ASSESSMENT OF OPERATIONAL WATER EFFECTS FOR THE PŪHOI TO WARKWORTH RONS PROJECT

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ABSTRACT

The Pūhoi to Warkworth Project realigns the existing SH1 from the Northern Gateway Toll Road at the Johnstone's Hill tunnels via an 18.5 km four-lane dual carriageway road alignment that will tie into the existing SH1 north of Warkworth.

An Operational Water Assessment report formed part of a suite of technical reports prepared for the Transport Agency to inform the Assessment of Environmental Effects and to support the Resource Consent applications and Notices of Requirement for the Project.

The Further North Alliance was formed to develop the Transport Agency's applications to the Environmental Protection Authority. The Alliance included the Transport Agency, engineering consultants (GHD and Jacobs SKM) and lawyers (Chapman Tripp), plus a number of expert sub-consultants. The Alliance proved to be a vibrant working environment where an extremely demanding timeframe demanded efficient and innovative approaches to ensure sufficient assessment of effects were satisfactorily carried out.

A variety of measures to avoid, remedy or mitigate adverse environmental effects were designed into the Project's operational water systems based on a best practicable option approach. The mitigation measures were determined through a robust evaluation of options and drawing on the collective knowledge and experience within the Alliance.

The operational water aspects of the indicative design features 27 constructed wetlands, 40 culverts, seven large viaducts and five bridges, of which nine are required because of stream / river crossings.

KEYWORDS

Alliance, Stormwater, Consenting, Assessment, Flooding, Mitigation, AEE

PRESENTER PROFILES

David Sloan is a Water Engineer in GHD's Northern Stormwater and Asset Planning Service Group, based in Auckland. He holds a BEng (Hons) in Civil Engineering with Project Management from the University of West of Scotland. David has nine years' experience in civil engineering including 18 months on site with a major contractor in the UK, and design experience in Australia. His experience covers a wide range of project work including sewer and stormwater networks, assessing operational water effects, gravity pipeline design, pump station and rising main design, construction management, and scoping and assessing pipeline conditions.

Tim Fisher is the Water Sector Leader and a Project Director at Tonkin & Taylor Ltd. He holds a PhD (Civil) from University of British Columbia in Canada and Master of

Engineering (Civil) from University of Canterbury. Tim is CPEng with 19 years' experience in New Zealand, Malaysia, Philippines, Canada and UK. Tim has unique skills in the consent design and expert witness for water aspects of major transport projects including Pūhoi to Warkworth (SH1), Transmission Gully and Waterview Connection Project. His other areas of expertise are stormwater, sediment, water quality, flooding and river engineering.

1 INTRODUCTION

Tim and I led an assessment of the operational water effects of the Pūhoi to Warkworth Project (the Project), which is a section of the Ara Tūhono Pūhoi to Wellsford Road of National Significance. Operational water effects are those arising from stormwater, streamworks and flooding associated with the operational phase of the Project.

We delivered the Operational Water Assessment Report to inform the Assessment of Environmental Effects (AEE) and to support the resource consent applications for the Project.

The report also describes the operational water systems, including the permanent stormwater management systems and modifications to streams/floodplains for the operation of the motorway.

We minimised effects by designing mitigation measures into the Project's operational water systems based on a best practicable option (BPO) approach. The extent of mitigation measures is based on consideration of the sensitivity of the receiving environment and our assessments of the potential unmitigated effects.

2 THE PROJECT

The Project realigns the existing State Highway 1 (SH1) from the Northern Gateway Toll Road (NGTR) at the Johnstone's Hill tunnels and joins back in to the existing SH1 just north of Warkworth. The indicative alignment will bypass Warkworth on the western side and tie into the existing SH1 north of Warkworth. It will be a total of 18.5km in length. The upgrade will be a new four-lane dual carriageway road, designed and constructed to motorway standards and the Transport Agency RoNS standards.

2.1 THE PURPOSE

The purpose of the proposed Pūhoi to Warkworth project is:

- To enhance inter-regional and national economic growth and productivity;
- To improve movement of freight and people between Auckland and Northland;
- To improve the connectivity between growth areas North of Auckland; and
- To improve the reliability and safety of the transport network between Auckland and Northland.

Other benefits of the Project include:

- Reducing congestion during peak periods;
- Improving economic development and tourism opportunities in Northland; and
- Reduced travel times between Northland and Auckland.

2.2 PROJECT FEATURES

Subject to further refinements at the detailed design stage, key features of the Project are:

- A four lane dual carriageway (two lanes in each direction with a median and barrier dividing oncoming lanes);
- A connection with the existing NGTR at the Project's southern extent;
- A half diamond interchange providing a northbound off-ramp at Pūhoi Road and a southbound on-ramp from existing SH1 just south of Pūhoi;
- A western bypass of Warkworth;
- A roundabout at the Project's northern extent, just south of Kaipara Flats Road to tie-in to the existing SH1 north of Warkworth and provide connections north to Wellsford and Whangarei;
- Construction of seven large viaducts, five bridges (largely underpasses or overpasses and one flood bridge), and 40 culverts in two drainage catchments: the Pūhoi River catchment and the Mahurangi River catchment;
- Construction of 3,075 m of stream diversions with natural stream forms;
- Construction of 27 wetlands; and
- A volume of earthworks based on the indicative design (and likely to be refined) of approximately 8 Million m^3 cut and 6.2 Million m^3 fill within a proposed designation area of approximately 189 ha earthworks.

3 THE FURTHER NORTH ALLIANCE

The Further North Alliance is the Transport Agency's first planning alliance and is made up of the Transport Agency, GHD, Jacobs SKM and Chapman Tripp. Sub-consultants have been used for some specialist tasks including Tonkin & Taylor, Ridley Dunphy Environmental Ltd, Bioresearchers, Boffa Miskell, NIWA and eCoast. The Alliance was tasked with preparing the Notice of Requirement and Resource Consent documentation for the project.

The Alliance has a clear vision:

- **Pathway to a strong North.**

Enabled by key objectives:

- Safety first;
- Deliver on or before time to be construction ready for August 2014;

- Deliver and demonstrate value for money; and
- Create a positive legacy.

Delivered with the strength of the following core Values and Behaviours:

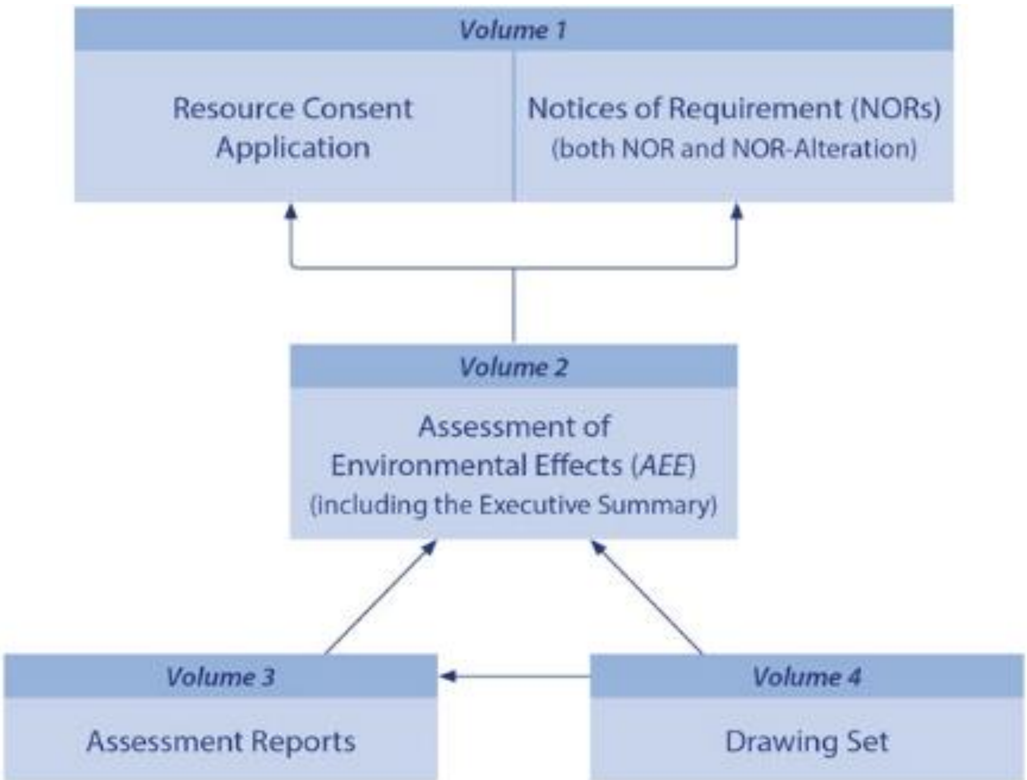
- **Support** – Promote and realise a strong alliance culture by actively supporting our people;
- **Integrity** – Do what you say and be honest;
- **Courage** – Challenge yourself and others and embrace change; and
- **Respect** – Adopt a positive attitude. Listen and Understand.

The Alliance created a special working environment where all disciplines shared a common working space. Having all technical specialists based in the one office promoted teamwork and provided a collaborative environment that achieved innovative breakthroughs needed to meet or exceed the project programme and goals. 'On the job' resolution of issues with relevant skills available for ad hoc as well as scheduled discussions produced speedy and continual resolution of issues and project refinements. Project tasks were completed in compressed timeframes with optimum efficiency and expenditure. As a result, there was very little if any duplication or replication of effort.

3.1 STRUCTURE

The Project's Resource Consent Application and Notices of Requirement are supported by the AEE. The AEE is informed by the Assessment Reports and Drawings. Figure 1 shows the documentation structure for the Project.

Figure 1: Documentation structure



3.2 PROGRAMME

The programme was exceptionally tight with only 5 Months (22 Weeks) to complete a design and an assessment for a major transport project:

- Start: 12th February 2013
- First Draft: 31st March 2013
- Design Freeze 30th April 2013
- Second Draft: 18th May 2013
- Design change end of May – Adjusted approx. 40% of Alignment
- Final Draft: 18th June 2013
- FINAL Final Draft: 18th July 2013

Management of design changes was important. Due to the timeframe constraints, it was important to have cut off points in the conceptual design programme that all disciplines bought into. We collectively recognised that a design change that is minor to one particular discipline has the potential to have significant impact on the assessments being carried out by another discipline. An example is a minor change to the extent of an area of fill for the motorway may impact on an existing stream and result in a stream diversion being required. That stream diversion requires assessment.

Design freeze milestones were identified from the outset and while design changes occurred beyond these dates an effort was made to stop design changes once there was an indicative design that could be assessed. Obvious design modifications such as to the cut to fill balance are left for future design refinement at later design stages.

3.3 METHODOLOGY INNOVATIONS

A fast tracked programme meant we were forced to work efficiently and focus on activities that we actually needed to do. Tasks that needed to be done were those that were critical to the assessment of effects. 'Nice to have' tasks were challenged and only carried out if they would offer significant input into our assessments. A 'do it once – do it right' attitude was shared throughout the team. Due to time constraints, we sought out information which could help us and adopted it if relevant for expediency. An example of this is our use of Auckland Council's Rapid Flood Hazard Model for the Warkworth region, which is discussed later in Section 4.4.

The expert discipline leads within the Alliance had been there and done it before in previous flagship RoNS projects. Tim has previously worked on the Waterview and Transmission Gully RoNS projects, and the earlier adjacent NGTR. We drew on this vital experience throughout our assessments. We had the opportunity to make decisions based on Tim and other Alliance team member's experience and lessons learnt and then backed it up with analysis when required. This approach streamlined our assessment methodology.

The Project was focused on performance based resource consent conditions. Therefore, "in general accordance conditions" were avoided in preference for conditions that set performance limits to limit effects or mitigate adverse effects. The Transport Agency wanted to maximise the opportunities for value engineering at the detailed design and construction stages. For similar reasons a wide designation is being sought.

This approach enabled us to minimise the design and focus on assessment of effects and mitigation of these. As a result only an indicative design was provided with the consent application. Our approach was that innovation in the "design and constructability phase" will happen later and at this stage the focus should be on the assessment. This is deemed sensible, as from our experience, the consent design always changes at the design and construction stage.

The Alliance structure avoided the traditional approach of allocating project tasks, deliverables and risks to different parties. Alliance members share all the risks equally, and share the "Gain" if the targets are met or share the "Pain" if the targets are not met.

The 'business as usual' approach is to distribute tasks and each team and organisation goes away and does their own thing, working on the relevant tasks through to delivery. With this approach, consistency and integration of each component of the assessment can be compromised. At the Further North Alliance, we collectively invested time up front to develop and agree on our assessment methodology. The collective input from technical experts across all disciplines resulted in 'buy in' to the consenting strategy and therefore a united approach.

Chapman Tripp was included in the Alliance, which is a first for a legal firm. The involvement of a legal partner that specialises in environmental, planning and resource management law from the outset allowed key assumptions and 'business as usual' approaches to be tested. Our assessment report went through a number of reviews where the legal team checked to ensure our assessments were robust and efficiently prepared for the consent application submission. The reviews ensured that the report covered all aspects required, and also didn't include anything that it didn't need to.

The 'business as usual' approach for a major project like Pūhoi to Warkworth is for the legal team to be introduced to the project after design development, and often after the briefing of consultants and specialists. The legal team often has to rework assessments with regards to RMA tests and evidentiary standards. With the involvement of Chapman Tripp from the outset in the Further North Alliance, we believe that extensive re-work and the potential for impacts on programme and budget were avoided or minimised. Similarly, the involvement of planning specialists throughout the project allowed for assessment criteria related to planning documents to be identified and the assessment methodology targeted to these matters. As a result of the legal and planning services being integrated into the team, the technical specialists and their assessments are concentrated on the key planning matters and RMA tests, and therefore the assessments are focused, specific and more effective.

The Alliance also developed a progressive alliance called Hōkai Nuku with the mana whenua of the project area. Hōkai Nuku has provided cultural advice and valuable input into many design and assessment aspects. This created an opportunity for collaboration of social, environmental and economic issues of mutual benefit.

We also gave thought to the planning and structure of the assessment reports and a number of reports were integrated into one. In past projects there have been different reports for hydrology, stormwater philosophy, water quality baseline, water quality assessment, water quantity assessment, etc. We integrated these into one Operational Water Assessment Report, which led to a more integrated and readable assessment.

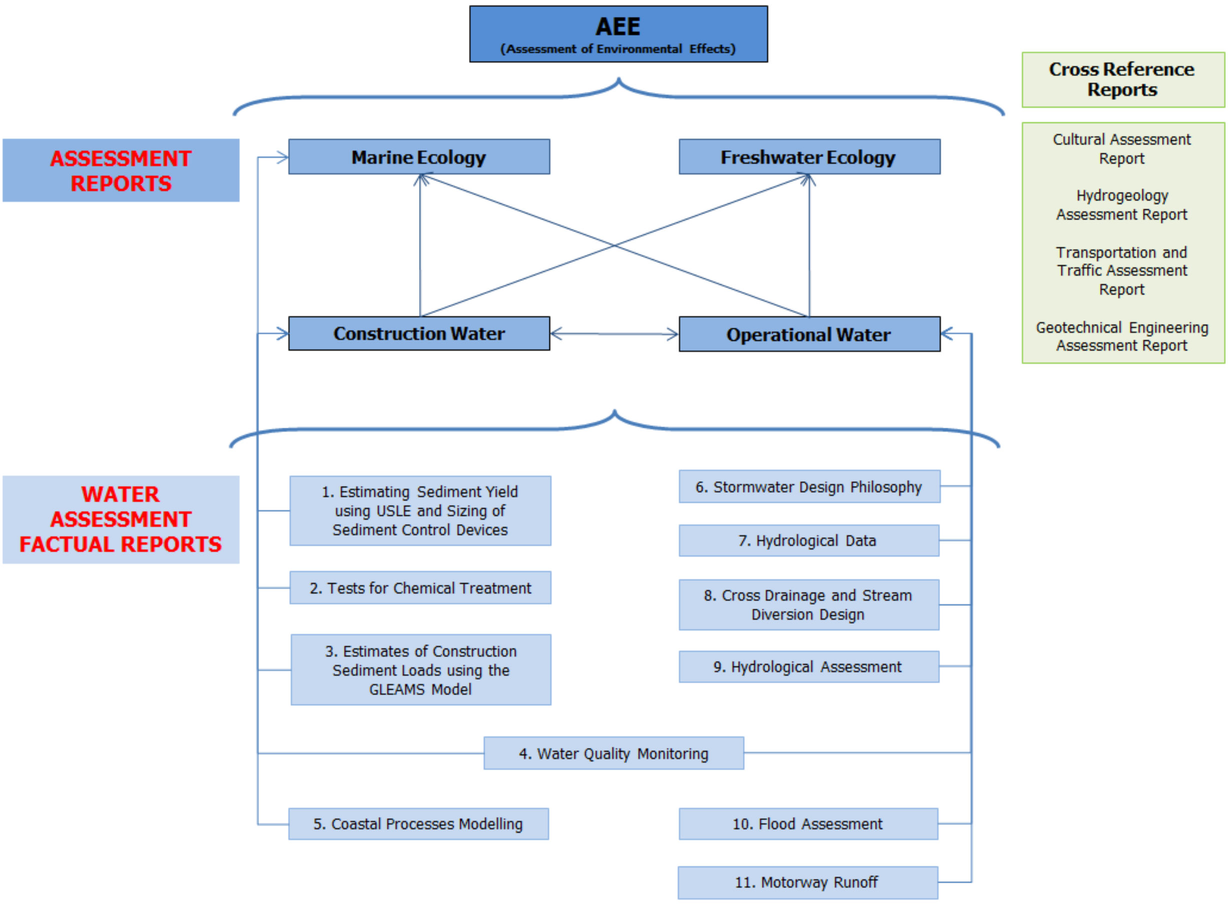
The presentation of our deliverables was designed to accommodate the diversity of expected readers and reviewers, from non-technical persons to technical experts. Our assessment report did not have the commonly used executive summary at the start of the document. Instead, the report is structured with summary boxes for each section, which collectively form an executive summary. By reading the summary boxes, the reader is provided with an overview of that particular section. For more detail, the reader can then read the relevant section.

We also produced a number of Water Assessment Factual Reports to supplement and inform the preparation of this Operational Water Assessment Report. These Water Assessment Factual Reports contain detailed calculations, design details and supporting information. Whilst they do not form part of the application documentation for the Project, they are available for review if required.

This approach allows the reader to access as much or as little detail as they wish / require.

Figure 2 describes the interaction between some of the Project Assessment Reports and the background Water Assessment Factual Reports.

Figure 2: Operational water assessment report – relationship to other reports



4 STORMWATER MANAGEMENT AND FLOODING

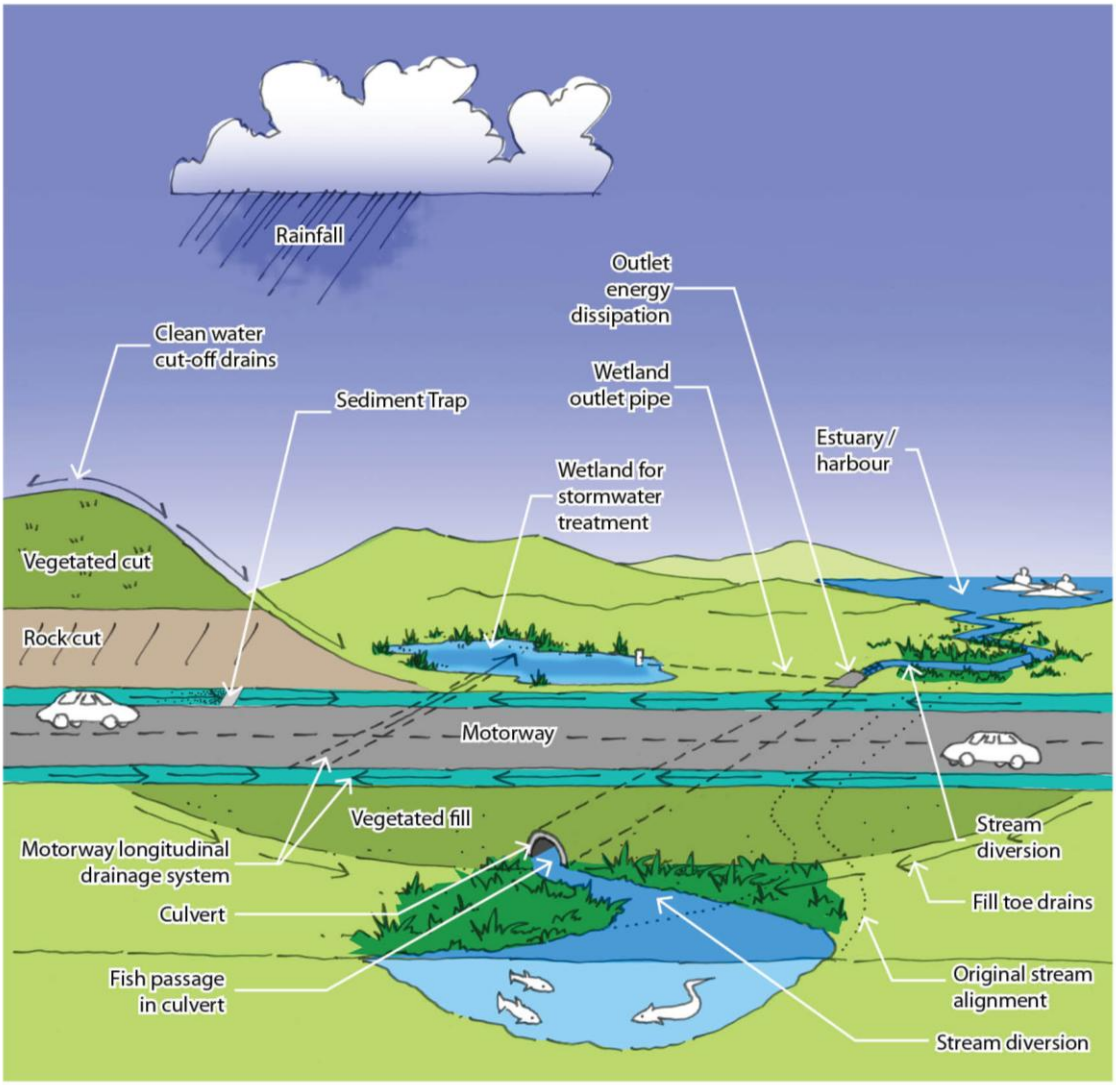
4.1 GENERAL

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 (Figure 1). Rainfall onto 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.

Figure 1 provided a useful pictorial overview of how water is managed in the operational phase of the Project, and was used for consultation with stakeholders. This simplified presentation of the water management systems was useful for non-technical persons to understand what was proposed and the language used in the assessments.

Figure 3: Motorway Operational Water Systems and the Environment



The following operational activities arising from the Project have the potential to create adverse effects on the environment:

- Stormwater from the road;
- Diversion and culverting of streams; and
- Flooding.

We adopted the following design principles for the operational water systems:

- The design will provide a best practicable option (BPO) 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.

4.2 CATCHMENTS

The Project traverses two major river catchments; the Pūhoi and the Mahurangi. Moirs Hill Road represents the approximate catchment divide.

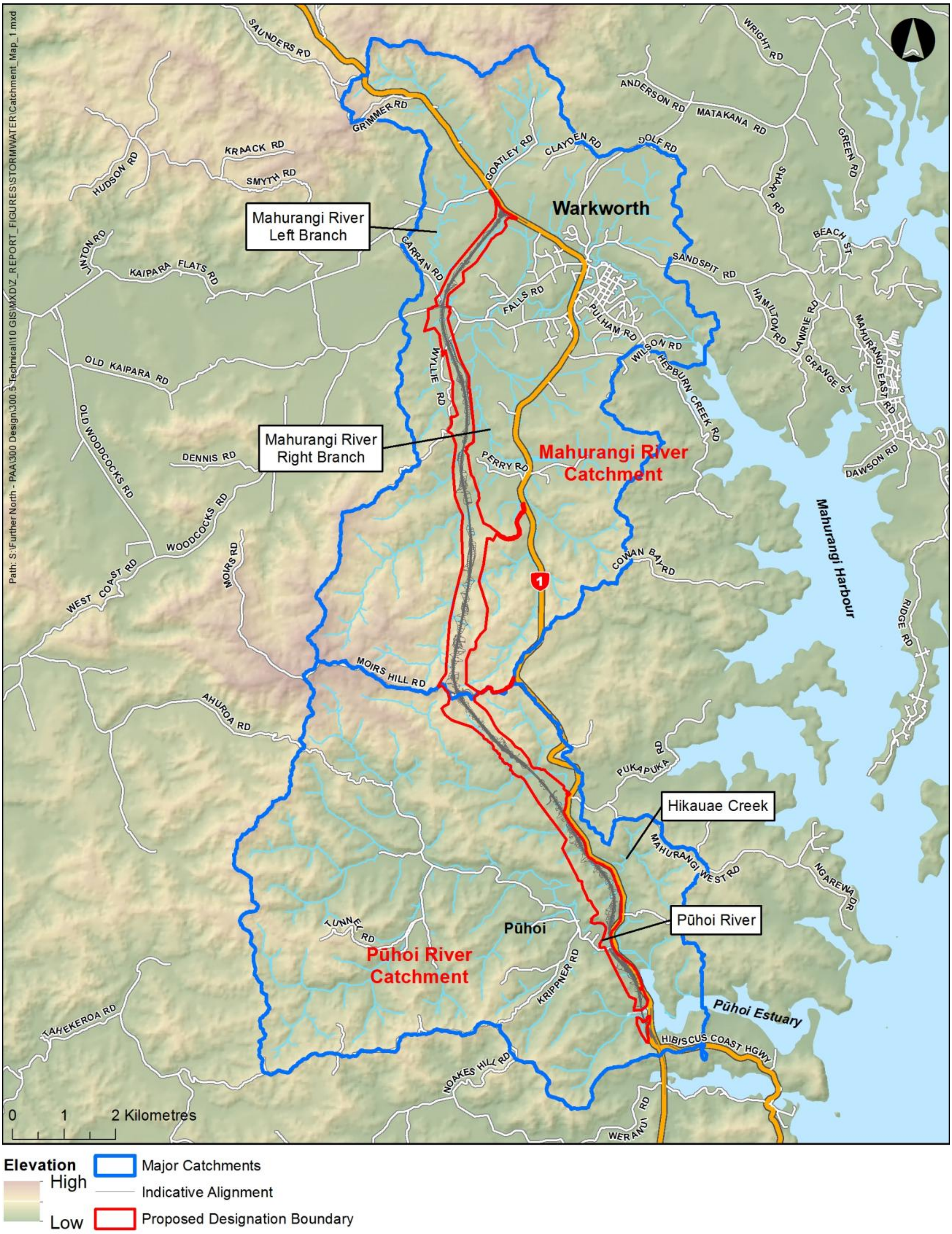
In the Pūhoi catchment the receiving environments are the tributaries and main streams of the Hikauae Creek and Pūhoi River, and ultimately the Pūhoi Estuary.

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 stream inverts have rock outcrops in places, but also consist of soft bottom streams.

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

The catchments and Project alignment are shown in Figure 4.

Figure 4: Pūhoi and Mahurangi catchments with proposed alignment



4.3 STORMWATER MANAGEMENT

As described in Section 3.3, our design and assessment was focused on the aspects that were most important to the assessment, with 'Nice to have' tasks challenged and only carried out if they would benefit our assessments. The challenging timeframes ensured we focussed on key issues relevant to our assessment of operational water effects. As a wider team (with input from legal and planning specialists), we determined what matters and then went into more detail for those aspects. A summary of some of these key aspects is provided below.

4.3.1 STREAM TYPES

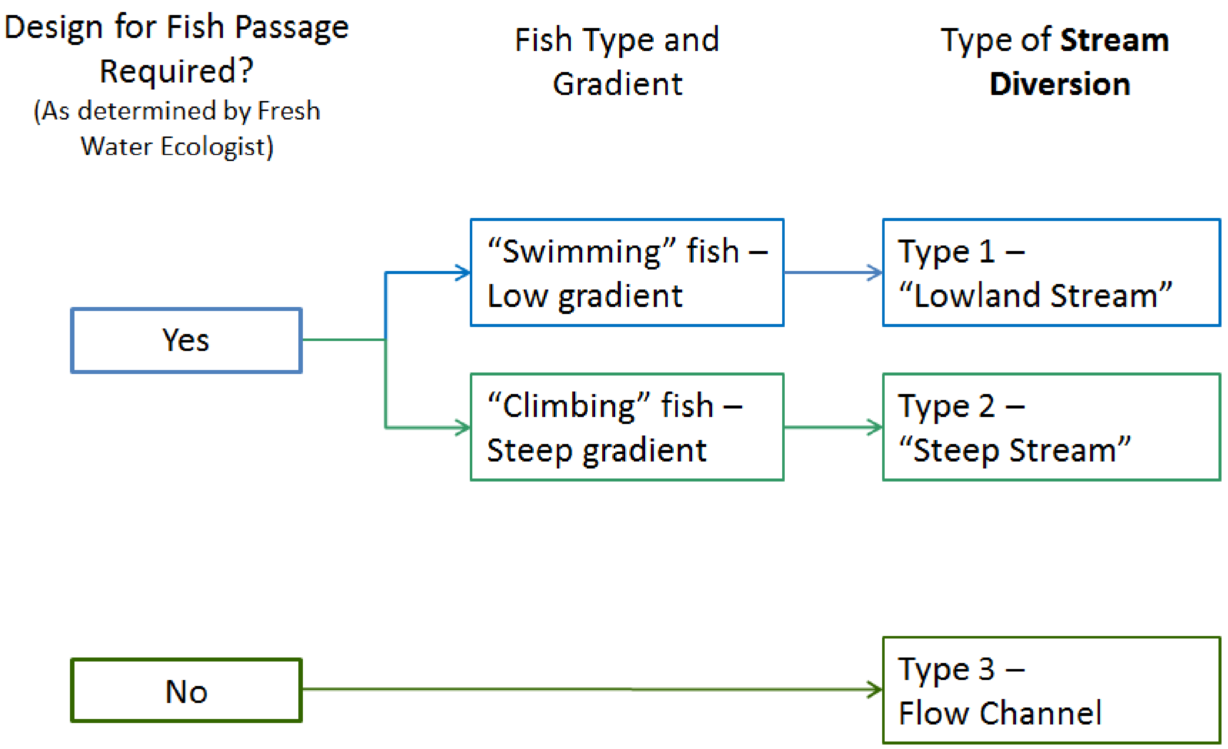
Permanent diversions and flow channels are required to manage surface water for the Project. We have minimised the extent to which stream diversions of main streams are required via the overall route selection process.

Diversions are required:

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

As part of our BPO process to select a stream diversion type for each specific site, we developed a simple flow chart that selected the most suitable type of stream diversion based on fish passage criteria. Our flow chart is shown in Figure 5.

Figure 5: Flow chart for stream diversion type



Stream diversions with natural stream forms (referred to as "Type 1 – Lowland Stream" and "Type 2 – Steep Stream") are proposed where the streams are permanent and support fish habitats, and also for those intermittent streams where there is potential for fish habitat upstream. The principal objective for stream diversions is to recreate streams and habitats to replicate the natural state of the steams that exists prior to the Project.

Stream type 1 – Lowland Stream

- Low continuous gradient; meanders; complexity (variety of logs and rocks that change flow patterns and provide resting places); and continuous low flow channel.

Stream type 2 – Steep Stream

- 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.

Stream type 3 – Flow Channel

- No requirement for in-stream habitat.

The Project's freshwater ecologists identified the streams in the Project area requiring fish passage in the Freshwater Ecology Assessment Report. Fish passage is required where there is currently fish habitat in or near the streams being affected, or where there is potential for future fish habitat. We provide fish passage in all these instances for the Project with the exception of two culverts where drop structures are required at the upstream end.

We developed our three stream/channel types based on design requirements we developed in collaboration with the Freshwater Ecologists – an example of how we streamlined our methodology based on expert's experience within the team. The stream diversion requirements include riparian planting 10 m to 20 m either side of the stream, populated with assorted species found in the Rodney Ecological District to replicate the natural planting in the area where the stream is lost. These measures will ensure colonisation of diverted streams by aquatic flora and fauna. We consulted with Hōkai Nuku on the design requirements for the stream types. We proposed consent conditions should require for stream diversions with natural stream forms and riparian habitats where the streams are permanent and supporting fish habitats.

4.3.2 WETLAND FEASIBILITY

The indicative alignment for the Project is through similar geological terrain to the NGTR where a number of wetlands have been constructed. We visited the NGTR with the Auckland Motorway Alliance and looked at the performance and location of selected wetlands.

Our experience gained from the design and operation of the NGTR supports the feasibility of the wetlands we propose for the Project, in particular those in the hill country areas.

We did not model the earthworks associated with the proposed wetlands and associated cut and fill as we consider this is best done at the detailed design phase. Our experience from the design phase for the NGTR is that the wetland locations will be developed and refined once further site investigation and design is carried out. The majority of the proposed NGTR treatment devices were optimised during the design phase and have been moved from their specimen design locations. This is an example of the Alliance focus on activities that we actually needed to do.

An example of an observation we made during our NGTR visits was that while some wetlands have healthy vegetation, some wetlands have sparser planting. We therefore recommended a consent condition for the Project requiring establishment of healthy wetland plants. Consideration should also be given to riparian plants especially on northern aspects that would increase the shading of the wetlands.

It is less frequent than it should be that an engineer's design is visited and physically observed in its operational phase. Our NGTR visits were an important reminder to us that design and maintenance are interdependent. We benefitted greatly reviewing what worked well on NGTR and what could be improved, and encourage our peers to seek feedback from their own designs as well as designs by others, in their operational phase. The opportunity to maximise lessons learnt is valuable.

4.3.3 DEBRIS FLOW AND MANAGEMENT

We used a risk framework to assess the risk from debris to culvert blockage and determine mitigation measures for inclusion in the Project. Debris is carried by flood flows and by less frequent and more hazardous debris flows.

Debris flows are a fast flowing mixture of water with a medium or high proportion of solids, which moves down watercourses. Debris flows are triggered by heavy rainfall and occur in conjunction with landslides within the catchment. Debris flows are potentially destructive and can encompass a wide range of objects, such as fallen trees, stumps, boulders, gravels and soils, plus water.

The risk associated with debris flow occurrence is a product of the likelihood of debris flows and culvert blockage, and the consequence of this culvert being blocked.

We qualitatively assessed the likelihood of debris being generated based on the size of and land use in the catchment. The consequence associated with a blocked culvert is related to the potential flooding impact on the upstream side of the motorway and the risk to downstream areas from failure of road embankments.

Where the risk of blockage of a culvert by debris is moderate or high, this risk needs to be mitigated by incorporating debris control measures. Table 1 lists the mitigation measures we propose for the Project for different degrees of risk of blockage of a culvert by debris flow.

Table 1: Debris blockage mitigation measures

Risk	Mitigation
High	Debris rack upstream of culvert AND Culvert sized to pass 100 year ARI without heading up
Moderate	Relief inlet
Low	None

4.3.4 ENERGY DISSIPATION AND EROSION CONTROL

Wetland outfalls will incorporate erosion protection measures to minimise bed scour and bank erosion in the receiving waterway. Typically this protection will be through an energy dissipation device and/or rock aprons.

For works associated with culverts/streams the BPO approach is for energy dissipation to be in place at all culverts to minimise erosion. Our assessment of the effects of the Project on erosion has been supported by site visits to key culvert locations for example at the location of proposed concrete arch culvert 54,700 m. Bedrock was sighted in the existing stream bed at the approximate location of the culvert outlet, shown in Photo 1 below. Bedrock is resistant to erosion and if it exists in the bottom or sides of the stream channel, this provides protection against degradation. Thus we can be confident that there is low risk of erosion of the stream bed and banks at the outlet of culvert 54,700 m.

Photo 1: Bedrock sighted at outlet of culvert 54,700

4.3.5 STORMWATER MANAGEMENT

Stormwater systems need to perform reliably and minimise the generation of additional sediment.

Clear water cut-off drains are proposed 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 interception of (clean water) flow.

Cut and fill faces (batters) are required as part of the Project and rainfall and runoff have the potential to erode new sediment from the batters and transport that sediment downstream. The potential for erosion of cut and fill faces post-construction will remain throughout the life of the Project. This sediment generation can be seen in rock cuts in the NGTR section of SH1 immediately south of the Project. The Project proposes the following measures to minimise generation or to control the sediment load:

- Vegetation cover on cut and fill slopes to minimise generation of new sediment; and

- Capture and treatment of runoff from cut slopes using;

  i. Sediment traps proposed for drains at the base of rock cut faces. These sediment traps are bespoke treatment devices that will capture sediment generated from rock cuts. On the NGTR project, cut faces have yielded larger sediment loads than anticipated over the initial years since becoming operational in 2009; and

  ii. Wetlands – Stormwater collected in motorway drainage systems will be conveyed by roadside drains, swales or pipes to the constructed wetlands. The wetlands will be designed in accordance with TP10. During Project design, wetland locations will be refined with consideration given to landscape, constructability maintenance and ecological values. The outlets from wetlands will be piped to adjacent streams. The wetlands will be constructed and located off-line, i.e. not constructed in or on the bed of an existing stream.

Wetland outfalls will be sized to convey the 100 year ARI flow rate. These flows will be piped to the adjacent stream.

4.3.6 FISH PASSAGE

The freshwater ecologist within the Further North Alliance team identified and named the streams and rivers crossed by the alignment that are permanent or intermittent and which of those have habitat suitable for a range of fish species.

As part of our BPO design approach, we have considered the type of fish passage for each culvert based on the characteristic of the site and the type of fish passage required.

The baffle design is based on Auckland Regional Council Technical Report Number 84, June 2009 (Fish Passage in the Auckland Region – a synthesis of current research). Plastic rectangular baffles create low velocity zones allowing fish to rest as they move through the culvert. These baffles are successfully used for fish passage in concrete pipe culverts for the adjacent NGTR section of SH1. We propose a baffle type fish passage for concrete pipe culverts where both swimming and climbing fish species are expected.

The natural bed type of fish passage replicates a natural stream bed by using raised baffles at intervals to hold sediment within the bed of the culvert. The alternating baffle openings and sediment basins create a low flow channel with low velocity zones to encourage fish passage through the culvert. We propose a natural bed type of fish passage in large concrete arch culverts where both swimming and climbing fish species are expected.

4.3.7 STORMWATER RETICULATION

The stormwater reticulation has not been designed in this phase of the Project because it is not material to the consent applications. The stormwater reticulation is an engineering feature that is designed to convey stormwater from the Project carriageway and from the toe of cut (and fill) slopes to stormwater treatment devices. We only included stormwater reticulation in the cross-section drawings in order to adequately represent the Project area for assessment of effects and the designation requirements.

This is a very clear example demonstrating the Alliance attitude to only do the activities necessary and relevant to the consenting of the Project. This is a detailed design task that will be carried out in the design phase of the project to parameters not significantly influenced by assessments carried out during the consenting phase.

4.4 FLOODING

Our approach to assess flooding has been to work cooperatively with Auckland Council and its modelling team who are actively assessing the flood risk in the Warkworth region. Auckland Council has a rapid flood hazard model built using InfoWorks ICM software, which was supplied for our flood assessment. The advantage of using this model is a consistent approach to flood planning and assessment. The rapid flood hazard tool is a high level type model used to screen for flood hazard issues.

By working with Auckland Council and using their rapid flood hazard model and maps, this saved us time and enabled collaboration with Auckland Council.

We undertook our own assessment of the Auckland Council rapid flood hazard models. We consider the Auckland Council models to be of relevance and of sufficient accuracy for our assessment of the Project effects on flooding, as our assessments are based on comparisons between existing and post-development i.e. the relative difference (the change). In our experience however, the models are often conservative and over-predict flows and water depth, which is why Auckland Council used a rapid modelling approach to develop an understanding of flooding issues prior to development of more accurate models. We acknowledge that more detailed modelling and calibration of the model will more accurately define peak flood levels in the Project's detailed design phase and have suggested this as a condition of consent.

We added the indicative alignment into the Council rapid flood hazard model to create a post-development scenario. Only the motorway alignment between and inclusive of the Woodcocks Road Bridge and the Carran Road Flood Relief Bridge was incorporated into the post-development scenario as these locations are the only parts of the motorway that potentially impact on the main floodplains within the project footprint.

We ran the post-development scenario for a 100 year ARI rainfall event and included allowance for the effects of climate change. We compared the differences in floodplain extents and flood water levels between the pre and post-development situations.

The Carran Road Sector is a key area for flooding as the motorway crosses the Mahurangi floodplain at the proposed Woodcocks Road Bridge, and crosses a major secondary flow path between Woodcocks Road and SH1. Our BPO approach is to minimise the effects of flooding in these areas by changing the alignment of the motorway to avoid the floodplain where possible, and by using bridges to cross the floodplain where necessary to mitigate potential adverse effects where avoidance is not possible.

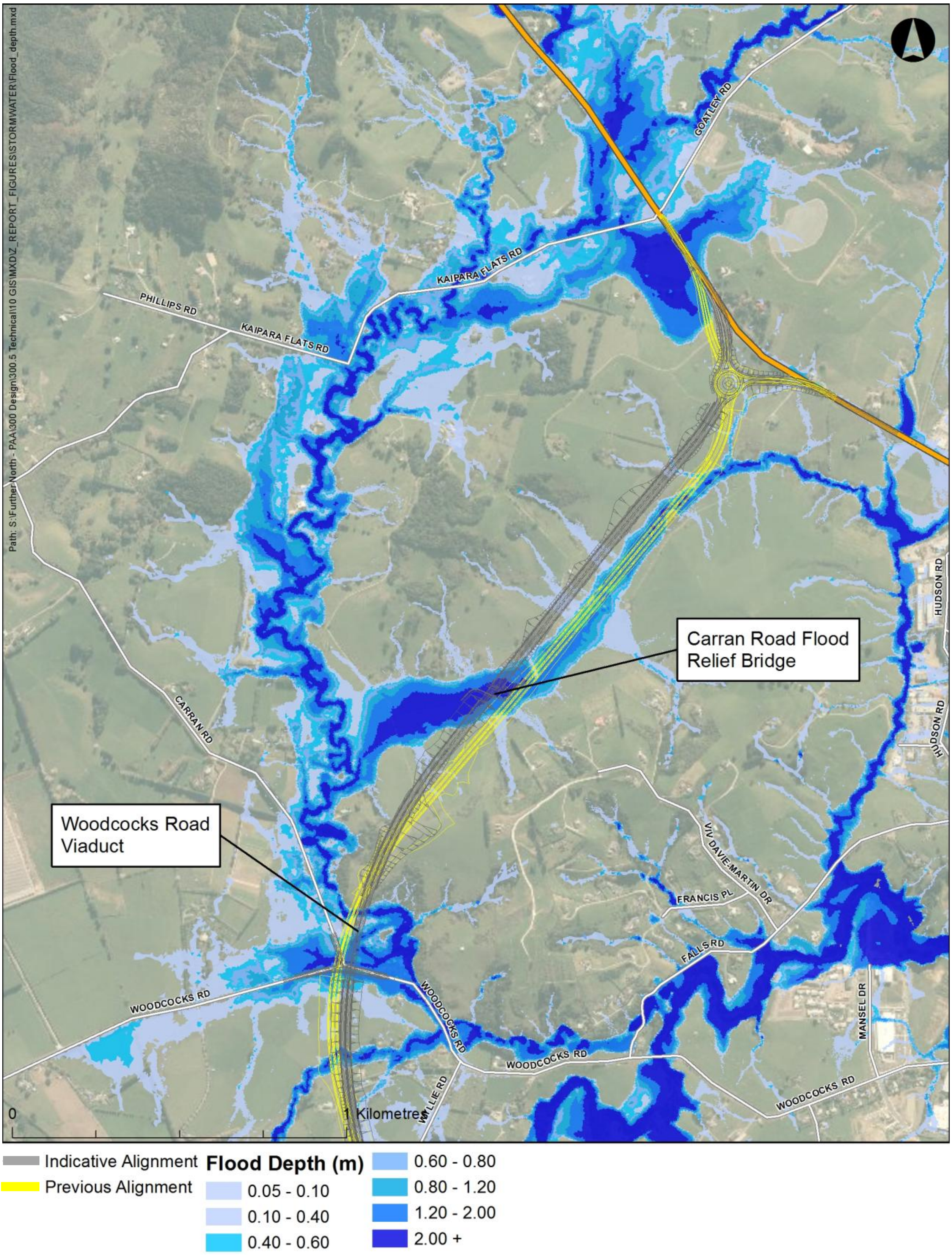
The Project design team revised the alignment in response to results from the Auckland Council rapid flood hazard modelling, which showed that the previous alignment occupied the secondary flow path. To mitigate effects of this impact on the secondary flow path, we moved the alignment to a position further west to avoid the floodplain. Figure 6 is based on the Auckland Council rapid flood hazard model and shows the original alignment, the current indicative alignment, and the 100 year ARI floodplain for the Carran Road Sector.

The Carran Road Flood Relief Bridge is proposed and has been sized to pass the 100 year ARI flood where the motorway crosses the secondary flow path. We initially sized the Carran Road Flood Relief Bridge with a 28 m span and incorporated this into the rapid flood hazard model. The differences between pre and post-development flood flows for the Carran Road Flood Relief Bridge with a 28 m span showed that the bridge passes the secondary flow, but with an afflux of 250 mm upstream of the bridge.

To achieve a higher level of mitigation by a greater reduction of effect, we increased the bridge span at the Carran Road Flood Relief Bridge to 60 m, and incorporated this bridge span into the rapid flood hazard model. The differences between pre and post-development flood flows for the Carran Road Flood Relief Bridge with a 60 m span show that the bridge can convey the secondary flow with an afflux of less than 100 mm.

A 60 m span Carran Road Flood Relief Bridge is the BPO that provides an afflux we consider acceptable.

Figure 6: Motorway alignment to avoid flood plain



With regards to Figure 6, it is worth commenting on how important a tool GIS was for our assessments. The plans produced were clear and understandable to all disciplines. The general public and laypersons were also able to read and understand GIS plans which was a great advantage during the consultation phase.

5 ASSESSMENTS

We developed our assessment criteria and conditions from the RMA, ARP:ALW and Auckland District Plan: Operative Rodney Section. The key assessment matters concern stormwater quantity, stormwater quality, human impacts, ecological impacts and flooding. For each of the assessment matters, various criteria and considerations formed the framework for our assessment of effects.

Common to the RMA and all plans is the requirement for options to be assessed and the BPO selected. We therefore developed the 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.

We have assessed the effects of the Project based on our indicative design that incorporates BPO measures to avoid, remedy and mitigate effects.

The water quality effects are mitigated by stormwater treatment systems that include wetlands throughout the Project and sediment traps at the base of rock cuts. We propose vegetated roadside drains for ancillary roads.

The water quantity effects are mitigated by extended detention systems in wetlands to minimise stream erosion.

The human impacts are mitigated by the stormwater treatment systems. We have also considered the effects on the Warkworth potable water supply, amenity, recreation, water users and farm takes.

The operational water systems include bridges over streams, culverts with fish passage and stream diversions with natural stream forms. These mitigation measures provide fish passage and restoration of stream habitats.

Flooding effects are mitigated for culverts 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.

The recommendations we propose to mitigate adverse effects are likely to be applicable to other similar areas within the proposed designation boundary, subject to confirmation of their suitability at the detailed design stage. This enables flexibility in the design within the approved designation boundary. Similarly, we are confident our assessments apply to variations of the current concept design, where operational water systems are revised but kept within the designation applied for as part of this consenting process.

6 CONCLUSIONS

The Further North Alliance was formed as a planning alliance for the consenting and designation for the Pūhoi to Warkworth RoNS. The Alliance proved to be a vibrant working environment with an extremely demanding timeframe which demanded efficient and innovative approaches to ensure sufficient assessment of effects were satisfactorily carried out. Our conclusion is that collaborative working via the planning alliance has led to new approaches to the consent design phase and assessment of the water aspects of this major transport project.

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