-1: Motorway operational water systems and the environment

The proposed operational water systems for the motorway include measures designed to minimise adverse effects on receiving environments.

Stormwater collected in motorway drainage systems will be conveyed by drains, swales or pipes to constructed wetlands for treatment prior to discharge to the natural environment. Wetlands are the preferred stormwater treatment device and 27 are potentially required for the Project. Sediment traps will also be installed to provide initial capture of sediment generated from rock cuts upstream of the wetlands.

The constructed wetlands have been designed to achieve:

- Treatment of all runoff from the motorway for 75% TSS removal; and

- Extended detention for most areas of the motorway to reduce the potential for erosion of streams. However, extended detention is not required in four locations where the Project discharges to the Pūhoi Estuary.

The Project proposes seven large viaducts and five bridges along the indicative alignment. Nine of these structures cross streams or rivers. Two structures (Woodcocks Road Viaduct and the Carran Road Flood Relief Bridge) span the lower Mahurangi floodplain and have been designed to minimise effects on the floodplain.

The Project also proposes 40 culverts, three of which will be concrete arch culverts. The total length of culverts is approximately 1,120m for permanent streams and approximately 3,050m for intermittent streams. Energy dissipation and erosion control will be provided for all stormwater outfalls. Fish passage is provided in all but two culverts for permanent streams with upstream habitats (post-development). The two exceptions are where required upstream drop structures create a barrier to fish passage. Fish passage is provided in culverts for all intermittent streams where the Freshwater Ecology team has identified potential for fish habitat upstream. Refer to Section 7 of the Freshwater Ecology Assessment Report for information regarding fish passage for diadromous species.

A summary of the proposed culverts and bridge structures is included in Section 3.2 of the Operational Water Assessment Report and in Drawings S-121 to S-111 and SW-101 to SW-307 (refer Volume 4).

The stream diversions are characterised into three typologies with approximate total lengths as follows:

- Stream Diversion Type 1: Lowland Stream with estimated length = 1,500m;
- Stream Diversion Type 2: Steep Stream with estimated length = 1,575m; and
- Stream Diversion Type 3: Flow Channel with estimated length = 4,695m.

Type 1 and Type 2 are natural stream forms that replicate the stream bed morphology and the flow hydraulics of the natural stream being diverted and are proposed for permanent streams that support fish habitat and also for intermittent streams where there is potential for fish habitat upstream[122]. Type 3 provides only for flow requirements. Refer to Drawings SW-401 to SW-403 for further details of stream diversions.

21.2 Existing environment

The Project traverses the Pūhoi and Mahurangi catchments, as shown in Figure 21-2. The Project area is largely characterised by steeper rolling hill country with interconnected ridge and valley systems in the central Sectors. The terrain changes to low undulating country in the northern parts of the Mahurangi catchment. Moirs Hill Road represents the approximate divide between the Pūhoi and Mahurangi catchments.

[122] Based on the Freshwater Ecology Assessment Report

21.2.1 Catchment descriptions

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, its Left and Right Branches, and ultimately the Mahurangi Harbour. The indicative alignment crosses a mixture of permanent and intermittent streams and rivers, varying from natural streams with good riparian vegetation to farm drains. The streams have rock outcrops in places, but also consist of soft bottom streams.

Refer to Sections 4.2, 10.4, 11.1 and 19.1 of this AEE for a description of the catchments and existing water environment within the Project area.

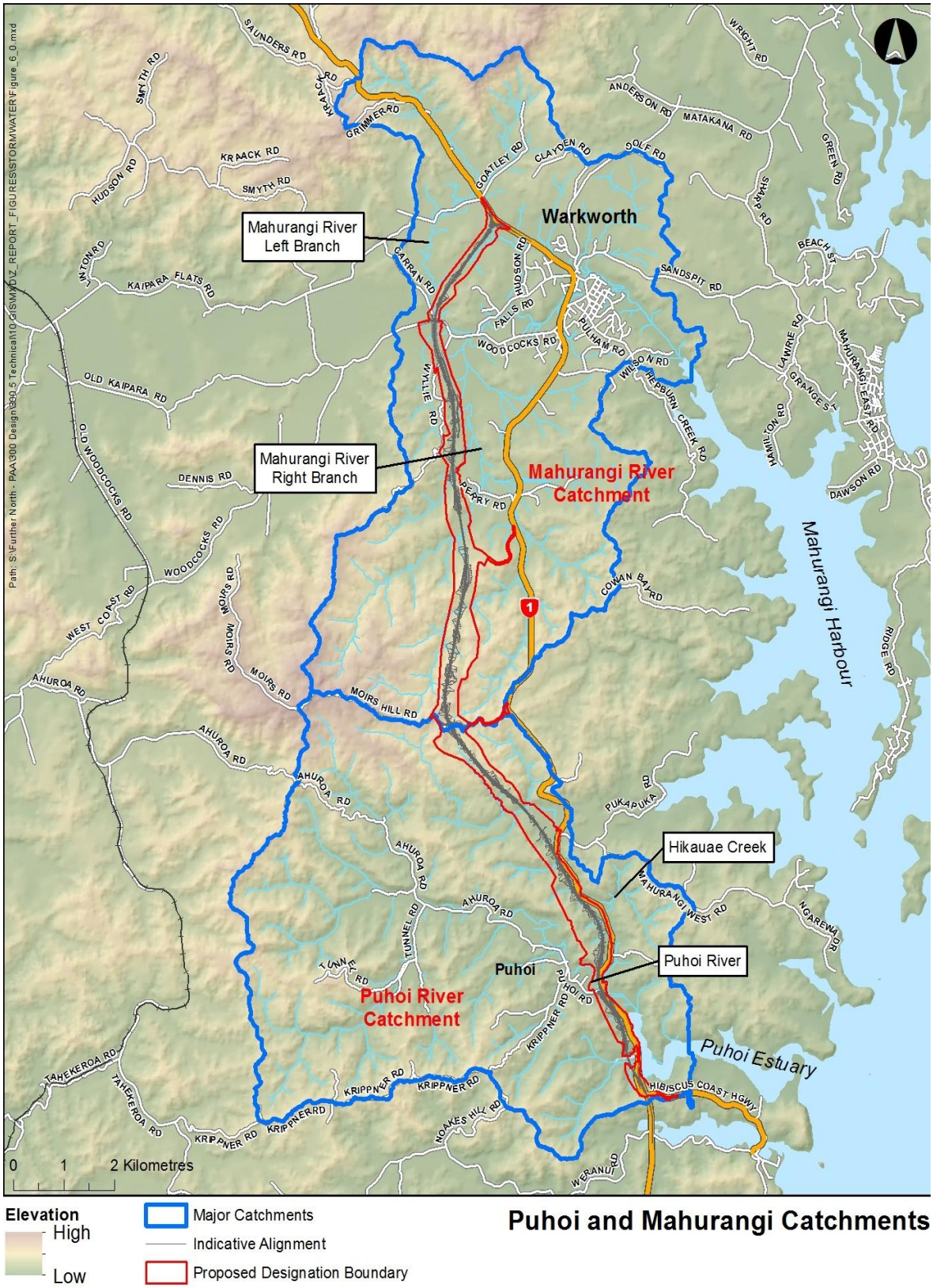

Figure 21-2: Catchments and key watercourses in the Project area

21.2.2 Flooding

Flooding is an existing issue in the lower Mahurangi catchment, including in parts of Warkworth. Auckland Council is developing flood management models for the Mahurangi and Warkworth area to define hazards and to plan for mitigation options. The Water team used this initial data from Council to identify areas of flooding within the Project area.

The key areas of flooding that interact with the Project are as follows:

- Mahurangi River Left Branch in the vicinity of Woodcocks Road; and
- Secondary flow path from Mahurangi River Left Branch up the flat valley to the north following the indicative alignment. The secondary flow path has depths up to 3m with water levels grading from 35.5m RL to 35m RL at the north and it is estimated to convey a peak 100 year ARI flow of approximately $90m^3/s$. The secondary flow path flows north before returning via the Hudson Road area to the Mahurangi River downstream of Falls Road. During normal flows the farm drains in this area flow both north and south. Essentially the secondary flow path conveys flood flow out of the Mahurangi River Left Branch into an adjacent sub-catchment and back into the Mahurangi River.

The Water team reviewed Auckland Council GIS data showing the extent of flooding in a 100 year ARI rainfall event in the Pūhoi catchment. Flooding in the Pūhoi catchment is not a concern for the Project due to the limited works proposed in proximity to the Pūhoi River. The Pūhoi Viaduct will span the river and floodplain. The viaduct is significantly larger than the existing SH1 bridge across the river and therefore will not impact on flooding. Similarly, the proposed Okahu Viaduct will not impact on flooding.

The 100 year ARI floodplain for both the Pūhoi and Mahurangi catchments is shown on Drawings SW-101 to SW-115 Volume 4.

21.2.3 Water quality

Water quality in the Project catchments is discussed in in Section 4.4 of the Operational Water Assessment Report.

21.2.4 Existing catchment uses and values

The existing and potential uses and values of the Project catchments and estuarine and harbour catchments are shown in Table 21-1 and Table 21-2 below.

Table 21-1: Existing freshwater catchment land uses and values

Value or use	Details
Aquatic ecology	The nature of the existing freshwater ecology and the assessment of effects of the Project on aquatic ecology, are provided Sections 5 and 6 and 7 respectively in the Freshwater Ecology Assessment Report. The in-stream water quality is a significant control on aquatic ecology. As such, water quality has been compared to guideline values intended to protect aquatic ecology values.
Cultural values	Cultural values include use of freshwater resources for food and their general cultural history and significance. These matters are covered in the Cultural Assessment Report.
Stock watering	Stock watering is provided in the catchment through direct stock access to waterways or through stock watering systems reticulated from streams. Stock water takes from surface waters would generally be permitted activities so no consents would be held.
Irrigation	Irrigation activities include horticulture and small scale pasture irrigation. No resource consents exist for irrigation from surface water within the Project area. The only consent for irrigation in the Mahurangi catchment is for irrigation of a 1.5 ha nursery, where water is taken from a tributary that will be unaffected by the Project (consent 21828). Permitted takes for small scale irrigation may however be undertaken in areas the Project could affect but no records are kept by AC to determine whether any exist or not.
Aquaculture	Genesis Aquaculture fish farm is located within the Mahurangi catchment and takes water from a tributary of the Mahurangi adjacent to the fish farm and downstream of the proposed Kauri Eco Viaduct.
Water supply from surface water	As discussed previously, Watercare holds consent for the take of surface water from the lower Mahurangi to provide for the Warkworth town water supply. Watercare holds consent for the taking of surface water (from the River) and another recently acquired consent for the taking of ground water. It is in the process of developing a water supply bore. Watercare anticipates the bore will be in operation from 2016 It is envisaged the bore will be the primary water supply for Warkworth and the surface water will be a back-up supply, but the bore is still in development, and therefore the bore source is not guaranteed at this point. No other consented surface water takes are known. However, surface water may be abstracted under the permitted rule.
Recreational activities	Recreational activities include contact recreation, kayaking, fishing and general amenity use of streams from accessible reserve areas. No bathing areas have been identified within the freshwater catchments in proximity to the indicative Project alignment. Many small streams are in private land and are unlikely to be used for contact recreation because they are generally small and shallow. The lower reaches of the Mahurangi and Pūhoi have areas where access can be gained. Occasional informal use of the streams for bathing may occur. There is a popular swimming hole at Falls Road on the Mahurangi River. Kayaking is a popular recreational activity in the lower Pūhoi River Estuary. Fishing may also occur in lower areas of the river and the estuaries. However, no specific data has been identified to indicate whether fishing does occur. Fishing, with the exception of eeling, is less likely to occur in streams higher in the catchment as they are so small. Public access is limited in most of the Hikauae Creek and upper streams of the Mahurangi. The watercourse is visible to property owners and also to the public at bridge locations. The lower Mahurangi has areas within Warkworth where the general public can view the watercourse. The main recreational opportunities occur along the banks of the tidal area of the Mahurangi estuary.

Table 21-2: Existing estuarine and harbour catchment uses and values

Value or use	Details
Marine aquatic ecology	The nature of the existing ecology and assessment of effects of the Project on the marine aquatic ecology are provided in Marine Ecology Assessment Report. The estuarine and harbour water quality is a significant influence on aquatic ecology. As such water quality has been compared to guideline values intended to protect marine aquatic ecology values.
Cultural Values	Cultural values include use of marine aquatic ecology resources for food and the general cultural history and significance of the coast, estuary and harbour. These matters are covered in the Cultural Assessment Report.
Aquaculture	Oyster farms are located in the Mahurangi Harbour and are detailed in the Marine Ecology Assessment Report. There are currently 42 AC resource consents granted for marine farming activities in the Mahurangi. There are no oyster farms or other aquaculture within the Pūhoi estuary.
Other consented activities	Other than the marine farming consents there are few other activities with resource consents associated with the estuarine environments recorded in information provided by Auckland Council. NZTA has consents for some earthworks and coastal reclamation associated with the existing State Highway 1. There is a consent for the network discharge of stormwater from Warkworth and a discharge consent for the Warkworth wastewater treatment plant. The Project activities are not considered likely to affect any of these consented activities.
Recreational activities	Recreational activities include contact recreation, kayaking, boating (motor and sail), fishing and food gathering and general amenity use of coastal areas. The marine areas of the Mahurangi and Pūhoi estuaries are managed for contact recreation with bathing being more common in the lower estuaries. Kayaking is a popular recreational activity in the Pūhoi estuary and also in the Mahurangi estuary and harbour. Other surface based recreational activities such as sailing and boating occur throughout the Mahurangi Harbour. Fishing and gathering of other food (eg shellfish) occurs throughout the Pūhoi Estuary and Mahurangi Harbours. Public access is provided to the Mahurangi estuary with a waterfront walkway in Warkworth town. Access to the shoreline is also possible in many other areas of the Mahurangi Harbour. The estuaries contain the Mahurangi and Wenderholm (in Pūhoi estuary) regional parks.

21.2.5 Existing infrastructure

There is limited downstream infrastructure (such as roading or drainage of water supply infrastructure) that has the potential to be affected by the Project.

In the Mahurangi catchment there are bridges on Perry Road, Woodcocks Road, SH1 and Elizabeth Street, and a ford at Falls Road, which are all remote from the Project.

In the Pūhoi catchment there are culverts on the existing SH1 downstream of the indicative alignment in the Pūhoi and Hungry Creek Sectors. Details of these existing culverts are provided in the Operational Water Assessment Report.

Water is taken for supply for Warkworth by Watercare and used for aquaculture by Genesis Aquaculture. There may also be other users operating under the permitted activity threshold.

21.3 Assessment criteria and considerations

The assessment criteria and conditions applying to the Operational Water Assessment Report are based on the requirements of the RMA, ARP:ALW, the ACDP (Rodney Section), relevant Auckland Council guidelines and the NZTA policy, standards and guidelines. Assessment matters relevant to operational water management include:

- The BPO approach;
- Stormwater quantity, including attenuation, bed/channel disturbance, erosion control at stormwater outfalls and overland flow;
- Stormwater quality, including water quality treatment, aesthetics and odour and sediment discharge;
- Human impacts, including human health and amenity and water users;
- Ecological impacts, including protection of aquatic ecosystems and habitat, effects of piping/culverting and fish passage; and
- Flooding.

These assessment matters establish the framework for the assessment of effects relating to operational water management. Refer to Section 5.5 of the Operational Water Assessment Report for further detail on assessment matters.

There are 417 regional consents, including stormwater discharge consents, in the Mahurangi and Pūhoi catchments. The NZTA holds 66 of these consents for stormwater discharges, earthworks, coastal structures, reclamation, stream works and bores. The NZTA holds a number of relevant consents for the diversion and discharge of stormwater for the NGTR (including the Johnstone's Hill tunnels and the northern portal area), Titfords Bridge and the turnaround area at the SH1 toll booth. The NZTA also holds consents for culverts that will be affected by the Project at the Hungry Creek passing lane (Pūhoi catchment) and Twin Streams (Mahurangi catchment).

The consents relevant to the potential effects of discharges to water from the Project are:

- A consent held by Watercare for the supply of the Warkworth water treatment plant from the Mahurangi River at Warkworth; and
- Resource consents for 42 marine aquaculture activities in the Mahurangi Harbour. Section 3.1.2 of the Marine Ecology Assessment Report provides further information regarding the nature and locations of these activities.

With the exception of the Watercare surface water abstraction on the Mahurangi River, there are no consented surface water abstractions on watercourses within the Pūhoi or Mahurangi catchments that could be affected by the Project.

Surface water abstractions within the permitted activity thresholds of the ARP:ALW have not been considered as part of the Operational Water Assessment Report. The permitted surface water abstraction rule in the ARP:ALW allows for the taking and use of no more than $5m^3$/day of water from a river, stream or spring, subject to the relevant permitted activity conditions. No information on permitted users is available from Auckland Council. For purposes of their assessment the Water team assumed that surface water is taken by Genesis Aquaculture as a permitted activity for the fish farm.

The Operational Water team identified that there is a pending Auckland Council consent in process for revised stormwater network discharge consent for Warkworth township.

Further information regarding existing consents is contained in Section 5.4 of the Operational Water Assessment Report.

21.4 Methodology

The Operational Water team applied the following methodologies throughout the design of the Project's operational water systems and for the assessment of related effects:

- Designing stormwater treatment devices based on TP10;
- Assessing stormwater quality aspects using the water quality datasets for the catchments, stormwater contaminant concentrations from motorway studies and the Auckland Council Contaminated Load Model;
- Designing and assessing stormwater quantity aspects based on the TP108 method and the XP- SWMM[123] model;
- Designing and assessing culverts using the TP108 method and HY-8 culvert model for culvert sizing, HEC14 for energy dissipation design and assessment of velocity changes, and TR 2009/084[124] for fish passage design; and
- Assessing flooding aspects from the motorway footprint using the Auckland Council rapid flood hazard model.

21.5 Mitigation measures in Project design

The Project includes mitigation measures within the proposed operational water systems. These measures are incorporated into the Project to mitigate any potential adverse environmental effects associated with stormwater management and stream works. The Operational Water team developed these mitigation measures through the assessment of a number of potential options and the selection of a BPO for avoiding, remedying or mitigating effects. Mitigation measures are also included for key areas of risk.

In this consenting phase, the recommended mitigation aims to provide flexibility for designers and contractors in subsequent phases of the Project. This flexibility allows for alternative and innovative designs to meet or exceed the stormwater management objectives, and can react to and account for design changes that may result from design refinement.

Specific measures for stormwater treatment and stream works, including bridges, culverts and diversions, are discussed in the following sections.

[123] XP Solution Storm Water Management Model (software) refer Section 6.2.1 of the Operational Water Assessment Report.

[124] Refer Section 8.5.3 of the Operational Water Assessment Report.

21.5.1 Stormwater treatment systems

For stormwater systems, the BPO approaches include:

- Stormwater treatment for all of the motorway and cut slopes by wetlands to remove sediment and contaminants from the runoff;
- Stormwater treatment for rock cuts with sediment traps for near source capture of additional sediment prior to wetlands; and
- Stormwater outfalls with erosion protection to minimise erosion.

In addition to the measures listed above, permanent planting will be adopted to stabilise slopes following construction. Early stabilisation will be implemented, as discussed in the Construction Water Assessment Report. The Landscape and Visual Assessment Report and Terrestrial Ecology Assessment Report refer to the need to provide a proper vegetation cover following the construction of the Project.

The Operational Water team used the BPO approach to determine the most appropriate stormwater treatment devices based on the options in TP10. The BPO assessment described in Section 7 of the Operational Water Assessment Report concludes that constructed wetlands are the preferred stormwater treatment devices due to the overall water quality treatment achieved and their ability to provide attenuation.

Constructed wetlands perform well as treatment devices by removing a range of contaminants and have advantages over ponds due to increased filtering and biological treatment performance. The treatment features of wetlands include:

- Settling of suspended solids;
- Uptake by wetland plants of nutrients and soluble metals;
- Filtering of particulates and absorption of nutrients and trace elements by wetland plants;
- Organic bottom sediments providing nitrification / dentrification (transformation and loss of nitrogen);
- Evaporation of (volatile) petroleum compounds; and
- Trapping of gross pollutants.

Wetlands limit temperature increases better than ponds, mainly because the vegetation protects the water from light penetration. Temperature changes can provide direct stresses on aquatic species and also make nutrients in sediments more susceptible to algal growth. Compared to other treatment devices available, wetlands incorporate low impact design principles, have low maintenance requirements, low whole-of–life costs, and provide visual amenity and are a better habitat for wildlife.

Constructed wetlands for the motorway will be densely planted to maximise the treatment effectiveness. A staggered series of depths will be used to increase the wetland vegetation, and planting will be in accordance with Auckland Council and NZTA standards.

Wetland outfalls will be sized to convey the 100 year ARI flow rate and will incorporate erosion protection measures to minimise bed scour and bank erosion in the receiving watercourse. Typically this protection will be through an energy dissipation device and/or rock aprons.

The Operational Water team proposes sediment traps in the drains at the base of cut faces as an extra treatment measure. These sediment traps are bespoke treatment devices that will capture sediment generated from rock cuts. The sumps will be used as additional treatment devices upstream of wetlands.

The Operational Water team proposes clear water cut-off drains at the top of all cut faces where flow from above would otherwise flow over the downstream cut face. These drains will reduce erosion on cut faces by intercepting clean water flow. Vegetation cover on cut and fill slopes and the capture and treatment of runoff from cut slopes will assist in minimising and controlling sediment generation.

The Operational Water team considers that vegetated roadside drains are the BPO for treatment of runoff for existing low traffic ancillary roads that will be constructed or upgraded as part of the Project. These include the proposed access road off Wyllie Road, the access road to the Perry Road Viaduct, upgrades to Moirs Hill Road, and roads associated with underpasses. The primary function of vegetated roadside drains is to capture runoff. However, research has shown that they are effective at TSS removal and achieve high removal rates for particulates, total copper and zinc through filtration and infiltration.

21.5.2 Stream works

For works associated with streams, the BPO approaches include:

- Bridge or viaduct structures over nine river / stream crossings;
- Culverts for other stream crossings;
- Fish passage at culverts where the freshwater ecologists identified freshwater habitats with the exception of two culverts in the Carran Road sector;
- Energy dissipation measures at all culverts to minimise erosion;
- Ecological features included in stream diversions to restore stream and riparian habitats where the freshwater ecologists identified freshwater habitats;
- A risk framework to assess the risk from debris and determine mitigation measures such as larger culverts and debris racks for culverts at high risk and relief inlets for culverts at moderate risk; and
- Alignment of the motorway to avoid the floodplain and minimise hydraulic effects where it is necessary to cross floodplains with bridges.

(a) Bridges

Bridges are proposed as the BPO for seven stream crossing locations. These locations and the key considerations at each site are shown in Table 21-3.

Table 21-3: Overall design considerations and BPO assessment for bridges

Bridge name	Consideration
Okahu Viaduct	• Estuary crossing • Moderate size catchment • Desire to avoid reclamations and effects on estuary • Combined crossing of Billing Road driveway • Height and length crossing (vertical grade from Johnstone's Hill Tunnels) • Prestressed concrete box girder has 75m spans which reduce the piers and construction activity in water • Reduced impact on Te Pā o Te Hēmara Tauhia at the southern abutment
Pūhoi Viaduct	• Significant river crossing (design flow too high for culvert) • Desire to avoid reclamations • Major road crossing (Pūhoi Road) • Height and length of crossing • Good crane access available from flat terrain, concrete box girder gantry launching not required
Hikauae Viaduct	• Minor creek crossing • Hikauae access track required to private residence
Schedewys Viaduct	• Major river crossing • Height and length of crossing • Geotechnical conditions make embankment unsuitable • Prestressed concrete box girder has 75m spans reduced piers in rolling terrain
Perry Road Viaduct	• Major river crossing • Height and length of crossing • Height and length crossing geotechnical conditions make embankment unsuitable
Kauri Eco Viaduct	• Major river crossing • Height and length of crossing • Kauri natural forest in area
Wyllie Road Overpass	• Passing over local road
Woodcocks Road Viaduct	• Major river crossing and floodplain – Mahurangi River Left Branch • Road crossing
Carran Road Flood Relief Bridge	• Major secondary flow path • Stock access incorporated

Bridge name	Consideration
Minor Bridge – Property access road	• Stream crossing • Natural bush area conserved by minor bridge structure

Where possible, bridge and viaduct piers are positioned outside of watercourses to:

- Reduce impacts of working within a watercourse during construction;
- Reduce potential scour of the riverbed; and
- Minimise the need for abutments and piers being located within the CMA.

(b) Culverts

Culverts represent the BPO for 40 stream crossings where they meet the following conditions:

- Culverts have sufficient capacity for the design flows and satisfy the relevant sizing criteria;
- Flooding effects from predicted afflux (rise in water level on the upstream side of a bridge/culvert) are acceptable;
- Environmental requirements such as fish passage, erosion control and energy dissipation are met; and
- Debris and sediment transport is managed.

The horizontal and vertical alignments of the culverts have been designed to limit their environmental impacts. In general, the culverts will be concrete pipes. Larger concrete arch culverts are proposed for three crossings of main tributaries of the Mahurangi River because the design flows are too large for concrete pipe culverts. Special features of the concrete arch culverts include:

- Arch to achieve sufficient cross-section areas to meet the flow capacity and debris mitigation requirements;
- Racks upstream of the arch entrance to mitigate the risk of blockage by intercepting logs and other debris;
- Natural bed for fish passage; and
- Maintenance access through the culvert.

Refer to Drawings SW-201 to SW-203 Volume 4 for indicative design of culverts for the Project.

Fish passage in culverts has been provided for permanent streams with upstream habitats, and for intermittent streams where there is potential for fish habitat upstream. The only exception is two streams in the northern valley area of the indicative alignment, where upstream drop structures required due to geometric constraints mean that the provision of fish passage is not possible. The identification of these streams and the effect of no fish passage for two culverts were undertaken by the Freshwater Ecology team and are documented in the Freshwater Ecology Assessment Report.

Figure 21-3 shows the process for determining the type of fish passage required for the 40 culverts. Refer to Section 7.7 of the Operational Water Assessment Report for a description of the types of fish passage incorporated into culvert design.

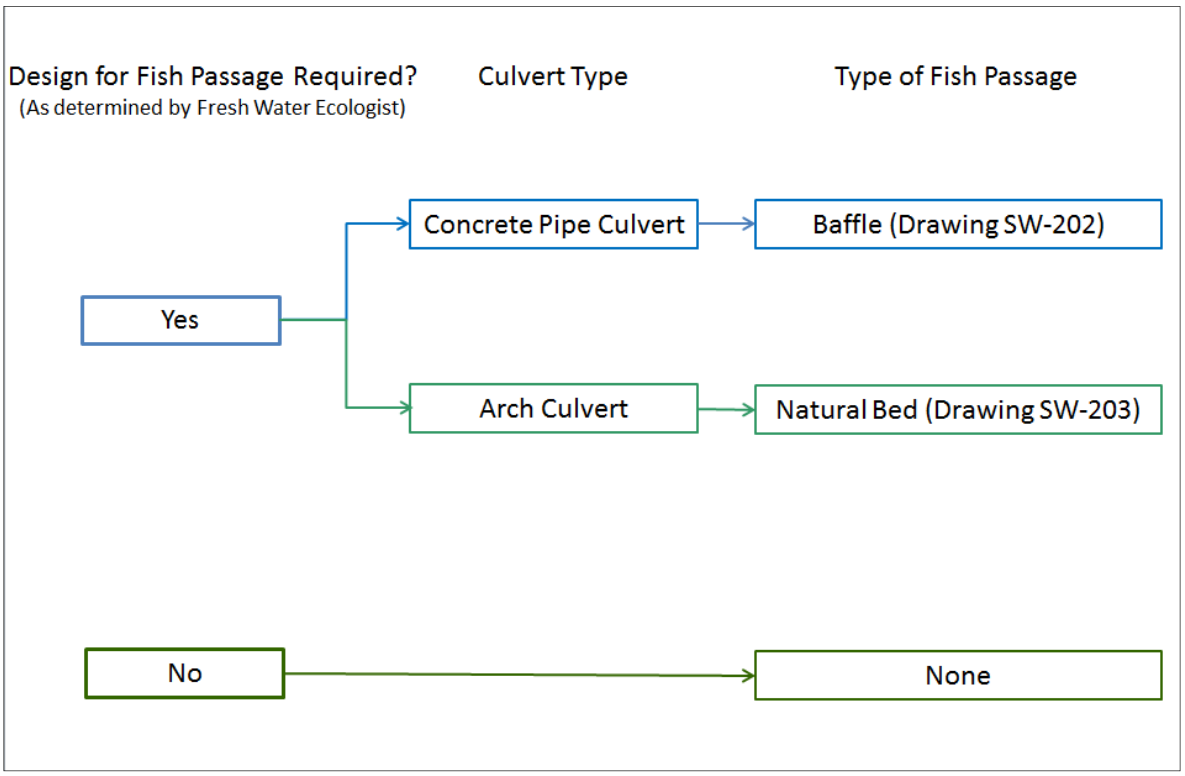

Figure 21-3: Flow chart for fish passage

The Operational Water team assessed all culvert flows and velocities and assigned energy dissipation structures to ensure that downstream erosion potential is minimised. These structures are discussed in Section 7.7.3 of the Operational Water Assessment Report and indicative design for culverts is shown in Drawings SW-201 to SW-203 in Volume 4.

Debris control measures have also been incorporated into culvert design where there is a high or moderate risk of debris blockage. The Operational Water team used a risk framework to assess the risk to culverts from debris sand determine mitigation measures for inclusion in the Project. This framework is discussed in Section 7.8 of the Operational Water Assessment Report.

(c) Overland flow paths

Culverts, bridges or stream diversions will convey flows for permanent and intermittent streams up to the 100 year ARI peak flow.

Identified floodplains and major secondary flow paths in the Carran Road Sector will be crossed with bridges designed to convey the 100 year ARI flood event.

All constructed wetlands will be designed during the detailed design phase so that local overland flow will be diverted away from the wetland. Each wetland will be located off-line. Additional clean water cut-off drains will be constructed above the new motorway to prevent overland flow from entering the Project.

(d) Stream diversions

The Project will require a number of stream diversions. The extent to which diversions of main streams are required has been minimised through the overall route selection and the development of the indicative alignment. However, diversions are required:

- Where fill and spoil sites impinge on streams and/or flow channels; and
- Where proposed culverts are built off-line and require a diversion to and from the natural stream to convey the flow.

The Operational Water team determined the most appropriate type of stream diversion for different stream types using a BPO approach based on fish passage criteria. Figure 21-4 shows how the most suitable type of stream diversion was selected.

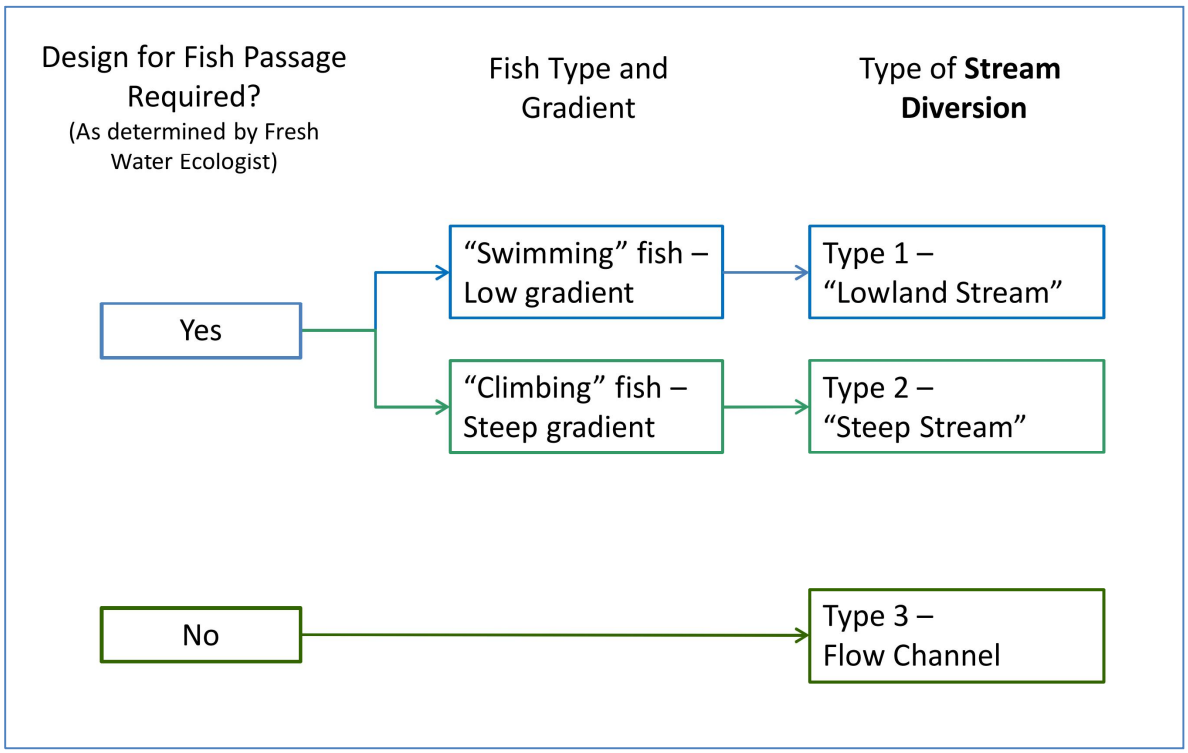

Figure 21-4: Flow chart for selection of stream diversion type

Additional considerations and requirements for stream diversion Types 1, 2 and 3 are discussed in Section 7.10 of the Operational Water Assessment Report. Refer to Drawings SW-101 to SW-115 Volume 4 for locations and details of stream diversions.

(e) Flooding

The Carran Road Sector is a key area for flooding as the motorway crosses the Mahurangi floodplain at the Woodcocks Road Viaduct, and again crosses a major secondary flow path between Woodcocks Road and SH1. The BPO approach was to minimise the effects of flooding in these areas by changing the indicative alignment to avoid the floodplain where possible, and by

using bridges to cross the floodplain where necessary to mitigate those adverse effects where avoidance was not possible.

In response to rapid flood hazard modelling undertaken by Auckland Council to determine flood hazards the indicative alignment was moved to a position further north-west to avoid the floodplain in this area. The Carran Road Flood Relief Bridge has been designed to pass the 100 year ARI flood with a maximum afflux of 100mm, where the indicative alignment crosses the secondary flow path. A 60m span Carran Road Flood Relief Bridge is the BPO that is considered to provide an acceptable afflux (less than 100m). The flooding effects are partly mitigated by these avoidance and mitigation measures incorporated in the Project, but the residual effects remain minor to moderate (refer to Section 21.6.5 below).

The hydraulic sizing of both the Carran Road Flood Relief Bridge and the Woodcocks Road Viaduct will be refined during detailed design when further hydraulic modelling will be carried out.

21.6 Assessment of effects

The Operational Water team assessed the effects of the Project based on the design that incorporates BPO measures to avoid, remedy and mitigate effects. Overall, the Team considers the residual operational water effects of the Project to be negligible to minor, with the exception of the flooding predicted where the current design has moderate potential effects.

21.6.1 Stormwater quantity

The assessment of effects in relation to stormwater quantity is summarised as follows:

- Changes in flow, volume and time to peak for the 2, 10 and 100 year ARI events at locations downstream of the Project are predicted to be small and have negligible effect on flooding and infrastructure, which confirms that attenuation of flood flows is not required;
- There are changes in flows in tributaries that result from changes to drainage patterns associated with the motorway. Tributaries that receive flow from the motorway will have an increased flow. The risk of erosion for tributary streams receiving discharges from the motorway will be mitigated by providing extended detention for all wetlands. Meanwhile, in the main branches of the Mahurangi and Pūhoi Rivers the predicted flow changes are no more than 5%;
- The potential effects of the Project on stream bed / channel disturbance will be moderate due to the loss of stream habitat. However, these effects will be mitigated by replacement with natural stream forms and the overall effect will be minor; and
- The effects of the Project on overland flow will be minor as these effects will be mitigated by the use of bridges, culverts and stream diversions.

21.6.2 Stormwater quality

The assessment of effects in relation to stormwater quality is summarised as follows:

- Runoff from all new impervious motorway surfaces and rock cuts for the Project will be captured and then treated by the wetlands whereas there is currently no formal treatment for the SH1;

- Wetlands are an appropriate BPO method for managing the stormwater runoff from the motorway and associated rock and vegetated cuts;
- Wetlands will treat for TSS removal and toxic, persistent and bioaccumulative contaminants;
- Vegetated roadside drains are an appropriate BPO for managing the stormwater runoff from ancillary roads being constructed or upgraded by the Project;
- Water quality will be maintained with the proposed treatment in place;
- Effects from oil, grease films and litter will be negligible;
- Effects of the wetlands and permanent streamworks on the development of foams and scums in receiving freshwater will be minor, and there is no anticipated change in the risk of scums and foams associated with algal blooms in the harbours;
- Contaminant loads associated with the Project are negligible compared to existing loads;
- Marine sediment quality will experience only a minor change (refer to Section 12 of this AEE);
- There may be changes in colour and clarity at discharge locations. However, these changes will be temporary, and are likely to coincide largely with the natural change in colour and clarity that will occur during storm events;
- There will be no effect on the colour and clarity of water in the lower reaches of the Mahurangi or Pūhoi Rivers or in the harbours;
- Effects on aesthetics and odour will be minor; and
- Any physical changes on the surrounding environment from the deposition of sediment will be minor.

21.6.3 Human impacts

The assessment of effects in relation to human impacts is summarised as follows:

- Predicted increases in TSS and contaminants will have a minor impact on the suitability of the Mahurangi River water for potable municipal water supply at Warkworth.
- The effects on Warkworth Town potable supply will be minor with the proposed Warkworth groundwater supply expected to come on line in 2016 and predicted to provide the main potable municipal water supply by 2021;
- Effects on human health and amenity will be minor;
- Effects on stock drinking water quality will be negligible; and
- Effects on water users will be minor.

21.6.4 Ecological effects

A full assessment of ecological effects is provided in the Freshwater and Marine Ecology Assessment Reports and summarised in Sections 5 and 6, and 4 and 5 of those Reports, respectively.

The following points from the Operational Water Assessment Report regarding ecological effects support those assessments:

- Nine stream/river crossings will have bridges and therefore avoid the potential ecological effects of culverts;

- Fish passage in culverts will be provided for all but two permanent streams and in intermittent streams where potential suitable habitat exists upstream; and
- Stream diversion Types 1 and 2 will have a natural form and include riparian planting.

Fish passage is provided in all instances for the Project with the exception of two culverts where drop structures are required at the upstream end. These drop structures create a barrier to fish passage. These drop structures are required because the motorway is in cut or close to the level of the existing ground, which requires a drop at the inlet to the culvert for the culvert to be located at sufficient depth under the road surface.

21.6.5 Flooding

The Operational Water team designed culverts to head up in accordance with the relevant design sizing criteria described in Section 6.7 of the Operational Water Assessment Report. This design approach is standard practice to efficiently convey flow through a culvert.

The headwater extents are generally local and/or within the floodplain of the streams. The only location where 100 year ARI flood headwater extents are predicted to extend beyond the designation is at Culvert 49500 (refer to the SW-101 to SW-115 of Drawings in Volume 4). The headwater floods a major branch of the Mahurangi River for approximately 500m of stream length beyond the proposed designation (measured inclusive of stream meander). No dwellings are affected. The predicted headwater extent is contained within the floodplain of the rapid flood hazard assessment for the area outside the proposed designation, indicating that flooding here is not made worse by the Project.

The Operational Water team assessed the performance of existing SH1 culverts through the Pūhoi and Hungry Creek Sectors in the hydrological model described in Section 6.2 of the Operational Water Assessment Report. Upgrades to three of the existing SH1 culverts will allow conveyance of 100 year ARI flood flows with a minimum of 500mm freeboard.

Overall the Team considers the effects of the Project on flooding in relation to culverts to be minor.

Flooding in the Carran Road Sector is an important consideration for the new motorway. The main issues are the floodplain of the Mahurangi River Left Branch, and the major secondary flow path that spills from the Mahurangi River Left Branch and flows north before returning via the Hudson Road area to the Mahurangi River downstream of Falls Road. The Operational Water team undertook rapid flood hazard modelling for the pre-development and post development scenarios to determine potential effects in relation to flooding in the Carran Road Sector.

Based on the Team's pre-development model results:

- The indicative alignment was moved north-west to avoid the floodplain;
- Woodcocks Road Viaduct (280m span) is provided which crosses the floodplain of the Mahurangi River Left Branch. Whilst flooding is not the sole driver for the span of this viaduct, it has been sized to accommodate the predicted floodplain extent. A key consideration for the detailed design phase is where the southern abutment of the proposed viaduct occupies a small area of the floodplain which may reduce flood conveyance; and

- Carran Road Flood Relief Bridge (60m span) is provided to cross the major secondary flow path. Flooding is the primary reason for the specified span of this bridge as discussed in Section 7.6 of the Operational Water Assessment Report. A key consideration for the detailed design phase is where the approach abutments occupy the floodplain which may reduce flood conveyance.

The results of the Operational Water team's post-development modelling indicate that:

- The indicative alignment north of the Carran Road Flood Relief Bridge is located outside the floodplain, with the exception of where it is necessary to cross it;
- The Carran Road Flood Relief Bridge conveys the secondary flow path, but there is an afflux upstream of the bridge that results in an increase in flood levels of up to 100mm. There is also an increase in flood levels of up to 100mm in the vicinity of the Woodcocks Road Viaduct. The extent of the increase in flood levels occurs along the Mahurangi River until the Falls Road area. The flood levels decrease along the secondary flow path downstream of the Carran Road Flood Relief Bridge;
- The dwelling floor levels at 151 Carran Road and 346 and 372 Woodcocks Road are below the pre-development flood level. The dwellings flood pre-development and the flood level increases by only 30mm, 70mm and 80mm respectively post-development. The Water team considers the effect of these increased flood levels on the dwellings to be moderate;
- At 152 Carran Road, the dwelling floor level is 260mm above the pre-development flood level. The Project increases this flood level by only 50mm. Therefore, the flood level remains 210mm below the floor level of the dwelling. The Water team considers the effect of the increased flood level at 152 Carran Road to be minor; and
- No dwellings in the Carran Road Sector located within the predicted 100 year ARI floodplain, with a floor level above the flood level pre-development, become inundated by a higher flood level caused by the Project.

There is potential during the detailed design phase to improve the capacity of the secondary flow path at the northern end of the alignment, which may enable the proposed Carran Road Flood Relief Bridge span to be reduced.

It has not been possible to provide an alignment that does not occupy the flood storage volume below the 100 year ARI flood level in some areas in the Carran Road sector. However, the BPO to mitigate the effects of this was to move the indicative alignment out of the floodplain north of the Carran Road Flood Relief Bridge, and provide sufficient cross drainage and bridges to allow the floodplain and secondary flow paths to get from one side of the alignment to the other. With mitigation of the effects by BPO, the Operational Water team considers the effects of the Project occupying an area of flood storage volume below the 100 year ARI flood level to be minor.

There may be a slight shift in the frequency at which flood depths occur as a result of the Project ie the pre-development 100 year ARI flood depth will occur slightly more frequently with the Project. This change is expected to be minimal and of minor effect.

Overall, the Operational Water team considers that the Project has a minor to moderate effect on flooding in the Carran Road Sector due to the afflux upstream of the Carran Road Flood Relief Bridge and the increase in flood depth predicted for four dwellings. The flooding effects are partly

mitigated by avoidance and mitigation measures incorporated in the Project, resulting in residual effects due to the increase in flood levels being minor to moderate. Further investigation during the detailed design phase will refine the mitigation measures proposed.

21.7 Overall effects and mitigation

The Operational Water team developed operational water systems for the Project based on a BPO approach that considered alternatives and how to best practically minimise adverse effects on the environment.

Effects on water quality are mitigated by stormwater treatment systems that include wetlands throughout the Project and sediment traps at the base of rock cuts. Vegetated roadside drains are proposed for ancillary roads. Overall, effects on water quality will be minor.

Water quantity effects are mitigated by extended detention systems in wetlands to minimise stream erosion. Overall, the effects from changes to water quantity will be minor.

Human impacts, including effects on the Warkworth potable water supply, amenity, recreation, water users and farm takes, are mitigated by the stormwater treatment systems. Overall, the effects on humans will be minor.

The stream work elements of the Project include bridges over streams, culverts with fish passage and stream diversions with natural stream forms. These measures provide fish passage and restoration of stream habitats. Ecological effects are assessed in detail in the Freshwater Ecology Assessment Report and in Section 11.4 of this AEE.

Flooding effects will be mitigated by designing culverts to convey the 100 year ARI flood. Impacts on the existing floodplain of the Mahurangi Left Branch River are avoided by changing the alignment and mitigated by the Woodcocks Road Viaduct and Carran Road Flood Relief Bridge. Overall, effects in relation to flooding will be minor to moderate.

Based on the Operational Water Assessment Report I support the use of wetlands for stormwater treatment, and the provision of sediment traps and extended detention as an integral component of the Project design. I support the use of extended detention within the wetlands to minimise stream erosion.