24 Stormwater and hydrology

Overview

The proposed Expressway could potentially result in flooding effects resulting from changes to stormwater and surface water hydrology over the Project area. The Project area crosses a number of low-lying and flood prone areas that provide significant floodwater storage.

The design approach of the Project sought to achieve hydraulic neutrality (i.e. no exacerbation of the existing situation), taking into account both the increased run-off from the proposed Expressway footprint and the loss of flood plain storage under the footprint.

To assess potential stormwater and surface water hydrology effects, calibrated models from both KCDC and GWRC were used, with the proposed Expressway alignment superimposed into the existing environment as represented in the models. Further stormwater modelling was undertaken by the Project team, the results of which were incorporated in the KCDC and GWRC models. The models tested the efficiency of the proposed mitigation used in the design of the proposed Expressway.

The modelling demonstrates that the potential effects of the proposed Expressway on stormwater and surface water will be mitigated by a number of methods. The proposed mitigation measures are: attenuation in swales and wetlands to no more than 80% of pre-Expressway peak flows; creation of off-set storage areas; low head culvert designs; rip rap protected culverts and outlets; and the creation of new open channel drains resembling natural streams.

The potential adverse effects of the proposed Expressway on flood risk are able to be avoided or satisfactorily addressed through mitigation.

24.1 Introduction

Stormwater is water that originates during precipitation events and runs off impervious surfaces such as roads, driveways, footpaths and rooftops. Stormwater either flows directly into surface waterways or is channelled into stormwater sewers, which eventually discharge to surface water. Stormwater design features of the proposed Expressway shape the nature of hydrological effects from the Project. Hydrology refers to the movement, distribution and interaction of water with the ground. The hydrological system comprises the continuous movement of water on, above and below the land surface of the Earth.

The information contained in this Chapter is based on the following Technical Report:

- Assessment of Hydrology and Stormwater Effects (Technical Report 22, Volume 3).

Technical Report 22 has been prepared in association with a number of other stormwater related Technical Reports and Management Plans as documented in the introduction to Technical Report 22.

This Chapter describes the potential stormwater and hydrological effects of the proposed Expressway and the actions that are proposed to be taken to mitigate these effects (where not avoidable) in terms of:

- The potential for increased flooding caused by the introduction of impervious surfaces and the infilling of floodplains; and,
- The disruption to watercourses from new culvert and bridge crossings and watercourse realignments.

The assessment of hydrological effects has involved comprehensive hydrological and hydraulic modelling which informed the design of the proposed stormwater systems and watercourse crossings. The modelling and how it relates to the assessment of hydrological effects is summarised in Section 24.3 of this Chapter, and further details are contained in Technical Report 22, Volume 3 and the Drainage Plans in Volume 5.

Where stormwater and hydrological effects have the potential to impact on other aspects of the environment, these effects are discussed in the relevant assessment Chapters of the AEE. In particular, this relates to potential effects on:

- Cultural values associated with water bodies (Chapter 14).
- Freshwater ecology (Chapter 22);
- Groundwater (Chapter 25);
- Contamination (Chapter 27);
- Receiving watercourse water quality (Chapter 28); and,
- Recreational uses of water bodies (Chapter 30).

24.2 Existing hydrological environment

The proposed Expressway crosses the low-lying coastal plains and dune areas of the Kāpiti District. This land is characterised by a mix of low peat flats and sand dune formations. There are many wet areas and wetlands along the route, the majority of which have been heavily modified by farm or urban development.

The Waikanae River is the largest watercourse that will be crossed by the proposed Expressway. There are also a number of streams and drains that will also be crossed. As with the wetlands, all of the watercourses in the Project area have been heavily modified by farm and/or urban development.

The majority of the low lying areas of land within the Project area are floodplains and as such are subject to significant flooding during large rainfall events. These floodplains also generally coincide with peat flats and are particularly dominant at the southern and northern ends of the Project.

The rainfall patterns of the District are strongly influenced by the prevailing westerly winds along with the presence of the coastal hills and, further east, the Tararua Ranges. Mean rainfall across the Project area is of the order of 1100 to 1200mm per year[189], with a strong west to east increasing gradient, with higher rainfall in the hills than on the coast. There is also a tendency for greater rainfall in winter than in summer.

A brief description of the existing hydrological and stormwater features in each of the sectors is provided below.

24.2.1 Sector 1 – Raumati South

The key stormwater features in this Sector, are described and illustrated in Section 2.2 of Technical Report 22, Volume 3 and include:

- Queen Elizabeth (QE) Park Drain;
- Drain 7 south; and
- Flood storage area along Drain 7.

The main watercourse in south Sector 1 is the Whareroa Drain in QE Park which eventually flows into the Whareroa Stream. It drains part of the hillside catchments east of SH1, the railway, SH1 itself, the northeastern end of QE Park and a small partially urbanised catchment north of Poplar Avenue.

Drain 7 serves the area west of Leinster Avenue and runs north to Raumati Road where it is culverted under Raumati Road. Drain 7 has limited capacity, leading to significant flooding issues along its length all the way down to its confluence with the Wharemauku Stream near Paraparaumu Airport.

There is an area of low lying land around the Raumati wetland (adjacent to Drain 7 between Leinster Avenue and Raumati Road) that functions as flood storage area. The land northwest of this flood storage area, through to north of Raumati Road, contains sand dunes that, aside from a small marshy depression at the Raumati Road, are relatively free of flooding issues.

24.2.2 Sector 2 – Raumati/Paraparaumu

The key stormwater features in this Sector, which are described and illustrated in Section 2.3 of Technical Report 22, Volume 3, include:

- Drain 7 north;
- Wharemauku Stream;
- Wharemauku flood storage area;
- Drain 5 and Kāpiti Road; and

[189] Figures from NIWA's Water Resource Explorer (WRENZ), as of September 2011.

- Mazengarb Drain.

Drain 7 flows northwards from Sector 1, to pass under Raumati Road, through residential areas to Rata Road where it is culverted under Rata Road and then runs in an open drain through pastoral land at the foot of a sand dune formation. It is then culverted under Kiwi Road before draining into the Wharemauku Stream at the south end of the Airport.

The Wharemauku Stream is the main watercourse through Paraparaumu town centre and is fed by many smaller tributary watercourses that generally all come together in the area between the town centre and the Airport. The Wharemauku discharges to the sea at Raumati Beach, west of the Airport. Upstream of the Airport, the Stream passes through a narrow gap between sand dunes at the end of Kiwi Road, which acts to constrict flood flows so that floodwater overflows into upstream paddocks. This large open area is zoned as a KCDC flood storage area and is integral to KCDC's flood management for the Wharemauku catchment.

The residential area between Kāpiti Road and Mazengarb Road is drained by KCDC's sump and pipe network that discharges into the top of Drain 5 on the southern side of Kāpiti Road, opposite Arawhata Road. Drain 5 joins the Wharemauku Stream upstream of Kiwi Road.

The Mazengarb catchment is similar to the Wharemauku in land use, but on a smaller scale. The wider Mazengarb catchment includes the Waikanae Wastewater Treatment Plant (WWTP) and the Otaihanga Landfill (now closed). The Mazengarb Drain discharges into the lower reaches of the Waikanae River.

24.2.3 Sector 3 – Otaihanga/Waikanae

The key stormwater features in this Sector, which are described and illustrated in Section 2.4 of Technical Report 22, Volume 3, include:

- WWTP Drain;
- Landfill Drain and wetlands;
- Otaihanga Drain;
- Muaupoko Stream;
- Waikanae River and floodplain;
- Te Moana floodway;
- Wetlands north of the Waikanae River; and
- Waimeha Stream.

The WWTP drain serves a relatively small catchment upstream of the proposed Expressway and its main source of flow is the discharge from the WWTP. Downstream of the proposed Expressway, this drain passes through the southern end of a line of sand dunes and the southern end of the Otaihanga Landfill wetland complex. It then flows west through low lying rural properties before joining the Mazengarb Drain.

The Otaihanga Landfill is drained by an open channel drain that runs through a series of wetlands that have formed between bands of sand dunes. The drain then passes through private rural lifestyle properties west of the proposed Expressway and ultimately drains into the Waikanae River.

North of Otaihanga Road there is a relatively small open channel farm drain that serves a small rural catchment. The drain ultimately outfalls into the Waikanae River, much further downstream from where the proposed Expressway will cross the Waikanae River.

The Muaupoko Stream has a relatively large catchment east of the existing SH1, linking several important ecological areas along the way. Ultimately draining into the Waikanae River, the lower reaches of the Stream frequently flood the low lying farm land along its bank, which are part of the southern flood plain of the Waikanae River.

The Waikanae River is the largest watercourse along the proposed Expressway alignment. It is a large gravel and sand bed river. The River is actively managed by GWRC for flood and erosion protection purposes and gravel is intermittently extracted from the bed for construction and river management purposes. The area of the combined Waikanae and Muaupoko catchment upstream of the proposed Expressway is approximately 13,000ha of which most is located in the steep hills east of the existing SH1. The Kāpiti Coast water supply draws from the Waikanae River, upstream of SH1.

Floods in the Waikanae River rise and fall relatively rapidly due to the steep upper catchment and a flat lower catchment. The proposed Expressway crosses a relatively narrow (150m wide) point on the floodplain. GWRC's modelling has shown that flooding from the River near the proposed crossing is not significantly affected by high tides.

GWRC is responsible for managing the River and it is progressively constructing flood and river management works. GWRC's policy is to generally to maintain the main river channel so that it is kept within its preferred 35m wide corridor. For example, if the river breaks out significantly from the preferred 35m design alignment, then GWRC will act to re-train the River back into the corridor. Stopbanks and a pump station have been installed on the northern side of the River to protect the residential development along Greenaway, Kauri and Puriri Roads from flooding.

The gradient of the river flattens out as it crosses the coastal lowlands, causing deposition of sediment. GWRC has consent to remove gravel from this area, as well as to excavate the sand bar at the River mouth to avoid any restriction of the discharge to the sea.

The KCDC District Plan includes a protected floodway from the Waikanae River to Waimeha Stream, termed a "residual overflow" as this is still the route floodwater would take if the stopbanks in this location were to be overtopped or breached. The critical location for a stopbank breach in regard to any effects of the proposed Expressway is at the Chillingworth stopbank. A breach in this stopbank would flow north through residential areas arriving at Te Moana Road near to the location of the proposed Expressway crossing.

There are several significant wetlands north of the Waikanae River. To the immediate west of the proposed Expressway is the large El Rancho wetland that has no formal surface drainage outlet and is isolated in a pocket within the sand dunes. The proposed Expressway will cross the edges of two modified wetlands known as the Tuku Rakau ponds. Historically, these wetlands would have been a single wetland complex before the land was drained and developed. These areas are now highly modified.

The Waimeha Stream is fed by a mix of natural springs and discharges from the municipal stormwater network for Waikanae Township. The Stream runs along the southern edge of a line of sand dunes that separate it from the Te Harakeke/Kawakahia wetland. Further downstream the Waimeha Stream is joined by the Ngarara Stream prior to its outfall to the sea at Waikanae Beach. The Waimeha Stream is very low lying and tidally affected as far up as the proposed Expressway crossing.

North of the Waimeha Stream is a small catchment that has not formal surface drainage outlet. It is an isolated basin in the sand dunes. Stormwater collected in this area percolates into the ground over time.

24.2.4 Sector 4 – Waikanae/Peka Peka

The key stormwater features in this Sector, which are described and illustrated in Section 2.5 of Technical Report 22, Volume 3, include:

- Ngarara Stream and Te Harakeke/Kawakahia wetland;
- Ngarara Creek;
- Kakariki Stream and floodplain;
- Smithfield Drain;
- Paetawa Drain and floodplain; and,
- Hadfield's/Te Kowhai Stream.

North of Smithfield Road, the watercourses have been highly modified and channelised as part of making the land suitable for farming. However, this area also contains the Te Harakeke/Kawakahia wetland, the largest and most ecologically significant wetland in the region. All of the watercourses between the Waimeha Stream and Peka Peka Road drain into Te Harakeke/Kawakahia. The largest of these are the Ngarara Creek, Kakariki Stream and Ngarara Stream (of which Paetawa Drain is a tributary). The Ngarara Stream continues through the Te Harakeke/Kawakahia and joins with the Waimeha Stream prior to its outfall to the sea.

Ngarara Creek drains part of the Waikanae township and its lower reaches pass through pastoral land. The proposed Expressway will cross the creek where it runs through some forestry blocks prior to discharging to the Te Harakeke / Kawakahia wetland.

The Kakariki Stream runs from the steep western slopes of the hills, through Waikanae township before passing Nga Manu Bird Sanctuary and flowing into the Te Harakeke/Kawakahia wetland. The Kakariki Stream forms an important part of an ecological corridor being developed by the community to enhance the linkages from Kāpiti Island through Te Harakeke and Nga Manu to the Tararua Ranges beyond. Surrounding pastoral land and access to Nga Manu is occasionally cut off by flooding from the Kakariki Stream.

The Smithfield Drain is a significant tributary of the Kakariki Stream. The drain generally runs parallel to the proposed Expressway, with a substantial length that will run directly beneath the proposed Expressway corridor.

The Paetawa Drain is a large tributary of the Ngarara Stream and is the main drain for the peat flats south of Peka Peka Road. Much of the low lying land on either side of the Paetawa Drain becomes inundated during floods and stores large volumes of ponded floodwater. The Paetawa Drain passes through a gap in a local dune formation that acts as a flood control, holding back floodwater and creating a floodplain.

Hadfield's/Te Kowhai Stream serves a moderately sized steep hillside catchment east of SH1. The stream runs west through rural / pastoral land to outfall at the coast to the near Peka Peka beach settlement. Gravel deposits are evident at the culvert inverts which pass the stream under both SH1 and the railway.

24.3 Hydrological and hydraulic modelling and design principles

Stormwater assessment and design for the proposed Expressway falls into three broad components:

i. Hydrology – rainfall, catchments and runoff;

ii. Hydraulics – flow, velocity, water levels and pipe sizes; and

iii. Water Quality – treatment of runoff[190].

The design process started with investigating and assessing catchments, their characteristics, determining rainfall intensities and calculating subsequent runoff quantities (flow rate and volume).

Once the hydrology of a catchment had been determined and the design flows understood, then the hydraulic design was investigated. This includes determining flood level and water depth, sizing of structures (bridges and culverts) and investigating how these behave under various scenarios.

KCDC has calibrated hydrological and hydraulic models for the majority of the catchments crossed by the Project. GWRC has a calibrated model of the Waikanae River and its flood plain. Rather than duplicating these models, the Project team reached an agreement to use both models, and to superimpose the proposed Expressway onto the existing environment as represented in these models. The models were run for the Project team by KCDC/GWRC's incumbent modelling consultants, with the details of the proposed Expressway and the modelling scenarios supplied by the Project team.

The key design storms modelled were:

- 10% Annual Exceedance Probability (AEP);
- 1% AEP;

[190] Effects on water quality are assessed in Chapter 28 of this AEE Report.

- 1.5 x 1% AEP; and,
- 0.04% AEP (Waikanae River only)

The models have also included mid-range climate change effects estimates out to 2090. These parameters are:

- 16% increase in rainfall intensity; and
- 0.8m rise in sea level.

While KCDC and GWRC have developed and used these models to set building floor levels and to quantify flood risks, the Project team were primarily interested in understanding the effect of the proposed Expressway on existing flood levels, determining the extent of any consequences and developing mitigation as required. In this respect, it is the relative difference between the pre-Expressway (existing) and post-Expressway (after) that the Project team sought to understand rather than absolute flood levels. This is why modelled water surface levels, rather than with freeboard[191] added (as per KCDC and GWRC practice), was determined to be the most appropriate method to ascertain potential hydrological effects. Appropriate freeboard was then added on a site-specific basis to meet the NZTA and GWRC standards at culverts and bridges.

The key methodologies applied to each facet of the design are summarised below:

- Where available, use existing KCDC and GWRC hydrological and hydraulic models to:
    - determine design flows;
    - determine pre and post Expressway flood levels (in both floodplains and watercourses);
    - confirm culvert/bridge waterway sizing;
    - determine the effects of proposed Expressway discharges and the efficiency of proposed Expressway peak flow attenuation;
    - determine the effects of in-fill of floodplains and size any subsequent offset storage; and
    - confirm the adequacy of proposed mitigation measures.
- All design storms to include mid-range climate change effects estimates out to 2090 in accordance with KCDC practice for the District and to allow for this increase when sizing culverts, bridges and when determining peak flow attenuation requirements – i.e. this is one part of achieving hydraulic neutrality.
- Mitigate for the effect of the proposed Expressway partially filling in existing floodplain storage – i.e. this is the other part of achieving hydraulic neutrality.
- Proposed Expressway stormwater will be treated prior to discharge.

[191] The amount of watertight surface between a given level of river water and the lowest possible entry point during flooding.

- Culverts will be designed to “fish friendly” guidelines.
- Culvert alignment and structural form will be designed to reduce the extent of culverts and disturbance of watercourses, as far as practicable.
- Where watercourses and open channel drains will need to be diverted, a “natural” stream channel cross section will be applied wherever practicable.

In order to meet the above criteria, the design process undertook to avoid adverse effects through good design wherever practicable. The potential effects are described in more detail below.

24.4 Assessment of hydrological and stormwater effects during construction

The ESCP (Appendix H of the CEMP Volume 4) provides an assessment of methods to adequately mitigate potential adverse stormwater and hydrological effects during construction.

ESC measures to manage erosion and sediment effects during construction have been designed in accordance with Wellington Regional Council and draft NZTA guidelines[192]. All sediment retention ponds have been sized based on a volume of 2% of the catchment area, length to width ration of 3:1[193], side slopes of 2:1 and a depth of 1m. Cleanwater channels and dirtywater run-off diversion channels have been based on a conveyance system that will transfer up to the 1% AEP[194] storm event to the treatment device. In addition, and to the extent practicable, ESC devices will be located outside the 5% AEP flood level.

Temporary culverts required during construction will be determined through the development of site specific CESCPs. This determination, including specific culvert sizing, will be undertaken with the endorsement of Wellington Regional Council and will be based upon stream flows and upstream catchment areas, timing and duration of works.

Methods to avoid and mitigate the release of sediment into receiving watercourses during construction are summarised in Chapter 28 of this AEE, and detailed in the Appendix H of the CEMP, Volume 4.

24.5 Assessment of hydrological and stormwater effects during operation

A summary of the potential effects associated with the operation of the Project is provided below. Technical Report 22, Volume 4, provides a detailed description of each Sector and the potential effects of the proposed stormwater design for the Project.

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[192] Wellington Regional Council, Erosion and Sediment Control Guidelines for the Wellington Region, September 2002 (GWRC Guidelines) and the New Zealand Transport Agency, draft NZTA Erosion and Sediment Control Standard for State Highway Infrastructure, August 2010.

[193] Sediment retention pond 4 has been designed at a length to width ration of 5:1 to ensure it can be accommodated within the designation boundary.

[194] Annual Exceedence Probability.

24.5.1 Potential adverse effects

A brief summary of the potential adverse stormwater and hydrological effects is provided below:

- Increased peak flow discharge - the proposed Expressway will replace existing pervious surfaces with impervious surfaces. During heavy rainfall events, this change will result in greater peak flow rate and volume of runoff, therefore increasing the peak flow discharged to the receiving environment, and hence potentially increasing flood levels downstream.
- Watercourse crossings – culverts required for the proposed Expressway will change the form of that watercourse and potentially introduce flow (and fish passage barriers).
- Increased flood levels – from the infill of floodplains and/or from constraints resulting from culverts and bridges leading to flooding in areas that do not currently flood; and,
- Increased scour and erosion of watercourses - alteration of stream beds through the installation of culverts/bridges, diversion of stream beds and discharge from new stormwater drains can cause scouring and erosion to the receiving watercourse.

As detailed in the following section, adverse effects will be avoided through design to the extent practicable. Where avoidance is not possible, the effects of the proposed Expressway will be suitably mitigated through design.

Because of this design approach, the overall change in the environment from a hydrological perspective will be a positive one.

24.6 Measures to avoid, remedy or mitigate actual or potential adverse effects on hydrology and stormwater

The stormwater design for the Project has followed the broad principles outlined above in Section 24.3, and is consistent with NZTA's Stormwater Treatment Standard for State Highway Infrastructure.[195]

Overall, the Project design seeks to avoid and/or mitigate adverse effects and to provide an opportunity for potential positive hydrological and stormwater effects to occur. Technical Report 22 details (Project Sector by Project Sector) the proposed mitigation measures that have been incorporated into the stormwater and hydrology design to avoid and/or mitigate the potential adverse effects of the Project. These measures are summarised below.

[195] Stormwater Treatment Standard for State Highway Infrastructure (May 2010)

24.6.1 Flood effects

24.6.1.1 Peak flow attenuation

The proposed Expressway will change the existing ground surface from pervious grass/bush/scrub cover to impervious pavement, causing stormwater to run off much faster than it currently does from the same footprint.

Both NZTA and KCDC design standards require attenuation of peak flows prior to discharge in order to avoid downstream effects on flooding and watercourse erosion. KCDC refers to this as “hydraulic neutrality”, meaning that areas outside the proposed Expressway are not anticipated to experience any increased flood risk from increased peak flow discharges and/or loss of floodplain storage.

The design of the Project provides attenuation of peak flows from the proposed Expressway through the use of swales and/or wetlands. These have been modelled to target restricting peak flow discharges to no more than 80% of pre–Expressway peak discharges for the 1%, 10% and 50% AEP storms, in accordance with KCDC practice.

The complex undulating sand dune topography and the linear nature of the proposed Expressway has required the modelling to focus on attenuation to areas that drain to an existing watercourse instead of at every local low point and gully in every sand dune along the alignment. This approach allows the assessment to focus on the potential effects on flooding associated with each watercourse which, in terms of assessing the overall effects, is the most important relationship to identify and understand.

The proposed swales and wetlands will provide attenuation to varying degrees, ranging from 6% to 82% of pre-development flow for the 1% AEP event. In overall terms, this attenuation will generally achieve the targeted 80%, although in some cases significantly better results will be achieved. While results in a few areas are not predicted to achieve the 80% target at this stage of the design, the final design can and will be optimised to achieve this target during later design stages of the Project.

At this stage of the design, attenuation is focused on the 1% AEP storm. Some of the proposed swales at this stage of the Project design are not currently predicted to achieve the 80% target for the other storms but this is a reflection of how the outlet orifice has been modelled rather than an actual effect. Further refinement of the outlet design will see the swales meet the target attenuation requirements.

Therefore, the proposed Expressway swales and wetlands will fully mitigate the effects of increased peak flows on flood levels.

24.6.1.2 Floodplain storage

Where the proposed Expressway crosses low-lying floodplains, it will need to be built on a low embankment to protect it from flooding. This will result in parts of the floodplain being filled in and consequently the loss of some of the volume currently available for flood storage. Without mitigation, this change would have the effect of raising flood levels in adjacent areas. In the majority of cases, this effect has been fully mitigated through the proposed provision of large areas of offset storage and in overall terms, this attenuation would have the effect of slightly lowering flood levels across the Project area.

The proposed offset storage areas will be formed by lowering local ground levels to hold more floodwater than these areas currently can. In addition, flows in the proposed stormwater wetlands and swales will act to attenuate flood flows, and reduce the need for offset storage.

The largest offset storage areas will be located at:

- Drain 7 South;
- Wharemauku Stream;
- Kakariki Stream; and
- Paetawa Drain/Peka Peka interchange.

The effect of the proposed mitigation will be an overall improvement of flood levels during the 1% and the 10% AEP storms when compared to existing flood levels.

24.6.2 Watercourse crossings

Bridges or culverts will be used where the proposed Expressway crosses watercourses.

24.6.2.1 Bridges

Watercourses of high environmental value (i.e., the Waikanae River and the Waimeha and Kakariki Streams) are proposed to be bridged in order to achieve the desired design standards to protect their environmental values.

Several large bridges are needed along the route to span watercourses and their floodplains. These bridges are designed to span the entire width of the watercourse: i.e. no piers are proposed to be located within the main channel of any of these watercourses.

The length and clearance of the proposed bridge over the Wharemauku Stream was predominantly derived from the need to accommodate a future local road underneath (the Ihakara Street extension). As a result, this structure will not adversely affect the flood flow on the Wharemauku Stream.

The Waikanae River Bridge needs to be 180m long to minimise potential effects on flooding. The works to the river channel will actually result in flood levels decreasing slightly upstream of the bridge. The outlet of the Muaupoko Stream will need to be slightly diverted in order for rock armouring to be placed around the Waikanae Bridge piers. The downstream end of the Stream will be relocated out from under the bridge to allow the re-establishment of a more natural planted stream. As the effects of this realignment will be mainly ecological and aesthetic (rather than flood related) the mitigation of these aspects is not summarised here, but is covered in Chapters 17 (Landscape and Visual), 21 (Terrestrial Ecology) and 22 (Freshwater Ecology) of this AEE.

The Waikanae River bridge design has been peer reviewed by GWRC’s consultant river designer who considers that the proposed crossing position, length, freeboard and span arrangement are acceptable. The peer reviewer’s recommendations have been adopted into the design.

The responsibility for the future maintenance of those areas of the Waikanae River not directly related to protecting and maintaining the new bridge structure will remain with GWRC, which will then manage them as part of its overall responsibility for the river.

The length and height of the Te Moana Interchange Bridge has been designed to clear both the road and the Waimeha Stream, as well as to provide for continuity of the residual flow path from the Waikanae River to the Waimeha Stream. Without such a long bridge, the proposed Expressway would present a barrier to the passage of flood flows potentially resulting in a breach of the Waikanae River stopbanks, which could result in significant additional localised flooding. The proposed bridge and associated floodway mitigates this potential effect and is anticipated to allow Te Moana Road to remain flood free through the proposed Interchange.

The spring-fed Waimeha Stream will be crossed by three bridges near Te Moana Road, one for the proposed Expressway itself and one for each for the two north-facing ramps. Bridges were chosen for the ramps due to the potential difficulty in realigning the Stream into culverts, and the effects on flood levels and ecological values that culverting would create.

The Kakariki Stream is an important ecological corridor. If a culvert was to be used, instead of a bridge as currently proposed, it could significantly increase flood levels or be so large as to be a bridge in all but name.

The Paetawa Drain is to be bridged primarily due to the very large peak flow that needs to pass under the proposed Expressway. A culvert was ruled out as it would need to be so large that it would, in effect, be a bridge.

Under all of the proposed bridges, the existing vegetation will no longer be able to be relied on to protect against scour of the river banks and berms. This is because the bridge decks will block direct sunshine and rainfall, thus will limit the viability of planting. In order to mitigate this effect, rock rip rap will be placed on areas under the footprint of the decks (both floodplain and waterway). Where practicable, the introduced rip rap will be inter-planted with shade tolerant vegetation species to soften its appearance, albeit to a limited degree.

24.6.2.2 Culverts

The culverts proposed as part of the Project have been sized and tested in KCDC's models. As for any structure in a watercourse, it is inevitable that there will be some effect on water levels, however small. As a result, the culverts have been sized to be large enough to have a minimal practical effect on flooding. Often the effect will be offset in an overall reduction in flood levels provided by the proposed stormwater attenuation and offset storage.

The proposed culverts have generally been aligned with the direction of the existing watercourses. However, in some cases this alignment will result in long culverts which could have adverse ecological effects (e.g. hinder and / or prevent fish passage). As a result, reduced skew (shorter) alignments will be investigated during later design stages. If implemented, this will result in a reduction of these adverse effects.

All culverts will have fish friendly design features. The larger box culverts will have "natural stream bed" features consistent with naturally occurring streams in the vicinity, while the smaller pipe culverts will have "low slope" features. In one part of the Project, the use of such culverts will restore fish passage into the wetlands west of the proposed Expressway via the Muaupoko Stream where access has been historically severed by farming practices. Due to the naturally flat topography, all culverts will have very little fall along them, resulting in relatively low flow velocity and the ability to maintain water in them in times of low flow.

The inlets and outlets will be protected from scour and erosion through rock rip rap armour and planting or by using similar means of protection.

For further details of the mitigation proposed to offset the "culverting in" of watercourses refer to Ecological Impact Assessment in Technical Report 26, Volume 3,

24.6.3 Stormwater improvements

The construction of the proposed Expressway will result in several improvements to existing stormwater management, relative to the existing SH1:

- Flat, grassed or planted swales (which have little fall in either direction) will provide for stormwater attenuation, treatment and conveyance all at once;
- The development of wetlands for stormwater treatment and flood storage purposes will provide flora and fauna habitat, attenuation and treatment. In particular, there will be an opportunity to reduce existing local flooding problems in low rainfall events in some areas by reducing high water tables. Furthermore, there is an opportunity to alleviate local flooding problems during moderate to large rainfall events as a direct result of low lying and poor draining land (for example, Kiwi Pond adjacent to the Wharemauku Stream); and,
- Offset flood storage areas will be provided by large planted or grassed areas adjacent to the proposed Expressway.