



Western Ring Route – Waterview Connection



Assessment of Stormwater and Streamworks Effects



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List of Abbreviations

| | |
|----------|--|
| ACC | Auckland City Council |
| AEP | Annual Exceedance Probability |
| ALD | Average Longitudinal Dimension |
| ARC | Auckland Regional Council |
| ARI | Average Return Interval |
| ASCV | Area of Significant Conservation Value |
| BOD | Biological Oxygen Demand |
| BPO | Best Practicable Option |
| CD | Temporary stormwater treatment device |
| Ch | Chainage |
| CMA | Coastal Marine Area |
| CPA1 | Coastal Protection Area 1 |
| DHI | Danish Hydraulic Institute |
| DoC | Department of Conservation |
| DPS | Design Philosophy Statement |
| EB | East bound direction of travel on motorway |
| ERC | Environmental Response Criteria |
| GAC | Granular Activated Carbon |
| GNR | Great North Road |
| ha | Hectares |
| HEC | Hydraulic Engineering Centre |
| HOV | High Occupancy Vehicle |
| m | Metres |
| MHWS | Mean High Water Springs level |
| MPD | Maximum Probable Development |
| OGPA | Open-graded porous asphalt |
| PAH | Polycyclic Aromatic Hydrocarbons |
| PARP:ALW | Proposed Auckland Regional Plan: Air Land and Water |
| PARP:C | Proposed Auckland Regional Plan: Coastal |
| RDP | Regional Discharges Project |
| RoNS | Road of National Significance |
| SEV | Stream Ecological Valuation |
| SH16 | State Highway 16 |
| SH20 | State Highway 20 |
| SRP | Sediment Retention Pond |
| TD | Permanent treatment devices |
| TP10 | ARC Technical Publication 10: Stormwater Management Devices: Design Guidelines Manual |
| TP108 | ARC Technical Publication 108: Guidelines for Stormwater Runoff Modelling in the Auckland Region |

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|-------|---|
| TP124 | ARC Technical Publication 124: Low Impact Design Manual for the Auckland Region |
| TP90 | ARC Technical Publication 90: Erosion and sediment control guidelines for land disturbing activities in the Auckland Region |
| TSS | Total Suspended Solids |
| USACE | US Army Corps of Engineers |
| WB | West bound direction of travel on Motorway |
| WQV | Water Quality Volume |
| WCC | Waitakere City Council |
| WRR | Western Ring Route |

1. Summary Statement

1.1 General

The Waterview Connection Project (Project) is the final Project to complete the Western Ring Route (WRR), providing for works on both State Highway 16 (SH16) and State Highway 20 (SH20) to establish a high-quality motorway link that will deliver the WRR. The WRR is identified as a Road of National Significance (RoNS).

Through the Project, the New Zealand Transport Agency (NZTA) proposes to designate land and obtain resource consents in order to construct, operate and maintain the motorway extension of SH20 from Maioro Street (New Windsor) to connect with SH16 at the Great North Road (GNR) Interchange (Waterview). The majority of this section of SH20 will be constructed via deep tunnels.

In addition, the Project provides for work on SH16. This includes works to improve the resilience of the WRR and wider transport network; raising the causeway on SH16 between Great North Road and Rosebank Interchanges, which will respond to historic subsidence of the causeway and “future proof” it against sea level rise. In addition, the Project provides for increased capacity on the SH16 corridor; with additional lanes provided on the State highway between the St Lukes and Te Atatu Interchanges; and works to improve the functioning and capacity of the Te Atatu Interchange.

This report is an assessment of environmental effects carried out for the stormwater and streamworks aspects of the Project. The initial sections consist of descriptions of the Project, methodology, assessment matters and existing environment, as they relate to stormwater and streamworks. The latter sections summarise the best practicable option analysis of solutions and the assessment of effects for both the operational and construction phases of the Project for the stormwater and streamworks components.

The resource consents that are sought, that related to stormwater and streamworks, are detailed in the Assessment of Environmental Effects, Chapter 7, Section 7.3.

The existing environment in relation to the stormwater and streamworks components of the Project consists of Oakley Creek, Meola Creek and Pixie Stream catchments and the Coastal Marine Area (CMA) including the Waterview Estuary, Oakley Inlet, Waitemata Harbour, Whau Creek and Henderson Creek. Oakley Creek is an urban stream, highly modified in its upstream reaches and through Alan Wood Reserve. Flooding occurs in the Oakley Catchment, caused by urbanisation and increased imperviousness in the catchment and the construction of dwellings within the flood plain. The Motu Manawa Marine Reserve covers parts of the Waterview Estuary, Waterview Inlet, Waitemata Harbour and Whau Creek. Technical Report No G.6 *Assessment of Freshwater Ecological Effects* and Technical Report No G.11 *Assessment of Marine Ecological Effects* provides more detail of these existing environments.

1.2 Stormwater- Operational

The effects of stormwater discharge from the Project during the operational phase will be mitigated by treatment devices that meet the requirements of the Auckland Regional Council (ARC) Proposed Auckland Regional Plan: Air, Land and Water (PARP:ALW) using the Best Practicable Option (BPO) approach, and designed using ARC's Technical Publication 10 - Stormwater Management Devices: Design Guidelines Manual (TP10)(2003) as a basis. The stormwater generated from the motorway contains pollutants from vehicles such as suspended solids, heavy metals and hydrocarbons. The change in land use to motorway increases the impervious area, which increases the volume of runoff from the catchment, and potentially the peak flow during flood events unless mitigation is provided. The proposed treatment devices address both quality and quantity as required and have been selected using a BPO approach. The devices include a combination of wetlands, bio-filter strips, swales and proprietary cartridge filters.

The PARP:ALW requires, and ARC TP10 targets, removal of 75% Total Suspended Solid (TSS) on a long term average basis. For this Project however, treatment of stormwater runoff to remove more than 75% TSS has been identified as a way of mitigating for the coastal reclamation, required as part of the Project, and associated loss of biological habitat. For this reason the stormwater treatment devices for the Project that discharge to the CMA (Sectors 1-5) have been designed for removal of 80% TSS on a long term average basis.

There are 23.31 hectares of additional impervious surfaces resulting in an approximate total impervious area of 56.83 hectares across the Project area. Water quality treatment will be provided for 99.4 % of the additional impervious areas. Of the 33.52 hectares of existing impervious motorway surfaces within the Project area water quality treatment is currently provided for only 3.30 hectares (9.8 % by area). The proposed treatment devices for the Project will significantly increase the area of existing motorway treatment to 30.40 hectares (90.7 % by area), achieving 80% treatment efficiency over the majority of this area. Water quantity treatment will be provided for all motorway areas with stormwater discharges to Oakley Creek to avoid flooding effects.

By providing stormwater treatment to meet the requirements of the PARP:ALW for all of the new motorway areas, the effects from stormwater discharge on the receiving environment have been minimised. In addition, improved environmental outcomes will be achieved by the stormwater treatment of existing motorway areas that currently only have minimal treatment. A higher than usual level of treatment of 80% TSS removal is proposed for areas of the Project that discharge to the CMA. The effects of residual contaminants and change in stormwater flows are assessed in Technical Report No G.6 *Assessment of Freshwater Ecological Effects* and Technical Report No G.11 *Assessment of Marine Ecological Effects*.

1.3 Stormwater- Construction

The effects of stormwater discharge from the Project during the construction phase will also be mitigated by treatment devices designed using the BPO approach. The stormwater generated from impervious construction areas and the pavement for the proposed motorway will carry pollutants dominated by suspended solids. The types of impervious surfaces expected during construction and the treatment approaches include the following:

- Construction yards will be established early in the construction process and runoff will be treated with construction treatment devices (for example wet ponds). The construction yards will be removed at the end of construction.
- Prior to use new sections of motorway (SH20) will be treated by a construction treatment devices, and ultimately by operational phase treatment devices.
- Widening for SH16 will get stormwater treatment once the lanes become live.
- For causeway sections of SH16, where the pavements will be constructed in stages, a series of construction treatment devices for the different stages of construction are proposed.
- For the Great North Road Interchange ramps, it is assumed proposed permanent stormwater treatment devices and reticulation will be constructed simultaneous with the works, and will therefore service these areas once they become live to public traffic. Therefore no separate devices for the construction phase are proposed.

Note that the Technical Report No G.22 *Erosion and Sediment Control Plan* provides details of erosion and sediment discharge control measures employed during the construction phase. By providing stormwater treatment during the construction phase the effects from stormwater discharge on the receiving environment have been minimised. The effects of residual contaminants and change in stormwater flows are assessed in Technical Report No G.6 *Assessment of Freshwater Ecological Effects* and Technical Report No G.11 *Assessment of Marine Ecological Effects*.

1.4 Streamworks

The approach to streamworks was developed and is expressed in the Western Ring Route: Oakley Creek Re-alignment and Rehabilitation Guidelines (Boffa Miskell, 2010), appendix in Technical Report No G.11 *Assessment of Marine Ecological Effects*. These Guidelines were developed by Project ecologists, landscape architects and engineers and propose a set of integrated principles for ecological function, landscape values and stream hydraulics.

The proposed Oakley Creek streamworks for the Project involve:

- SH20 Bridge and cycleway bridge across Oakley Creek, including enabling abutments for the rail corridor, and associated channel works
- Construction of SH20 motorway in areas of Oakley Creek floodplain
- Realignment of the creek for three discrete lengths in Alan Wood Reserve; stream realignments A, B & C
- Rehabilitation of the creek in four reaches, upstream, downstream and between the proposed realignment sections; stream rehabilitations A, B, C & D

- Realignment of the Stoddard Road tributary, to be undertaken when necessary for the future for railway development
- Provision of floodplain storage over future sports fields in Goldstar property
- Placing of engineered fill associated with the southbound cut and cover tunnel structure at Ch 3880m in the floodplain of Oakley Creek (Sector 7).

The proposed realignment and rehabilitation will be based on a naturalised channel, with meanders, riffle-run-pool features, biotechnical engineering of banks and riparian planting.

The proposed stream realignments and rehabilitations will have a positive effect on the environment as a natural channel form will replace the existing manmade basalt rock wall channel. The Project streamworks will have net ecological, environmental and recreational benefits by providing greater access to the stream, better ecological habitats, and more vegetation than currently exists in these reaches. No adverse effects are anticipated to the stream bed morphology, flow hydraulics or sediment. The ecological effects are considered in Technical Report No G.6 *Assessment of Freshwater Ecological Effects*.

The flooding effects of the proposed motorway and streamworks have been assessed using the catchment model developed by AECOM for Metrowater/ACC. The proposed streamworks result in a lower maximum water level in the Project area, which reduces the extent of flooding. The flood storage is reduced by the SH20 motorway, but also by the lower flood water levels. As a result the peak flow downstream of the site increases by 3.3%. These changes result in an increase in water levels upstream of the Bollard Avenue culverts of 150mm for an 100 year ARI flood event. Downstream of this location, no effects are evident from the modelling.

The Project slightly reduces flood extents upstream of the SH20 Oakley Bridge, and more significantly reduces flood extents through the streamworks reach of the Project area. In general, more of the peak flow is contained within the channel, and less overflows to surrounding reserve land and properties, resulting in an overall positive environmental effect of the Project on flood extents.

Six habitable floors have been identified as at risk of flooding in the Project area and downstream (Bollard to western railway line) by AECOM (2010c). The Project reduces the flood risk for two houses, and leaves it unchanged for four other houses. No additional habitable floor levels are put at risk due to the Project. The extent of flooding reduces due to the Project for properties along Valonia Street, Whittle Place, Methuen Road (large improvement) and Hendon Avenue. There are minor adverse effects to properties upstream of the Bollard Avenue culverts and a basement garage at 12a Bollard Avenue from an increase in peak water level during the 100 year ARI rainfall event.

The Project streamworks will provide a net benefit in terms of peak flood levels and extents. The minor effect of increased peak water levels upstream of the Bollard Avenue culverts is mitigated by reductions in flood risk for two houses, and the reduction in total flood extent within the Project area.

Flood protection standards are proposed for the motorway, including the SH20 Oakley Creek Bridge and tunnels. Flood protection levels are dependent on flood management options in the Oakley Catchment to be implemented by Metrowater.

1.5 Notice of Requirement

The land requirements for the Project are influenced by the requirements of stormwater treatment and streamworks. The report provides justification for these land requirements as part of the BPO assessment of each device. The key areas where the Project footprint and designation requirements are affected by stormwater and streamworks are listed below with cross-references to the BPO discussion in the report text:

- Jack Colvin wetland (refer to Section 6.3.2)
- Bio-filter strips along the causeway (refer to Section 6.4.2 and 6.6.2 and 11.5.5, Part D of the AEE)
- Meola wetland (refer to Section 6.8.2)
- Alan Wood wetland (refer to Section 6.10.2)
- Valonia wetland, streamworks and flood storage in the Goldstar property (refer to Section 6.10.2 and Section 8.2).

The report provides justification for these land requirements as part of the BPO assessment of each device.

1.6 Summary of Effects

Although the Project will result in an increase in motorway surfaces, the proposed stormwater treatment will meet or exceed the requirements of PARP:ALW and TP10, to mitigate the effects from stormwater discharges. Net benefits from stormwater are provided by treating runoff from existing impervious areas, that was not previously treated, and providing a greater level of treatment for discharges to the CMA than is required by legislation. These benefits contribute to mitigation for the adverse effects of proposed reclamation within the CMA. Flow and erosion effects from stormwater are mitigated by the proposed stormwater measures, so that the effects are no more than minor. The effects of residual stormwater contaminants, including cumulative effects, on freshwater and marine ecology are assessed in Technical Reports G.6 and G.11.

The streamworks proposed for the Project result in a small loss in the Oakley Creek stream length and the modification of the stream over 1318m. However, the proposed stream realignments and rehabilitations will have a positive effect on the environment, as a natural channel form is proposed to replace the existing basalt rock wall channel. The streamworks proposed for the Project will have net ecological, environmental and recreational benefits by providing greater access to the stream, improved ecological habitats, and more vegetation than currently exists in these reaches. Refer to Technical Report No G.6. for the assessment of freshwater ecological effects.

The Project will reduce the flood storage of Oakley Creek available within the Project area. However, the streamworks proposed will lower flood levels and flood extents in the Project area. This is achieved by channel design and the preservation of flood plain storage than would otherwise have been lost to already consented development (Goldstar property). The only adverse effect is the increase in peak flood flows and increase in flood water level upstream of the Bollard Avenue Culverts, which increases the 100 year ARI water level at a basement garage for one property. Overall, the number of properties affected by flooding decreases and the number of habitable floors at risk of flood decrease as a result of the Project works. The Project streamworks will provide a net benefit in terms of peak flood levels and extents. The minor adverse effect to properties and a basement garage at 12a Bollard Avenue from the increase in peak water level upstream of the Bollard Avenue culverts is mitigated by reductions in flood risk for two houses, and the reduction in total flood extent within the Project area. Therefore, the effects of the streamworks on flooding are considered to be no more than minor.

2. Description of Project

2.1 General

In 2009 the NZTA confirmed its intention that the Project would be lodged with the Environmental Protection Authority as a Proposal of National Significance. The Project includes works previously investigated and developed as two separate Projects: being the SH16 Causeway Project and the SH20 Waterview Connection. The key elements of the Project are:

- Completing the Western Ring Route (which extends from Manukau to Albany via Waitakere)
- Improving resilience of the SH16 causeway between the Great North Road and Rosebank Interchanges to correct historic subsidence and “future proof” it against sea level rise
- Providing increased capacity on the SH16 corridor (between the St Lukes and Te Atatu Interchanges)
- Providing a new section of SH20 (through a combination of surface and tunnelled road) between the Great North Road and Maioro Street Interchanges
- Providing a cycleway throughout the surface road elements of the Project corridor.

The Waterview Connection Project is the key Project to complete the Western Ring Route (WRR).

Resource consents and designations are required to enable construction and operation of the Project. This report will focus on the assessment of effects in relation to obtaining resource consents for the discharge of stormwater to the CMA, works to divert and discharge surface water, stormwater and groundwater, and for works within watercourses. Further detail on the relevant works for these activities, proposed for each Sector of the Project is provided in Section 2.2 of this report.

2.2 Description of Project by Sector

The Project has been divided into Sectors, as shown in Figure 2.1. The purpose of the Sectors is to partition the Project into manageable areas for the assessment of effects. The Sectors divide the Project into areas based on activity and environments as follows:

- Sector 1: Te Atatu Interchange
- Sector 2: Whau River
- Sector 3: Rosebank – Terrestrial
- Sector 4: Reclamation

- Sector 5: Great North Road Interchange
- Sector 6: SH16 to St Lukes
- Sector 7: Great North Road Underpass
- Sector 8: Avondale Heights Tunnel
- Sector 9: Alan Wood Reserve.

Western Ring Route: Waterview Connection (SH16-20) - Sector Diagram

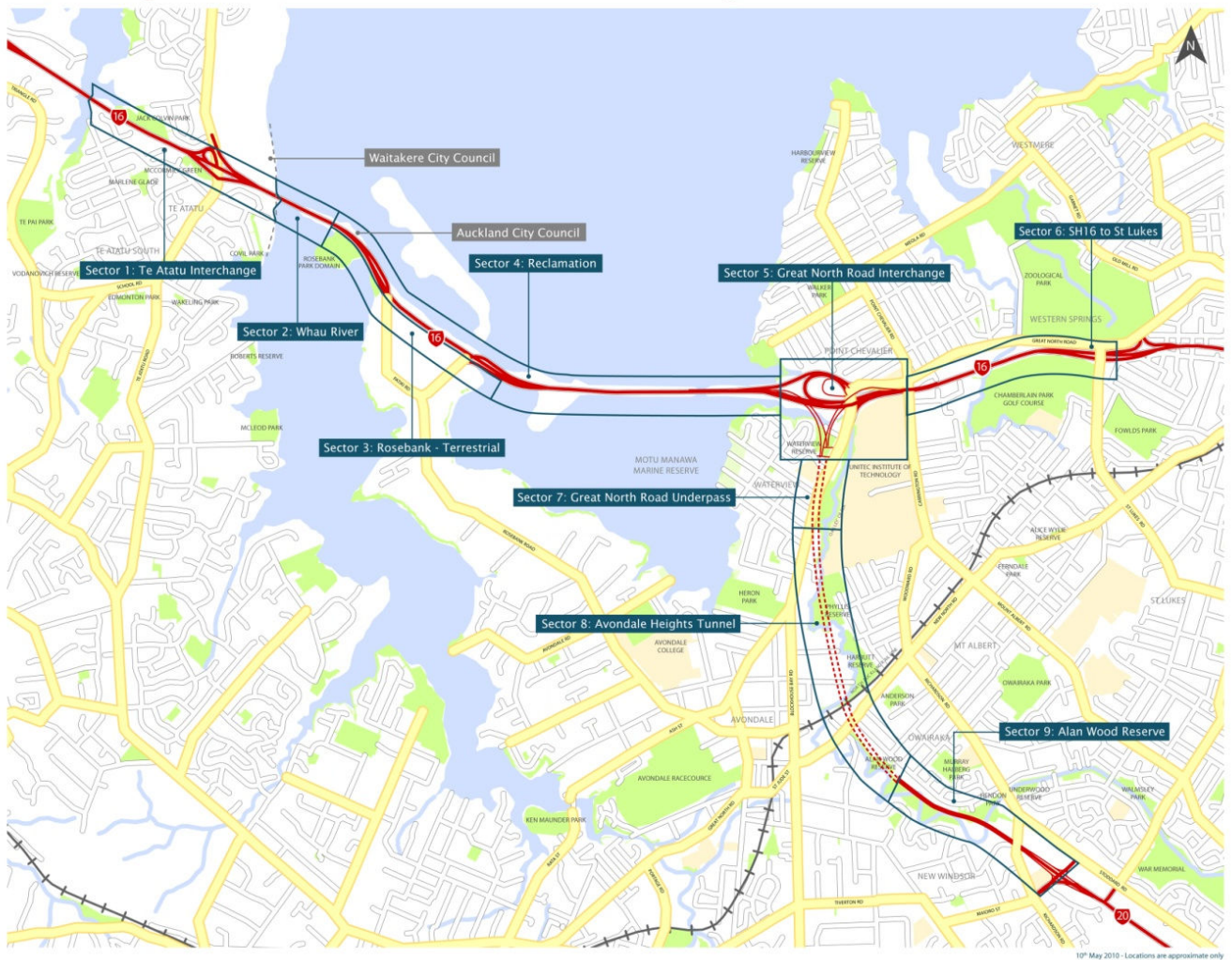


Figure 2.1: Waterview Connection Project Sector diagram

2.2.1 Sector 1 – Te Atatu Interchange

SH16 will be widened to accommodate extra lanes. Significant improvements to the Te Atatu Interchange include enlarging and re-configuring off and on ramps to accommodate additional lanes and to provide for bus shoulder and priority for buses and other High Occupancy Vehicles (HOVs).

Stormwater treatment will be provided by a wetland and two treatment swales. During construction, stormwater will be managed by maintaining sediment discharge controls. Permanent treatment devices will be constructed and ready for use when additional impervious areas are commissioned. In addition, a temporary stormwater pond will treat runoff from the construction yard.

2.2.2 Sector 2 – Whau River

SH16 will be widened to accommodate extra lanes, which includes the enlargement of the existing Whau River Bridge. A separate dedicated cycle/pedestrian bridge will be constructed alongside the widened Whau River Bridge.

Stormwater treatment will be provided by two proprietary filter cartridge vaults and two bio-filter strips. During construction, management of stormwater will be achieved by maintaining sediment controls and by constructing the permanent treatment devices to be ready for use when additional impervious areas are commissioned.

2.2.3 Sector 3 – Rosebank – Terrestrial

SH16 will be widened to accommodate extra lanes, which involves the re-configuration of the existing Rosebank on and off ramps to improve merging traffic. The westbound outside lane will be “dropped” at the Rosebank exit ramp.

Stormwater treatment will be provided by five proprietary filter cartridge vaults. During construction, management of stormwater will be achieved by maintaining sediment controls and by constructing the permanent treatment devices to be ready for use when additional impervious areas are commissioned. In addition, three cartridge filter vaults will be used during construction to treat stormwater from the Rosebank on and off ramp, and Patiki Road off ramp.

2.2.4 Sector 4 – Reclamation

Sector 4 involves the provision of two additional westbound lanes from the Great North Road Interchange to the Rosebank Road Interchange to create a total of five westbound lanes, plus a dedicated bus shoulder. An additional lane will be added from the Rosebank Interchange to the Great North Road Interchange to create a total of four eastbound lanes.

Stormwater treatment will be provided by a combination of cartridge filter vaults and bio-filter strips. During construction, management of stormwater will be maintained for areas equivalent to those for which treatment is currently provided, by the use of filter trenches, during all stages of the construction process. In other areas erosion and sediment discharge controls will be maintained, with permanent treatment

devices to be ready for use when additional impervious areas are commissioned.

2.2.5 Sector 5 – Great North Road Interchange

Sector 5 of the Project includes the ramps and alignment associated with the connection of SH20 to SH16 (the Great North Road Interchange) and extends from the Waterview Park area to the causeway in the west and Carrington Road in the east.

Key elements include four new ramps to connect SH20 to SH16. These are:

- A two lane westbound ramp will take traffic from the tunnel (SH20) towards Waitakere (SH16);
- A two lane southbound ramp will take traffic from Waitakere (SH16) towards Maioro Street, the Airport and SH1;
- A two lane eastbound ramp for traffic emerging from the tunnel (SH20) will connect with SH16 towards the city in the vicinity of the Carrington Road Bridge; and
- A single lane southbound ramp will take traffic coming from the City (SH16) and connect with SH20 towards Maioro, the Airport and SH1.

Stormwater treatment will be provided by a combination of treatment devices; two wetlands, a treatment swale, three cartridge filters and two lengths of bio-filter strips (continued from Sector 4). During construction, management of stormwater will be maintained for areas for which treatment is currently provided, and treatment will be provided for construction yards. Elsewhere erosion and sediment discharge control measures will remain in place throughout construction.

2.2.6 Sector 6 – SH16 to St Lukes

Sector 6 of the Project includes the additional lanes on SH16, between the Great North Road Interchange and St Lukes Interchange.

Stormwater treatment and extended detention will be provided by a wetland in Sector 6. During construction, management of stormwater will be achieved by constructing the permanent treatment wetland to be ready for use when additional impervious areas are commissioned. Elsewhere erosion and sediment discharge control measures will remain in place throughout construction.

2.2.7 Sector 7 – Great North Road Underpass

Sector 7 refers to the 'cut and cover' section of tunnel from the northern portal at (Waterview Park), crossing beneath Great North Road to connect with the deep tunnel (Sector 8).

Drainage flows from this section are limited to a small amount of groundwater that may enter through the tunnel lining, tunnel washdown flows, and flows from the deluge system during an emergency. Collection, conveyance, storage and pumping systems have been designed for these flows. The low point in the tunnel occurs in Sector 8 and pump out will be to the northern portal in Sector 5. Depending on the level of water contamination, the flows can be discharged to either the northern portal wetland (normal levels of stormwater pollutants in water, or tanker trucks for offsite treatment and disposal (highly contaminated water).

During the construction phase stormwater runoff from the contractor's working area in this Sector will be treated by a wet pond. Stormwater treatment for temporary diversions of Great North Road will be provided by upflow filters.

2.2.8 Sector 8 – Avondale Heights Tunnel

Sector 8 refers to the section of the Project from the southern portal located in Alan Wood Reserve, two driven tunnels under Avondale Height/Springleigh providing three lanes in each direction, connecting to the cut and cover section of the tunnel (Sector 7) and northern portal at Waterview.

Provision will be made for treatment of drainage flows from this section, which are limited to a small amount of groundwater that may enter through the tunnel lining, tunnel washdown flows, and flows from the deluge system during an emergency. Collection, conveyance, storage and pumping systems have been designed for these flows. The low point in the tunnel occurs in Sector 8 and pump out will be to the northern portal in Sector 5. Depending on the level of water contamination, the flows can be discharged to either the northern portal wetland (normal levels of stormwater pollutants in water), or tanker trucks for offsite treatment and disposal (highly contaminated water).

During construction tunnel water will be treated at both portals (refer to the Technical Report No G.22 *Erosion and Sediment Control Plan*) and discharged through temporary stormwater systems.

2.2.9 Sector 9 – Alan Wood Reserve

Sector 9 covers that area of the Project from the Maioro Street Intersection to the tunnel portal in Alan Wood Reserve (the 'at-surface' section of SH20). The new carriageway follows the ground profile, and enters a "trench" at the approach to the southern portal.

Stormwater quality treatment, extended detention and flood attenuation will be provided by two constructed wetlands. During construction, management of stormwater will be provided for the motorway and construction yards by temporary wetlands and wet ponds.

Streamworks for Oakley Creek in Sector 9 will include areas of realignment, areas of channel and habitat rehabilitation, and the bridging of SH20 over the stream at approximately SH20 Ch 1060.

3. Methodology

3.1 General

Stormwater, streamworks and flooding have the potential to create adverse effects on the environment. This section provides an overview of the potential adverse effects in relation to these issues and the approach that was taken to select the proposed solutions and to assess the remaining effects in the context of the Project.

3.1.1 The importance of assessing the effects of stormwater and streamworks

Stormwater runoff from urban areas (including motorways) carries pollutants such as particles from car exhausts, tyres and brakes, silt, fertilisers and oils, which often adhere to sediment particles. The accumulation of sediment, contaminants and changes to the chemical make-up of stormwater affect water quality, which can then have significant effects on the viability of aquatic ecosystems in streams, estuaries and harbours.

Urban development (including motorways) increases impervious areas, reducing infiltration into the ground, instead diverting it into stormwater systems. This increases the flow and volume of water discharging to streams and harbours. These changes in the hydrological cycle can cause flooding and stream erosion, which can have direct effects on public safety and property. Erosion and sedimentation can affect aquatic habitats.

The Project requires streamworks and alteration to the floodplain of Oakley Creek. These changes to the stream have the potential to cause adverse effects on aquatic habitats. Modifications to the Oakley Creek floodplain have the potential to affect flood water levels due to changes in flood storage and/or flow conveyance.

3.1.2 How stormwater is mitigated and effects assessed

The design of stormwater systems is based on standards set in Technical Report No G.27 *Stormwater and Streamworks Design Philosophy Statement*. The key design principles of the Design Philosophy Statement are summarised in Section 3.1.5.

The existing environment is described for each Sector to provide a context for the assessment of effects (refer Section 5). The existing environment includes the catchment, existing stormwater infrastructure, receiving environment and existing consents.

The effects have been assessed based on the requirements of the Resource Management Act 1991 (RMA), the PARP:ALW and other regional and district plans and existing resource consents. Criteria for assessment for stormwater have been developed from these documents (refer Section 4) and form the basis for the assessment of effects in Sections 6 and 7.

The effects of stormwater are assessed using hydrological methods and models (described in Section 3.2). The PARP:ALW requires treatment of stormwater to be achieved via the selection of the BPO and designed in accordance with ARC TP10 (described in Section 3.3). The assessment of effects is for the design that includes mitigation measures. Effects on ecology from stormwater are covered in ecological assessment reports,

principally in the Technical Report No G.6 *Assessment of Freshwater Ecological Effects* and Technical Report No G.11 *Assessment of Marine Ecological Effects*.

3.1.3 How streamworks are mitigated and effects assessed

Following a similar approach to stormwater, the criteria for assessment has been developed from the provisions of the RMA and plans including the PARP:ALW (refer Section 4). The existing environment is described for each Sector to provide a context for the assessment of effects (refer Section 5).

The approach to streamworks was developed and is expressed in the Western Ring Route: Oakley Creek Re-alignment and Rehabilitation Guidelines (Boffa Miskell, 2010), appendix in Technical Report No G.11 *Assessment of Marine Ecological Effects*. These guidelines were developed by Project ecologists, landscape architects and engineers and propose a set of integrated principles for ecological function, landscape values and stream hydraulics. The objects of the Guidelines are:

- 1) To inform concepts for potential stream realignments; and
- 2) To guide the rehabilitation of Oakley Creek in the Hendon Park - Alan Wood Reserve area.

The Guidelines reference the Oakley Creek Watercourse Management Plan (Morphum Environmental, in Press) undertaken for Metrowater.

The Guidelines have directed the design of motorway crossings of Oakley Creek, realignments of Oakley Creek and the Stoddard Road tributary and stream rehabilitation efforts. In particular, the typologies for stream reaches have been adopted in the design.

The hydraulic aspects of the streamworks design and assessment was undertaken using Danish Hydraulic Institute (DHI) MIKE software (refer to Section 3.4). Ecological effects are described in Section 8 and in Technical Report No G.6 *Assessment of Freshwater Ecological Effects*.

3.1.4 How flooding is mitigated and effects assessed

As per stormwater and streamworks, the criteria for assessment have been developed from the provisions of the RMA and plans including the PARP:ALW (refer Section 4). The existing environment is described for each Sector to provide a context for the assessment of effects (refer Section 5).

The approach to flooding has been to work cooperatively with ACC through Metrowater because flooding in the catchment is an issue for both ACC and the NZTA. The NZTA has funded part of the Oakley Creek flood management studies to ensure the results of ACC's work were available in time for this assessment report.

Metrowater has undertaken several flood studies since the last accepted catchment management plan by Beca in 1995. These studies had been unsuccessful for reasons described in Smedley et al (2010). The current modelling studies undertaken for ACC/Metrowater by AECOM have resulted in the most comprehensive modelling effort to date. This has been aided by better modelling technology (allowing three-way coupling of models describing stormwater networks, main streams and flood areas) and the catalyst of the Waterview Connection Project which has added the NZTA focus and resources.

NZTA designer's Tonkin & Taylor Ltd (T&T) developed designs for streamworks and these have been simulated in the independently validated models developed by AECOM for Metrowater. The model results have allowed the effects of the streamworks and works in the flood plain to be assessed. The cooperative approach has also allowed the effects of flood management options in the upper catchment to be assessed in the area of the motorway. This has been important as "pass-forward" flood management options potentially increase peak flows in the vicinity of the motorway. The design and modelling methodology is described in more detail in Section 3.4.

3.1.5 Design philosophy statement

The design standards referenced for the design are detailed in the Technical Report No G.27 *Stormwater and Streamworks Design Philosophy Statement*. The Design Philosophy Statement adopts the following principles for the design:

- The design will incorporate the total stormwater management system (collection and conveyance network; treatment devices; stormwater cross drainage; Oakley Creek culverts and diversions);
- The objective of the stormwater management system is to provide a BPO to avoid, remedy or mitigate more than minor adverse environmental effects, determined through a robust evaluation of options;
- The design should include full consideration of stormwater operational implications throughout the design life; and
- The design should best practicably mimic the existing hydrologic regime and setting, to deliver outcome objectives that remedy or mitigate adverse environmental effects. The design should also consider any measures to improve current flood issues in the catchment.

3.2 Hydrological Assessment

The rainfall data used in the calculation of the design flows were derived from the 24 hour rainfall depths provided in Guidelines for Stormwater Runoff Modelling in the Auckland Region, ARC Technical Publication No. 108, 1999 (ARC TP108). The rainfall depths from ARC TP108 were checked against the summary statistics for the National Institute of Water & Atmospheric Research (NIWA) Owairaka and Onehunga gauges, and the HIRDS databases, and found to be reasonably consistent with other data sources.

Based on a review of rainfall distributions, the Project area was divided into two areas of representative rainfall depths, one being Sectors 1-7 and the other Sector 9, due to the location of rainfall gauges in the area, and the distribution of isohyets in TP108 plots. The design rainfall hyetograph was based on the normalised 24 hour temporal pattern specified by ARC TP108, adjusted for the design 24 hour rainfall depths.

Predicted climate change effects, including an increase in rainfall intensity (Ministry for the Environment (MfE), 2008), were accounted for in design because these changes are predicted to occur over the life of the stormwater infrastructure. The TP108 rainfall data were factored by the recommended increment identified in Climate Change Effects and Impacts Assessment (MfE 2008). Values were determined assuming a mean

predicted temperature increase for the Auckland region of up to 2.1°C to 2090. This resulted in an increase in 24 hour rainfall depth for the 100 year Average Return Interval (ARI) event of 17%.

The runoff factors for the hydrological estimates were based on the underlying geology and the land use. The underlying geology within the catchment was defined based on the geological map for Auckland region (Kermode, L.O. 1992).

The catchment was assumed to have land use equivalent to maximum probable development (MPD) anticipated by the ARC's Transitional Regional Plan. This creates the highest anticipated imperviousness for the catchment and therefore the greatest runoff, for the design of streamworks and cross drainage infrastructure.

3.3 Stormwater Treatment

The PARP:ALW requires the BPO to be implemented with respect to minimising the effects of stormwater discharges. Section 2 (1) of the RMA (1991) similarly defines the "Best Practicable Option" as:

"Best Practical Option means the best method for preventing or minimising the adverse effects on the environment having regard, among other things, to:

- (a) the nature of the discharge or emission and the sensitivity of the receiving environment to adverse effects; and*
- (b) the financial implications, and the effects on the environment, of that option compared with other options; and*
- (c) the current state of technical knowledge and the likelihood that the option can be successfully applied."*

Runoff volumes and peak flows were determined using ARC TP108. The areas for stormwater treatment include:

- All additional motorway pavement surfaces above ground (tunnel sections of motorway pavement are treated separately)
- Tunnel drainage including groundwater, rainwater carried into the tunnel, washdown water from tunnel cleaning activities and deluge water from the tunnel fire fighting system
- Existing motorway pavement surfaces where it is practicable to do so, as discussed in detail in Section 6. This is considered to be a Project enhancement
- All additional ancillary pavement areas on local roads required for tie in to SH16 and SH20 motorways
- All cut batter slopes that cannot be managed through another method.
- Stormwater collected from the Maioro Interchange as part of the Mt Roskill SH20 extension Project that cannot be directed to the Roma Road pond (this was consented as part of Mt Roskill SH20 extension project).

- Stormwater from the Christ the King site as per the agreement between the NZTA and the owner of the property, which introduces approximately 4.1 ha.

3.3.1 Operational Phase Treatment

Permanent treatment devices (labelled TD) were selected using the BPO approach, and designed to meet the requirements of the PARP:ALW based on ARC TP10 guidelines. Water quality treatment is proposed for all new (additional) impervious areas, and existing impervious areas where practicable. The provision for water quantity treatment depends on the potential effects on the receiving environment. Where flooding or erosion are pertinent, treatment devices include flood attenuation and extended detention measures.

In Sector 9 the peak discharges from the motorway and Christ the King site have been limited to the predevelopment catchment flows for the 2, 10 and 100 year ARI design events, in recognition of the flooding issues in Oakley Creek. Where discharging to the estuarine environment or the harbour, only water quality treatment has been provided, because peak flow attenuation and extended detention are not required to areas where flooding and stream erosion are not an issue. For the device discharging to Meola Creek (low down in the catchment), water quality treatment and erosion control were provided after an evaluation of the timing of peak flows from the wider catchment showed no benefit from peak flow attenuation.

3.3.2 Construction Phase Treatment

Temporary stormwater treatment devices (labelled CD for Construction Device) are required during the construction period for new areas of imperviousness including permanent works such as the motorway and construction area such as contractors' facilities and laydown areas. These were also designed using the BPO approach. Where possible, permanent treatment devices or erosion and sediment discharge control ponds were selected to be adapted for use as temporary stormwater devices during the construction phase.

In recognition of the short period the temporary stormwater treatment devices will be in use, it is proposed that for Sector 9, the peak discharges from the motorway be limited to the predevelopment catchment flows for the 2, 10 and 20 year ARI design events. The 20 year ARI design event is consistent with the design standard used in TP90 (ARC 1999) for sediment and erosion control devices, which are also used as temporary devices during the construction phase of the Project. A BPO approach has been used for the selection of temporary stormwater treatment devices to meet the ARC TP10 guidelines or to justify alternate approaches.

3.4 Streamworks and Flood Protection Design

3.4.1 Overview

Oakley Creek runs parallel to the proposed SH20 Motorway alignment in Sectors 5, 7, 8 and 9. Streamworks are necessary due to the Project alignment in Sector 9. The streamworks have been developed with the objectives of not exacerbating flooding issues in the stream and surrounding areas, protecting the proposed motorway from flood waters, and improving the ecological and amenity values of the stream. The Oakley Creek Realignment and Rehabilitation Guidelines (appendix in Technical Report No G.11) were developed to establish the design principles for stream realignments and to identify the lengths of the stream to be rehabilitated as part of the environmental compensation.

The Guidelines were used in combination with hydraulic calculations to establish a cross section to be used for the realignment lengths. The preliminary design of realignments and stream structures such as bridges were based on the hydrology outlined in Section 3.3. The preliminary design of the realignment cross-section was undertaken using Haestad flowmaster, with culverts assessed using US Federal Highway Administration software HY-8.

The design was then refined using dynamic hydrological and hydraulic modelling (see descriptions of catchment and floodplain models below) of design flood events to establish the existing situation and the effects of the proposed changes to the stream and surrounding area on flood levels and velocities. Iterations of the design were modelled and assessed as the design progressed.

3.4.2 Modelling general

A comprehensive catchment study of the Oakley Creek catchment was undertaken by Metrowater independent of the Project. The objectives of that study were to develop catchment wide options for flood management. The model developed by Metrowater’s consultants AECOM uses the MIKE software which was developed by the Danish Hydraulic Institute (DHI), incorporating the Mike 11, Mike 21 and Mike Urban modules. This model is referred to as the “Catchment Model”.

Initial design of the streamworks was undertaken by the NZTA’s consultants T&T using a separate floodplain model, which was a reduced version of the catchment model. For the purposes of the preliminary design T&T used a simplified hydrology assessment based on TP108. This floodplain model allowed for the development and testing of design options. It subsequently also allowed for an independent assessment of flood flows and water levels that provided a useful verification of results from the catchment model.

The Catchment Model, having been refined, was used to assess the Project. The Catchment Model was considered to be the best tool to assess the design and effects from the motorway because it includes details such as the urban drainage (including soakage) and it was calibrated and validated for observed flood events. Further iterations of the design were undertaken and tested in the catchment model. The catchment modelling is detailed in the following reports:

- AECOM (2010a). Oakley Creek Flood Management - SH20 Options Modelling Report. For the NZTA (appended to this report in Appendix C)
- AECOM (2010b in press). Oakley Creek Flood Management – Model Build Report. For Metrowater/ACC.
- AECOM (2010c in press). Oakley Creek Flood Management – Flood Hazard Mapping Report. For Metrowater/ACC.
- AECOM, 2010d. Excerpts from Oakley FHM. For NZTA (appended to this report in Appendix C).

3.4.3 Modelling for assessment of effects

Two scenarios, modelled in the Catchment Model were used to assess the hydraulics and flooding aspects of the effects of the Project and incorporated streamworks on the environment. The first scenario was the 100

year ARI flood event in Oakley Creek for the existing situation (the baseline for the existing environment), referred to in this report as “existing”. The second scenario was the 100 year ARI flood event in Oakley Creek with the Project including the motorway and streamworks, referred to as the “with Motorway” case in this report. Note that both scenarios have the same hydrology of 100 year ARI rainfall with climate change allowances and MPD of the catchment. More details of these scenarios and associated models are provided in Section 8.4 and in AECOM (2010a) in Appendix C.

3.4.4 Modelling for future-proofing of design

The study of the Oakley Creek catchment undertaken by AECOM has identified flood mitigation options in the catchment and upstream of the Project area. These proposed flood mitigation options include an option to “pass forward” flood water by increasing conveyance capacity to alleviate flooding in the reaches upstream of the Project. However, this option will increase peak flows through the Project area. The impacts of these potential changes to the Oakley catchment and stream have been assessed in the Catchment Model to ensure the design of the streamworks are future proofed by providing enough capacity now or with modifications in the future, to convey the increased flow anticipated from these changes. The hydrological assumptions are the same for this scenario as the previous scenarios. Refer to Section 8.5 for details.

3.4.5 Modelling of other average return interval events

Additional scenarios have been modelled in the catchment model to assess the risk to the tunnels from a 2500 year ARI rainfall event. Also the sensitivity of the system to operational issues was tested by modelling 50% blockage (by area) of the Bollard Ave, New North Road, Railway and Bollard overflow culverts. Refer to Section 8.5 for details.

3.5 Cross Drainage Design

Where the Project works cut across existing stormwater drainage infrastructure or overland flow paths, provisions for maintaining or diverting these are required. It is proposed to achieve this through the use of swales and/or pipe systems, with the aim of minimising the effect on the existing flow conditions. There are three main areas requiring works to maintain cross drainage infrastructure:

- The length of surface motorway through Alan Wood Reserve where a primary network pipe and the overland flow regime will be affected
- The primary stormwater network where the cut and cover tunnel will be constructed across the alignment of GNR
- The SH16 widening works where stormwater network culverts pass under the existing motorway.

The existing primary stormwater network is assumed to convey flows up to the 10 year ARI peak flow. New primary drainage infrastructure was designed to this capacity (with allowances for MPD and climate change made as outlined in Section 3.2).

Overland flow paths need to ensure the 100 year ARI peak flow is safely accommodated. These flow paths were designed to convey the difference between the present climate 10 year ARI peak flow and the future climate 100 year ARI peak flow with Climate Change in the area of Alan Wood Reserve to ensure the 100yr ARI flow can be conveyed without the risk of blockage by the motorway structures. Where stormwater culverts exist under SH16 in the area of the Project where widening is proposed, these culverts will be extended as necessary. If these are undersized for MPD catchment conditions and climate change assumptions, options to increase the capacity of the culverts to provide for the design storm will be considered.

ARC TP108 was used to calculate design flows. The geometry and hydraulics of the pipes, culverts and swales were then determined using Haestad flowmaster, US Federal Highway Administration software HY-8, and Austroads Waterway Design Guide respectively.

3.6 Stormwater Reticulation Design

Stormwater reticulation has been developed to a conceptual level to determine the feasibility of the stormwater treatment options. However, stormwater reticulation has not been designed in detail, as the stormwater reticulation is not material to the consent applications; unlike the stormwater treatment that has been developed to a preliminary design level to support the resource consent application.

Therefore, stormwater treatment provided by sumps within catchpits is not included in the assessment. Nor is the removal of sediment by Open-graded porous asphalt (OGPA) pavement, which has been observed to remove sediment (NIWA, 2010)

4. Assessment Matters

Relevant planning documents for the assessment of effects of the stormwater and streamworks aspects of the Project include the Resource Management Act 1991, The Transitional Regional Plan, ARC's PARP:ALW, The Proposed Auckland Regional Plan : Coastal (PARP:C), the Auckland City Council (Isthmus Section) District Plan and the Waitakere City Council District Plan. Relevant sections of these documents are summarised in the Waterview Connection Project SH16/SH20 Assessment of Environmental Effects and summarised in Appendix B.

In Section 4.1 the current stormwater discharge consents for the area are summarised. In Section 4.2 the assessment criteria for stormwater and streamworks are summarised.

4.1 Relevant current consents

ACC holds a comprehensive discharge consent for the Oakley catchment, and consideration of this is relevant to stormwater criteria for the Project. Also, current consents held by the NZTA for the existing SH16 alignment are relevant as the baseline for stormwater treatment for the areas they relate to. A summary of each of the relevant stormwater consents follows.

4.1.1 ARC consent no. 24973 (Oakley Creek catchment stormwater discharge)

ACC currently holds a consent from the ARC "To divert and discharge stormwater within and from the Oakley Creek Catchment into the Waitemata Harbour" (ARC consent No. 24973). Considerations for the assessment criteria arising from this consent include:

- Piping of existing open channel watercourses and removal of riparian vegetation shall not be allowed unless covered under the General Authorisation or a separate resource consent obtained
- That, where possible, outfall structures shall be kept back from watercourses to allow the discharge of stormwater to pass over ground before entering the main stream flow
- That if further piping of watercourses takes place, a secondary flow path shall be provided so that the capacity of the overland flow path and the pipe shall not be less than the estimated 1% AEP (Annual Exceedance Probability) flood flow
- That, where kerbs and channels are to be constructed across overland flow paths, kerbs shall be set at a level to maximise the capture of water by road cesspits, and driveway crossings shall be constructed in such a manner to minimise the overflow of water from the road into private properties
- That, when any development or redevelopment of land takes place within the catchment, the ACC shall require developers of such land to investigate the opportunity for the implementation of stormwater quality measures on the developer's land to mitigate the adverse effects of stormwater quality and implement such measures.

4.1.2 ARC Consent No. 30235 (SH16 causeway bus lane stormwater discharge)

The NZTA currently holds a consent from the ARC “To divert and discharge stormwater between GNR and Rosebank Road Interchanges into the Waitemata Harbour” (ARC consent No. 30236). The consent was granted for the shoulder widening on a section of SH16 between GNR Interchange (Waterview) and the Rosebank Road Interchange, involving approximately 2 km of roading. The widened shoulder lane is used as a bus lane during peak traffic times. Considerations for the assessment criteria arising from this consent include:

- The hybrid system installed treats approximately 1.17ha of the total impervious area of 4.67ha. New works were expected to be undertaken as part of the SH16 and SH20 linkage (e.g. Waterview Connection Project), when full stormwater treatment facilities were expected to be provided along the proposed length of works. It was therefore considered that a moderate term of consent is reasonable and a 15 year term was recommended.
- Regional Discharges Project – to ensure that this consent does not compromise and is consistent with the overall Regional Discharges Project (RDP), a review condition was recommended that will allow for the outcomes of the RDP to be incorporated as necessary into this specific consent.

4.1.3 ARC Consent No. 35626 (State Highway 16 ramp metering)

The NZTA currently holds consent from the ARC “To divert and discharge stormwater from alterations to State Highway 16” (ARC consent number 35626). The consent was granted for the Traffic Demand Management Project involving ramp metering (including widening) of 15 on-ramps located on the Northwestern Motorway between Newton and the Royal Road on-ramps. Considerations for the assessment criteria arising from this consent include;

- Flooding – The additional 9935m² of new road pavement at 12 sites is spread over 15 km and will not result in any additional flooding issues within the respective catchments. The proposed new stormwater wetland has been designed and sized to attenuate the post-development peak flows from the 100 year ARI storm event to the pre-development levels, and the wetland will discharge back to the existing drainage networks.
- Ensure that, for stormwater flows in excess of the capacity of the primary systems, secondary flow paths are provided and maintained to allow surplus stormwater from critical storms, up to the 100 year ARI event, to discharge with the minimum of nuisance and damage.
- For the purposes of this Consent “major overland flow paths” are those that accompany a primary drainage system of a nominal 600mm diameter pipe or larger or with peak overland flow exceeding 0.5 m³/s in the 100 year ARI event.
- That major secondary flow paths on land are kept free from significant obstructions such as buildings and solid fences.

- That, where kerbs and channels are to be constructed across secondary flow paths, kerbs shall be set at a level to maximise the capture of water by road cesspits, and driveway crossings shall be constructed in such a manner to minimise the overflow of water from the road into private properties.
- Any stormwater outfalls shall incorporate erosion protection measures to minimise the occurrence of bed scour and bank erosion for a distance of five times the pipe diameter from the outfall.
- Water Quality - The proposed upgrade and widening will create an additional impervious area of approximately 9,935m² of new road pavement. Approximately 2,150m² of new road pavement will be treated via exiting swales and filter strips. For the remaining 7,785m², the NZTA proposed to treat approximately 20,340m² of road pavement in and around the Te Atatu Peninsula Eastbound and Waterview Eastbound, via swales and wetland.
- Regional Discharges Project - To ensure that this consent does not compromise and is consistent with the overall Regional Discharges Project (RDP), a review condition has been recommended that will allow for the outcomes of the RDP to be incorporated as necessary into this specific consent.

4.1.4 ARC Discharge Permit No. BH/8735 (Rosebank Road and Patiki Road on-ramp and off-ramp motorway structures)

The NZTA currently holds consent from the ARC "To divert and discharge stormwater from the motorway interchange development at Rosebank and Patiki Roads" (ARC discharge permit number BH/8735). The consent was granted for the diversion and discharge of stormwater from the motorway interchange into the Coastal Marine Area of the Waitemata Harbour through six outfalls. Three outfalls are located on the Pollen Island side and three on the Waterview Estuary side of SH16. Relevant assessment criteria arising from this consent include:

- All runoff from sealed and other impervious parts of the carriageway shall be passed through a stormwater treatment device.
- Stormwater quality treatment devices shall include isolation valves to contain hazardous or contaminated spillages.
- The stormwater outfalls shall be terminated with structures of such design and location as to avoid erosion of the intertidal area and the formation of new drainage flow paths.
- All outfall pipes from the stormwater treatment devices to the outfall structures shall be sealed where laid within the reclamations.

4.2 Summary of criteria for assessment

The RMA, ARC PARP:ALW, ACC (Isthmus Section) District Plan and Waitakere City Council District Plan focus on similar criteria to assess stormwater and streamworks aspects of projects. Common to the RMA and all plans is the requirement for options to be assessed and the BPO selected.

Criteria for the assessment of effects for stormwater, streamworks and flooding, are summarised in Tables 4.1, 4.2 and 4.3 respectively. These summary criteria are based on the review of legal and planning framework (refer to Appendix B).

Table 4.1: Stormwater Assessment Criteria

| Stormwater Assessment Criteria | Description |
|--------------------------------|---|
| Erosion control | All outfall discharges that are likely to cause scour at the outfall incorporate erosion control measures. |
| Water quality treatment | <p>Have regard to the nature of the discharge and the sensitivity of the receiving environment to adverse effects (RMA S105).</p> <p>Discharges to be treated to remove at least 75% of TSS loads on an average annual basis (ARC PARP:ALW).</p> <p>Management of run-off from land uses with a high contaminant generation potential.</p> |
| Overland flow | Overland flow paths are provided and maintained for flows in excess of the primary drainage network capacity to allow flows up to and including the 100 year ARI storm. |
| Attenuation | <p>The method of stormwater disposal shall minimise changes to the pre-development hydrological regime. In particular:</p> <ul style="list-style-type: none"> i) the peak flows for the 2 year and 10 year ARI post-development events shall not be greater than the corresponding peak flows for pre-development events ii) the volume of stormwater runoff for post-development events shall be minimised iii) the time of concentration for post-development events shall be maximised so that it is as close as practicable to those for pre-development events. <p>Does not cause downstream channel erosion.</p> |
| Aesthetics and odour | <p>After reasonable mixing, the contaminant or water discharged shall not give rise to the following effects in the receiving waters (RMA S107):</p> <ul style="list-style-type: none"> • Conspicuous oil or grease films, scums or foams, or floatable or suspended materials • Any conspicuous change in the colour or visual clarity |

| Stormwater Assessment Criteria | Description |
|----------------------------------|--|
| | <ul style="list-style-type: none"> Any emission of objectionable odour. |
| Best Practicable Option approach | <ul style="list-style-type: none"> Have regard to the applicant’s reason for the proposed choice and any possible alternative methods of discharge, including discharge into any other receiving environment (RMA s105) incorporating low impact design principles discharging water within the catchment from which it originates ensuring that structures in the CMA are either ancillary to an activity which has a functional need to be located in the CMA; or no reasonable or practicable alternative location exists including any location outside of the CMA efficient use being made of the CMA by using the minimum area of the CMA necessary for the structure considering Operation and Management Programmes considering the overall effects of stormwater discharges and diversion at the discharge points. |

Table 4.2: Criteria for Streamworks Assessment of Effects

| Streamworks Assessment Criteria |
|--|
| Avoid, remedy or mitigate significant adverse changes to a river/stream bed morphology and flow hydraulics. |
| Avoid, remedy or mitigate permanent adverse effects on the surrounding environment from the deposition of sediment, including the effects on ecological values and physical processes within the river or stream, and the potential to cause or exacerbate erosion or deposition within the river/stream or on adjacent land. |
| <p>Avoid remedy or mitigate significant adverse changes to ecological habitat including:</p> <ul style="list-style-type: none"> • maintaining the passage of fish and other aquatic organisms both up and down stream • enabling the colonisation of the diverted river or stream by aquatic flora and fauna following the completion of the diversion activities • enabling the restoration or enhancement of wetlands, or areas of indigenous vegetation or the habitats of indigenous fauna in any river/stream • not resulting in the permanent loss of any habitat of a rare or endangered species. |

Table 4.3: Criteria for Flooding Assessment of Effects

| Flooding Assessment Criteria |
|---|
| <p>Not give rise to flooding of adjacent land or exacerbate existing flooding:</p> <ul style="list-style-type: none"> • does not cause flooding, in a 100 year ARI storm, of a habitable floor level in any dwelling • extent occupies flood storage volume below the 100 year ARI flood level. |
| <p>Avoid adverse hydrological effects:</p> <ul style="list-style-type: none"> • does not increase downstream flows and thereby worsen flooding in downstream areas |

5. Existing Environment

The existing environment is described in this section to provide a context for the assessment of effects for the stormwater and streamworks that follow. The existing environment of the Project consists of terrestrial, freshwater and marine areas in urban areas of Auckland and Waitakere cities.

The main hydrological features of the existing environment are the Oakley, Meola and Pixie catchments (refer to Figure 5.1). The marine areas include the Waterview Estuary, Waitemata Harbour, Whau River and Henderson Creek. These environments are described Sector by Sector in the following sections.

The various ecological and coastal assessment reports provide more detail on their respective aspects of the existing environment. In particular, with relevance to the stormwater and streamworks assessment, are the following reports:

- Waterview Connection Project: Technical Report No G.6 *Assessment of Freshwater Ecological Effects* (Boffa, 2010)
- Waterview Connection Project: Technical Report No G.11 *Assessment of Marine Ecological Effects* (Boffa Miskell, 2010)
- Waterview Connection Project: Technical Report No G.4 *Assessment of Coastal Processes* (T&T, NIWA 2010).

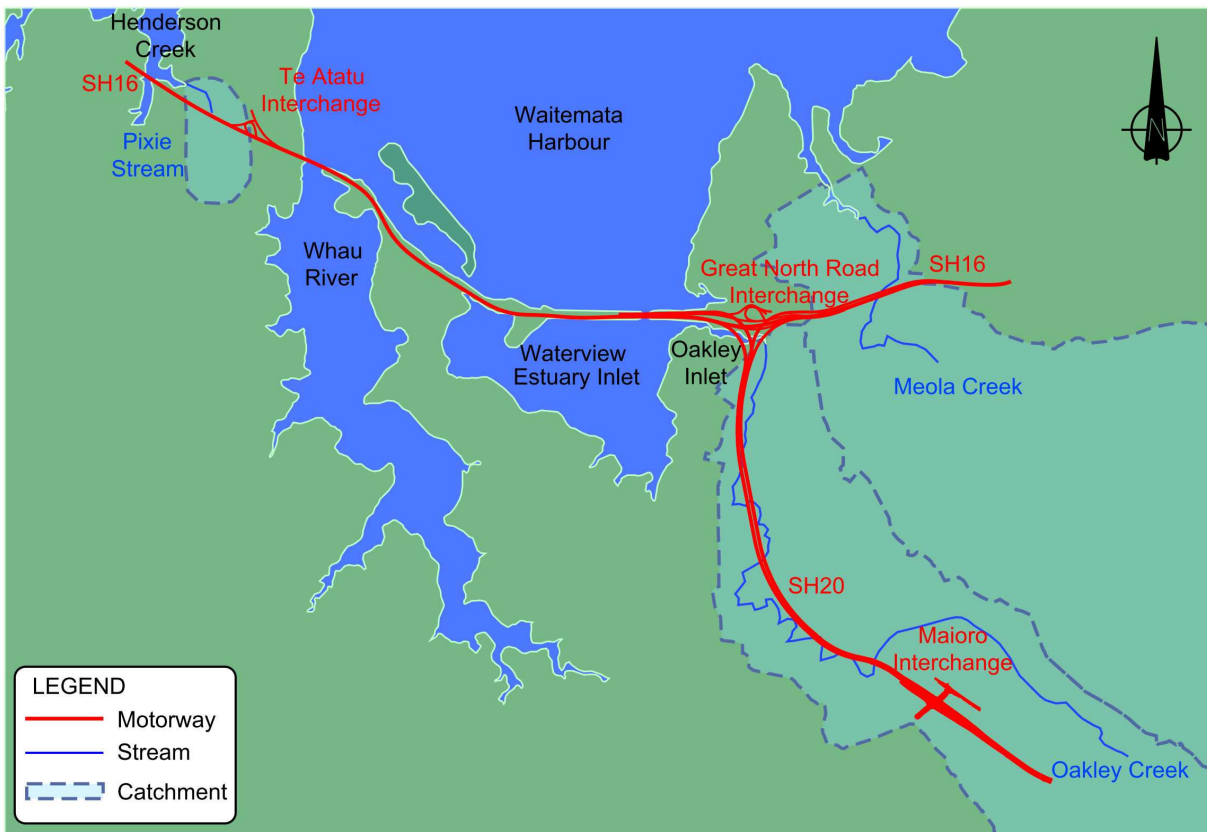


Figure 5.1: Waterview Connection Project with main hydrological and marine features

5.1 Sector 1: Te Atatu Interchange

5.1.1 Existing catchments

The area is divided into catchments draining to either Whau River or Henderson Creek by a watershed along Te Atatu Road. These catchments between the Whau River and Henderson Creek and on both sides of the motorway are urbanised residential areas. The catchment area to the west of Te Atatu Road falls within the "Project Twin Streams Catchment" for which, according to WCC, the integrated catchment management planning is still underway.

The Pixie Stream flows along the northern boundary of Jack Colvin Park before discharging to the estuarine reaches of Henderson Creek. The catchment has a predominantly urban land-use. The stream has been piped for significant lengths, with the only stretch of open channel being the reaches downstream of the existing SH16 carriageway.

Henderson Creek runs through residential and industrial areas, discharging into the Waitemata Harbour to the north-west of the Te Atatu Peninsula. The motorway crosses the upper reaches of the Henderson Creek, approximately five kilometres from where it opens up into the Waitemata Harbour at West Harbour. Henderson Creek at this point is a tidal channel bordered by mangrove covered tidal flats.

For a description of the Whau River Catchment see Section 5.2.1.

5.1.2 Existing motorway stormwater infrastructure

Sector 1 consists of the area from the western abutment of the Whau River Bridges to the eastern abutment of the Henderson Creek Bridge and includes the Te Atatu Interchange. Refer to Figure 2.1 and Drawings 20.1.11-3-D-D-300-101 to 103 in Appendix A.

The motorway from Whau River Bridges to (and throughout) the Te Atatu Interchange the carriageway is in a normal camber profile draining from the median barrier to the northern and southern outer edges of the carriageway. The motorway is at a high point as it passes under the Te Atatu Interchange over bridges (at approximately SH16 Ch 5400).

To the east of this high point, existing V-shaped drains and swales collect the runoff from the carriageway and discharges it directly into the Whau River. No erosion or littering was observed at the outlets into the Whau River. Runoff from the southbound Te Atatu Road carriageway drains into the catchment east of the interchange via a grass swale adjacent to the eastbound onramp. The grass swale provides stormwater treatment (see details below).

Throughout the Te Atatu Interchange there are cesspits, pipes and berms to collect the stormwater runoff. These are reticulated and outfall either directly into Whau River (for catchments east of Te Atatu Bridges) or into a 1.2m diameter culvert (for catchments west of Te Atatu Bridges).

This 1.2m diameter culvert is located under the motorway at the western end of the interchange (at approximately SH16 Ch 5800) discharging to Pixie Stream (Drawing 20.1.11-3-D-D-300-101, Appendix A). The culvert inlet is located on the westbound berm and collects runoff from the westbound carriageway, the

westbound on-ramp and Te Atatu Road north bound between Alwyn Avenue and the motorway over bridge. The 1.2m diameter culvert passes beneath the motorway with its outlet located on the eastbound berm. At this point the runoff from the eastbound carriageway and eastbound off-ramp combines with the flow from the culvert discharging into Pixie Stream towards Henderson Creek. The existing berms/overland flows provide some treatment to the motorway runoff, but most likely do not fully comply with ARC current guidelines because the as-built data does not indicate these berms/overland flow paths to be engineered treatment swales. In addition, some erosion was detected at the outlets in the Pixie Stream area, and there is dense weed and algae at times in the stream as well as floatable litter.

West of the Te Atatu Interchange, between the 1.2m diameter culvert and Henderson Creek, there are a further three culverts under the motorway providing cross drainage from south of the motorway to the northern side. The carriageway is in a normal camber profile draining from the median barrier to the northern and southern outer edges of the carriageway. This runoff drains to existing V-shaped drains adjacent to the westbound lanes, which convey the runoff along the motorway until it discharges through the culverts to the northern side of the motorway. The culverts are a 750mm diameter culvert at approximately Ch6020, 450mm diameter culvert at approximately Ch6100 and 675mm diameter culvert at approximately Ch6290 (Drawing 20.1.11-3-D-D-300-101, Appendix A). The culverts all discharge to a V-drain along the northern side of the motorway and discharge into the tidal channel at the mouth of the Pixie Stream, into the Henderson Creek. The sag (low point) in the motorway is at Ch6368, approximately 140m east of the Henderson Creek bridges. Floatable litter and erosion was observed at the cross drainage culvert outlet at Jack Colvin Park discharging into the mangroves in the tidal zone of the Henderson Creek.

The culverts between Te Atatu Interchange and the Henderson Creek are summarised in Table 5.1.

Table 5.1: Culverts between Te Atatu Interchange and Henderson Creek

| Culvert*1 | Purpose | Description |
|-----------------------------|---|---|
| CH 5810 under SH16 Motorway | All flows south to north cross drainage to Pixie Stream | 1200mmØ, circular, approx. 50m in length. |
| CH 6020 under SH16 Motorway | All flows south to north cross drainage | 750mmØ, circular, approx. 46m in length. |
| CH 6100 under SH16 Motorway | All flows south to north cross drainage | 450mmØ, circular, approx. 40m in length |
| CH 6290 under SH16 Motorway | All flows south to north cross drainage | 675mmØ, circular, approx. 45m in length. |

*1 Refer to Drawing 20.1.11-3-D-D-300-101, Appendix A

The NZTA has an existing resource consent in Sector 1; Diversion and Discharge of Stormwater, ARC Permit 35626 (Ramp metering) (*Te Atatu Swale, 1380m² impervious & 19,420 m² pervious to 75% TSS removal*). Refer to Section 4 for details.

5.1.3 Receiving environment

The estuarine reaches of Pixie Stream (connecting to Henderson Creek) are dominated by mangroves and common estuarine inhabitants. The estuarine habitat receives stormwater discharges from the adjacent residential catchment. The ecology of this area contains mainly commonly found organisms and appears to be in relatively good health given the surrounding land use. Metals (copper, lead and zinc) in sediment were within the ARC Environmental Response Criteria (ERC) amber to red range in the stormwater discharge channels, reducing to green further into the estuarine environment. In contrast, PAHs were below the green threshold (Technical Report No G.11 *Assessment of Marine Ecological Effects*).

A Stream Ecological Valuations (SEV) was undertaken within Pixie Stream. The overall SEV score for the stream was 0.67 (maximum score of 1) indicating that the tributary is of moderate ecological value and has been impacted by both catchment and instream changes. The major factors detracting from the ecological value of Pixie stream were the imperviousness of the upper catchment, the patchy riparian cover and the presence of some anaerobic sediment. These factors all contribute to the limited macro invertebrate diversity (Technical Report No G.6 *Assessment of Freshwater Ecological Effects*).

Refer to Section 5.2.3 for a summary description of the Whau Creek receiving environment.



Figure 5.2: Existing outlet at 675 diameter culvert at the proposed site for Jack Colvin Wetland



Figure 5.3: Pixie Stream

5.2 Sector 2: Whau River

5.2.1 Existing Catchments

The Sector 2 catchment consists of the motorway itself, including the Whau River Bridge. The receiving environment for stormwater discharges is the tidal flats of the Whau River and Waitemata Harbour. The Whau River catchment covers 2,940ha and consists of areas within the suburbs of Te Atatu South, Glendene, Kelston, Titirangi, Titirangi North, Green Bay, New Lynn, Glen Eden, Avondale, Blockhouse Bay and Mt Albert. The catchment is highly urbanised with a high degree of imperviousness.

5.2.2 Existing motorway stormwater infrastructure

Sector 2 consists of the area from Ch 4400 at the west of the Rosebank Park Domain Go-kart track to the western abutment of the Whau River Bridge (including the Whau River Bridge). Refer to Figure 2.1 and Drawings 20.1.11-3-D-D-300-102 in Appendix A.

SH16 between the Rosebank Park Domain Go-kart track and the Whau River Bridge upon leaving the Patiki Road Interchange and travelling in a westerly direction the carriageway is super-elevated into the left hand bend. In the westbound direction, for a distance of about 250m (Sectors 2 and 3) the stormwater runoff is collected by standard cesspits located in front of a concrete kerb and channel located on the shoulder edge. These cesspits are connected to a reticulated network and the flow discharges to the CMA on the western side of the Rosebank Park Domain Raceway. There is no evidence of any stormwater quality treatment.

In the eastbound direction (on the high side of the same super-elevated bend) surface water runoff from the carriageway is directed towards cesspits and piped reticulation located against the kerbed central island. This network of cesspits and pipe work is connected to the system serving the westbound traffic lanes, discharging to the CMA. Again there is no evidence of any stormwater quality treatment.

Between Ch4400 to Ch4700 at the eastern abutment of the Whau River Bridges, the carriageway transitions from super-elevation to a normal camber profile. The kerb and channel to the shoulder edge is replaced by flush concrete edge beams, allowing the stormwater runoff across the east and westbound shoulders. From there it runs across vegetated berms and discharge is direct to the CMA. The passage of the runoff across the vegetated areas will provide some water quality treatment, but these are not designed to (and nor do they comply with) the ARC TP10.

Pavement (subsoil) drains are located on the outer edge of both carriageway shoulders, discharging typically at 100m centers, either directly into the tidal streams and mangroves or to a convenient stormwater cesspit.

This area falls within the jurisdiction of the ACC, and no ICMP information could be obtained.

5.2.3 Receiving environment

The Whau Creek has a long history of boating use, as well as discharges from industrial land use along Rosebank Road. Concentrations of contaminants in sediment within the Whau Estuary (particularly the upper reaches) are among some of the highest in the Auckland region, and the ecological health of the estuary has been assessed as being low (Kelly, 2007; McHugh & Reed, 2006).

The Whau River adjacent to the Whau River Bridge contains a typical subtidal invertebrate assemblage, with low sediment contaminant concentrations due to the flushing out of fine sediment from the immediate area. Flora and fauna on the intertidal banks adjacent to the existing bridge abutments are also typical for this type of habitat, predominantly comprising mangroves, some saltmarsh species, exotic weed species above MHS and mud crabs and worms dominating the invertebrate assemblage. Upstream of the Whau River Bridge, sediment quality declines significantly in depositional areas and the ecological values are likely to be adversely affected. Downstream of the Whau River Bridge, contaminant concentrations are low and the ecology is likely to be unaffected (Technical Report No G.6 *Assessment of Freshwater Ecological Effects*).

The marine areas north of the motorway include parts of the Motu Manawa (Pollen Island) Marine Reserve (refer to 5.4.3). Refer to marine ecological reports for further description of the existing environment.



Figure 5.4: Whau River Bridge

5.3 Sector 3: Rosebank - Terrestrial

5.3.1 Existing Catchments

The immediate catchment for this section of SH16 is just the westbound lanes of the motorway itself, and it is not part of a wider catchment discharging to a watercourse (refer Figure 5.1). This Sector borders the terrestrial areas of the Rosebank peninsula situated to the south. The existing catchment drains to the landward and seaward tidal flats and channels, and is mainly an industrial urban area. There are dense mangroves in areas as well as floatable litter at the various outlets.

The receiving environment for stormwater discharges from this Sector will be tidal flats of the Whau River and Waterview Estuary between Traherne Island and the Rosebank Peninsula on the south side of the motorway, and the Waitemata Harbour on the northern side of the motorway (see Sections 5.2 and 5.4 for a description of these catchments).

5.3.2 Existing motorway stormwater infrastructure

Sector 3 consists of the area of the westbound lanes from Ch 2800 between Traherne Island and the Rosebank Peninsula to Ch 4400 situated to the west of the Rosebank Park Domain Go-kart track. Refer to Figure 2.1 and Drawings 20.1.11-3-D-D-300-104 to 105 in Appendix A.

Westbound on the approach to the Rosebank Road off-ramp structure there are twin 600mm diameter culverts that transverse the motorway (at approximately Ch2900). These link the tidal creeks (to the south) with the main harbour waters (to the north). The existing culverts east of the Rosebank Peninsula are summarised in Table 5.2.

Table 5.2: Culverts at Rosebank Peninsula

| Culvert | Purpose | Description |
|-----------------------------|----------------------------|---|
| CH 2900 under SH16 Motorway | Tidal flows cross drainage | Twin 600mmØ, circular, approximately 36m in length. Below MHWS and inlet & outlet overgrown by mangroves. |

At the Rosebank Road Interchange as-built information show stormwater reticulation systems intercept surface runoff from the ramps and the gore areas. The stormwater passes through one settlement tank at each ramp before it outfalls into the tidal mangrove flats. Although the settlement tanks were designed while ARC TP10 was being published; the document was in its infancy and settlement tanks are not to ARC TP10 design standards. Due to the proposed widening of the motorway these settlement tanks will be situated inside the lanes and will therefore have to be removed.

In the westbound direction, from Patiki Road to the western side of the Rosebank Park Domain the stormwater runoff is collected by standard cesspits located in front of a concrete kerb and channel located on the shoulder edge. These cesspits are connected to a reticulated network and the flow discharges to the CMA on the eastern side of the Rosebank Park Domain Raceway. There is no evidence of any stormwater quality treatment.

Pavement drains are located on the outer edge of both carriageway shoulders, discharging typically at 100m centres, either directly into the tidal streams and mangroves or to a convenient stormwater cesspit.

Apart from the four existing settlement tanks at Rosebank and Patiki Interchanges, there is little if any effective quality treatment of stormwater from the existing motorway.

This area falls within the jurisdiction of the ACC, and no ICMP information could be obtained.

The NZTA has three existing resource consents relevant in Sector 3 (refer Section 4 for details):

- Diversion and Discharge of Stormwater, ARC Permit 35626 (Ramp metering)
- Discharge Permit BH/8735
Coastal Permit H/8736 (Rosebank Peninsula – Patiki Road Ramps A & D) *(Reclaim two areas totalling 3500m²) (Treat all impervious areas)*
- Diversion and Discharge of Stormwater, ARC Permit 30235 (Widening of Causeway for Bus Lanes) *(Treatment of 1.16ha impervious to 82% TSS removal).*



Figure 5.5: Patiki Road onramp looking westward

5.3.3 Receiving environment

The receiving environment for stormwater discharges from this Sector will be tidal flats of the Whau River and Waterview Estuary on the south side of the motorway, and the Waitemata Harbour on the northern side of the motorway (see Sections 5.2 and 5.4 for a description of these receiving environments).

5.4 Sector 4: Reclamation

5.4.1 Existing Catchments

Sector 4 includes SH16 from the Rosebank Park Domain to the GNR Interchange, excluding the westbound lanes of the motorway at Rosebank (Sector 3). Stormwater runoff from the motorway will discharge to the marine/estuarine environments of the Waterview Estuary on the southern side and the Waitemata Harbour on northern side of the motorway.

The catchment for the Waterview Estuary includes all of the Oakley Creek Catchment and the estuary side of the Rosebank peninsula. Both catchments are highly urbanised. The catchment for the Waitemata Harbour on the northern side of the causeway includes that discharging to the Waterview Estuary with the addition of the

Whau River catchment, also a heavily urbanised catchment (refer to Section 5.2.1).

5.4.2 Existing motorway stormwater infrastructure

Sector 4 consists of the causeway and reclamation areas from Ch 900 to Ch 2800 westbound at Traherne Island, and along the eastbound lanes up to the west of the Rosebank Park Domain. Refer to Figure 2.1 and Drawings 20.1.11-3-D-D-300-105 to 108 in Appendix A.

For the Causeway, between GNR Interchange and Traherne Island, the stormwater runoff from the normal camber profile passes as sheet flow across the carriageway surface to the outer edge of the sealed shoulder. It then crosses a small area of grass (and paved cycleway - westbound only) before discharging onto the tidal mangrove flats. The passage of the runoff across the vegetated areas will provide some water quality treatment, but these are not designed to (and nor do they comply with) the ARC TP10.

The only engineered stormwater treatment system in this sector was installed as part of the bus shoulder widening Project from the GNR Interchange to the Rosebank Road Interchange. Resource Consent was granted (Permit no. 30235) and required a catchment area of 1.16ha be treated to 82% TSS removal. This hybrid treatment device, which comprised part filter strip, part grass swale, part sand filter and part infiltration, was installed on the north side of the causeway running for a length of about 800m from near the western limit of the Rosebank Bridge (CH1300) westward to approximately Ch2100.

Travelling westward, beyond Traherne Island and towards Rosebank Road, the carriageway is super-elevated into the right hand curve. Surface water runoff from the westbound carriageway is directed towards cesspits and piped reticulation, captured by a median slot drain located against the kerbed central island. Discharge of the stormwater runoff, either across Traherne Island itself or direct into the Waitemata Harbour, is by means of a number of individual outfall structures situated beneath the westbound shoulder.

A slotted median drain, with interconnected cesspits, is also evident on the sections of motorway in superelevation where the eastbound lanes traverse the Rosebank peninsula, and according to the as-built data discharges directly into the tidal waters.

Cross drainage in this Sector is provided by the Causeway Bridges (at approximately Ch1200 to 1270) which link the Waterview Estuary (to the south) with the Waitemata Harbour (to the north). Refer to Technical Report No G2 *Assessment of Coastal Processes for details*.

Pavement drains are located on the outer edge of both carriageway shoulders, discharging typically at 100 meter centres, directly into the harbour waters.

This area falls within the jurisdiction of the ACC, and no ICMP information could be obtained.

The NZTA has two existing resource consents relevant in Sector 4 (refer Section 4 for details):

- Discharge Permit BH/8735
Coastal Permit H/8736 (Rosebank Peninsula – Patiki Road Ramps A & D) (*Reclaim two areas totalling 3500 m² (Treat all impervious areas)*)

- Diversion and Discharge of Stormwater, ARC Permit 30235 (Widening of Causeway for Bus lanes)
(*Treatment of 1.16ha impervious to 82% TSS removal*).

5.4.3 Receiving environment

The marine ecology contained within this Sector includes mangrove forest, saltmarsh, shellbanks, intertidal mudflats and sandflats, subtidal soft muds and man-made rocky shore (existing rock revetment).

Along the northern side of SH16 within this Sector, ecological values are high to moderate. The interface between the mown grass edge seaward of the existing causeway and the saline habitat comprises a mixture of native and exotic vegetation and an accumulation of rubbish and debris. Seaward of this interface area, depending on the hydrology of the immediate area and its sediment characteristics, the vegetation often grades into coastal saltmarsh species and then into mangroves. On the western side of Pollen Island there are ecologically important drainage channels present that strongly influence the surrounding resident ecology (Technical Report No G.11 *Assessment of Marine Ecological Effects*).

Shellbanks are present on and around Traherne Island and sandflats. There is a higher diversity of marine invertebrates in the immediate estuarine environment on the northern side of the motorway due to the presence of habitats with reasonable ecological value. Where the habitat comprises mudflats with mangroves present, the species of invertebrates are not very diverse. Where the sediment contains more sand, cobbles or shell material, some different species are present. The rock revetment provides further habitat diversity (Technical Report No G.11 *Assessment of Marine Ecological Effects*).

The Waterview Estuary is a relatively modified marine environment, as a result of the original construction of SH16 in 1952-53 (Hume, 1991) and urban land use practices. The original construction of the SH16 causeway had a significant effect on flow dynamics and restricted tidal flushing considerably (Bell et al., 2009). This is evident in the build-up of soft sediments throughout the estuary. In addition, industrial activity and a long history of poor environmental practices (including the disposal of waste into the estuary both directly and through improper drain connections), has likely caused long-term impacts here (Briggs & Flannigan, 1984).

The intertidal mudflats of this inner harbour estuary comprise deep soft mud and are dominated by mangroves. The subtidal channels are similarly characterised by fine muddy sediment. Within the intertidal habitat, there are some small shellbank areas where sediment grain size is coarser and some saltmarsh vegetation is supported (Technical Report No G.11 *Assessment of Marine Ecological Effects*).

The Waterview Estuary and areas surrounding Pollen Island are classified as a Coastal Protection Area 1 (CPA1) in the Auckland Regional Plan: Coastal. Together, these form the Motu Manawa (Pollen Island) Marine Reserve. The Department of Conservation (DoC) has classified the area as an Area of Significant Conservation Value (ASCV). These flats are an important feeding area for a wide variety of both national and international shore bird species (Technical Report No G.11 *Assessment of Marine Ecological Effect*).

The southern side of the Causeway, seaward of the cycleway path between the Whau Bridge and the eastern end of Traherne Island, has high to moderate ecological values. Within approximately 10m from MHWS common estuarine invertebrates are present (Technical Report No G.11 *Assessment of Marine Ecological Effects*).

Eastward of Traherne Island extending to the mouth of Oakley Inlet, the benthic sediment largely comprises soft deep mud flats and the intertidal invertebrate assemblage is less diverse, as the range of species that can tolerate such habitat conditions is less extensive. Habitat modification from the existing environment is extensive, including the historic severing of the mudflat adjacent to the eastern abutment of the Causeway Bridges and realignment of the discharge from Oakley Inlet. Ecological values in this area are moderate to low (Technical Report No G.11 *Assessment of Marine Ecological Effects*).

Adjacent to the Causeway Bridges typical invertebrate species are present. Organisms that tend to inhabit soft mud habitats with inner harbour sites are generally relatively tolerant of disturbance and other stressors (Technical Report No G.11 *Assessment of Marine Ecological Effects*).

The concentration of common stormwater contaminants in surface sediment is low on the northern side, and elevated around the Causeway Bridges and within the Waterview Estuary close to the causeway and the mouth of Oakley Inlet. A higher concentration of contaminants was detected in the fine grain size component of sediment samples. Zinc was commonly detected in concentrations above the ARC ERC red threshold. Sediment samples collected from the mouth of Oakley Inlet revealed zinc typically above ARC ERC red, whereas lead and copper were generally detected within the ERC amber concentration range (Technical Report No G.11 *Assessment of Marine Ecological Effects*).

The ecological values within this Sector are variable, with a generalised trend of decreasing ecological value with increasing proximity to the Causeway and mouth of the Oakley Inlet. One hot spot beneath the west-bound SH16 Rosebank off ramp was detected, with the concentration of zinc particularly being very high (Technical Report No G.11 *Assessment of Marine Ecological Effects*).

For more information on the receiving environment refer to the Technical Report No G.11 *Assessment of Marine Ecological Effects* and Technical Report No G4 *Assessment of Coastal Processes*.



Figure 5.6: Seaward side of causeway looking west



Figure 5.7: Landward side of causeway looking west with minor flooding from high spring tide

5.5 Sector 5: Great North Road Interchange

5.5.1 Existing catchments

Sector 5 consists of the existing Great North Road Interchange on SH16 and the proposed connection to SH20 including the tunnel northern portal (Figure 2.1). The catchment for the existing and proposed motorway drainage is self contained.

Sector 5 discharges to the Oakley Inlet, Waterview Estuary and Waitemata Harbour. The catchments for these receiving environments are highly urbanised, refer to Section 5.4.1 for further information. The Oakley Inlet is the tidal section of Oakley Creek. Oakley Creek and its catchment are described in detail in Section 5.9.1.

5.5.2 Existing motorway stormwater infrastructure

Within Sector 5 the existing motorway infrastructure includes SH16 in the easterly/westerly axis, and the existing Great North Road Interchange on and off ramps. Currently some stormwater treatment is provided for a section of the SH16 carriageway by a treatment swale located just to the North of the carriageway within the interchange. Refer to Drawings 20.1.11-3-D-D-300-108 to 110 in Appendix A.

In addition, there is an existing wet pond and associated swales within the bounds of the Great North Road Interchange that is consented to treat runoff from some of the interchange carriageway. This wetland does not meet the recommendations of ARC TP10, but was consented with the understanding that the Waterview Connect Project would be undertaken in the near future, and upgrades would be made at that time to the stormwater management systems.

5.5.3 Receiving environment

Stormwater treatment devices for Sector 5 will discharge to Oakley Inlet, Waterview Estuary and Waitemata Harbour. Waterview Estuary and parts of the Waitemata Harbour are within the Motu Manawa Marine Reserve, (refer to Section 5.4.3). For more information on the receiving environment refer to the Technical Report No G.11 *Assessment of Marine Ecological Effects* and Technical Report No G.4 *Assessment of Coastal Processes*.

5.6 Sector 6: SH16 to St Lukes

5.6.1 Existing catchments

Sector 6 discharges to Meola Creek, part of the Meola catchment. Meola Creek is 2.6km in length with its headwaters entirely piped above the Chamberlain Park Golf Course (Technical Report No G.6 *Assessment of Freshwater Ecological Effects*). It flows alongside Western Springs Park on the western side of Motions Road, to its mouth at the Meola Reef Reserve, where it enters the Waitemata Harbour. It has a catchment area of 16.5 km², which is predominantly urban (residential) land-use.

5.6.2 Existing motorway stormwater infrastructure

The existing SH16 carriageway in Sector 6 has no formal stormwater treatment. Runoff drains via catchpits and open drains, and is discharged to ground or untreated to the Meola Creek. Refer to Figure 2.1 and Drawings 20.1.11-3-D-D-300-110 to 112 in Appendix A.

5.6.3 Receiving environment

Meola Creek is a moderately long stream (2.6 km), but its headwaters are entirely piped. The riparian vegetation below the SH16 carriageway consists of tall shading exotic vegetation (primarily willows) with an understory / ground cover of weed species. The stream is swiftly flowing, clear and quite deep (up to 0.8m in places). The substrate is dominated by mud and bedrock (Technical Report No G.6 *Assessment of Freshwater Ecological Effects*).

The invertebrate fauna of Meola Creek immediately below SH16 is limited with no sensitive macroinvertebrates present. Such a species depauperate fauna is typical of that of other Auckland urban streams, and reflects the high degree of habitat modification and/or low water quality in these streams (Technical Report No G.6 *Assessment of Freshwater Ecological Effects*).



Figure 5.8: Meola Creek upstream of SH16

5.7 Sector 7: Great North Road Underpass

5.7.1 Existing catchments

There will be limited streamworks and no stormwater discharges into the Oakley Creek in the Sector 7: Great North Road (refer to Figure 2.1) for the operational phase of the Project. However, during the construction phase stormwater will be discharged to Oakley Creek. The catchment for Oakley Creek is described in Section 5.9.1. Refer to Drawings 20.1.11-3-D-D-300-113 to 114 (Appendix A) for site locations.

5.7.2 Existing motorway stormwater infrastructure

There is no existing motorway infrastructure in Sector 7.

5.7.3 Receiving environment

The downstream reaches of Oakley Creek run through reserve land in the vicinity of Sector 7. The Stream in this reach is in relatively good condition compared to the upstream reaches in Sector 9, being mostly natural channel with riparian vegetation. However the culvert under Great North Road provides a barrier to fish passage at the downstream end, and the level of metals in the stream such as zinc copper and lead are high as is typical for highly urbanised catchments (Technical Report No G.6 *Assessment of Freshwater Ecological Effects*).

For more information on the Oakley Creek receiving environment refer to Section 5.9.3 and the Technical Report No G.6 *Assessment of Freshwater Ecological Effects*.

5.8 Sector 8: Avondale Heights Tunnel

5.8.1 Existing catchments

There will be no streamworks or stormwater discharges into the Oakley Creek in the Sector 8: Avondale Heights Deep Tunnel Area (refer to Figure 2.1). The catchment for Oakley Creek is described in Section 5.9.1. Refer to Drawings 20.1.11-3-D-D-300-114 to 117 for site locations (Appendix A).

5.8.2 Existing motorway stormwater infrastructure

There is no existing motorway infrastructure in Sector 8.

5.8.3 Receiving environment

The characteristics of Oakley Creek in Sector 8 are similar to those in Sector 7. A natural barrier to fish passage is created by the waterfall (approximately 6m high) in Oakley Creek Esplanade, approximately 900m above its mouth, located opposite Fir Street on Great North Road. For more information on the Oakley Creek receiving environment refer to Section 5.9.3 and the Technical Report No G.6 *Assessment of Freshwater Ecological Effects*.

5.9 Sector 9: Alan Wood Reserve

5.9.1 Existing catchments

The Oakley Creek is an 11.3km stream with its headwaters in the vicinity of Keith Hay Park in Hillsborough (Suren, 2001). It flows through Mt Roskill, Wesley and Owairaka to its mouth at Waterview, where it enters the Waitemata Harbour. It has a catchment area of 12.9km², and has an estimated 84% of its catchment urbanised.

For much of its length it flows through parks and reserves, and it is the largest stream in Auckland City. It has a predominantly residential land-use, although there is a small area of industrial and commercial land-use located at Stoddard Road, Mt Roskill. Its catchment is relatively long and narrow, so most of its tributaries would have been small and most are now piped. Tributaries enter the stream at and around Keith Hay Park and in Alan Wood Reserve (from the Stoddard Road area).

5.9.2 Existing motorway stormwater infrastructure

There is no existing motorway infrastructure in Sector 9.

The proposed motorway alignment in Sector 9 (refer to Figure 2.1) passes mainly through areas of reserve land in Hendon Park and Alan Wood Reserve. In some areas it intersects with the Oakley Creek alignment and floodplain. The land use will change to impervious motorway surface, having an effect on both water quality and quantity generated. Refer to Drawings 20.1.11-3-D-D-300-117 to 119 for site locations (Appendix A).

5.9.3 Receiving environment

For much of Sector 9 the SH20 motorway alignment will run approximately parallel to Oakley Creek in Alan Wood Reserve. The catchment of Oakley Creek is urbanised and the flows in the creek are from stormwater and base flow from groundwater. During recorded flood events in the stream, adjacent properties have been flooded. This occurs due to the high level of urbanisation and imperviousness in the catchment, a highly modified stream channel and flood plain, and the construction of dwellings within the flood plain.

The existing catchment draining to Oakley Creek in Alan Wood Reserve, is a mixed use urban area suffering from water quality issues common to residential catchments, including high levels of suspended solids, metals, hydrocarbons and elevated temperatures, biological oxygen demand (BOD) and faecal contaminants (from combined sewer overflows). In addition there is dense weed and algae at times, as well as floatable litter in the stream.

To assess the effects of any streamworks on Oakley Creek, the creek's current condition has been inspected. T&T and Boffa Miskell have walked the stream alignment and Boffa Miskell carried out a SEV in September 2009. Morphum Environmental (2009), for Metrowater, has collected information on the stream condition and this information has been used by the Waterview Project team.

Oakley Creek is an open channel within Sector 9, and its alignment follows the edge of the basalt geology, which forms sections of the true right bank. The edge of the basalt geology is also the boundary of a volcanic aquifer and there are groundwater inflows into the stream (refer to Technical Report No G.7: *Assessment of*

Groundwater Effects). The true left bank is formed in Tauranga Group geology, the weathered soils of which are susceptible to erosion.

Within Alan Wood Reserve, Oakley Creek has a relatively low gradient, and is channelised in many portions by manmade basalt rock walls (refer Figure 5.9). Reaches of the stream that are not channelised are steeply incised, with sedimentary and basalt rock appearing in places, with a combination of cobble, bedrock and soft bottom substrates. A feature of the stream in this area is a cascade formed by basalt bedrock where the stream invert drops approximately 2m at approximately motorway Ch 1450m.



Figure 5.9: Oakley Creek in Alan Wood Reserve showing basalt rock wall channel section

Vegetation on the true right bank of Oakley Creek is herbaceous within the floodberm. The true left bank supports mixed native, but primarily exotic, herbaceous shrub and tree species. Property boundaries have various methods of slope retention and slope subsidence occurs in some areas.

There are a number of major culverts upstream and downstream of Alan Wood Reserve and these are summarised in Table 5.3. These include the culverts under Richardson Road for Oakley Creek and the Stoddard Road Tributary to Oakley Creek. The Stoddard Road Tributary is also culverted under the Mt Roskill section of SH20 and to be culverted under the Maioro Interchange (under construction). At the downstream end of Alan Wood Reserve the stream is culverted under Bollard Avenue (Figure 5.10), New North Road and the western line railway with open channel sections in between. At the Bollard Avenue inlet (Figure 5.10) there is a

high flow culvert that runs directly under New North Road and the railway and discharges back to Oakley Creek.

Sector 9 stormwater will discharge to Oakley Creek. The ACC currently holds a consent from the ARC “To divert and discharge stormwater within and from the Oakley Creek Catchment into the Waitemata Harbour”; ARC consent No. 24973 (refer Section 4.1.1).

Table 5.3: Oakley Creek Culverts in vicinity of Alan Wood Reserve

| Culvert* ¹ | Purpose | Description |
|---|-----------|--|
| Oakley Creek under Richardson Road | All flows | 3.52(w)x2.5(h)m, rectangular, 31 m in length |
| Stoddard Road Tributary to Oakley Creek under Richardson Road | All flows | 2.1 m Ø, circular, 117m in length 1.8m Ø, circular, 117m in length |
| Oakley Creek under Bollard Ave | Low flows | Twin 1.82(w)x1.55(h)m, rectangular, 25m in length |
| Oakley Creek under New North | Low flows | Irregular (2.1(w)m x 1.8(h)m circular corners), 101m in length 1.5m Ø, circular, 109m in length |
| Oakley Creek under railway | Low flows | Twin 1.2x1.2m, rectangular, 40.5m in length |
| Oakley Creek under New North Road and Railway | Overflows | 2.55m Ø, circular, 315m in length |

*1 Refer to Drawing 20.1.11-3-D-D-300-116, Appendix A



Figure 5.10: Bollard Avenue and Bollard Overflow culvert

In the upper reaches, the Oakley Creek supports a limited diversity of pollution tolerant macroinvertebrates, two native fish species (short and long finned eel), with native fish access restricted by the Oakley Creek waterfall further downstream (Technical Report No G.6 *Assessment of Freshwater Ecological Effects*).

Overall Oakley Creek within the Project area has relatively low ecological health, in terms of physical habitat modification and diversity and sensitivity of macroinvertebrates. Water quality is low but is similar to other urban catchments. The SEV scores in the parts of the stream directly affected by the Project (i.e. Stoddard Road and Hendon Park) are generally low (0.39 and 0.34 respectively). However, outside of the Project area in the lower reaches of the stream (below the waterfall) the SEV score is higher (0.45), reflecting greater ecological values in these areas compared to the upstream areas affected by the Project (Technical Report No G.6 *Assessment of Freshwater Ecological Effects*).

According to SEV assessments and physical habitat character assessments, the existing instream habitat generally represents poor functional value based on the following parameters (Western Ring Route: Oakley Creek Re-alignment and Rehabilitation Guidelines (appendix in Technical Report No G.11):

- Poor instream water quality
- Extensive channel modification
- Artificial, mortared rock banks
- Low import of vegetation debris to support habitat diversity

- High catchment imperviousness
- Poor floodplain connectivity
- Fish passage barriers in downstream environments
- Lack of overhead and littoral vegetation
- Incised naturalised bank forms with accelerated erosion and slumping.

For more information on the existing environment in Sector 9, refer to the Technical Report No G.6 *Assessment of Freshwater Ecological Effects*.

Flooding is a major issue in the catchment and the Project is located in the Oakley floodplain. Observed flooding in the Project area is shown in Figures 5.11 and 5.12 for the 1 June 2010 minor flood event that occurred after rainfall equivalent to 1 to 2 year ARI rainfall intensity. The flooding issues were investigated by Beca (1995) who developed a catchment management plan, and subsequently in a number of modelling studies (Smedley et al., 2010). Metrowater and ACC are currently defining the flood hazard areas (AECOM, 2010b in press) and flood management options (refer Section 3.4.2).



Figure 5.11: Flooding downstream of Richardson Road culvert on 1 June 2010 after rainfall equivalent to 1 to 2 year ARI rainfall intensity



Figure 5.12: Flooding in Oakley Creek adjacent to location of proposed stream realignment B (1 June 2010)

6. Effects Assessment: Operation of Project

6.1 Summary

An assessment of the effects of the stormwater aspects of the Project during the operation phase was carried out. This assessment included an evaluation of the matters that were taken account of during the design, the BPO selection of solutions, (as required by the RMA and PARP:ALW and PARP:C), and an assessment of the cumulative effects of stormwater discharge from the Project on the environment during the operational phase. The following subsections outline the design process, the proposed solutions, and the assessment of effects.

The proposed BPO solutions are intended to demonstrate that feasible solutions exist to meet stormwater treatment objectives. However, as the criteria for assessment are performance based, it is intended that there is flexibility for Contractors to provide innovative or alternative designs to meet or better the criteria, or account for Project design changes.

Stormwater treatment devices used during the operational phase of the Project are referred to as permanent devices. This is to distinguish them from stormwater treatment devices used during the construction phase of the Project, which are referred to as temporary devices.

The PARP:ALW requires that the BPO for stormwater treatment be applied, using the ARC TP10 as a basis. ARC TP10 devices aim for removal of 75% TSS on a long term average basis, acknowledging that to aim for 100% contaminant removal is not feasible. Treatment of stormwater runoff to achieve greater than 75% TSS removal efficiency has been identified as a way of providing mitigation for the reclamation required for the Project within the CMA and associated loss of biological habitat. For this reason the stormwater treatment devices for the Project that discharge to the CMA (Sectors 1 – 5) have been designed to remove 80% or more TSS on a long term average basis.

Treatment of runoff from within Sectors 5 and 9 have been designed to 75% TSS removal. To provide 80% TSS removal for these areas is unnecessary because the receiving environments are unlikely to be adversely affected by stormwater discharge from the project, refer to Technical Report No G.6 *Assessment of Freshwater Ecological Effects*, and impracticable because of space constraints caused by existing stormwater pipes (in Sector 6) and competition with open space requirements (In Sector 9).

Table 6.1 below gives a summary of the proposed treatment devices for the operational phase of the Project, and the treatment functions provided by each.

Table 6.1: Summary of Stormwater Treatment Devices for Operational phase

| Sector | Treatment Device | Catchment Area (ha) | Water Quality Treatment Provided | TSS Removal | Extended Detention Provided | Flood Attenuation Provided | Erosion Protection Provided | Discharge location |
|--------|--|---------------------|----------------------------------|-------------|-----------------------------|----------------------------|-----------------------------|---|
| 1 | TD1A – Jack Colvin Wetland | 9.45 | ✓ | 80% | N/R | N/R | ✓ | Tidal channel at Henderson Creek |
| 1 | TD1B – Te Atatu Eastbound on-ramp swale | 2.94 | ✓ | 80% | N/R | N/R | ✓ | North of western abutment of bridge into Whau River |
| 1 | TD1C – Te Atatu Westbound off-ramp swale | 3.27 | ✓ | 80% | N/R | N/R | ✓ | South of western abutment of bridge into Whau River |
| 2 | TD2A – Whau Bridges eastbound cartridge filter vault | 0.57 | ✓ | 80% | N/R | N/R | ✓ | North of eastern abutment of bridge into Whau River |
| 2 | TD2B – Whau Bridges westbound cartridge filter vault | 0.57 | ✓ | 80% | N/R | N/R | ✓ | South of eastern abutment of bridge into Whau River |
| 2 | TD2C – Whau eastbound bio-filter strips | 0.55 | ✓ | 80% | N/R | N/R | ✓ | On northern side into CMA along eastern approach to Whau River Bridge |
| 2 | TD2D – Whau westbound bio-filter strips | 0.83 | ✓ | 80% | N/R | N/R | ✓ | On southern side into estuary along eastern approach to Whau River Bridge |
| 3 | TD3A – Rosebank Domain cartridge filter vault | 0.36 | ✓ | 80% | N/R | N/R | ✓ | West of Rosebank Domain into Whau River tidal flats |

Waterview Connection

| | | | | | | | | |
|---|---|------|---|-----|-----|-----|---|--|
| 3 | TD3B - Patiki Off-ramp cartridge filter vault | 0.84 | ✓ | 80% | N/R | N/R | ✓ | North of Rosebank Domain into the Waitemata Harbour |
| 3 | TD3C - Go Kart Track cartridge filter vault | 0.44 | ✓ | 80% | N/R | N/R | ✓ | East of Rosebank Domain into Whau River tidal flats |
| 3 | TD3D - Rosebank cartridge filter vault | 2.31 | ✓ | 80% | N/R | N/R | ✓ | West of Rosebank Peninsula into Whau River tidal flats |
| 3 | TD3E - Rosebank Off-ramp cartridge filter vault | 2.94 | ✓ | 80% | N/R | N/R | ✓ | East of Rosebank Peninsula into Waterview Estuary |
| 4 | TD4A - Whau End EB cartridge filter vault | 0.56 | ✓ | 80% | N/R | N/R | ✓ | North of Rosebank Domain into the CMA |
| 4 | TD4B - Patiki Flyover EB cartridge filter vault | 0.39 | ✓ | 80% | N/R | N/R | ✓ | North of Rosebank Peninsula into the CMA |
| 4 | TD4C - Patiki eastbound bio-filter strips | 0.68 | ✓ | 80% | N/R | N/R | ✓ | On northern side into CMA at Patiki Road off-ramp |
| 4 | TD4D - Tidal Creek EB cartridge filter vault | 1.04 | ✓ | 80% | N/R | N/R | ✓ | North of Rosebank Peninsula into the tidal creek and CMA |
| 4 | TD4E - Pollen Island EB cartridge filter vault | 0.74 | ✓ | 80% | N/R | N/R | ✓ | North of Rosebank Peninsula into the tidal creek north of Pollen Island into CMA |
| 4 | TD4F - Rosebank On-ramp cartridge filter vault | 0.94 | ✓ | 80% | N/R | N/R | ✓ | North of Rosebank Peninsula into east of Pollen Island into CMA |

Waterview Connection

| | | | | | | | | |
|---|---|------|---|-----|-----|-----|---|--|
| 4 | TD4G – Rosebank Off-ramp cartridge filter vault | 0.44 | ✓ | 80% | N/R | N/R | ✓ | West of Traherne Island into the Waterview Estuary |
| 4 | TD4H – Traherne Island cartridge filter vault | 0.32 | ✓ | 80% | N/R | N/R | ✓ | West of Traherne Island into the Waterview Estuary |
| 4 | TD4I – RB Bridge to Traherne Island eastbound bio-filter strips | 4.19 | ✓ | 80% | N/R | N/R | ✓ | On northern side into Waitemata Harbour |
| 4 | TD4J – RB Bridge to Traherne Island westbound bio-filter strips | 3.83 | ✓ | 80% | N/R | N/R | ✓ | On southern side into Waterview estuary |
| 4 | TD4L – GNR to RB Bridge eastbound bio-filter strips | 0.94 | ✓ | 80% | N/R | N/R | ✓ | On northern side into Waitemata Harbour |
| 4 | TD4M – GNR to RB Bridge westbound bio-filter strips | 0.92 | ✓ | 80% | N/R | N/R | ✓ | On southern side into Waterview estuary |
| 5 | TD5A – Causeway East End Eastbound Bio-filter Strip | 0.46 | ✓ | 80% | N/R | N/R | ✓ | On northern side into Waitemata Harbour |
| 5 | TD5B – Causeway East End Westbound Bio-filter Strip | 0.96 | ✓ | 80% | N/R | N/R | ✓ | On southern side into Waterview Estuary |
| 5 | TD5C - SH16 to SH20 Southbound Cartridge Filter Vault | 0.48 | ✓ | 80% | N/R | N/R | ✓ | Existing culvert under Eastbound off ramp |
| 5 | TD5D - SH20 to SH16 Westbound Cartridge Filter Vault | 2.08 | ✓ | 80% | N/R | N/R | ✓ | Oakley Inlet |
| 5 | TD5E – SH16 Waterview | 0.58 | ✓ | 80% | N/R | N/R | ✓ | Existing culvert under Eastbound off |

| | | | | | | | | |
|---|--|-------|---|-----|-----|-----|---|--|
| | Interchange Swale | | | | | | | ramp |
| 5 | TD5F - Northern Portal Wetland | 1.79 | ✓ | 80% | N/R | N/R | ✓ | Oakley Inlet |
| 5 | TD5G - SH16 Onramp Eastbound TDM Wetland | 5.19 | ✓ | 80% | N/R | N/R | ✓ | Existing culvert under Eastbound off ramp |
| 5 | TD5H - Cartridge Filter Retrofit | 1.66 | ✓ | 80% | N/R | N/R | ✓ | Existing stormwater system to Oakley Inlet |
| 6 | TD6A - Meola Wetland | 4.47 | ✓ | 75% | ✓ | N/R | ✓ | Meola Creek |
| 9 | TD9A - Alan Wood Wetland | 2.94 | ✓ | 75% | ✓ | ✓ | ✓ | Oakley Creek in Alan Wood Reserve |
| 9 | TD9B- Hendon Wetland | 11.59 | ✓ | 75% | ✓ | ✓ | ✓ | Oakley Creek in Alan Wood Reserve |

6.2 BPO Discussion of Stormwater Aspects

The options considered for stormwater treatment are presented with a discussion of the merits of each in Sections 6.2.1 and 6.2.2 respectively. Section 6.2.3 outlines how assessment matters that do not form the stormwater assessment criteria were considered during design and incorporated into the proposed solutions.

6.2.1 Best Practicable Stormwater Treatment Options for the Project

The best practicable option (BPO) approach was used to determine the most appropriate treatment devices for each catchment in each of the Sectors as required by the PARP:ALW and PARP:C. All permanent treatment devices proposed are approved ARC TP10 devices, or designed in accordance with TP10 or in the case of proprietary devices assessed and approved by the ARC. A discussion of the merits of each is provided in this section to highlight which devices are viewed as the best option for stormwater treatment for the Project, where not constrained by site considerations. The BPO approach and devices are summarised here to avoid repetition in the Sector by Sector descriptions that follow, although site factors affecting the choice of BPO are still highlighted.

ARC TP10 Chapter 4 and in particular Tables 4-8 and 4-9, which summarise the effectiveness of various treatment devices in removing contaminants and attenuating peak flows, give a comparison of treatment devices.

The stormwater treatment devices considered for the Project include:

- Constructed Wetlands
- Wet ponds
- Grass swales
- Grass swales with infiltration
- Proprietary Filter Cartridges
- Grassed Filter Strips
- Rain gardens
- Bio-filter Strip (Hybrid Grassed Filter Strip / Rain Garden) Treatment Device
- Sand Filters.

Constructed Wetlands

Constructed wetlands have many benefits over other treatment devices making them the BPO for this Project, where there is space and it is hydraulically feasible to direct runoff to, and discharge from, a wetland. Wetlands and wet ponds are the only devices which provide attenuation of peak flows or extended detention, and therefore the only options considered where water quantity treatment is required. Constructed wetlands provide superior water quality treatment to wet ponds, greater visual amenity and a better habitat for wildlife and are therefore the preferred option.

Constructed wetlands perform well as treatment devices removing a range of contaminants. Wetlands provide many benefits over unvegetated treatment ponds such as increased filtering and biological treatment performance. In addition, wetlands can provide a permanent and valuable ecological habitat and aesthetic amenity. Wetlands are natural to the Alan Wood Reserve area and are likely to have existed in areas, notably the Goldstar property, prior to drainage measures being put in place. Wetlands have been promoted by, and are consistent with, the Urban and Landscape Design Framework.

Treatment features of wetlands include (ARC TP10):

- Settling of total suspended solids
- Uptake by wetland plants of nutrients and soluble metals
- Filtering and absorption by wetland plants
- Organic bottom sediments provide nitrification/denitrification and better sink than inorganic sediments
- Volatilisation of petroleum.

Other major benefits of constructed wetlands compared to other treatment devices are the incorporation of low impact design principles, low maintenance requirements and low whole-of-life cost.

For catchments where attenuation is not required (those discharging to the CMA), to limit velocities through the wetland and avoid resuspension of sediment, a high flow bypass will be provided to divert flood flows around the constructed wetland. This can be achieved with a splitter manhole and bypass pipe.

Typical details for stormwater wetlands are provided in Drawing 20.1.11-3-D-D-340-201 (Appendix A). A banded bathymetry will be used to increase the wetland vegetation. Stormwater wetlands will be optimised for potential landscape and ecology values. Visual and physical access for the public can be integrated where appropriate, and safe maintenance access will be assured. Design criteria will reference ARC’s TP10 and ARC Guideline 01 (to press).

Wetlands will be densely planted to provide for the removal of targeted contaminants associated with roadway runoff (PAH’s, hydrocarbons, and metals). Planting will be in accordance with ARC TP148 Riparian Zone Management (2001), ACC Watercourse Guidelines (2003), NZTA Oakley Creek Rehabilitation and Re-alignment Guidelines (July 2010), and ARC Guideline 01 (to press) and specifically the volume, “*Landscape and Ecology Values within Stormwater Management.*” Figure 6.1 shows a wetland section with indicative wetland and riparian planting.

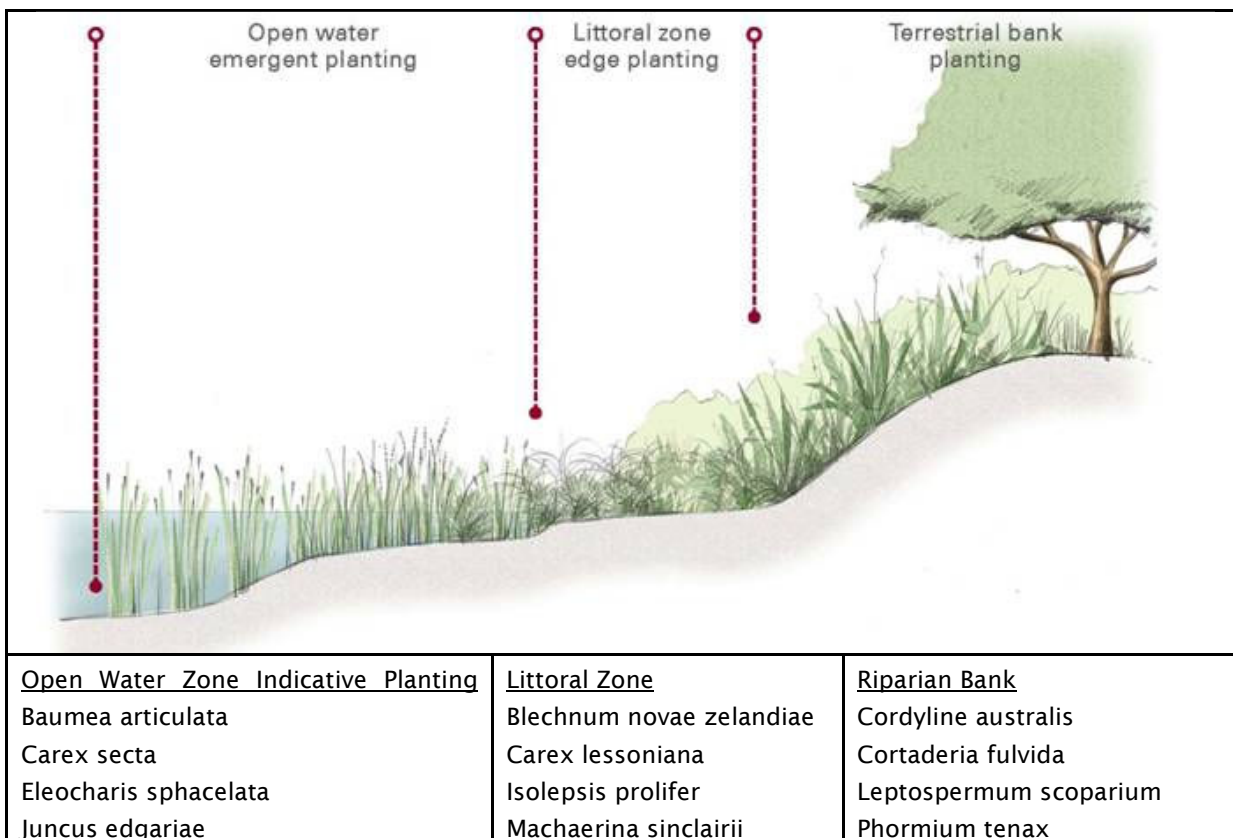


Figure 6.1: Typical wetland section and indicative species.

An isolating valve/device will be located on the outlet structure/pipe from the wetland to enable containment of contaminated and/or hazardous spill from the motorway.

Wet ponds

Wet ponds provide both peak flow attenuation and efficient water quality treatment, and are therefore a viable option throughout the Project area where there is sufficient space and it is hydraulically feasible to direct runoff to, and discharge from, a wet pond. However, wetlands provide superior water quality treatment to wet ponds, greater visual amenity and a better habitat for wildlife and are therefore the preferred option, where space constraints allow.

Grassed Swales

Engineered grassed swales are a desirable water quality solution; however do not provide any attenuation. Swales convey runoff at the same time as treatment and therefore eliminate impacts and costs associated with piping runoff over the same distance. Therefore swales have been selected as the BPO for areas of the Project where water quantity treatment is not required, and an area of sufficient length and appropriate longitudinal slope is available. Swales are an ideal solution where they can be located parallel to the motorway, receiving runoff from the motorway over their entire length. The space requirements for swales may sometime preclude their use. Swales provide the following benefits (ARC TP10):

- Effective at TSS concentration reduction (>80% removal)
- Effective at removal of Cu (typically 60%), Pb (typically 90%) and Zn (typically 80%)
- Can be used for vehicle recovery, sight lines
- Aesthetically pleasing and high degree of sustainability
- Low hydraulic head loss required.

Grass swales with an infiltration layer (and perforated under drain) are proposed in areas where 80% TSS removal is required. For details refer to Drawing 20.1.11-3-D-D-340-305. The basis for this design came from recent studies done by NIWA for the NZTA (Enhancing the control of contaminants from New Zealand's roads: results of a road runoff sampling programme - March 2010) which indicated that the removal rates of total copper and total zinc by infiltration in swales were similar to those for the most effective vegetative buffers and swales reported in the international literature. The performance of the swale studied at Northcote, along SH1, which reflects similar conditions as SH16, featured the high removal rate of dissolved copper and zinc (93%), and indicated that the primary mechanism by which treatment occurred was by infiltration. The proposed grass swale with infiltration essentially creates a bio-filter with combined benefits of filter processes and filter/rain garden treatment processes.

Proprietary Filter Cartridges

Cartridge filters such as the Stormwater 360 StormFilter are ARC approved for high traffic load applications (StormFilter Treatment Device - Discussion of Pre-treatment and Practice Acceptance, ARC letter dated 14 Nov 2007) and their suitability has been discussed with the NZTA and the Auckland Motorway Alliance (AMA) from a network operations and maintenance perspective. The filter media used in the cartridges for highway applications is ZPG, a proprietary blend of Zeolite, Perlite, and Granular Activated Carbon (GAC). Zeolite utilises cation exchange to remove dissolved metals such as zinc, copper, and lead. Perlite is a porous material that removes particles through direct filtration and absorbs oil and grease via capillary action. GAC removes hydrocarbons via adsorption. These cartridges result in discharge stormwater quality that has been approved by the ARC to meet TP10 Guideline requirements of 75% removal of total suspended solids. A benefit of using StormFilters to treat runoff from motorway catchments is the targeted removal of metals and hydrocarbons.

In addition Stormwater 360 have calculated that provided specific flow rates are limited to 0.7 l/sec/m² of filter surface area or smaller, the StormFilters will remove greater than 80% TSS on a long term average basis. This result assumes that the devices are installed and maintained in accordance with the manufacturer's recommendations. The evaluation was made using research into Auckland's sediment loads and particle size distribution; "Analysis of particle size distributions from Auckland data" (Skeen et al 2009), and data from the paper "Evaluation of the stormwater management StormFilter treatment system" (Minton, 2004). Relevant supporting documents include the following papers, which are included in Appendix H - Calculations;

- Performance of the Stormwater Management StormFilter relative to Ecology Performance Goals for Basic Treatment by Contech Stormwater Solutions
- Stormwater Contaminant land sediment load Modelling in the Central Waitemata and South Eastern Manukau Harbour Catchments (Timperley, 2009)
- ARC Contaminant load model (Timperley, 2009).

Cartridge filters are often used for quality treatment only at the end of pipe network. Cartridge filters create more waste than wetlands, wet ponds swales or filter strips and have a high maintenance requirement, due to the cartridges needing regular replacement. A minimum hydraulic head loss is also needed through the devices, making them inappropriate for installation on the causeway section of SH16. An advantage of cartridge filters over other devices is the small space requirement for the device (critical where reclamation in the CMA would result for larger devices). For these reasons proprietary cartridge filters were selected as the BPO for areas of the Project where water quantity treatment is not required, swales or filters are unable to be installed due to geometric or space constraints, and there is sufficient hydraulic head difference between the inlet and discharge point to allow treatment.

The advantages of proprietary filters include the following benefits (Performance of the StormFilter, Stormwater 360, 2008);

- High potential for TSS removal (>80% removal)
- Effective at removal of Cu (typ 60%), Pb (typ 90%) and Zn (typ 80%)

- Can be installed below the road or verge surface in concrete vaults, reducing the amount of reclamation and saving space. Cartridge vaults have a smaller footprint than sand filters and filter strips.

The cartridge filter vaults proposed for the Project will be sized based on cartridges containing ZPG filter media and at half flow rate to provide an estimated maintenance frequency of 12 months. The specific flow rates should not exceed 0.7 l/sec/m² to achieve 80% TSS removal. An isolating valve/device will be located on the outlet pipe to enable containment of contaminated and/or hazardous spill from the motorway. For details refer to Drawing 20.1.11-3-D-D-340-304 (Appendix A).

Grassed Filter Strips

Grassed filter strips are uniformly graded and densely vegetated strips of grass designed to treat stormwater runoff by filtration, infiltration, adsorption and biological uptake. Filter strips accept distributed or sheet flow and convey the runoff laterally from the roadside, meaning that runoff from the catchment is not collected and discharged at one point. Therefore the potential of erosion and scour due to the discharge is reduced. The main disadvantage of using filter strips on SH16 is the large area required for the device, and therefore extra reclamation with the associated negative effects in the CMA. Advantages of filter strips over other treatment devices include the fact that piped reticulation and outfall structures are not required. Filter strips were initially selected as the BPO in areas of the Project where water quantity treatment is not required, and swales and cartridges are not feasible because of the hydraulic head loss required for these devices, but were replaced by bio-filter strips which offered higher treatment efficiency targeted at heavy metals. Filter strips provide the following benefits (ARC TP10):

- Effective at TSS concentration reduction (>80% removal)
- Effective at removal of Cu (typically 60%), Pb (typically 90%) and Zn (typically 80%)
- Can be used for vehicle recovery and sight lines
- Aesthetically pleasing and incorporate of low impact design principles
- Low hydraulic head loss required
- Eliminate need for capture and conveyance drainage network.

Rain gardens

Rain gardens utilise the process of bio-detention whereby stormwater runoff is treated by passing the water through a filter media containing an organic component. The uniformly graded soil media planting area and vegetated strip are designed to treat stormwater runoff by filtration, infiltration, adsorption and biological uptake. Rain gardens accept distributed or sheet flow and convey the runoff laterally from the roadside, collect the surface water in an extended detention zone, and through infiltration discharge it through a subsurface drainage layer. This entails that runoff from the catchment is not collected and discharged at one point, and therefore the potential of erosion and scour due to the discharge is reduced. To retain the filter media within

the rain garden and aid drainage, one or more layers are used at the bottom of the filter. The surface can be planted with a range of vegetation. The main disadvantage of using rain gardens for SH16 catchments is the large area required for the devices, and therefore extra reclamation with the associated negative effects in the CMA. Advantages of rain gardens over other treatment devices include the fact that piped reticulation and outfall structures are not required. Rain gardens provide similar benefits as described above for filter strips (ARC TP10).

Bio-filter Strip (Hybrid Grassed Filter Strip / Rain Garden) Treatment Device

Bio-filter strips are a hybrid treatment device combining the grassed filter strip and rain garden concepts to provide enhanced treatment. Bio-filter strips were selected as the BPO in areas of the Project where 80% TSS removal is proposed, to provide mitigation for reclamation within the CMA. The main components of the bio-filter include:

- Grass filter strip for pre-treatment
- Ponding area to store the water quality volume
- Rain garden type soils
- Ground cover or mulch layer
- Plant material
- Underdrain system.

Recent studies done by NIWA for the NZTA (Enhancing the control of contaminants from New Zealand's roads: results of a road runoff sampling programme – March 2010) indicated that the removal rates of total copper and total zinc by infiltration are similar to those for the most effective vegetative buffers and swales reported in the international literature. The performance of the swale studied at Northcote, along SH1, which reflects similar conditions as SH16, featured the high removal rate of dissolved copper and zinc (93%), and indicated that the primary mechanism by which treatment occurred was by infiltration. Initial calculations indicate that the proposed hybrid treatment device using filtration (filter strip) as well as infiltration (rain garden) will achieve a relative TSS removal efficiency exceeding 80%. A combination of perennial rye grass species and Oioi, a jointed wire rush (*Lepcarpus (Apodasmia) similus*) as vegetative cover are proposed. The drainage layer consisting of a mixture of scoria and oyster shells will further contribute to the removal of contaminants. For details refer to Drawing 20.1.11-3-D-D-340-304 (Appendix A).

Sand Filters

Traditional sand filters were considered as an alternative to proprietary cartridge filters in areas of the Project, where filters were the preferred solution due to space constraints and there is sufficient hydraulic head through the device. The merits of sand filters and cartridge filters were assessed by asking the relevant suppliers to provide preliminary sizing of filters for the Whau River Bridge's catchments (refer to Section 6.4.2). The head loss requirement through the sand filters was larger than that through the Stormwater 360 StormFilter devices. The sand filters also required a larger physical space and more space for maintenance activities. Therefore sand filters would require greater reclamation than proprietary cartridge filters.

For example, initial calculations to size the treatment devices for 75% TSS removal for 5000m² of impervious carriageway surfacing using cartridge filters indicate one vault (4.2m long x 1.5m wide x 1.5m high) containing 10 cartridges would be required. However, to treat the same area to the same standard using sand filters one would require three box culvert sand filters (4m long x 3m wide x 1.5m high) and an additional box culvert dedicated to sedimentation. Furthermore, the maintenance of cartridge filters is more time and labour efficient than sand filters, which is especially important on an operating motorway where safety is paramount and the cost of traffic control measures is high. Therefore sand filters were not selected as the BPO for stormwater treatment of the Project catchments.

6.2.2 Erosion Control Outfall Options

A criterion for the assessment of the effects of stormwater discharge is the requirement that all outfall discharges that are likely to cause scour at the outfall incorporate erosion control measures. The options considered for erosion control at outlets are outlined in this section, with a brief discussion of the merits of each provided to highlight which solutions are viewed as the best practical options for the Project. The BPO approach and devices are summarised here to avoid repetition in the Sector by Sector descriptions that follow, although site factors affecting the choice of BPO are still highlighted.

Energy Dissipation Structure

Energy dissipation structures are the most effective means of energy dissipation, and are typically used when a discharge has high velocity and energy. Energy dissipation structures include stilling basins, impact basins and a range of US Army Corps of Engineers (USACE) and Hydraulic Engineering Centre (HEC) energy dissipation structures to suit different applications. However, energy dissipation structures are often large, and so are only appropriate where a large or rapid flow is entering a sensitive receiving environment. Within the Project area, where discharges are to the Oakley Creek from a device situated at a significant height above the stream, energy dissipation structures are the BPO for outfalls.

Wing wall

A concrete wing wall provides energy dissipation (by spreading flow and creating hydraulic jumps (in certain conditions)). Wing walls incorporate a scour resistant apron. Wing walls provide suitable energy dissipation and erosion protection method in areas where the velocities are low to moderate and the device outlet elevation is similar to the water elevation. Advantages of wing walls over stilling basins are their smaller size and therefore lesser visual impact. Baffles within the concrete apron can be used for additional energy dissipation. Where space permits, a length of rock lined channel between the outlet and the stream will be constructed for additional energy dissipation. Otherwise a rock armour apron will be used to protect the receiving environment. Within the Project area, where the velocity of discharges are low to moderate and the elevation differences between the treatment device outlet and the receiving water level are small, wing walls are the BPO for outfalls.

Rock Lined Channel

Rock lined channels provide scour protection at outfall locations and some energy dissipation due to their roughness that reduces velocities. In areas of the Project where swales are the BPO for stormwater treatment, a rock lined channel at the downstream end of the swale is the BPO for outfalls.

Discharge to Rip Rap revetment

Where bio-filters are proposed as the BPO for stormwater treatment, the discharge is to the CMA and in the form of sheet flow over the length of the device. This results in a diffuse discharge, rather than flows at discrete locations. The discharge from the bio-filter strips does not require specific energy dissipation or scour design as this is provided by the downstream rip rap rock revetment along the causeway foreshore. The discharge from the bio-filter strips to the rock revetments is the BPO.

Discharge to CMA via pipe

Where stormwater discharges are from a discrete outlet point to the CMA, for example where cartridge filters are proposed as the BPO for stormwater treatment, outfalls are proposed by discharging via a pipe fitted with a flap valve, a wing wall structure, and the rock revetment/apron. The outlets will be fitted with flap valves to ensure there is minimal risk to flooding of the carriageway when the tidal flap valves are closed. The treatment vaults will contain a high level overflow to prevent water back-accessing the reticulation network. The manufacturers have also confirmed that if the motorway becomes inundated during a storm surge intermittent exposure to sea water will not adversely affect the filter cartridge components or media. The structure proposed in these areas is the ACC standard outlet structure (apron and wing walls).

This method combines the advantages of a wing wall, and the rock revetment, with the back-flow protection provided by the flap valve. The disadvantages include the visual impact of a wing wall in the CMA, and the potential for sea water to travel back through the pipes.

6.2.3 Stormwater Objectives and Policies Influencing Design

Consideration was given during the BPO selection process and design to objectives and policies in the PARP:ALW relating to stormwater. Individual objectives and policies from the plan (refer to Section 4 for a discussion of assessment matters) are discussed.

Incorporate Low Impact Design Principles

Low Impact Design was considered as part of the BPOs process, with stormwater treatment devices, which are recommended in the ARC's Technical Publication 124: Low Impact Design Manual for the Auckland Region (1999), 2000 such as swales, bio-filter strips and wetlands incorporated in design where possible. These devices fulfil the objective of "Replication of natural treatment and attenuation" (TP124 -Low Impact Design Manual for the Auckland Region (ARC 1999)).

Discharge water within the catchment from which it originates

All stormwater treatment devices discharge water within the catchment from which it originates as far as this is possible.

Structures within the CMA are ancillary to an activity which has a functional need to locate in the CMA; or no reasonable or practicable alternative location exists including any location outside of the CMA

Stormwater treatment devices located within the CMA for the Project are ancillary to the widening of the SH16 causeway, being an activity which has a functional need to locate in the CMA. An effort has been made to reduce the number of outfalls within the CMA by maximising catchment sizes where possible, and providing solutions such as bio-filter strips and swales that do not require outfall structures.

Efficient use will be made of the CMA by using the minimum area for the CMA necessary for the structure

Bio-filter strips along the causeway eliminate the need for outfall structures from this catchment, maintain and enhance the integrity of the coastal environment and provide un-obstructed views of surrounding coastal area, where practicable enhancing visual links between the coastal marine area and adjacent land. Where outfalls are necessary, they have been designed to the minimum size required to perform the required functions.

Operation and Management Programmes

Operation and Management Programmes have been considered during stormwater BPO selection. Design and Operation and Maintenance Plans have been produced for stormwater treatment devices and outfalls within the Project area. Refer to the Operational Stormwater Management Plan and Temporary Stormwater Management Plan, attached as Appendix D and E, respectively.

The overall effects of stormwater discharges and diversion at the discharge points

Design factors considered to minimise the overall effects of stormwater discharges and diversion at the discharge points include:

- aligning the direction of discharge as closely as possible to the direction of flow in the receiving environment (where discharges are to stream environments)
- setting the elevation of treatment device outlets as close as possible to the elevation of the receiving waters (ensuring back flow does not become an issue) to reduce energy generated by discharge
- endeavouring to keep discharge locations out of particularly sensitive receiving environments.

6.3 Sector 1

6.3.1 Description

The Sector 1 catchment for stormwater consists of the SH16 carriageway from the western abutment of the Whau River Bridge to the eastern abutments of the Henderson Creek Bridge and includes the Te Atatu Interchange. The carriageway in this Sector will be widened from two main traffic lanes each direction to three main traffic lanes each direction with the addition of a standard width bus shoulders and median shoulders. There is currently no formal means of providing treatment for runoff from the pavement on this section of the motorway, except for a swale along the Te Atatu Peninsula eastbound on-ramp.

Stormwater treatment to remove 80% TSS on a long term average basis is proposed for this Sector. As the receiving environment is tidal, and stormwater discharge will be to CMA areas where flooding and stream erosion are not of concern, peak flow attenuation and extended detention are not required. However, energy dissipation and erosion protection will be provided at the discharge outlets.

The Sector has been broken into three catchments for treatment devices, based mainly on elevation and reticulation restrictions, which are shown on Drawings 20.1.11-3-D-D-300-101 and 20.1.11-3-D-D-300-102 (Appendix A).

- The catchment for TD1A consists of the SH16 carriageway from the western extent of the Sector to the highpoint approximately under the Te Atatu overbridge, the west facing interchange ramps and the western side of the Te Atatu overbridge.
- The catchment for TD1B consists of the SH16 east bound carriageway between the Te Atatu overbridge and Whau River, the east bound on ramp, and part of the overbridge.
- The catchment for TD1C consists of the SH16 westbound carriageway between the Te Atatu overbridge and Whau River, the west bound off ramp, part of the overbridge and Te Atatu Road southbound.

6.3.2 Options Considered

Treatment Device 1A

Eight treatment devices and their respective land requirements were considered including wetlands, wet ponds, combination of wet ponds and wetlands, dry pond and proprietary cartridge filters. These options were narrowed to two preferred options (in consultation with the NZTA) based mainly on treatment efficiency, capital and maintenance costs, (refer to Section 6.2.1 for a general discussion of treatment devices). The preferred options were both located at Jack Colvin Park and were:

- A. a wetland
- B. a wetland and wet pond.

A brief comparison of the two options is provided below:

- Option A is a wetland which was sized to remove 80% TSS from the full catchment (both new and existing impervious motorway) between Te Atatu overbridge and Henderson Creek. Some reclamation of the Coastal Marine Area is required. (Note: as a minimum only the Water Quality Volume from the additional proposed road pavement needs to be collected and treated. The proposed treatment of the existing road pavement provides a significant enhancement to stormwater management for this section of motorway).
- Option B consists of a wetland and a wet pond as separate devices. The combined catchment for the wet pond and wetland is the same as that for Option A. This option was designed to eliminate the reclamation and therefore has a smaller volume that reduces the overall treatment efficiency for the wet pond and wetland combined to 67% TSS removal.

Option A is considered to be the preferred option because the single wetland is able to treat runoff to at least 80% TSS removal for new and existing impervious motorway. This level of treatment exceeds the standards of the ARC TP10 Stormwater Management Devices: Design Guidelines Manual, a Project objective (refer Section 6.1). Minor reclamation of the adjacent Coastal Marine Area is required for construction, and is not considered to cause adverse environmental impacts, refer to Technical Report No G.11 *Assessment of Marine Ecological Effects*.

For more information regarding the selection of the BPO for this treatment location, refer to the Stormwater Options Paper: Western Ring Route – SH16 Upgrade, Report Ref. B289, Rev1 dated 14 December 2009 compiled for the NZTA by Aurecon (refer Appendix G).

The best practicable option for reticulation of runoff from Catchment 1A was evaluated. Swales or catchpit and pipe systems were considered, with the latter being selected due to the narrower footprint required and feasibility for embankment sections of the ramps. The space constraints in the area preclude the use of swales.

TD1B and TD1C

For treatment of runoff from catchments 1B and 1C there is no appropriate location for a wetland or wet pond. Filters, cartridges and swales were considered, with swales being selected as the BPO as they provide both treatment and reticulation, and there is space and longitudinal grade to make swales feasible.

6.3.3 Best Practical Options

Treatment Device 1A - Jack Colvin Wetland (TD1A)

The proposed TD1A is shown on Drawings 20.1.11-3-D-D-300-101 and 20.1.11-3-D-D-341-201 and 20.1.11-3-D-D-341-202 (Appendix A). The key operating levels and volumes are summarised in Table 6.2 below. The catchment area for TD1A is 9.45ha. The Water Quality Volume (WQV) for TD1A is 1569m³, of which 100% will be retained as the permanent volume of water in the wetland. An additional 50% of the WQV will be attenuated and released over a 24 hour period through a low flow orifice. The wetland has been designed taking the MHWS at 1.63m RL as a downstream hydraulic condition into account. The outfalls from the wetland and the

by-pass pipe will be concrete wing walls with rock aprons. The design to treat 150% of the WQV will achieve an 82% efficiency for TSS removal based on Table 3-1 TP10.

Design of the wetland has allowed for the catchment outlined in Section 6.3.1 above plus an area of SH16 carriageway west of Henderson Creek. The area west of Henderson Creek is outside the Project, but widening through this area is proposed as part of a separate NZTA Project. The use of the proposed wetland is also the BPO for this additional area. This extra catchment extends to a highpoint at SH16 Ch 6750. The size of the assumed catchment that is outside the Project area is 0.28ha.

Table 6.2: Wetland Design Geometry for TD1A – Jack Colvin Wetland

| Parameter | Elevation (m RL) | Area (m ²) | Volume (m ³) |
|--|------------------|------------------------|--------------------------|
| Wetland Invert | 1.70 | 900 | 0 |
| Normal Water Level | 2.64 | 2240 | 1569 |
| Water Quality Detention Level | 2.93 | 3244 | 2354 |
| Max. water level during 100 year ARI event | 3.30 | 3979 | 3750 |
| Approximate footprint of works | 130m x 50m | 5750 | 4900 |

Treatment Devices 1B & 1C - Te Atatu Eastbound on-ramp swale and Westbound off ramp swale

The proposed swales TD1B and TD1C are shown on Drawing 20.1.11-3-D-D-300-102 (Appendix A). TD1B runs parallel to the SH16 Eastbound Carriageway from the Te Atatu overbridge to Ch 4950. TD1C consists of two swales, one adjacent to the SH16 westbound carriageway and one adjacent to the west bound off ramp, which converge into one swale at approximately SH16 Ch 5000. The design geometries of TD1B and TD1C are summarised in Table 6.3 below. The catchment areas for TD1B and TD1C are 2.94ha and 3.27ha respectively. These swales will outfall into Whau River via two rock lined channels, located on either side of the motorway by the western abutment of the proposed widened Whau River Bridge. Under swale carrier drains with grated catch pits seated proud of the swale base are proposed for both TD1A and TD1B in order to convey higher intensity rain events than the WQ event and will outfall via concrete wing walls with rock aprons, integrated into the rock lined channels outfalls of the swales.

For both TD1B and TD1C the estimated residence time of 19 minutes and 13 minutes respectively is in excess of the 9 minutes required to achieve 75% TSS removal. In addition an infiltration layer with perforated underdrain will be combined with the grassed swale to provide a level of treatment exceeding 80% TSS removal on a long term basis, refer to calculations in Appendix G for supporting calculations.

Table 6.3: Swale design summary for Treatment Devices 1B & 1C:

| Parameter | Swale TD1B | Swale TD1C |
|--|------------|------------|
| Length (m) | 530 | 340 |
| Minimum length for 9 minute residence time 9 (m) | 85 | 85 |
| Average longitudinal slope (%) | 2.9 | 2.6 |
| Side slopes (Vertical : Horizontal) | 1 : 3 | 1 : 3 |
| Base width (m) | 1.5 | 1.5 |
| Max velocity during 10 yr ARI event (m/s) | 0.31 | 0.30 |
| Infiltration volume (m ³) | 308 | 191 |

Cross Drainage

There are four existing culverts under SH16 in Sector 1 (at SH16 Chainages 5810, 6020, 6100 and 6290) that convey the Pixie Stream and overland flows from the southern side of the motorway to the northern side. As part of the Project works these will be extended, and a duplicate culvert at SH16 5810 will be installed to provide adequate, future-proofed conveyance for the Pixie Stream. An overland flow conveyance channel will also be constructed to intercept flows along the northern edge of the westbound Te Atatu offramp and discharge to the Pixie stream. The proposed cross drainage infrastructure is shown on Drawings 20.1.11-D-D-300-101 & 102 (Appendix A).

The key design parameters of the proposed network components are shown in Table 6.4 and 6.5 below.

Table 6.4: Culvert extensions, duplication Sector 1

| Component | Design Flow (m ³ /s) | Existing length (m) | Proposed Length (m) | Diameter (m) |
|---------------------------------------|---------------------------------|---------------------|---------------------|--------------|
| Culvert SH16 Chainage 5810 | 2.76 | 50 | 76 | 1.2 |
| Additional Culvert SH16 Chainage 5810 | 3.21 | 0 | 76 | 1.5 |
| Culvert SH16 Chainage 6020 | 0.83 | 46 | 52 | 0.75 |
| Culvert SH16 Chainage 6100 | 0.33 | 40 | 50 | 0.45 |
| Culvert SH16 Chainage 6290 | 0.68 | 45 | 90 | 0.675 |

Table 6.5: Sector 1 Overland flow channel key geometry

| Component | Design Flow (m ³ /s) | Average Longitudinal Slope (%) | Length (m) | Side slopes | Base width (m) | Design flow depth (m) |
|--------------------------------|---------------------------------|--------------------------------|------------|-------------|----------------|-----------------------|
| Overland Flow Channel Sector 1 | 0.15 | 1.5 | 330 | 3H:1V | 1.5 | 0.173 |

6.4 Sector 2

6.4.1 Description

The area requiring stormwater treatment in Sector 2 consists of the SH16 carriageway Whau River Bridge, including the extra width due to the enlargement of the existing bridge to accommodate additional lanes. There is currently no formal treatment for runoff from the pavement on this section of the motorway.

Stormwater treatment to remove 80% TSS on a long term average basis is proposed for this Sector. As the receiving environment is tidal, and stormwater discharge will be to CMA areas where flooding and erosion is

not of concern, it has been considered that peak flow attenuation and extended detention are not required. However, energy dissipation and erosion protection will be provided at the discharge outlet.

The Sector has been broken into catchments for treatment devices, based mainly on elevation and reticulation restrictions.

- The catchments for TD2A and TD2B are defined as the SH16 carriageway from the eastern abutment of the Whau Bridge westward including the bridge to Ch 4970, eastbound and westbound lanes respectively. The catchments include an area of Sector 1 approximately 70m long, west of the bridges.
- The catchment for TD2C consists of the eastbound section of motorway area from Ch4500 to the eastern abutment of the Whau Bridge (CH 4700) that drains onto the northern verge.
- The catchment for TD2D consists of the westbound section of motorway area from Ch4400 to Ch4700 that drains onto the southern verge.

Refer to Drawing 20.1.11-3-D-D-300-103 (Appendix A) for catchment boundaries.

6.4.2 Options Considered

Treatment Devices 2A and 2B

Wetlands, swales, grassed filter strips, sand filters or proprietary cartridge filters were considered for Treatment Devices 2A and 2B. The width and environment requirements of swales and filter strips preclude their use on the Whau Bridges, and there is no appropriate location in the vicinity for a wetland. Preliminary sizing for sand filters indicated that the larger hydraulic headless through the filter and greater area required for installation and maintenance than that for cartridge filters rendered sand filters impractical. Therefore cartridge filters were selected as the BPO.

Options were considered for reticulation of runoff to TD2A and TD2B. Cesspit and pipe systems were selected due to space constraints and their being the only practicable method to convey runoff across the bridges.

Treatment Devices 2C and 2D

Sand filters, cartridges, filter strips, bio-filter strips and swales were considered for Treatment Devices 2C and 2D as there is no appropriate location in this vicinity for a wetland or wet pond. Swales were precluded due to the longitudinal slope required, and cartridge filters were precluded due to the piped reticulation system required and head loss through the device. Bio-filter strips are preferred compared to filter strips due to better treatment efficiency. Therefore bio-filter strips were selected as the BPO for both treatment and reticulation.

6.4.3 Best Practicable Solutions

Treatment Devices 2A & 2B – Whau River Cartridge Filters (TD2A & TD2B)

Runoff from the widened Whau River Bridge and a motorway section, approximately 70m long, west of the bridges will be intercepted by catch pits and piped eastwards to treatment devices located on both sides of the eastern abutment of the Whau Bridge and discharged directly into Whau River.

The catchment areas for TD2A and TD2B are both 0.57ha. A cartridge filter system is proposed for stormwater treatment for each of the stormwater catchments. Initial calculations show for each 5715m² of impervious carriageway, a vault (approximately 4.5m long x 2.4m wide x 1.8m high) containing 13 cartridges is required, with a maintenance frequency of 12 months. The precast vault with forebay can be fitted with up to 18 cartridges which will reduce the maintenance frequency and/or increase the volume of water treated with a resultant increase in long term treatment efficiency.

The outfalls will be concrete wing walls, with flap valves for backflow prevention, integrated into the rock armour revetment with an additional rock apron as necessary along the edge of the wing wall.

Table 6.6: Cartridge Filter Design Summary for Treatment Devices 2A & 2B:

| Parameter | Cartridge Filter TD2A | Cartridge Filter TD2B |
|---|--------------------------------|--------------------------------|
| Number of Cartridges | 13 | 13 |
| Vault capacity (total number of cartridges) | 18 | 18 |
| Approximate Vault Area (m ²) | 4.5mx2.4m = 10.8m ² | 4.5mx2.4m = 10.8m ² |
| Outlet Level (RLm) | 3.40 | 3.40 |

Treatment Devices 2C & 2D – Whau River EB (TD2C) & WB (TD2D) bio-filter strips

It is proposed that stormwater runoff from the motorway between the Rosebank Park Domain Go-kart track and the Whau River Bridge (catchments 2C and 2D) be provided by bio-filter strips. The bio-filter strips are to be located along the side of the motorway to provide treatment for the adjacent pavement area.

The bio-filter strips are proposed to be 7.0m wide with a 1% cross fall. Preliminary calculations based upon TP10 and TP108, indicated minimum filter widths of 6.39m and 6.20m for the westbound and eastbound carriageways to achieve 75% TSS removal. The proposed width of 7.0m exceeds the minimum filter width that is required to achieve treatment to TP10 standards. For the rain garden component of the hybrid device, the 0.60m deep infiltration trench (rain garden) required a minimum width of 4.69m for the westbound carriageway and 4.05m wide for the eastbound carriageway to achieve 75% TSS removal. For the design width

the volume the device stores is 150% of the WQV. Calculations indicate the hybrid device with both filter and infiltration mechanisms achieves > 82% treatment efficiency.

Table 6.7: Treatment Devices 2C & 2D – Peak flows

| Parameter | Bio-filter Strip TD2C | Bio-filter Strip TD2D |
|--|-----------------------|-----------------------|
| Catchment Area (ha) | 0.55 | 0.83 |
| Length (m) | 300 | 250 |
| Width of hybrid device (m) | 7.0 | 7.0 |
| Minimum treatment width assuming 75% TSS removal by grassed filter strip (m) | 4.05 | 4.69 |
| Depth of hybrid device media (m) | 0.60 | 0.60 |
| Cross fall of hybrid device surface (%) | 1.00 | 1.00 |
| Max velocity during 10yr ARI event | 0.023 | 0.023 |
| Percentage of WQV ponded for treatment by infiltration | 173 | 149 |

6.5 Sector 3

6.5.1 Description

Sector 3 consists of the area of the westbound lanes of SH16, including the extra width required to accommodate additional lanes, from Ch 2800 between Traherne Island and the Rosebank Peninsula to Ch 4400 situated to the west of the Rosebank Park Domain Go-kart track. This Sector borders the terrestrial areas of the Rosebank Peninsula to the south. Both Rosebank on and off-ramps have been lengthened to accommodate improved lane configuration and achieve satisfactory merging lengths. Sector 3 is bordered on the northern side by Sector 4.

The shared use path from the southern (landward) side of the Causeway continues under the westbound off-ramp at Rosebank Interchange. The shared use footway/cycleway path width remains generally 3m through Sector 3, though reduces to 2m between Ch 3540 and 3620 to avoid directly affecting an existing industrial building. A new footbridge is being proposed to facilitate pedestrians and cyclists over Patiki Road westbound on-ramp, providing an alignment that is better suited to the users (removes right angles), and fits with proposed Patiki westbound on-ramp alignment.

Widening the motorway between Ch3800 and Ch4150 significantly affects the existing access road into the 'Rosebank Park Domain Go-Kart Track', so a new two lane local access road has been designed to maintain access. The local road has been designed to Auckland City Council standard, as the road is currently outside NZTA designation. The new local road is approximately 420m in length and consists of two 3m lanes.

Stormwater treatment to remove 80% TSS on a long term average basis is proposed for this Sector. As the receiving environment is tidal, and stormwater discharge will be to CMA areas where flooding and erosion are not of concern, it is considered that peak flow attenuation and extended detention are not required. However, energy dissipation and erosion protection will be provided at the discharge outlet.

The Sector has been broken into 5 catchments based on treatment device capacity and reticulation restrictions as shown on Drawings 20.1.11-3-D-D-300-103 to 20.1.11-3-D-D-300-105 (Appendix A)

- The catchment for TD3A consists of the westbound section of motorway area from Ch 4400 to Ch 4400 that drains to the southern verge.
- The catchment for TD3B consists of the westbound section of motorway area from Ch 4150 to Ch 4400 and eastbound section (part of Sector 4) of motorway area from Ch 4210 to Ch 4400 as well as the Patiki off ramp and bridge that drains onto the median and southern verge.
- The catchment for TD3C consists of the westbound section of motorway area from Ch 4000 to Ch 4150 that drains to the south.
- The catchment for TD3D consists of the westbound section of motorway area from Ch 3400 to Ch 4000 and the westbound Patiki on-ramp that drains onto the median and southern verge.
- The catchment for TD3E consists of the westbound section of motorway area from Ch 2770 to Ch 3400 and eastbound section (part of Sector 4) of motorway area from Ch 3090 to Ch 3400.

6.5.2 Options Considered

Treatment Devices 3A to 3E

There is no appropriate location in Sector 3 for a wetland, wet pond, bio-filter strips or swales because of tight space constraints adjacent to the proposed widened carriageway. Cartridge filters or sand filters were considered as potential options with cartridge filters being selected as the BPO (refer to Section 6.2.1 for full description of attributes)

The BPOs for reticulation of runoff to Treatment Devices 3A to 3E were evaluated. Kerb or dish channel edging combined with grated channels/slot drains, cesspits and pipe systems was selected due to space constraints. There are sections of superelevation within this Sector, for which the runoff drains towards the SH16 centreline, making a swale system impractical.

6.5.3 Best Practicable Options

Treatment Devices 3A to 3E – Cartridge Filters (TD3A to TD3E)

Runoff from the widened motorway section in Sector 3 will be intercepted by slot drains, dish channels and/or catch pits, and piped to Treatment Devices 3A to 3E located on the verge of the motorway and then discharged directly into the CMA. Calculations show that one cartridge filter is required to treat approximately 500m² of impervious carriageway surfacing to the required TP10 standards.

Cartridge vault treatment devices will be designed individually, and their design will be dependent on the impervious area, pollutant load, flow rate and head loss at each location. The outfalls will be concrete wing walls, with flap valves for backflow prevention, integrated into the rock armour revetment with an additional rock apron as necessary along the edge of the wing wall.

The proposed treatment devices are listed below with their outfall locations. The approximate sizing and proposed number of cartridges is shown in Table 6.8.

- Treatment Device 3A – Rosebank Domain Cartridge Filter Vault (TD3A), discharging directly into the tidal mangrove flats of the CMA to the west of the Rosebank Park Domain Go Karting Track. Catchment area is 0.36ha.
- Treatment Device 3B – Patiki Off Ramp Cartridge Filter Vault (TD3B) will discharge directly into the CMA to the north of the Rosebank Park Domain Go Karting Track. Catchment area is 0.84ha.
- Treatment Device 3C – Go Kart Track Cartridge Filter Vault (TD3C) will discharge directly into the tidal mangrove flats of the CMA to the east of the Rosebank Park Domain Go Karting Track. Catchment area is 0.44ha.
- Treatment Device 3D – Rosebank Cartridge Filter Vault (TD3D) will discharge directly into the CMA to the west of the Rosebank Peninsula. Catchment area is 2.31 ha.
- Treatment Device 3E – Rosebank Off Ramp Cartridge Filter Vault (TD3E) will discharge directly into the CMA to the east of the Rosebank Peninsula. Catchment area is 2.94 ha.

The outfalls will be concrete wing walls, with flap valves for backflow prevention, integrated into the rock armour revetment with an additional rock apron as necessary along the edge of the wing wall.

The precast vaults with forebays can in some instances be fitted with more cartridges, as indicated in the table below, which will reduce the maintenance frequency and/or increase the volume of water treated with a resultant increase in long term treatment efficiency.

Table 6.8: Cartridge Filter Design Summary for Treatment Devices 3A to 3E:

| Parameter | Cartridge Filter TD3A | Cartridge Filter TD3B | Cartridge Filter TD3C | Cartridge Filter TD3D | Cartridge Filter TD3E |
|---|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Number of Cartridges | 5 | 12 | 8 | 39 | 52 |
| Vault Capacity (Total number of Cartridges) | 5 | 18 | 8 | 46 | 88 |
| Approximate Vault Area (m ²) | 3.5 | 10.8 | 7.0 | 22.6 | 43.7 |
| Outlet Level (RLm) | 1.49 | 1.06 | 1.38 | 1.87 | 1.50 |

6.6 Sector 4

6.6.1 Description

Sector 4 consists of the reclamation area from Ch 900 on the causeway to the Rosebank Road westbound off ramp (Ch 2800) of the SH16 westbound lanes, and the SH16 eastbound lanes up to the west of the Rosebank Park Domain. The catchments for stormwater treatment will include the entire SH16 carriageway after the raising and widening is complete.

There is currently limited treatment for runoff from the pavement on this section of the motorway as discussed in Section 5.4 of this report. The existing levels of treatment are summarised in Section 6.11.

As the receiving environment is tidal, and stormwater discharge will be to CMA areas where flooding and erosion are not of concern, therefore it has been assumed that peak flow attenuation and extended detention are not required. However, energy dissipation and erosion protection will be provided at the discharge outlet.

The Sector has been broken into 12 catchments for treatment devices, based on elevation and reticulation restrictions and on treatment device capacity as shown on Drawings 20.1.11-3-D-D-300-103 to 20.1.11-3-D-D-300-108 (Appendix A).

The SH16 Causeway Bridges are shown on Drawing 20.1.11-3-D-D-300-108. Stormwater treatment options were considered for the bridges but all were considered to be not practicable, due to reticulation difficulties, and low hydraulic head difference between the pavement and the MHWS level. This bridge area is small (0.39 ha) with most of it already impervious and with no existing treatment. The potential for pollutant generation is low compared to other parts of the motorway because traffic will not be cornering, and is unlikely to be braking or accelerating within this section. Therefore no stormwater treatment is proposed for the small catchment consisting of the Causeway Bridges.

6.6.2 Options Considered

Treatment Devices 4A, 4B, 4D to 4H

For the seven catchments for Treatment Devices 4A to 4H excluding 4C the BPO approach was used to select treatment devices. There is no appropriate location adjacent to this area of motorway for a wetland, wet pond, bio-filter strips or swales as most of the verge areas require reclamation. There is enough longitudinal slope along the proposed SH16 alignment for runoff from these catchments to be collected and conveyed to a single treatment device location for each catchment. Therefore, cartridge filters and sand filters were considered, with cartridge filters being selected as the BPO (refer to Section 6.2.1 for full description of attributes).

The BPOs for reticulation of runoff to Treatment Devices 4A, 4B, 4D to 4H were evaluated. A grated / slot drain, catchpit and pipe system was selected due to space constraints within the areas of reclamation.

Treatment Devices 4C and 4I, 4J, 4K & 4L

For the four catchments along the causeway and the section below the Patiki Road overbridge there is no appropriate location in the vicinity for a wetland or wet pond. Sand filters, cartridges, filter strips, bio-filter strips, rain gardens and swales were considered as potential options. Because of the effectively flat longitudinal gradient of the SH16 carriageway within these catchments, treatment by swale is not feasible and large pipe diameters with frequently spaced discharges would be needed for a piped reticulation system. The risk of damage to pipe systems from differential settlement of the causeway is another disadvantage of conveying runoff to one point for treatment. Bio-filter strips, were selected as the BPO for these catchments (refer to Section 6.2 for a discussion of the advantages of the bio-filter strips within the Project).

Bio-filter strips can be used for both treatment and reticulation by conveying the runoff laterally from the roadside and are therefore the BPO option for reticulation of these catchments.

6.6.3 Best Practicable Options

Treatment Devices 4A, 4B, 4D, 4E, 4F, 4G & 4H – Cartridge Filters (TD4A, TD4B, TD4D, TD4E, TD4F, TD4G & TD4H)

Runoff from the 4A, 4B, 4D, 4E, 4F, 4G & 4H catchments in Sector 4 will be intercepted by slot drains, dish channels and/or catch pits, and piped to cartridge vault treatment devices located on the verge of the motorway and discharged directly into the CMA. Cartridge vault treatment devices will be designed individually because they are dependent on the impervious area, pollutant load, flow rate and head loss at each location. The design parameters and geometry for Cartridge Filters TD5C and TD5D are shown in Table 6.9 below.

The number of cartridges estimated to provide treatment to the respective cartridge areas, and an approximate vault size for each is summarised in Table 6.9. The devices are named as follows, with the catchment area that drains to them:

- Treatment Device 4A – Whau End Cartridge Filter Vault (TD4A) - 0.56 ha
- Treatment Device 4B – Patiki Flyover Cartridge Filter Vault (TD4B) - 0.39 ha

- Treatment Device 4D – Tidal Creek Cartridge Filter Vault (TD4D) – 1.04 ha
- Treatment Device 4E – Pollen Island Cartridge Filter Vault (TD4E) – 0.74 ha
- Treatment Device 4F – Rosebank On-Ramp Cartridge Filter Vault (TD4F) – 0.94 ha
- Treatment Device 4G – Traherne West Cartridge Filter Vault (TD4G) – 0.44 ha
- Treatment Device 4H – Traherne East Cartridge Filter Vault (TD4H) – 0.32 ha.

The precast vaults with forebay can in some instances be fitted with more cartridges, as indicated in the table below, which will reduce the maintenance frequency and/or increase the volume of water treated with a resultant increase in long term treatment efficiency.

The outfalls will be concrete wing walls, with flap valves for backflow prevention, integrated into the rock armour revetment with an additional rock apron as necessary along the edge of the wing wall.

Table 6.9: Cartridge Filter Design Summary for Treatment Devices 4A to 4H (Excl 4C)

| Parameter | Cartridge Filter TD4A | Cartridge Filter TD4B | Cartridge Filter TD4D | Cartridge Filter TD4E | Cartridge Filter TD4F | Cartridge Filter TD4G | Cartridge Filter TD4H |
|--|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Number of Cartridges | 9 | 9 | 18 | 14 | 19 | 9 | 6 |
| Vault Capacity (Total no. of cart.) | 18 | 18 | 18 | 18 | 28 | 18 | 8 |
| Approximate Vault Area (m ²) | 10.8 | 10.8 | 10.8 | 10.8 | 15.4 | 10.8 | 7.0 |
| Outlet Level (RLm) | 1.83 | 2.15 | 1.77 | 1.54 | 1.54 | 2.20 | 2.20 |

Treatment Devices 4C, 4I, 4J, 4L & 4M – Causeway Bio-filter strips

The bio-filter strips for Treatment Devices 4C, 4I, 4J, 4L & 4M are to be located along the side of the motorway to provide treatment for the respective adjacent pavement areas. The catchment areas draining to each are summarised in Table 6.10.

The bio-filter strips are proposed to be 7.0m wide with a 1% cross fall. Preliminary calculations based upon TP10 and TP108, indicated a minimum filter width of 4.05 – 4.69m for the westbound and eastbound carriageways to achieve 75% TSS removal. The proposed width of 7.0m exceeds the minimum filter width that is required to achieve treatment to TP10 standards. For the rain garden component of the hybrid device, the 0.60m deep infiltration trench (rain garden) requires approximately 4.0m width to achieve 75% TSS removal. For the design width the volume the device stores is 150% of the WQV. Calculations indicate the hybrid device with both filter and infiltration mechanisms achieves > 82% treatment efficiency.

To allow for the 9m clear zone a minimum width of 5.5m is required to negate the use of crash barriers. The proposed width exceeds the minimum width that is required to achieve treatment to TP10 standards. Table 6.10 below shows the design parameters and geometry for the proposed bio-filter strips.

The bio-filter strips will discharge diffusely to the rock armour revetments along the causeway edge, which in turn will discharge diffusely to the coast. No erosion is expected.

Table 6.10: Summary of Treatment Devices 4C & 4I to 4M

| Parameter | Bio-filter Strip TD4C | Bio-filter Strip TD4I | Bio-filter Strip TD4J | Bio-filter Strip TD4L | Bio-filter Strip TD4M |
|--|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Catchment Area (ha) | 0.68 | 4.19 | 3.84 | 0.94 | 0.92 |
| Length (m) | 200 | 1375 | 1100 | 290 | 290 |
| Width of hybrid device (m) | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 |
| Minimum treatment width assuming 75% TSS removal by grassed filter strip (m) | 4.05 | 4.05 | 4.69 | 4.05 | 4.69 |
| Depth of hybrid device media (m) | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 |
| Cross fall of hybrid device surface (%) | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| Max velocity during 10yr ARI event | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 |
| Percentage of WQV ponded for treatment by infiltration | 173 | 173 | 149 | 173 | 149 |

6.7 Sector 5

6.7.1 Description

The Project extent and new impervious catchment in this Sector consists of the on and off ramps connecting SH16 and SH20, and the lane widening areas of SH16 within the Sector at the Eastern end of the causeway. There are four separate ramp alignments, (Ramps 1, 2, 3 and 4) consisting of a mixture of viaducts, embankments and cut sections. There are also existing impervious areas of motorway for which treatment is provided by a wet pond adjacent to the eastbound onramp (refer Section 5.5). Stormwater treatment will be maintained or provided for these areas. In addition, where practicable, treatment will be provided for some of the existing interchange motorway surface that is currently untreated.

Stormwater treatment to remove 80% TSS on a long term average basis is proposed for this Sector. Treatment devices for the Waterview Interchange catchments will discharge to the Oakley Creek estuarine area, Waterview

Inlet and the Upper Waitemata harbour (north of causeway) which are designated as a CPA 1 under the ARC PARP:C. As the stormwater discharge will be to estuarine areas where flooding is not of concern, it has been assumed that peak flow attenuation and extended detention are not required. Therefore treatment devices for this Sector are required to provide water quality treatment only. Energy dissipation and erosion protection will be provided at the discharge outlets.

The Sector has been broken into six catchments for treatment devices, based mainly on elevation and reticulation restrictions as shown on Drawings 20.1.11-3-D-D-300-108, 109,110 & 113 (Appendix A).

6.7.2 Options Considered

Treatment Devices 5A and 5B

Swales, cartridge filters, filter strips and bio-filter strips were considered for the catchments at the eastern end of the causeway. There is no space available in the vicinity to construct a wetland or wet pond. Bio-Filter strips were selected as the BPO, because of the flat longitudinal gradients, and low elevation of the carriageway in relation to the water levels in the receiving environment. Furthermore, potential differential settlement of the reclamation precludes treatment devices that require reticulation of runoff. The bio-filter strips of Sector 5 are essentially a continuation of the bio-filter strips in Sector 4

Treatment Devices 5C and 5D

Wetlands, wet ponds, swales, cartridge filters, filter strips and bio-filter strips were considered for the catchments formed by the western sections of Ramps 2 and 3. Cartridge filters were selected as the BPO, due to the limited space in the area for treatment devices and the small area required for cartridge filters and therefore minimal required amount of reclamation. Swales and filter type strips are inappropriate for viaduct sections of the alignments, and wetlands or wet ponds would require reclamation in the CMA, making them undesirable in this location.

Treatment Device 5E

Wetlands, cartridge filters or a swale were considered for maintaining treatment of this section of SH16 existing pavement. A swale was selected as the BPO. There is an existing swale in this location and new reticulation works will not be required for this option, as swales provide both treatment and reticulation.

Treatment Device 5F

A wetland was selected as the BPO for the ramp sections falling towards the cut and cover tunnel at GNR, given that there is space between ramps, and feasible ground profile to construct a wetland in the vicinity.

Treatment Device 5G

A wetland was constructed within the GNR Interchange as part of the NZTA's Traffic Demand Management Project. The wetland is undersized and the layout does not meet the guidelines of TP10. This wetland was consented based on the assumption that the Project would include works in this area, and the wetland would

be upgraded at this time. Wet ponds, swales or wetlands were considered, with a wetland being selected as the BPO due to the low hydraulic head available, and the treatment advantages of a wetland.

Treatment Device 5H

A large section of SH16 from between GNR and Carrington Road is currently untreated. This Section of SH16 motorway is unchanged by the Project (with exception of interchange ramps tie-ins). However, stormwater treatment is proposed as a Project enhancement. Gross pollutant traps, cartridge filters or no treatment were considered for this catchment, with cartridge filters being selected as the BPO due to the superior treatment achievable, and the added environmental benefits to the Project.

6.7.3 Best Practicable Options

Treatment Devices 5A & 5B - Causeway East End EB & WB Bio-Filter Strips

The proposed devices TD5A and TD5B are bio-filter strips to treat runoff from the east end of the causeway section of SH16 are shown on Drawing 20.1.11-3-D-D-300-108 (Appendix A). The bio-filter strips are to be located along the side of the motorway to provide treatment for the adjacent pavement area.

The bio-filter strips are proposed to be 7.0m wide with a 1% cross fall. The stormwater calculations for TD5A are the same as the adjacent TD4L, and TD5B is the same as the adjacent TD4M. Preliminary calculations based upon TP10 and TP108 indicated a minimum filter width of 4.05 – 4.69m for the westbound and eastbound carriageways to achieve 75% TSS removal. The proposed width of 7.0m exceeds the minimum filter width that is required to achieve treatment to TP10 standards. For the rain garden component of the hybrid device, the 0.60m deep infiltration trench (rain garden) requires approximately 4.0m width to achieve 75% TSS removal. For the design width the volume the device stores is 150% of the WQV. Calculations indicate the hybrid device with both filter and infiltration mechanisms achieves > 82% treatment efficiency.

To allow for the 9m clear zone a minimum width of 5.5m is required to negate the use of crash barriers. The proposed width exceeds the minimum width that is required to achieve treatment to TP10 standards.

The bio-filter strips will discharge diffusely to the rock armour revetments along the causeway edge, which in turn will discharge diffusely to the coast. Design velocities are such that no erosion is expected.

The 10 year ARI event was used to check that the velocity of flow does not exceed the maximum allowable velocity of 0.4m/s. Table 6.11 below shows the design parameters and geometry for the proposed filter strips TD5A and TD5B. The design will need to be refined at the detailed design stage to accommodate the gore zone and on and off ramps.

Table 6.11: Treatment Devices 5A & 5B – Peak flows

| Parameter | Filter Strip TD5A | Filter Strip TD5B |
|--|-------------------|-------------------|
| Catchment area (ha) | 0.46 | 0.96 |
| Length (m) | 270 | 307 |
| Width of hybrid device (m) | 7.0 | 7.0 |
| Minimum treatment width assuming 75% TSS removal by grassed filter strip (m) | 4.05 | 4.69 |
| Depth of hybrid device media (m) | 0.6 | 0.6 |
| Cross fall of hybrid device surface (%) | 1 | 1 |
| Max velocity during 10yr ARI event | 0.023 | 0.023 |
| Percentage of WQV ponded for treatment by infiltration | 173 | 149 |

Treatment Devices 5C & 5D - SH16 to SH20 SB & SH20 to SH16 WB Cartridge Filters

The proposed cartridge filters TD5C and TD5D are shown on Drawings 20.1.11-3-D-D-300-109 & 113 (Appendix A). TD5C is located to the north of Ramp 3 at Ch 807, and will discharge to the north into the Upper Waitemata Harbour. TD5D is located to the south of Ramp 2 at Ch 1014 and will discharge to the Waterview Inlet.

Runoff will be intercepted by slot drains, dish channels and/or catchpits and piped to cartridge vault treatment devices located on the verge of the motorway and discharged directly into the CMA. Cartridge vault treatment devices will be designed individually for dependant on the impervious area, pollutant load, flow rate and head loss at each location. The catchment areas for TD5C and TD5D are 0.48ha and 2.09ha, respectively.

The outfalls will be concrete wing walls, with flap valves for backflow prevention, integrated into the rock armour revetment with an additional rock apron as necessary along the edge of the wing wall.

Table 6.11: TD5C & TD5D – Design Summary

| Parameter | Cartridge Filter TD5C | Cartridge Filter TD5D |
|--|-----------------------|-----------------------|
| Number of Cartridges | 10 | 36 |
| Vault Capacity (Total no. of Cartridges) | 18 | 46 |
| Approximate Vault Area (m ²) | 10.8 | 22.6 |
| Outlet Level (RLm) | 4.4 | -0.2 |

Treatment Devices 5E- SH16 Waterview Interchange Swale

The proposed swale TD5E is shown on Drawing 20.1.11-3-D-D-300-109 (Appendix A). The swale runs parallel to the SH16 Eastbound Carriageway in the westerly direction from 175m eastwards of Ch 955 on Ramp 2 to 955, and then towards the Culvert under Ramp 3 at Ramp 3 Ch 795. TD5E has a residence time of 18 minutes, which is in excess of the 9 minutes required to achieve 75% TSS removal. In addition, an infiltration layer with perforated underdrain will be combined with the grass swale to provide a level of treatment exceeding 80% TSS removal on a long term basis. After treatment in the swale runoff will discharge through the culvert at the existing outlet to the Upper Waitemata Harbour. The design geometry of TD5E is summarised in Table 6.13 below. The catchment area for TD5E is 0.58ha.

Table 6.13: TD5E Design Summary

| Parameter | Value |
|--|-------|
| Length (m) | 175 |
| Minimum length for 9 minute residence time 9 (m) | 94 |
| Longitudinal slope (%) | 3 |
| Side slopes (m/m) | 3:1 |
| Base width (m) | 2 |
| Max velocity during 10 yr ARI event (m/s) | 1.1 |
| Infiltration volume (m ³) | 86 |

Treatment Devices 5F - Northern Portal Wetland

The proposed wetland TD5F is shown on Drawings 20.1.11-3-D-D-300-113 & 109 (Appendix A). The key operating levels and volumes are summarised in Table 6.14. The catchment area for TD5F is 1.79ha. The WQV is 423m³. The permanent volume of water in the wetland will be 376m³ with the remaining volume for water quality treatment captured and released over 24 hours.

There is provision within the proposed design of TD5F for the wetland to receive flows pumped from the tunnel low point (which could include groundwater seepage to the tunnel, washdown flows, or in the event of an emergency, deluge flows). Depending on the water quality of these potential tunnel drainage flows, operating procedures will direct whether they are pumped to TD5F or by tanker truck to special facility off site. The Permanent Volume stored in Wetland 5F is 376m³, more than the minimum required based on half of the WQV plus the daily expected groundwater seepage to the tunnel (16.43m³/day). The extended detention volume is equal to half of the WQV, plus the inflows from one day of 8 l/s traffic stormwater into the tunnel. Details of the tunnel drainage system are provided in Section 6.9.

The outfall from TD5F will require an energy dissipation structure due to the drop from the wetland to Waterview Inlet. An impact basin has been designed for this purpose and is detailed in Drawing 20.1.11-3-D-D-310-211 (Appendix A).

Table 6.14: Wetland Design Geometry for TD5F – Northern Portal Wetland

| Parameter | Elevation (mRL) | Area (m ²) | Volume (m ³) |
|---|-----------------|------------------------|--------------------------|
| Wetland Invert | 7.0 | 412 | - |
| Normal Water Level | 7.5 | 1033 | 376 |
| Extended Detention Level | 8.2 | 1449 | 1279 |
| Maximum water level during 100 year ARI event | 8.5 | 1642 | 1705 |
| Approximate footprint of works | N/A | - | N/A |

Treatment Device 5G – TDM Wetland Upgrade

The proposed wetland TD5G is shown on Drawings 20.1.11-3-D-D-300-109 (Appendix A). The key operating levels and volumes are summarised in Table 6.15. The catchment area for TD5F is 5.19ha. The WQV is 551m³. The permanent volume of water in the wetland will be 803m³. The permanent volume is 146% of the WQV and therefore the estimated treatment efficiency is 81% based on Table 3-1 of TP10.

The outfall from TD5G will drain to the existing 1050mm diameter culvert under the SH16 eastbound onramp, as per the existing wetland outlet.

Table 6.15: Wetland Design Geometry for TD5G – TDM Wetland Upgrade

| Parameter | Elevation (mRL) | Area (m ²) | Volume (m ³) |
|---|-----------------|------------------------|--------------------------|
| Wetland Invert | 2.1 | 839 | - |
| Normal Water Level | 2.2 | 1662 | 803 |
| Extended Detention Level | - | - | - |
| Maximum water level during 100 year ARI event | 3.1 | 1927 | 1503 |

Treatment Device 5H - Cartridge filter retrofit

The proposed cartridge filters TD5H is shown on Drawing 20.1.11-3-D-D-300-109 (Appendix A). TD5H is located to the north of the SH16 alignment, where the existing catchment reticulation discharges to the larger stormwater network. The catchment area for TD5H is 1.66ha. Table 6.16 shows the retrofit cartridge filter parameters.

Table 6.16: Cartridge Filter Design Summary for Treatment Device 5H

| Parameter | Cartridge Filter TD5G |
|---|-----------------------|
| Number of Cartridges | 33 |
| Vault capacity (total number of Cartridges) | 33 |
| Approximate Vault Area (m ²) | 15.4 |
| Outlet Level (RLm) | 13.2 |

6.8 Sector 6

6.8.1 Description

The stormwater for Sector 6 can all be drained by gravity to a site to the north of SH16. The catchment is shown on Drawings 20.1.11-3-D-D-300-110 and 20.1.11-3-D-D-300-111 (Appendix A) and includes the SH16 carriageway (existing and extra width) and parts of Ramp 1 and Ramp 4 on and off ramps between SH16 and SH20 which converge and diverge respectively with SH16 east of the GNR Interchange (in Sector 5).

The catchment excludes a small section of motorway within the Project extent at the eastern end of Sector 6, which drains west towards St Lukes Road.

Water quality treatment of runoff is required in this area, as well as water quantity treatment due to increased flows generated and the discharge to the stream. The treatment device for Sector 6 will discharge to the Meola Creek, downstream of the SH16 culvert. This location is at the downstream end of the Meola Creek catchment. Attenuating, and therefore delaying, the peak flows from the local motorway catchment will increase the peak flow in Meola Creek due to coincidence with peak flows from further up the catchment. For this reason attenuation of motorway runoff flows in this area is not proposed. However, Meola Creek has problems with bank erosion, and therefore extended detention of stormwater is proposed to protect the stream.

6.8.2 Options considered

The BPO approach was used to determine the most appropriate treatment devices for the Sector 6, refer to Section 6.2.1 for a discussion of devices. The requirement to provide storage for extended detention means that wetlands or wet ponds are the only viable options in Sector 6. A wetland is considered the BPO for TD6A given that there is space available in the vicinity to locate one.

The BPO for reticulation of runoff from Sector 6 was evaluated. Swales or catchpit and pipe systems were considered, with the latter being selected due to the narrower footprint required, which is necessary for viaduct and constrained areas such as under the Carrington Road overpass.

6.8.3 Best Practicable Options

Treatment Device 6A – Meola Wetland

The proposed TD6A is shown on Drawing 20.1.11-3-D-D-300-111 (Appendix A). The key operating levels and volumes are summarised in Table 6.17. The catchment area for TD6A is 4.74ha. The WQV is 1121m³. The permanent volume of water in the wetland will be 560m³ with the remaining volume for water quality treatment captured and released slowly as part of the extended detention volume. The pond outlet will combine with an existing stormwater pipe (to be rebuilt) and will outfall to the existing wingwall at the downstream end of the Meola Culvert replacing the existing stormwater outfall.

Table 6.17: TD6A -Meola Wetland Design Geometry

| Parameter | Elevation (mRL) | Area (m ²) | Volume (m ³) |
|---|-----------------|------------------------|--------------------------|
| Wetland Invert | 8.0 | 479 | - |
| Normal Water Level | 8.7 | 1328 | 564 |
| Extended Detention Level | 9.6 | 1807 | 1971 |
| Maximum water level during 100 year ARI event | 9.9 | 2035 | 2739 |

6.9 Sector 7 and 8 – Tunnel Drainage and Outflows

6.9.1 Description

Sector 7 refers to the ‘cut and cover’ section of the tunnel from the northern portal (Waterview Park), which crosses beneath Great North road to connect to the driven section of the tunnel referred to as Sector 8. The southern portal of the driven tunnel is located in Alan Wood Reserve. Both tunnel sections have similar drainage details and share the same collection point.

As the Sector 7 and 8 motorway alignment is below ground surface, no stormwater runoff is generated from the motorway carriageway. However, drainage within the tunnel is necessary for the small amount of groundwater infiltration into the tunnel (approximately 16 m³/day), rainwater carried into the tunnel by vehicles during rainfall events estimated at 8 l/s, flows generated by tunnel washdown procedures (small flow and volume), and deluge flows activated during emergencies, such as fires, of 222 l/s and 700m³ in volume.

The tunnel drainage collection system must be capable of capturing deluge flows over a 60m length, made up of three deluge zones (20m per deluge zone). The collection system includes grated channels, and pits that incorporate flames traps and hold down covers for explosive protection. The pits create a water seal to prevent fire from entering the drainage conveyance system and spreading to other parts of the tunnel. The tunnel collection system has been designed to capture up to 222 L/s within 60 m, during a deluge event.

Captured flows are conveyed to the tunnel low point through a piped network located under the centre of the lowest (with regard to road cross fall) traffic lane. The conveyance system has been designed to convey up to 232 L/s (allowing for groundwater infiltration and trafficked stormwater).

The flow is collected in a sump located at the low point. The water is then pumped to the northern portal and discharged to either the wetland (clean water), the trade sewer (mildly contaminated water), or tanker trucks for offsite treatment and disposal (heavily contaminated water).

6.9.2 Options Considered

Collection and Conveyance

There is limited space within the tunnel cavities below road level to incorporate an effective drainage system. The curve of the tunnel liners provides insufficient space below road level to locate the entire drainage system within the road shoulder. The space below the road pavement increases towards the centre of the tunnels. However, this requires elements of the drainage system, such as conveyance pipes and manholes, to be located with traffic lanes.

A number of options for providing collection within the road shoulder and incorporating the pits (flame traps) within the main conveyance system located with the traffic lane were considered. However, all of these options require manhole access every 20m (within each deluge zone) for maintenance purposes. Providing, a manhole and cover within a traffic lane every 20m was not considered desirable.

Alternative options of providing the collection system and flame traps within the road shoulder, and connecting them to a main conveyance system located within a traffic lane were also considered. A number of these options were not considered feasible as the flame trap was insufficient to prevent fire from entering the conveyance system or adjacent deluge zone.

A best practical option (BPO) that meets the tunnel drainage requirements and reduces the number of manholes within traffic lanes is outlined in Section 6.9.3.

Storage and Pumping

A number of tunnel low point sump and pumping options were considered. These were:

1. Small sump with a large pump discharging to the northern portal
2. Small sump with a large pump discharging vertically (directly above the tunnel low point)
3. Large sump with a small pump discharging to the northern portal
4. Large sump with a small pump discharging vertically.

To manage the discharge of tunnel water, storage is needed as all disposal options have volume constraints. The storage can be either provided above ground (necessary for Options 1 and 2) or below ground (Options 3 and 4).

Options 1 and 2, small sump/large pump, require reliable primary and backup power sources for the pumps. With minimal storage provided, the risk of tunnel flooding due to pump failure is significantly increased.

Options 2 and 4 are reliant on the central smoke extraction system being located at the sump, as the pump rising main would share part of the vertical chamber. Even if this option is chosen for the tunnels then the central smoke extraction system will also occupy most of the flat area of the site above the tunnels. Therefore,

locating the treatment device and storage (Option 2) will require addition land purchase. Removal of highly contaminated water by tanker truck would cause significant vehicle movements (albeit on rare occasions) on a residential street.

Option 3 is considered the BPO as it provides the best engineering solution, particularly in terms of reliability, and least impact on the community.

Disposal

There are a number of disposal options to consider:

- 1) Stormwater treatment device and disposal to Oakley Creek at the northern portal wetland. This would be suitable for normal levels of stormwater contamination from groundwater infiltration and trafficked stormwater.
- 2) Tanker trucks contaminated for disposal off-site to contaminated liquid facility. This would be suitable for tunnel washdown or deluge flows during fires.
- 3) The other disposal option is to discharge to sewer as trade waste. This discharge would need to get Watercare approval and meet their standards. To date, Watercare have been unwilling to accept water from the tunnel, but there are considerable advantages such as reducing tanker truck movements, treatment and cost, that warrant further discussion with Watercare at the detailed design stage.

6.9.3 Best Practicable Options

Collection and Conveyance

The tunnel drainage BPO is detailed in drawings 20.1.11-1-D-D-310-301 to 302. The BPO is considered to be:

- A continuous grated channel with pits located every 20m, located within the road shoulder.
- The pits include a flame trap to prevent fire from entering the conveyance system and spreading to other parts of the tunnel. To incorporate the flame trap 1.2m deep pits are required. Therefore, the pits will extend into the tunnel liner.
- The pits connect to a central conveyance system, which consists of a continuous piped network, located with the centre of the traffic lane adjacent to the downstream road shoulder.
- To reduce manhole connections within traffic lanes the pit connections will be saddled into the main conveyance pipeline. Manholes will be located every 100m along the piped network to allow for access and maintenance of the pipeline.
- The manhole covers are located within the centre of a traffic lane. Therefore, square "Wunder Covers" are proposed, which include a recessed cover that can be infilled with pavement asphalt to reduce their visibility.

Storage, Pumping and Disposal

It is considered that the BPO is to provide a large sump at the tunnel low point and pump the flows to the northern portal. Providing greater sump storage within the tunnel means that there is not absolute dependence on the pump, and electrical systems and power supplies (including backups); i.e. pump failure will not result in tunnel flooding.

With a large sump there is more time to assess the most appropriate disposal option for the deluge event water volume. Depending on the level of water contamination, the flows can be discharged to either the northern portal wetland (normal levels of stormwater pollutants in water), or tanker trucks for offsite treatment and disposal (highly contaminated water). The minimum deluge flow volume to be stored with the tunnel sump is 700m³. However, an additional 100m³ storage is considered necessary to allow low flows to be stored and pumped to the wetland at regular intervals, while ensuring 700m³ is always available for deluge events.

The operation and maintenance of the tunnel drainage systems is described in the Operational Stormwater Management Plan (Appendix D). This will need to develop in detail with the design and construction of the tunnel to reflect the final system and its requirements.

The sump should have oil and grit separators to remove these pollutants from water to be pumped. Maintenance provisions for the oil and grit separators, wet well and pumps need to be allowed for in the design.

6.10 Sector 9 - Stormwater

6.10.1 Description

The new SH20 motorway follows a surface alignment through Sector 9, which will create new impervious areas, increasing runoff volumes and flow rates. Stormwater runoff from the proposed motorway and the Christ the King site (due to prior agreement) will be treated for both water quality and quantity by providing contaminant removal and attenuation, before discharge to the Oakley Creek. Stormwater attenuation provided will include extended detention to protect the stream, and peak flow attenuation for events up to the 100 year ARI event, to mitigate any potential flood effects.

The peak runoff from the motorway in the 2, 10 and 100 year ARI storms has been limited to the corresponding pre-development catchment peak runoff.

Sector 9 has been broken into two catchments for treatment devices, based mainly on elevation and reticulation restrictions as shown on Drawings 20.1.11-3-D-D-300-117, 118 and 119 (Appendix A). The catchment for TD9A consists of the motorway impervious surface from the southern tunnel portal to just north of the proposed Oakley Creek Bridge. Approximately half of this catchment is below the surrounding ground level in the motorway trench as it approaches the tunnel portal, and runoff from this area will be pumped to the treatment device location.

The catchment for TD9B consists of the SH20 carriageway from just north of the proposed Oakley Creek Bridge to the Maioro Interchange, the Christ the King site (as per the agreement between Transit and the Roman

Catholic Bishop of the Diocese of Auckland dated 9 February 2007), and the Maioro Interchange overbridge and on and off ramps. The catchment boundary was defined by how much of the carriageway can drain by gravity to a wetland in the Hendon park vicinity. The Maioro Interchange overbridge and south facing ramps will be constructed as part of the SH20 Maioro Interchange Project. Initially these areas will be serviced by a temporary stormwater pond until the sections of SH20 north of the Maioro Interchange overbridge are constructed as part of the Project. The details of the Maioro temporary stormwater treatment devices are provided in the consent documentation for that SH20 Maioro Interchange project.

Within Sector 9 the motorway alignment will necessitate the replacement of one existing stormwater pipe and the diversion of overland flow which currently drains from the vicinity of Hendon Ave, across the proposed motorway alignment into Oakley Creek. Systems to manage overland flow intercepted by the motorway have been designed for the difference between the 100 year ARI events and the 10 year ARI event, which is assumed to be intercepted by the ACC stormwater systems.

6.10.2 Options Considered

Stormwater Treatment

Devices for treatment of runoff from Sector 9 are required to provide quality treatment, as well as extended detention and attenuation. Therefore the only viable options are wetlands and wet ponds, as other treatment devices do not provide attenuation. Constructed wetlands are considered to be the BPO for the two catchments in Sector 9 as they provide superior water quality treatment to wet ponds (for more detail refer to section 6.2.1).

Swales or catchpit and pipe systems were considered for the reticulation of runoff in Sector 9. The latter was selected due to the narrower footprint required, and therefore greater area of open space preserved. The narrower motorway footprint allows more space for the Oakley Creek realignments and flood and noise bunds.

Locations considered for TD9A included the area just west of the southern portal (which will be used for construction yard 9) and the area enclosed by the creek and the motorway alignment just downstream of Stream Realignment 1. The second location was selected due to the shorter length of gravity pipeline required to drain runoff to this location (most of the catchment downstream of this point would need to be pumped to either location), the advantages of leaving the first site for a construction yard, and the fact most of the selected site is outside the 100 year ARI Oakley Creek floodplain.

Three possible locations were considered for TD9B (refer to Figure 6.1);

- ACC park area, Hendon Park
- NZTA owned land, north of Oakley Creek
- Privately owned (Goldstar) land, south of the motorway.



Figure 6.1 Locations considered for TD9B

The best practicable location for TD9B is the privately owned (Goldstar) land, south of the motorway. This site is the best technical location for the wetland because it is adjacent to the low side motorway, which has a superelevation (the cross fall of the motorway surface at a corner) that slopes towards the south at this location. In addition, this location is mostly outside of the 100 year ARI flood plain and avoids conflict with existing sewer mains. There are also benefits from the development of sports fields on the site and ecological benefits due to the retention of the Oakley Creek alignment. The concept design for TD9B Valonia Wetland has been developed at this location (Refer to Drawing 20.1.11-3-D-D-118).

Cross Drainage

Options for discharging flow from the stormwater pipe that crosses the alignment in Sector 9 are limited. The flow can either be piped following the alignment of the existing pipe to the stream (at a lower elevation than the profile of the motorway or the flow can be piped under the SH20 motorway to join the discharge from the proposed Treatment Device 9B – Valonia Wetland, where it discharges to the stream. The latter option is the BPO to avoid the installation of two separate pipes and two separate outfalls to the stream in this vicinity.

Options that were considered for diverting the overland flow from the Hendon Avenue area to the Oakley Creek considered included a rock lined channels, swales or pipes. Swales were selected as the BPO.

6.10.3 Best Practical Options

Treatment Device 9A- Alan Wood Wetland

The proposed TD9A is shown on Drawings 20.1.11-1-D-D-300-117 & 349-201 (Appendix A). The key operating levels and volumes are summarised in Table 6.18. The WQV for catchment 9A is 676m³. The permanent volume of water in the wetland will be 441m³ with the remaining volume for water quality treatment captured and released slowly as part of the extended detention volume. The flood attenuation performance is summarised in Table 6.19, which demonstrates that peak flows are attenuated to predevelopment levels for the 2 year, 10 year and 100 year ARI events.

Table 6.18: Wetland Design Geometry for TD9A – Alan Wood Wetland

| Parameter | Elevation (mRL) | Area (m ²) | Volume (m ³) |
|---|-----------------|------------------------|--------------------------|
| Wetland Invert | 37.3 | 276 | - |
| Normal Water Level | 38.1 | 1007 | 441 |
| Extended Detention Level | 38.8 | 1495 | 1313 |
| Maximum water level during 100 year ARI event | 39.8 | 2218 | 3192 |

Table 6.19: Treatment Device 9A – Peak flows for Alan Wood Wetland

| Parameter | 2 year ARI | 10 year ARI | 100 year ARI |
|---|------------|-------------|--------------|
| Pre-development catchment peak inflow (m ³ /s) | 0.06 | 0.14 | 0.27 |
| Post development catchment peak inflow (m ³ /s) | 0.38 | 0.65 | 0.99 |
| Post development wetland peak outflow (m ³ /s) | 0.04 | 0.13 | 0.27 |
| Attenuated peak flow as percentage of pre-development peak flow* ¹ | 67 % | 93 % | 100 % |

*¹ Attenuated peak flow as a percentage of pre-development peak may vary as dependent on detailed design. Design criteria are for the post development peak outflow to be less than the pre-development peak flow.

Treatment Device 9B- Valonia Wetland

The proposed TD9B is shown on Drawings 20.1.11-3-D-D-300-118 & 349-211 (Appendix A). The key operating levels and volumes are summarised in Table 6.20. The catchment area for TD9B is 11.59ha. The WQV is 1935m³. The permanent volume of water in the wetland will be 1984m³ with the remaining volume for water quality treatment captured and released slowly as part of the extended detention volume. The flood attenuation performance is summarised in Table 6.21, which demonstrates that peak flows are attenuated to predevelopment levels for the 2 year, 10 year and 100 year ARI events.

Table 6.20: Wetland Design Geometry for TD9B – Valonia Wetland

| Parameter | Elevation (mRL) | Area (m ²) | Volume (m ³) |
|---|-----------------|------------------------|--------------------------|
| Wetland Invert | 41.0 | 2727 | - |
| Normal Water Level | 41.5 | 4931 | 1984 |
| Extended Detention Level | 42.0 | 5672 | 4634 |
| Maximum water level during 100 year ARI event | 43.0 | 7185 | 10850 |

Table 6.21: Treatment Device 9B – Peak flows for Valonia Wetland

| Parameter | 2 year ARI | 10 year ARI | 100 year ARI |
|---|------------|-------------|--------------|
| Pre-development catchment peak inflow (m ³ /s) | 0.43 | 1.02 | 1.84 |
| Post development catchment peak inflow (m ³ /s) | 1.08 | 2.04 | 3.27 |
| Post development wetland peak outflow (m ³ /s) | 0.20 | 0.67 | 1.34 |
| Attenuated peak flow as percentage of pre-development peak flow* ¹ | 47 % | 66% | 73 % |

*¹ Attenuated peak flow as a percentage of pre-development peak may vary as dependent on detailed design. The design criterion is for the post development peak outflow to be less than the pre-development peak flow.

The outfalls from TD9A and TD9B have been designed to discharge the 100 year ARI peak outflows from the wetlands, of 0.29 and 1.34m³/s (also has local stormwater and swale flows), respectively. Energy dissipation is achieved by baffled outfalls. The outfalls have been aligned with the direction of flow similar to the stream alignment. A short channel lined with rock protection will be provided between the outfalls and the stream. The proposed details for these outfalls are shown on Drawings 20.1.11-D-D-320-294 & 304 (Appendix A).

Cross Drainage

The proposed alignment of SH20 in Sector 9 will interact with the primary stormwater network in two places, and with overland flow paths from the Hendon Avenue area to Oakley Creek. Two new stormwater pipes and three stormwater conveyance swales are proposed as part of the Project works to discharge existing stormwater flows to the stream. The proposed cross drainage infrastructure is shown on Drawings 20.1.11-D-D-300-117 & 118 and an outlet long section for the Hendon Avenue swale is detailed in Drawings 20.1.11-D-D-349-216 (Appendix A).

The key design parameters of the proposed network components are shown in Table 6.22 and Table 6.23 below.

Table 6.22: Sector 9 Primary Cross drainage component key geometry

| Component | Design Flow (m ³ /s) | Average Longitudinal Slope (%) | Length (m) | Dimensions (m) |
|--|---------------------------------|--------------------------------|------------|---------------------|
| Hendon Avenue Swale Outlet SH20 Ch 1800 | 3.12 | 0.5 | 88 | 1.5*1.5 Box culvert |
| Hendon Avenue Swale Outlet SH20 Ch 1300 | 0.80 | 3.5 | 70 | 0.625 Diameter |

Table 6.23: Sector 9 Overland flow swales component key geometry

| Component | Design Flow (m ³ /s) | Average Longitudinal Slope (%) | Length (m) | Side slopes | Base width (m) | Design flow depth (m) |
|--|---------------------------------|--------------------------------|------------|-------------|----------------|-----------------------|
| Swale A (eastern end drainage corridor, discharges SH20 Ch 1300) | 2.8 | 0.5 | 110 | 1:1 | 1.5 | 0.8 |
| Swale B (middle of drainage corridor, discharges SH20 Ch 1300) | 0.28 | 0.5 | 240 | 1:1 | 1.5 | 0.8 |
| Swale C (western end drainage corridor, discharges SH20 Ch 1800) | 0.80 | 0.5 | 320 | 1:1 | 1.0 | 0.5 |

6.11 Summary Assessment of Effects of Stormwater Discharge Operational Phase

An assessment of the effects of the stormwater aspects of the Project during operation of the motorway has been carried out. This section provides a summary of the stormwater quality and quantity treatment outcomes of the proposed stormwater system design to meet assessment criteria set out in relevant planning documents (summarised in Table 4.1). A discussion of the BPO selection process and influence of relevant planning objectives and policies on the proposed design is outlined in Section 6.2.

In addition to the assessment provided in the this section, the effects of stormwater and in particular residual contaminants (after treatment) and change in stormwater flows, are assessed in the following reports:

- Waterview Connection Project: Technical Report No G.6 *Assessment of Freshwater Ecological Effects*
- Waterview Connection Project: *Technical Report No G.11 Assessment of Marine Ecological Effects*
- Waterview Connection Project: *Technical Report No G.4 Assessment of Coastal Processes*

6.11.1 Water Quality Treatment

The stormwater generated from the areas of motorway during the operational phase of the Project contains pollutants from vehicles such as heavy metals, suspended solids, and hydrocarbons.

The criterion that water quality treatment design is measured against is the requirement to remove at least 75% of TSS loads on an average annual basis. This is the level of treatment required by the Proposed Auckland Regional Plan: Air, Land and Water and Proposed Auckland Regional Plan: Coastal to minimise the potential effects of stormwater discharge on the environment. Design guidance for devices that achieve this standard is contained within TP10. Subsequent planning documents for the Auckland region adopt this guideline in relation to stormwater. Section 105 of the RMA requires that regard is given to the nature of the discharge and the sensitivity of the receiving environment to adverse effects.

The Project proposes stormwater treatment devices to remove 75% TSS and associated pollutants in Sectors 6 and 9. Stormwater treatment devices providing a higher removal efficiency of 80% TSS and associated pollutants are proposed for Sectors 1-5 that discharge to the CMA, as offset mitigation for the reclamation required for the Project. The higher treatment efficiency for discharges to the CMA also reflects the values of these areas especially the CPA1 area forming the Motu Manawa (Pollen Island) Marine Reserve – refer to Technical Report No G11 *Assessment of Marine Ecological Effects*. The devices and the treatment efficiencies are summarised in Table 6.1.

Table 6.24 summarises the existing and additional impervious areas within the Project for each of the Sectors, and summarises the areas for receiving stormwater treatment. The minimum area of treatment is the additional impervious areas, and maintaining treatment for those areas for which treatment is currently provided. Stormwater quality treatment of existing impervious areas, for which treatment is not currently provided, or for which a higher efficiency than the standard is achieved, helps to mitigate the potential adverse effects of the Project on the environment. Where there are areas of pervious surface, the runoff from which cannot practically be separated from that from the impervious motorway, these areas have been added to the new stormwater systems and the treatment devices proposed are sized accordingly.

Across the Project there are 23.31ha of additional impervious area proposed for the operational phase of the Project, of which it is proposed to provide treatment for 23.18ha or 99.4%. There are 3.30ha of existing motorway for which treatment to TP10 standards was consented, and it is proposed to maintain or provide treatment to TP10 standards for 100% of these areas. In addition there are 30.22ha of existing motorway impervious surface for which stormwater treatment is not currently provided. It is proposed to provide stormwater quality treatment during the operational phase of the Project for 27.10ha of this area or 89.6%. In addition runoff from 19.26ha of pervious groundcover areas will be collected and conveyed through the Project stormwater devices, which have been designed to account for these flows. In summary, the Project will treat 90.7% of impervious areas, 99.4% of additional impervious and 94.3% of both existing and additional

impervious areas. All treatment devices for runoff from Sectors 1 to 5 are designed to achieve 80% TSS removal, as mitigation for reclamation within the CMA required for the Project.

Table 6.24: Summary of Areas with Water Quality Treatment for Operation Phase

| Sector | Existing Impervious | | | Additional Impervious | | Total | |
|----------------------|---------------------|------------------------------|-------------------------------|-----------------------|-------------------------------|--------------|-------------------------------|
| | Area (ha) | Percentage currently treated | Percentage proposed treatment | Area | Percentage proposed treatment | Area | Percentage proposed treatment |
| Sector 1 | 8.05 | 1.7 % | 100 % | 3.67 | 100 % | 11.72 | 100 % |
| Sector 2 | 1.45 | 0 % | 100 % | 0.72 | 100 % | 2.17 | 100 % |
| Sector 3 | 3.88 | 0 % | 100 % | 1.47 | 100 % | 5.35 | 100 % |
| Sector 4 | 8.37 | 13.7 % | 96.9 % | 3.40 | 96.2 % | 11.77 | 96.7 % |
| Sector 5 | 6.62 | 30.3 % | 84.8 % | 3.43 | 100 % | 10.05 | 90.0 % |
| Sector 6 | 4.08 | 0 % | 68.7 % | 1.06 | 100% | 5.14 | 75.2 % |
| Sector 7 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Sector 8 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Sector 9 | 1.04 | 0 % | 100 % | 8.49 | 100 % | 9.53 | 100 % |
| Total Project | 33.49 | 9.87 % | 92.41 % | 22.25 | 99.42 % | 55.74 | 95.21 % |

An assessment of the sediments and contaminant loads was undertaken by NIWA (2010) in Technical supporting report G.30 Associated Sediment and Contaminated Loads. The purpose of this investigation was to understand the existing sediment and contaminant loads to receiving environments within the Project area and the changes to these loads from the Project. The calculations used the contaminant load models developed for the ARC and used future daily traffic loads, assumed treatment areas (slightly less than achieved in Table 6.24) and 75% removal rates for sediment and contaminant (again less than achieved by the Project).

At present, the existing SH16 motorway area within the Project is estimated to generate 29 tonnes of sediment, 379kg of zinc and 56kg of copper annually. In future years (2016 and 2026), without the Project

being built, these numbers are a little higher due expected increases in traffic volumes. Alternatively, with the Project being built, the estimated future annual loads generated by the SH16 motorway area are substantially lower (between 20 and 40% lower each year). This is because of the proposed improvements to stormwater treatment for SH16 with the Project, where very little treatment currently exists (NIWA, 2010).

During long-term operation of the Project, it is estimated that in 2016 the annual loads delivered to the Waterview Estuary from the Project motorway area will be 18 tonnes of sediment, 314kg of zinc and 39kg of copper. The annual loads delivered to the Waterview Estuary from the catchment area (inclusive of Project) are expected to be 455 tonnes of sediment, 944kg of zinc and 124g of copper. These values are less than the existing baseline annual loads from the catchment area (2% less for sediment, 8% less for zinc, and 10% less for copper), which is due to the proposed improvement to stormwater treatment for SH16 with the Project built. For 2026, the estimated annual sediment and contaminant loads delivered to the Waterview Inlet from the representative catchment areas are a slight increase on those for 2016 but still remain less than the existing baseline loads (NIWA, 2010).

The criteria for stormwater quality treatment have been met by the proposed treatment devices that comply with the regional plans and TP10 guidance document. The effects of residual contaminants and changes in stormwater flows are considered further in the following technical assessment reports:

- G.4 - Assessment of Coastal Processes (Tonkin & Taylor, NIWA, 2010)
- G.6 - Assessment of Freshwater Ecological Effects (Boffa Miskell, 2010)
- G.11 - Assessment of Marine Ecological Effects (Boffa Miskell, 2010).

6.11.2 Erosion Control

The criterion for assessing erosion control at outfalls across the Project is the requirement for all outfall discharges that are likely to cause scour at the outfall to incorporate erosion control measures.

Energy dissipation and erosion control measures are proposed at all treatment device outfalls for the operational phase of the Project. A summary of the treatment devices and proposed erosion control measures is shown in Table 6.25 below. For a discussion of the merits of each measure and a BPO discussion refer to Section 6.2.

Through provision for erosion control measures at all treatment device outfalls, the potential adverse effects on the surrounding environment from erosion or scour at discharge points during the operational phase of the Project will be avoided.

Table 6.25: Summary of Stormwater Outfalls for Operation Phase and Erosion Control Measures

| Source | 100 yr ARI peak discharge (m ³ /s) | Receiving Environment | Proposed Erosion Control Solution |
|--|---|---|---|
| TD1A – Jack Colvin Wetland | 2.78 | Pixie Stream tidal arm of Henderson Creek | Wing wall with rip rap rock apron (Average Longitudinal Diameter (ALD) 200mm x 6m long) |
| TD1B – Te Atatu Eastbound on-ramp swale | 1.04 | North of western abutment of bridge into Whau River | Swale as Rock lined channel (ALD 200mm x 30m long); under drain as Ø750mm Flume with wing wall and rip rap rock apron (ALD 250mm x 8m long) |
| TD1C – Te Atatu Westbound off-ramp swale | 1.06 | South of western abutment of bridge into Whau River | Swale as Rock lined channel (ALD 200mm x 40m long); under drain as Ø750mm Flume with wing wall and rip rap rock apron (ALD 250mm x 8m long) |
| TD2A – Whau Bridges eastbound cartridge filter vault | 0.27 | North of eastern abutment of bridge into Whau River | Ø450mm outlet pipe with wing wall and rip rap rock (ALD 100mm x 2m long) |
| TD2B – Whau Bridges westbound cartridge filter vault | 0.27 | South of eastern abutment of bridge into Whau River | Ø450mm outlet pipe with wing wall and rip rap rock (ALD 100mm x 2m long) |
| TD2C – Whau eastbound bio-filter strips | 0.22 (as sheet flow distributed over 300m; 0.0007m ³ /s/m) | North of eastern approach to Whau River bridge into CMA | Diffuse flow through/across bio-filter strip and rock revetment |
| TD2D – Whau westbound bio-filter strips | 0.30 (as sheet flow distributed over 300m; 0.0010m ³ /s/m) | South of eastern approach to Whau River bridge into Estuary | Diffuse flow through/across bio-filter strip and rock revetment |
| TD3A – Rosebank Domain cartridge filter | 0.15 | West of Rosebank Domain into Waterview | Ø450mm outlet pipe with flap valve, wing wall and rock revetment apron (ALD |

| | | | |
|---|--|--|--|
| vault | | Estuary | 100mm x 2m long) |
| TD3B – Patiki Off-ramp cartridge filter vault | 0.32 | North of Rosebank Domain into the CMA | Ø600mm outlet pipe with flap valve, wing wall and rock revetment apron (ALD 100mm x 3m long) |
| TD3C – Go Kart Track cartridge filter vault | 0.18 | East of Rosebank Domain into Waterview Estuary | Ø450mm outlet pipe with flap valve, wing wall and rock revetment apron (ALD 100mm x 2m long) |
| TD3D – Rosebank cartridge filter vault | 0.76 | West of Rosebank Peninsula into Waterview Estuary | Ø750mm outlet pipe with flap valve, wing wall and rock revetment apron (ALD 150mm x 3m long) |
| TD3E – Rosebank Off-ramp cartridge filter vault | 0.96 | East of Rosebank Peninsula into Waterview Estuary | Ø825mm outlet pipe with flap valve, wing wall and rock revetment apron (ALD 150mm x 4m long) |
| TD4A – Whau End EB cartridge filter vault | 0.22 | North of Rosebank Domain into the CMA | Ø525mm outlet pipe with flap valve, wing wall and rock revetment apron (ALD 100mm x 2m long) |
| TD4B – Patiki Flyover EB cartridge filter vault | 0.26 | North of Rosebank Peninsula into the CMA | Ø525mm outlet pipe with wing wall and rip rap rock apron (ALD 100mm x 2m long) |
| TD4C – Patiki Eastbound Bio-Filter Strip | 0.21 (as sheet flow distributed over 190m; 0.0011 m ³ /s/m) | North of motorway at Patiki Road off-ramp into CMA | Diffuse flow through/across bio-filter strip and rock revetment |
| TD4D – Tidal Creek EB cartridge filter vault | 0.40 | North of Rosebank Peninsula into the tidal creek and CMA | Ø600mm outlet pipe with flap valve, wing wall and rock revetment apron (ALD 100mm x 3m long) |
| TD4E – Pollen Island EB cartridge filter vault | 0.29 | North of Rosebank Peninsula into the tidal creek north of Pollen | Ø525mm outlet pipe with flap valve, wing wall and rock revetment apron (ALD |

| | | | |
|---|---|--|--|
| | | Island into CMA | 100mm x 2m long) |
| TD4I – RB Bridge to Traherne Eastbound Bio-Filter Strip | 0.64 (as sheet flow distributed over 1470m; 0.0004m ³ /s/m) | North of motorway from Causeway Bridge to west of Traherne Island into CMA | Diffuse flow through/across bio-filter strip and rock revetment |
| TD4J – RB Bridge to Traherne Westbound Bio-Filter Strip | 0.62 (as sheet flow distributed over 1120m; 0.0006m ³ /s/m) | South of motorway from Causeway Bridge to east of Traherne Island into Waterview Estuary | Diffuse flow through/across bio-filter strip and rock revetment |
| TD4L – GNR to RB Bridge Eastbound Bio-Filter Strip | 0.28 (as sheet flow distributed over 300m; 0.0009m ³ /s/m) | North of motorway from GNR Interchange to Causeway Bridge into Waitemata Harbour | Diffuse flow through/across bio-filter strip and rock revetment |
| TD4M – GNR to RB Bridge Westbound Bio-Filter Strip | 0.28 (as sheet flow distributed over 300m; 0.0009m ³ /s/m) | South of motorway from GNR Interchange to Causeway Bridge into Waterview Estuary | Diffuse flow through/across bio-filter strip and rock revetment |
| TD5A – Causeway East End Eastbound Bio-filter Strip | 0.17 (as sheet flow distributed over 260m; 0.0007m ³ /s/m) | East end of causeway into Waitemata Harbour | Diffuse flow through/across bio-filter strip and rock revetment |
| TD5B – Causeway East End Westbound Bio-filter Strip | 0.35 (as sheet flow distributed over 300m; 0.0012m ³ /s/m) | East end of causeway into Waterview Estuary | Diffuse flow through/across bio-filter strip and rock revetment |
| TD5C - SH16 to SH20 Southbound Cartridge Filter Vault | 0.18 | Waitemata Harbour | Ø450mm (assumed slope of 1 %) outlet pipe into existing Ø750mm culvert |
| TD5D - SH20 to SH16 Westbound Cartridge Filter Vault | 0.74 | Oakley Inlet | Ø600mm outlet pipe with wing wall and rip rap rock apron (ALD 250mm x 3.0m long) |
| TD5E - SH16 Waterview Interchange Swale | 0.21 | Waitemata Harbour | No outfall protection required to existing culvert |

| | | | |
|---|------|---|---|
| | | | (flows unchanged) |
| TD5F - Northern Portal Wetland | 0.65 | Oakley Creek | Ø600mm outlet pipe into USBR Type VI impact basin |
| TD5G - SH16 On-ramp Eastbound TDM Wetland | 1.48 | Existing culvert/channel leading to Waitemata Harbour | Ø825mm (assumed slope of 1 %) outlet pipe into existing Ø1050mm culvert |
| TD5H - SH16 Carrington Cartridge Filter Vault | 1.37 | Existing stormwater system to Oakley Inlet | Ø825mm (assumed slope of 1 %) outlet pipe into existing stormwater system (flows unchanged) |
| TD6A -Meola Wetland | 3.07 | Meola Creek | Ø1350mm outlet pipe into existing wing wall/ headwall |
| Hendon Avenue Swale (Ch 1890m) | 0.92 | Oakley Creek | Ø600mm outlet pipe with wing wall and rip rap rock apron (ALD 350mm x 3.6m long) |
| TD9A - Alan Wood Wetland | 0.29 | Oakley Creek | Ø450mm outlet pipe with wingwall and rip rap rock apron (ALD 100mm x 1.8m long) |
| Hendon Avenue Swale (Ch 1320m) | 1.06 | Oakley Creek | Ø1050mm outlet pipe with wing wall and rip rap rock apron (ALD 100mm x 4200m long) |
| TD9B Valonia Wetland | 1.34 | Oakley Creek | Ø600mm outlet pipe with wing wall and rip rap rock apron (ALD 500mm x 4200m long) |

6.11.3 Water Quantity Treatment

The conversion of pervious to impervious land uses within a catchment increases volumes of runoff and peak flow rates during rainfall events. Water quantity treatment is necessary to avoid and minimise the potential effects on the environment from the changes. The potential effects include increased flooding, and

downstream channel erosion where stormwater runoff is discharged to stream environments. These potential effects are not of concern in the CMA where flooding and erosion from freshwater flows are not issues.

The criteria for assessing the water quality treatment proposed for the operational phase of the Project are outlined in the ARC PARP:ALW;

“Discharges to land; the method of stormwater disposal shall minimise changes to the pre-development hydrological regime.

In particular:

- i) the peak flows for the 2 year and 10 year ARI post-development events shall not be greater than the corresponding peak flows for pre-development events; and*
- ii) the volume of stormwater runoff for post-development events shall be minimised; and*
- iii) the time of concentration for post-development events shall be maximised so that it is as close as practicable to those for pre-development events;*

Does not cause downstream channel erosion.”

Attenuation of peak flows has been provided within treatment devices which discharge to Oakley Creek during the operational phase of the Project. Attenuation within the wetlands is proposed by providing storage, and detailing outlet configurations. The proposed treatment devices would limit the 2 year, 10 year and 100 year ARI post-development events to the corresponding peak flows for pre-development events. This outcome reduces peak flows to meet the requirement of clause (i) of the assessment criteria.

An assessment of the potential benefit of providing attenuation of post development peak flows to discharge to Meola Creek was undertaken. It was found that attenuating and therefore delaying the peak flows from the local motorway catchment would slightly increase the peak flow in Meola Creek due to coincidence with peak flows from further up the catchment, due to the discharge point being within the lower reaches of the stream. Therefore not providing attenuation within the Meola wetland avoids increasing the peak flows in Meola Creek.

Attenuation of peak flows by detention in a storage device lengthens the time of concentration for the post development catchment, so that it is close to that of the predevelopment catchment, meeting clause (iii) of the assessment criteria.

The volume of stormwater runoff for post-development events has been minimised as far as possible by limiting impervious catchment sizes for the Project. The adoption of a tunnel for much of the alignment minimises the impervious area of surface motorway. Infiltration to ground was considered as an option for stormwater quantity treatment, however this is not considered practicable for the flow rates generated by the subcatchments. In this way clause (ii) of the assessment criteria has been met.

The criterion applied to minimise erosion of the downstream stream channel where discharges are to a stream environment is set by the TP10 and is the controlled release of the runoff generated in a rainfall event of

34.5mm, over a 24 hour period. This is known as ‘extended detention’. Extended detention has been provided for all stormwater discharges to stream environments within the Project, minimising the potential for erosion of the downstream channel in these environments.

The criteria for stormwater quantity treatment have been met by the proposed treatment devices. A summary of the water quantity criteria achieved by each of the proposed stormwater treatment devices is provided in Table 6.1 in Section 6.1.

6.11.4 Overland Flow

The criterion to assess the effects of overland flow is defined in the ARC PARP:ALW;

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

Where the primary drainage network is affected by the Project works, the proposed infrastructure to maintain service will convey flows up to the 10 year ARI peak flow through the primary drainage network during the operational phase of the Project. Allowance has been made for MPD catchment assumptions and climate change effects in the design of this infrastructure (refer to Section 3.3 for details), to ensure the design is able to meet the criteria throughout the design life.

Where the secondary drainage network (overland flow paths) is affected by the Project works, the proposed alternative flow paths to maintain service will convey flows up to the 100 year ARI peak flow. Allowance has been made for MPD catchment assumptions and climate change effects in the design of these flow paths (refer to Section 3.3 for details), to ensure the design is able to meet the criteria throughout the design life.

In this way the criterion to avoid potential effects on the environment from overland flow is met.

6.11.5 Aesthetics and Odour

The criterion to assess the effects of aesthetics and odour is defined in the RMA Section 107 as follows;

*“...a consent authority shall not grant a discharge permit...
...if after reasonable mixing, the contaminant or water discharged (either by itself or in combination with the same, similar, or other contaminants or water), is likely to give rise to all or any of the following effects in the receiving waters:*

- c. The production of any conspicuous oil or grease films, scums or foams, or floatable or suspended materials:*
- d. Any conspicuous change in the colour or visual clarity:*
- e. Any emission of objectionable odour:”*

The stormwater generated from the areas of motorway during the operational phase of the Project will be treated to remove 75% or 80% of TSS and associated pollutants, as detailed in Table 6.1. With treatment and

after mixing no conspicuous change to the receiving waters is expected. Similarly, no emission of objectionable odour is expected. The AMA report no complaints or problems with odour from stormwater treatment devices on the Auckland Motorway network (pers. comms. Peter Mitchell, AMA). Therefore, there are no adverse environmental effects expected due to aesthetic changes or odour from stormwater discharges.

7. Effects Assessment: Construction Activities

7.1 Summary

An assessment of the effects of the stormwater aspects of the Project during the construction phase has been carried out. This includes the BPO selection of solutions, as required by the RMA and ARC PARP:ALW, and an assessment of the cumulative effects of stormwater discharge from the Project on the environment during the construction phase. The following subsections outline the design process, the proposed solutions, and the assessment of effects.

The proposed BPO solutions are intended to demonstrate that feasible solutions exist to meet stormwater treatment objectives. However the criteria for assessment are performance based and it is intended that there is flexibility for Contractors to provide innovative or alternative designs to meet or better the criteria, or account for Project design changes or alternative construction methodologies.

Stormwater management during the construction phase is a separate and unique stage in the water management of the motorway. It occurs after earthworks activities have been stabilised in an area and erosion and sediment discharge controls are no longer appropriate, but before operational stormwater controls are in place. Erosion and sediment control devices are discussed in the Technical Report No G.22 *Erosion and Sediment Control Plan*.

The philosophy for stormwater management during the construction phases is as follows:

- 1) Maintain compliance with existing stormwater divert and discharge consents, specifically those requiring stormwater treatment for sections of SH16 and the GNR Interchange.
- 2) Provide stormwater quality treatment for impervious areas where there are potential water quality effects such as from construction yards. The construction yards and the expected activities are summarised in Table 7.2.
- 3) Provide stormwater quantity treatment such as attenuation where there are potential flood or stream erosion effects, such the surface section of SH20 motorway in the Oakley catchment.
- 4) Provide stormwater conveyance and overland flow paths to protect worksites and neighbouring properties from stormwater flooding.

Stormwater treatment, where it is practicable, is proposed to achieve 75% TSS removal. Attenuation is proposed for those areas discharging to Oakley Creek where flood and erosion risks exist.

Table 7.1 below gives a summary of the proposed treatment devices for the construction phase of the Project, and the treatment functions provided by each.

Table 7.1: Summary of Stormwater Treatment Devices for Construction phase

| Sector | Treatment Device | Catchment Area (ha) | Water Quality Treatment Provided | Extended Detention Provided | Flood Attenuation Provided | Erosion Protection Provided | Discharge location |
|--------|--|---------------------|----------------------------------|-----------------------------|----------------------------|-----------------------------|---|
| 1 | CD1A : Yard 1 (Orangahina Park) Wet pond | 4.20 | ✓ | N/R | N/R | ✓ | To swale along Te Atatu eastbound on-ramp to Whau River |
| 3 | CD3A : Patiki Rd off ramp cartridge filter | 0.23 | ✓ | N/R | N/R | ✓ | At Patiki Road off-ramp bridge into CMA |
| 3 | CD3B : Rosebank Rd off ramp cartridge filter | 0.08 | ✓ | N/R | N/R | ✓ | At Rosebank Road off-ramp bridge into Waterview Estuary |
| 3 | CD3C : Rosebank Rd on-ramp cartridge filter | 0.22 | ✓ | N/R | N/R | ✓ | At Rosebank Road on-ramp bridge into CMA west of Traherne Island |
| 3 | CD3D : Yard 2 (Patiki) Wet pond | 0.37 | ✓ | N/R | N/R | ✓ | At Patiki Road on-ramp into estuary between Rosebank peninsula and domain |
| 4 | CD4A : Eastbound outer sand filter trench | 4.24 | ✓ | N/R | N/R | ✓ | At 60m centres into CMA along causeway rock revetment |
| 4 | CD4B : Eastbound inner sand filter trench | 1.59 | ✓ | N/R | N/R | ✓ | At 120m centres into CMA along causeway rock revetment |
| 4 | CD4C : Eastbound 3m grassed filter strip | 2.91 | ✓ | N/R | N/R | ✓ | As sheet flow into CMA over causeway rock revetment |
| 4 | CD4D : Westbound inner sand filter | 2.33 | ✓ | N/R | N/R | ✓ | At 100m centres into estuary along causeway |

| | | | | | | | |
|---|---|------|---|-----|-----|---|--|
| | trench | | | | | | rock revetment |
| 4 | CD4E : Westbound outer sand filter trench | 3.18 | ✓ | N/R | N/R | ✓ | At 100m centres into estuary along causeway rock revetment |
| 5 | CD5A - Temporary Contractors' West Interchange Wet pond | | ✓ | N/R | N/R | ✓ | To the CMA via an existing culvert |
| 5 | CD5B - Temporary Waterview Park Wet pond | | ✓ | N/R | N/R | ✓ | To the Oakley Estuary |
| 6 | CD6A - Temporary Meola Wet pond | | ✓ | ✓ | N/R | ✓ | To the Meola Creek just downstream of the SH16 culverts |
| 7 | CD7A - Temporary GNR Diversion Cartridge Filter | | ✓ | N/R | N/R | ✓ | To the lower reaches of Oakley Creek |
| 7 | CD7B - Temporary Northern Portal East Wet pond | | ✓ | ✓ | N/R | ✓ | To the lower reaches of Oakley Creek |
| 9 | CD9A - Southern Portal Wet pond | | ✓ | ✓ | ✓ | ✓ | To the Oakley Creek in Alan Wood Reserve |
| 9 | CD9B - Vent Building Wet pond | | ✓ | ✓ | ✓ | ✓ | To the Oakley Creek in Alan Wood Reserve |
| 9 | CD9C- Alan Wood Wet pond | 0.46 | ✓ | ✓ | ✓ | ✓ | To the Oakley Creek in Alan Wood Reserve |
| 9 | CD9D - Valonia Wet Pond | 0.96 | ✓ | ✓ | ✓ | ✓ | To the Oakley Creek in Alan Wood Reserve |

Table 7.2: Summary of construction yards and expected activities

| Yard Name | Expected Activities |
|--|--|
| Yard 1 (Orangahina Park) - Road & Bridge Builders Yard | Offices/Ablutions, Construction plant & equipment parking, materials storage and lay down areas; Workshop Waste management/storage Refuelling facility. |
| Yard 2 (Patiki) - Road & Bridge Builders Yard | Construction plant & equipment parking, materials storage and lay down areas. |
| Yard 3 (GNR Interchange) - Causeway / Waterview Interchange Construction Yard | Construction plant & equipment parking, staff parking, materials storage and lay down areas; Laboratory (QA on granular fill/mudcrete) Workshop; Offices/Ablutions; Waste management/storage. |
| Yard 4 (GNR Interchange) Causeway / Tunnel / Waterview Interchange Construction Yard | Construction plant & equipment parking, staff parking, materials storage and lay down areas; Workshop; Pugmill; Waste management/storage; Conveyor and/or trucked Tunnel spoil; Screening of spoil Soil/rock stockpile for tunnel & portal excavation; Cement/Lime mixing and/or air drying of stockpiled material. |
| Yard 5 (Meola Creek) Road Builders Yard | Offices/Ablutions; Construction plant & equipment parking, staff parking, materials storage and lay down areas; Waste management/storage; Cement and/or Lime drying (rotary hoe). |
| Yard 6 (Waterview Park) Waterview Interchange / Tunnel Construction Yard | Offices/Ablutions; Construction plant & equipment parking, staff parking, material/aggregate storage and lay down areas; Workshop; Covered Stockpile; Waste management/storage; Refuelling facility; Conveyor and/or trucked Tunnel spoil; Steel Fixing; Concrete Batching Plant; Laboratory (Concrete QA); Bentonite Plant. |
| Yard 7 (Oakley Creek Reserve) Tunnel Construction Yard | Offices/Ablutions; Construction plant & equipment parking, staff parking, material/aggregate storage and lay down areas; Bentonite Plant; Waste management/storage; Conveyor and/or trucked Tunnel spoil; Refuelling facility; Ventilation compressors; Transformers. |
| Yard 8 (Alan Wood Park) Mechanical Laydown Area | Material storage, staff parking and lay down area. |
| Yard 9 (Alan Wood Park) Tunnel Contractor Yard | Offices/Ablutions; Construction plant & equipment parking, staff parking, material/aggregate storage and lay down areas; Vent Building construction; Workshop; Ventilation compressors; Transformers; Refuelling facility; Covered Stockpile; Waste management/ storage; Conveyed or Trucked Tunnel spoil. |
| Yard 10 (Alan Wood Park) | Offices/Ablutions; Storage and lay down areas; Concrete Batching Plant; |

| | |
|---|---|
| Driven Tunnel Operation | Laboratory (Concrete QA). |
| Yard 11 (Hendon Park) Piling Operation Yard | Offices/Ablutions; Workshop; Construction plant & equipment parking, staff parking, material/aggregate storage and lay down areas; Waste management/ storage. |
| Yard 12 (Valonia) Road Builders Yard | Offices/Ablutions; Construction plant & equipment parking, staff parking, material/aggregate storage and lay down areas; Waste management/ storage. |

7.2 Nomenclature

The stormwater treatment devices for the construction phase have been labelled “Construction Devices (CD)” to distinguish them from the proposed permanent stormwater treatment devices for the operational phase and from the erosion and sediment discharge control devices. Note that stormwater treatment devices used during the construction phase of the Project are also referred to as temporary devices.

7.3 BPO Discussion of Stormwater Aspects

The options considered for construction stormwater treatment devices included all of those devices detailed in the BPO discussion of permanent stormwater treatment devices in Sections 6.2.1. Also considered were the assessment matters outlined in Section 6.2.3. In addition, factors relating specifically to the BPO selection of construction phase stormwater treatment devices are discussed in Section 7.3.1 below.

7.3.1 Best Practicable Stormwater Treatment Options for Construction Phase Devices

The BPO approach was used to determine the most appropriate treatment devices for each construction phase catchment, in each of the Sectors, as required by the Proposed Auckland Regional Plan: Air, Land and Water. A discussion of the merits of treatment devices specifically for the construction phase of the Project is provided in this section. The BPO approach and devices for the construction phase are summarised here to avoid repetition in the Sector by Sector descriptions that follow, although site factors affecting the choice of BPO are still highlighted in the relevant sections.

Compatibility with Proposed Permanent Treatment Devices

The BPO for permanent stormwater treatment designs have been determined, and the proposed solutions are assessed in Section 6 above. For the least land disturbance, and cost, often it is practical for treatment devices for stormwater during the construction phase to be compatible with those proposed for the operational phase. For example, if a wetland is proposed for the operational phase, a wetland or wet pond in the same location, with similar contouring, creates minimal additional cost and effects, compared to a different type of treatment device and/or a different location.

Constructed wetlands & wet ponds

For the operational phase, constructed wetlands have been selected as the BPO when extended detention and flood attenuation are required. During the construction phase however, wet ponds have been selected as the BPO over wetlands, because it is not cost effective or practicable to install wetland plants for the short duration construction phase, and because the varying and sometimes high sediment loading of construction area runoff can be detrimental to the effectiveness of a wetland. Wet ponds are an effective, low maintenance, high durability treatment device, with the ability to provide water quantity treatment as well as water quality treatment.

An exception is where wetlands are used as the BPO to provide polishing treatment for inflows that include effluent from treatment systems treating high pH water from tunnel and batching plant areas. In these cases wetlands are the BPO because their high organic content can reduce elevated pH.

Attenuation Standards

Construction stormwater treatment devices that include stormwater attenuation are proposed for discharges to Oakley Creek as these areas have known flooding issues. For the construction phase, the attenuation devices proposed have been designed to limit post development peak flows to pre-development levels for the 2 year, 10 year and 20 year ARI rainfall events. The 100 year ARI event is not targeted for attenuation during the construction phase, as the duration of the construction phase is short, being approximately 5 years, and therefore the likelihood of a 100 year ARI event occurring during this period is low. The likelihood of a 20 year ARI event occurring during the construction period is 4 times smaller than the likelihood of 100 year ARI event occurring during the 100 year design life of the motorway. Therefore the level of risk managed during construction is considered appropriate. The 20 year ARI rainfall criterion that has been selected is consistent with the design criteria for extreme events used for other temporary devices such as erosion and sediment discharge control ponds.

The construction phase catchments include the construction yards, and therefore in many cases are larger than the operational phase catchments. However the maximum impervious catchment of the construction phase will only occur for part of the duration of construction period.

The construction stormwater treatment devices that provide attenuation for the 20 year ARI event can generally be located within the footprint of the proposed permanent stormwater treatment devices, designed to attenuate the 100 year ARI event. It is not considered practical to construct temporary ponds that are larger than final pond sizes, for a short period of use during construction.

Construction Phase Stormwater Catchments

All new impervious areas during construction require stormwater treatment. Surfaces are classed as impervious once earthworks have been stabilised, and an impermeable surface installed. Impervious surfaces include compacted gravel such as road base course and construction yards. The types of impervious surfaces expected during construction and the treatment approaches include the following;

- Construction yards which will be established early in the construction process with runoff treated by construction treatment devices. The construction yards will be removed at the end of construction.
- New sections of motorway to be treated initially by construction treatment devices, and ultimately by operational phase treatment devices.
- Widening for SH16 (although these will only get stormwater treatment once the lanes become live, see comments below).
- Causeway sections of SH16 where the pavements will be constructed in stages, a series of construction treatment devices for the different stages of construction is proposed.
- GNR Interchange ramps, where it is assumed proposed permanent stormwater treatment devices and reticulation are constructed simultaneous with the works, and will therefore service these areas once they become live to public traffic. Therefore no separate devices for the construction phase are proposed for these ramps.

Motorway widening

Stormwater treatment of areas of motorway widening during construction is not practical, until the stormwater systems and pavement are complete. The stormwater system is normally only completed at the very end of construction due to the sequencing of the road build. The sequence for widening works is governed by construction sequencing including traffic management, rather than stormwater management. The motorway widening advances at different stages for the east and westbound lanes. Stormwater drainage systems are not functional until the final pavement layer is constructed to the level of stormwater channels and catchpits. It is not practicable to have the permanent stormwater systems and treatment devices operational until the completion of the motorway widening construction.

The periods for which there will be no treatment for runoff from SH16 widening impervious areas will be short and there will not be public vehicles trafficking these areas during those periods. Therefore the BPO for treatment of runoff areas of motorway widening during the construction phase is to leave erosion and sediment discharge control devices in place until the pavement, stormwater reticulation and permanent stormwater treatment devices are in place. The erosion and sediment control devices will provide some benefit in terms of sediment removal from runoff from basecourse materials. The permanent stormwater management measures will be operational before the motorway widening is opened to public traffic.

Once complete, the stormwater systems for these areas of motorway widening will provide stormwater treatment for not only the additional impervious areas, but the existing impervious areas as well. So overall there is considered to be a significant improvement in stormwater treatment to these sections of the motorway (SH16 St Lukes to Te Atatu, Sectors 1 - 6).

7.4 Sector 1

7.4.1 Description

The works in Sector 1 consist mainly of SH16 carriageway widening and consequential realignments and safety improvements to the Te Atatu Interchange. Currently the only treatment device is the swale along the Te Atatu eastbound on-ramp. During the construction phase, the swale along the eastbound on-ramp will be removed and rebuilt as part of road widening works. A Sediment Retention Pond (SRP-1E) will be provided in the low point on the northern side of the Te Atatu eastbound on-ramp to treat runoff from parts of the north eastern clover of the Te Atatu Interchange and Te Atatu Road. This will provide treatment for the earthworks while the treatment swale is temporarily out of action. Once the earthworks are stabilised, and the grass has become established in the new swale, it will be used as a permanent treatment device.

In addition a temporary stormwater wet pond, modified from the erosion and sediment discharge control pond, will treat runoff from Construction Yard 1. This Construction Device 1A (CD1A) is proposed to treat runoff from the construction yard. Discharge from CD1A will be to the swale as described above, either using the existing or new swale, discharging to the Whau River, and therefore neither peak flow attenuation nor extended detention is required as flooding and erosion are not issues in this environment.

The catchments for Sector 1 temporary stormwater treatment are shown on Drawings 20.1.11-3-D-D-350-101 to 103 (Appendix A).

7.4.2 Options Considered

A wetland, wet pond or swale was considered for CD1A. Due to there being space available, and the ease of construction, durability and efficiency of contaminant removal by a wet pond, this was selected as the BPO for Sector 1 construction phase stormwater treatment. The wet pond will be converted from the erosion and sediment discharge control pond used during the earthworks to prepare the construction yard. A wetland would require a larger footprint and more extensive works than a pond, and it is not considered sensible to carry out extensive planting for a temporary treatment device.

The BPO for reticulation of the runoff from the contractor's working catchment area is to form a perimeter bund once the earthworks have been stabilised, to direct runoff to the wet pond. Runoff from the stabilized entrance and wheel wash area as well as other areas generating contaminant laden run-off will be channelled via dirty water diversion bunds to the proposed wet pond. A pipe and channel system would be unnecessary and a less sustainable option due to waste of materials when the yard is no longer required.

Stormwater treatment for areas of motorway widening during construction is not practical, until the storm water systems and pavement are complete. The BPO for treatment of runoff from motorway widening during the construction phase is to leave erosion and sediment control devices in place until the permanent stormwater treatment devices can be made operational (refer to Section 7.3.1).

7.4.3 Best Practicable Options

Construction Device 1A (CD1A) - Construction Yard 1 (Orangahina Park) Wet pond

The catchment area for treatment device CD1A is 4.2ha. The WQV is 536m³. The proposed CD1A is shown on Drawings 20.1.11-3-D-D-350-102 (Appendix A). The key operating levels and volumes are summarised in Table 7.3. The dead storage volume of water in the wet pond will be 536m³, representing 100% of the volume for water quality treatment. Some freeboard over the outlet level has been provided to route rainfall events through the pond.

Table 7.3: Wet Pond Design Geometry for CD1A – Construction Yard 1 (Orangahina Park) Wet Pond

| Parameter | Elevation (m RL) | Area (m ²) | Volume (m ³) |
|--------------------------------|------------------|------------------------|--------------------------|
| Wet pond Invert | 16.25 | 250 | 0 |
| Normal Water Level | 17.26 | 684 | 536 |
| Crest of pond | 18.00 | 945 | 1107 |
| Approximate footprint of works | 21m x 41m | 1140 | n/a |

CD1A (Orangahina Park) Wet Pond will be located within the yard to enable it to be fenced off from the public, and to eliminate the need for an extensive reticulation system.

The wet pond will be converted from the sediment discharge control pond, to be used for the earthworks to construct the yard area (to strip topsoil, shape as necessary). The inlet and outlets will be modified to comply with TP10. The volume and shape will be adjusted as necessary to achieve the design volumes.

The outfall structure from CD1A wet pond will incorporate energy dissipation and erosion protection measures to minimise scour at the discharge outfalls. Overflow paths from the motorway and stormwater wet pond will be designed to safely convey stormwater in excess of the stormwater primary drainage system capacity.

7.5 Sector 2

7.5.1 Description

The works in Sector 2 consist mainly of SH16 carriageway widening and the corresponding widening of the Whau Bridges. There is currently no stormwater treatment or any consent requiring treatment for the existing pavement in Sector 2. There is no construction yard planned for Sector 2.

The only construction phase catchments requiring treatment of stormwater consist of the additional impervious area created by the carriageway widening. Quantity control of stormwater in this area is not beneficial as runoff discharges directly to the CMA.

The catchments for Sector 2 temporary stormwater treatment are shown on Drawings 20.1.11-3-D-D-350-103 to 104 (Appendix A).

7.5.2 Options Considered

Options to treat runoff from the temporary catchment of Sector 2 were considered. The motorway widening advances progressively and at different stages for the east and westbound lanes. It is not practicable to install any of the TP10 approved treatment devices until the completion of the pavement, at which stage the permanent treatment devices for Sector 2 will be constructed. Therefore the BPO for treatment of runoff from Sector 2 during the construction phase is to leave erosion and sediment discharge control devices in place until the permanent stormwater treatment devices for Sector 2 are operational, refer to Section 7.3.1 for further explanation.

7.5.3 Best Practicable Options

In Sector 2 the proposed solution is to leave erosion and sediment discharge control devices in place until the permanent stormwater treatment devices for Sector 2 are operational.

7.6 Sector 3

7.6.1 Description

The works in Sector 3 consist of SH16 carriageway widening. There are currently 4 settlement tanks, approximately 20m long x 2m wide, treating runoff from the Rosebank Road and Patiki Road on- and off-ramps as required by Stormwater Discharge and Diversion Permit BH/8735. These settlement tanks will have to be demolished during construction to allow for the road widening. However, no alterations are proposed for the concrete bridge decks of the Rosebank Road on- and off ramps or the Patiki Road off ramp. It is proposed that the piped system conveying the stormwater to the settlement tanks can be intercepted at the bridge abutments and routed to temporary treatment devices to provide treatment during construction.

The carriageway widening requires consideration of stormwater treatment. Quantity control of stormwater in this area is not beneficial as runoff discharges directly to the CMA.

A temporary stormwater pond, Construction Device 3D (CD3D), modified from the erosion and sediment discharge control pond, will treat runoff from the Construction Yard 2 (Patiki) on the southern side of the motorway at Ch 3900. Discharge from CD3D will be to the tidal flats of the Whau River, and therefore neither peak flow attenuation nor extended detention is required as flooding and stream erosion are not issues in this environment.

The catchments for Sector 3 temporary stormwater treatment are shown on Drawings 20.1.11-3-D-D-350-104 to 105 (Appendix A).

7.6.2 Options Considered

Stormwater treatment for areas of motorway widening during construction is not practical, until the storm water systems and pavement are complete. The BPO for treatment of runoff from motorway widening during the construction phase is to leave Erosion and sediment control devices in place until the permanent stormwater treatment devices can be commissioned (refer to Section 7.3.1).

A wet pond, sand filters or proprietary devices were considered for treating runoff from the on- and off ramp bridge structures and the construction yard area.

The BPO for Rosebank Road on- and off-ramps and the Patiki Road off-ramps are cartridge filters due to their small footprint and the possibility of removal at the end of construction.

The BPO for the Construction Yard 2 (Patiki) is to convert the sediment retention pond SRP-3A into a temporary wet pond treatment device CD3D. The BPO for reticulation of the runoff from the Contractors' working catchment area is to form a perimeter bund once the earthworks have been stabilised, to direct runoff to the wet pond. Runoff from the stabilised entrance and wheel wash area as well as other areas generating contaminant laden run-off will be channelled via dirty water diversion bunds to the proposed wet pond. A pipe and channel system would be unnecessary and a less sustainable option due to waste of materials when the yard is no longer required.

The BPO for treatment of the stormwater from the Patiki Road westbound on-ramp will be to discharge temporary wet pond treatment device CD3D located in Construction Yard 2 (Patiki).

7.6.3 Best Practicable Options

In Sector 3 the proposed solution is to leave erosion and sediment discharge control devices in place until the permanent stormwater treatment devices for Sector 3 are operational for works on the approaches and motorway widening.

The proposed temporary stormwater treatment devices for areas that can be treated are described in more detail below.

Temporary Devices 3A, 3B & 3C – Cartridge Filters (CD3A to CD3C)

Runoff from the bridge decks in Sector 3 will be intercepted by the existing catch pits and piped to construction devices 3A, 3B & 3C to be located adjacent to, or under the first downhill span of each bridge, on the verge of the motorway, and then discharged directly into the CMA.

Cartridge vault treatment devices will be designed individually, their design dependant on the impervious area, pollutant load, flow rate and head loss at each location. The outfalls will be concrete wing walls, integrated into the rock armour revetment with an additional rock apron as necessary along the edge of the wing wall.

The proposed treatment devices are listed below with their outfall locations, and approximate sizing and proposed number of cartridges is shown in Table 7.4.

- Temporary Device 3A – Patiki Off Ramp Cartridge Filter Vault (CD3A), discharging directly into the tidal mangrove flats of the CMA.
- Temporary Device 3B – Rosebank Off Ramp Cartridge Filter Vault (CD3B) will discharge directly into the estuary to the east of the Rosebank Peninsula.
- Temporary Device 3C – Rosebank On-Ramp Cartridge Filter Vault (CD3C) will discharge directly into the CMA to the east of the Rosebank Peninsula.

Table 7.4: Cartridge Filter Vault Design Summary for Temporary Devices 3A to 3C:

| Parameter | Cartridge Filter CD3A | Cartridge Filter CD3B | Cartridge Filter CD3C |
|--|-----------------------|-----------------------|-----------------------|
| Impervious Area (m ²) | 0.23 | 0.08 | 0.22 |
| Number of Cartridges | 6 | 2 | 5 |
| Approximate Vault Area (m ²) | 7.0 | 4.5 | 4.5 |
| Outlet Level (RLm) | 2.15 | 1.50 | 1.54 |

Temporary Device 3D (CD3D) – Construction Yard 2 (Patiki) Wet pond

The catchment area for treatment device CD3D is 0.37ha. The WQV is 83m³. The proposed CD3D is shown on Drawings 20.1.11-3-D-D-350-104 (Appendix A). The key operating levels and volumes are summarised in Table 7.5. The dead storage volume of water in the wet pond will be 83m³, representing 100% of the volume for water quality treatment. Some freeboard over the outlet level has been provided to route rainfall events through the pond.

Table 7.5: Wet Pond Design Geometry for CD3D – Temporary Yard 2 (Patiki) Wet Pond

| Parameter | Elevation (m RL) | Area (m ²) | Volume (m ³) |
|--------------------------------|------------------|------------------------|--------------------------|
| Wet pond Invert | 2.40 | 38 | 0 |
| Normal Water Level | 3.24 | 172 | 83 |
| Crest of pond | 4.00 | 354 | 280 |
| Approximate footprint of works | 18m x 11m | 450 | 400 |

The Construction Yard 2 (Patiki) Wet Pond (CD3D) will be located within the yard to enable it to be fenced off from the public, and to eliminate the need for an extensive reticulation system.

The outfall structure from the CD3D wet pond will incorporate energy dissipation and erosion protection measures to minimise scour at the discharge outfalls. Overflow paths from the motorway and stormwater wet pond have been designed to safely convey stormwater in excess of the stormwater primary drainage system capacity.

7.7 Sector 4

7.7.1 Description

The works in Sector 4 consist of raising and widening the causeway section of the motorway. There is an existing stormwater treatment system installed as part of the bus shoulder widening Project from the GNR Interchange to the Rosebank Road Interchange as required by Stormwater Discharge and Diversion Permit no. 30235. This permit requires a catchment area of 1.16ha be treated to 82% TSS removal. A hybrid treatment device, which comprises part filter strip, part grass swale, part sand filter and part infiltration was installed on the north side of the causeway running for a length of approximately 800m from near the western limit of the Causeway Bridge (Ch 1300) westward to approximately Ch 2100. Considering the entire existing impervious catchment area of causeway section in Sector 4, treatment is currently provided to 1.16ha of the 5.385ha, indicating that 21.5% of this Sector is currently being treated.

Stormwater management during construction will be a challenge because it is proposed to widen and raise the causeway starting with the areas outside the existing motorway, so drainage paths will be blocked. Stormwater management for Sector 4 during construction focuses on (1) draining the motorway of surface water and (2) providing stormwater treatment to ensure that the current resource consents are complied with.

During the construction phase, it is proposed that the existing level of treatment for the causeway be maintained, plus full treatment of any additional impervious areas once they are paved. This presents as a

challenge due to the proposed construction sequencing which involves traffic being shifted onto different lanes while others are raised and widened.

The proposed phases of construction and the catchment areas required for treatment are summarised below. Treatment areas defined correspond to an area which can be directed to a particular treatment device, and may be relevant for one or more of the construction phases. For more information on the construction sequencing and temporary treatment catchments refer to drawings 20.1.11-3-D-D-350-103 to 20.1.11-3-D-D-350-108 (Appendix A) and 20.1.11-3-D-C-150-301 to 20.1.11-3-D-C-150-303.

Phase 1 of the works will consist of reclamation works on the eastbound (seaward) side and raising and enclosing a width of approximately 24m (Catchment 4A) of the eastbound causeway lanes. This section will accommodate three traffic lanes, a priority bus lane and a temporary access/haul road for construction machinery.

Phase 2 of the works will consist of raising of the existing causeway on the eastbound (seaward) side and enclosing approximately 9m wide (Catchment 4B) of the eastbound causeway lanes. This section will accommodate two traffic lanes. Construction machinery will utilise the fill area as a temporary access and haul road.

Phase 3 of the works will consist of providing two traffic lanes at the existing motorway level approximately 9m wide (Catchment 4B) and three traffic lanes with a priority bus lane on the raised eastbound (seaward) side causeway approximately 16.5m wide (Catchment 4C). The works will also consist of reclamation works on the landward side and raising and enclosing approximately 14m wide (Catchment 4D) of the westbound causeway lanes. Catchment 4D will consist of one traffic lane, a priority bus lane and the temporary cycleway.

Phase 4 of the works will consist of moving the traffic lanes onto the new widened shoulders of the causeway while filling over the median area of the existing motorway. Three traffic lanes with a priority bus lane will be provided on the raised eastbound (seaward) side causeway approximately 16.5m wide which form the catchment for CD4C. Three traffic lanes, a priority bus lane and the temporary cycleway will also be provided on the raised westbound (landward) side of the causeway approximately 20m wide which form the catchment for CD4E.

Phase 5 of the works will involve moving the traffic lanes back onto the middle of the raised and widened causeway while establishing the permanent bio-filter strips on the shoulders. A shoulder, three traffic lanes with a priority bus lane will be provided on the eastbound side causeway approximately 24m wide. A 3m wide shoulder, three traffic lanes and a priority bus lane will also be provided on the westbound side of the causeway approximately 18m wide allowing for a 14m wide construction and 1.8m wide temporary cycleway. Temporary treatment device CD4C on the eastbound shoulder will be incorporated into the permanent 7m wide grassed bio-filter strip, and temporary treatment device CD4E will stay operational until the permanent westbound bio-filter strip has been established.

Phase 6 of the works will be the completed causeway arrangement with shoulders, four eastbound traffic lanes, five westbound traffic lanes and a priority bus lane on both sides. A 3m wide cycleway will be constructed on the edge of the westbound side of the causeway and the 7m wide bio-filter strips will be established as permanent stormwater treatment devices.

Discharge from catchments 4A to 4E will be to the CMA, and therefore neither peak flow attenuation nor extended detention is required as flooding and stream erosion are not issues in this environment.

7.7.2 Options Considered

The BPO approach was used to determine the most appropriate temporary treatment devices for the Sector 4: Reclamation catchment, at different stages of the construction process.

Bio-filter strips were considered similar to those proposed for the operational phase. However, because the carriageway will be stepped up and widened gradually, the surface proposed for the bio-filter strips will not be constructed preceding the rest of the works, and the runoff from the carriageway would not be able to be directed to bio-filter strips during all stages. Similar issues arise when considering other devices such as cartridge filters.

Treatment devices to be used on the causeway during construction must be durable, flexible and easy to construct. A solution was considered using hybrid sand filter trenches with cesspits fitted with screening filters, and a limited width grassed bio-filter strip, configured in different combinations during the different phases of construction. This is proposed as the BPO solution for Sector 4 temporary stormwater treatment, due to the envisaged efficient contaminant removal and flexibility and ease of construction. The proposed hybrid sand filter trenches are similar to the treatment devices already in use in this area (as required by Stormwater Discharge and Diversion Permit no. 30235) explained above.

Catchment 4A, 4B, 4D & 4E will be treated by a hybrid sand filter trench combined with a perforated piped system connected to cesspits. Due to the longitudinal grade of the causeway being flat, runoff will have to be collected at relatively frequent intervals and discharged to the CMA.

Catchment 4C will be treated by a 3m wide grassed bio-filter strip established on the raised shoulder on the seaward side. This bio-filter strip will eventually form part of the permanent treatment device (7m wide grassed bio-filter strip).

7.7.3 Proposed solution

Table 7.6: Summary of Stormwater Treatment Areas for Construction phase in Sector 4

| Catchment | Area (Hectares) | Treatment Device |
|--------------|-----------------|--|
| Catchment 4A | 4.24 ha | Temporary Device 4A : Eastbound outer sand filter trench (CD4A) |
| Catchment 4B | 1.59 ha | Temporary Device 4B : Eastbound inner sand filter trench (CD4B) |
| Catchment 4C | 2.91 ha | Temporary Device 4C : Eastbound 3m grassed bio-filter strip (CD4C) |
| Catchment 4D | 2.23 ha | Temporary Device 4D : Westbound inner sand filter trench (CD4D) |
| Catchment 4E | 3.18 ha | Temporary Device 4E : Westbound outer sand filter trench (CD4E) |

Temporary Device 4A (CD4A) - Eastbound outer sand filter trench

The water quality flow for temporary catchment 4A is 0.32l/s per 1m wide strip and the WQV is 32m³ for the 60m long section of 24m wide roadway. The 10 year and 100 year ARI peak outflows for the temporary Catchment 4A are 0.54l/s and 0.78l/s per 1m wide strip respectively.

A 150mm diameter perforated pipe will be installed in a 0.6m wide x 0.6m deep trench at a slope of 0.5% and connect to cesspits at 60m intervals. The cesspits will be fitted with screening filter inserts (e.g. EnviroPod® or similar) to capture larger sediments and rubble. The trench will be lined with geotextile fabric (Bidim or similar) and filled with drainage material (Scoria AP 7/20). In Catchment 4A the cesspits and 225mm diameter outlet pipes at 1% slope will be spaced at 60m to accommodate the 1 in 100 year ARI flow and prevent flooding.

Temporary Device CD4A will treat 35% of the catchment to TP10 requirements, and is expected to achieve an overall efficiency of between 50% and 60% TSS removal, a higher level of treatment than currently exists.

Temporary Device 4B (CD4B) - Eastbound inner sand filter trench

The water quality flow for temporary catchment 4B is 0.12l/s per 1m wide strip and the WQV is 24m³ for each 120m long section of 9m wide roadway. The 10 year and 100 year ARI peak outflows for the temporary Catchment 4B are 0.20l/s and 0.29l/s per 1m wide strip respectively.

A 150mm diameter perforated pipe will be installed in a 0.6m wide x 0.6m deep trench at a slope of 0.5% and connect to cesspits at 120m intervals. The cesspits will be fitted with screening filter inserts (e.g. EnviroPod® or similar) to capture larger sediments and rubble. The trench will be lined with geotextile fabric and filled with drainage material (Scoria AP 7/20). In Catchment 4B the cesspits and 225mm diameter outlet pipes at 1% slope will be spaced at 120m to accommodate the 1 in 100 year ARI flow and prevent flooding.

Temporary Device CD4B will treat 93% of the catchment to TP10 requirements, and is expected to achieve an overall efficiency of between 70% and 75% TSS removal, a higher level of treatment than currently exists.

Temporary Device 4C (CD4C) - Eastbound grassed Bio-filter strip

The water quality flow for temporary catchment 4C is 0.068l/s per 1m wide strip.

The 3 metre wide bio-filter strip at 1% transverse slope will be installed on the seaward side of the shoulder next to the coastal protection. The required width to treat all of the runoff from catchment 4C to TP10 requirements is 3.0m. Therefore, the proposed 3.0 m wide strip will treat 100% of the catchment to TP10 requirements, and is expected to achieve an efficiency of 75% TSS removal.

Temporary Device 4D (CD4D) - Westbound inner sand filter trench

The Water Quality flow for temporary Catchment 4D is 0.06 l/s per 1m wide strip and the Water Quality Volume is 31m³ per 100m section of 14m wide roadway. The 10 year and 100 year ARI peak outflows for the temporary Catchment 4D are 0.5 l/s and 0.8 l/s per 1m wide strip respectively.

A 150mm diameter perforated pipe will be installed in a 0.6m wide x 0.6m deep trench at a slope of 0.5 % and connect to cesspits at 100m intervals. The cesspits will be fitted with screening filter inserts (e.g. EnviroPod® or similar) to capture larger sediments and rubble. The trench will be lined with geotextile fabric and filled with drainage material (Scoria AP 7/20). In Catchment 4D the cesspits and 225mm diameter outlet pipes at 1% slope will be spaced at 100m to accommodate the 1 in 100 year ARI flow and prevent flooding.

Temporary Device CD4D will treat 100% of the catchment to TP10 requirements, and is expected to achieve an overall efficiency of 75% TSS removal, a higher level of treatment than currently exists.

Temporary Device 4E (CD4E) - Westbound outer sand filter trench

The Water Quality flow for temporary Catchment 4E is 0.08 l/s per 1m wide strip and the Water Quality Volume is 45m³ per 100m section of 20m wide roadway. The 10 year and 100 year ARI peak outflows for the temporary Catchment 4E are 0.45l/s and 0.65l/s per 1m wide strip respectively.

A 150mm diameter perforated pipe will be installed in a 1.5m wide x 0.6m deep trench at a slope of 0.5% (1:200) and connect to cesspits at 100m intervals. The cesspits will be fitted with screening filter inserts (e.g. EnviroPod® or similar) to capture larger sediments and rubble. The trench will be lined with geotextile fabric and filled with drainage material (Scoria AP 7/20). In Catchment 4E the cesspits and 150mm diameter outlet pipes at 1% slope will be spaced at 100m to accommodate the 1 in 10 year ARI flow. There are no flooding issues as the excess water will spill directly over the revetment into the CMA.

Temporary Device CD4E will treat all of the catchment draining to it to TP10 requirements, and is expected to achieve an efficiency of 75% TSS removal on a long term average basis.

7.8 Sector 5

7.8.1 Description

The motorway construction in Sector 5 consists of four interchange links and the northern portal of the SH20 tunnel. The interchange links consist of ramps, viaducts and widening of SH16.

There are three construction yards, located at the Northern Portal of the tunnel (Waterview Reserve) and two within the GNR Interchange area, create additional impervious areas and source areas for stormwater pollutants, as shown of Drawings 20.1.11-3-D-D-350-109 and 20.1.11-3-D-D-350-113 (Appendix A).

Treatment devices for the GNR Interchange temporary catchments will discharge to the CMA, so flooding and stream erosion due to stormwater discharge is not of concern, and therefore peak flow attenuation and extended detention are not required.

7.8.2 Options Considered

During construction the proposed motorway interchange ramps will not be trafficked and therefore stormwater generated will not contain pollution from vehicles. However, runoff is likely to contain sediment from construction vehicles and activities. Therefore erosion and sediment control procedures will remain in place until permanent treatment devices are operational. Permanent treatment devices and reticulation will be in place when the pavement is completed prior to opening to the interchange ramps to public vehicular traffic.

The three construction yards within Sector 5 are higher risk areas for pollution generation and stormwater treatment is desirable.

Swales, cartridge filters, wetlands or wet ponds were considered for treating runoff from the construction yards in Sector 5. The potentially high and variable sediment loading from construction yards can reduce the effectiveness of vegetated devices and cartridge filters. Wet ponds have been selected as the BPO for these reasons as well as for their durability and ease of construction (refer to Section 7.3.1 for a discussion on BPO considerations for Temporary Stormwater treatment devices).

Construction Yard 4 is proposed for stockpiling of tunnel spoil prior to reuse as fill for the causeway construction. As this construction yard has predominantly earthworks activities it is proposed that sediment and erosion controls remain in place for water quality treatment. If the use of the construction yard changes to non-earthworks activities then stormwater controls should be considered at that time.

7.8.3 Best Practicable Option

Construction Device 5A –Contractors' West Interchange Wet Pond

The proposed wet pond CD5A is shown on Drawing 20.1.11-3-D-D-350-109 (Appendix A). The key operating levels and volumes are summarised in Table 7.7. The catchment area CD5B will service is 1.46ha. The WQV is 317m³ which will be stored as the permanent volume of water in the wet pond.

CD5A will discharge to the CMA via an existing culvert under the SH16 GNR off ramp, shown on drawing 20.1.11-3-D-D-350-109, the capacity of which is sufficient to pass the 100 year ARI event without flooding the carriageway.

Table 7.7: Wet Pond Design Geometry for CD5A –Contractors’ West Interchange Wet Pond

| Parameter | Elevation (mRL) | Area (m ²) | Volume (m ³) |
|--|-----------------|------------------------|--------------------------|
| Wet pond Invert | 1.5 | 347 | - |
| Normal Water Level | 2.3 | 472 | 317 |
| Maximum water level during 20 year ARI event | 2.4 | 498 | 376 |

The wet pond will be converted from a sediment control pond used for the earthworks phase of construction. The inlet and outlets will be modified to comply with TP10. The volume and shape will be adjusted as necessary to achieve the design volumes.

Construction Device 5B –Waterview Park Wetland

The proposed wetland CD5B is shown on Drawings 20.1.11-3-D-D-350-113 (Appendix A). The key operating levels and volumes are summarised in Table 7.8. The catchment area CD5B will service is 6.32ha. The WQV is 1370m³. The permanent volume of water in the wetland will be 685m³ half of the WQV. The remaining half of the WQV will be treated during extended detention, and will be held and released over 24 hours.

A wetland is proposed because activities in Construction Yard 6 include a concrete batching plant. While the concrete batching plant will have its own treatment facilities, it is intended that the CD5B be use to further polish the water quality, which it is better able to do as a wetland, as these can neutralise pH variations.

CD5B will discharge to the CMA in the area of the Oakley Creek estuarine area, as shown on drawing 20.1.11-3-D-D-350-113, via an energy dissipation structure to reduce the velocity of the discharge and avoid erosion at the discharge point.

Table 7.8: Wet pond Design Geometry for CD5B –Waterview Park Wetland

| Parameter | Elevation (mRL) | Area (m ²) | Volume (m ³) |
|--|-----------------|------------------------|--------------------------|
| Wet pond Invert | 4.5 | 434 | - |
| Normal Water Level | 5.5 | 1129 | 685 |
| Extended detention (WQ) | 6.0 | 1292 | 1370 |
| Maximum water level during 20 year ARI event | 6.5 | 1463 | 1963 |

7.9 Sector 6

7.9.1 Description

The works for Sector 6 consist of carriageway widening of SH16. There is currently no stormwater treatment provided for the SH16 carriageway in this Sector. Therefore the temporary catchment for stormwater treatment during the construction phase consists of the additional area of SH16 carriageway, once it becomes impervious. Construction Yard 5 is proposed for the area adjacent to where the proposed permanent wetland TD6A is located, stormwater from which will require treatment. Refer to Drawings 20.1.11-3-D-D-350-110 to 112 (Appendix A).

Temporary stormwater from Sector 6 will be discharged to the Meola Creek, both upstream and downstream of the SH16 culvert. This location is in the lower part of the Meola Creek catchment. Attenuating and therefore delaying the peak flows from the local motorway catchment would potentially increase the peak flow in Meola Creek due to coincidence with peak flows from further up the catchment. For this reason, attenuation of motorway runoff flows in this area is not proposed. However Meola Creek has issues with bank erosion, and therefore extended detention is proposed to protect the stream from erosion and scour.

7.9.2 Options Considered

Stormwater treatment for areas of motorway widening during construction is not practical, until the storm water systems and pavement are complete. The BPO for treatment of runoff from motorway widening during the construction phase is to leave Erosion and Sediment Discharge Control Devices in place until the permanent stormwater treatment devices can be made operational (refer to Section 7.3.1 for BPO discussion on motorway widening area).

The proposed Construction Yard 5 has a higher risk for pollution generation and stormwater treatment is desirable. In this area for the operational phase, a permanent wetland (TD6A) is proposed to treat runoff from Sector 6. For the construction phase it is proposed to construct the permanent stormwater device as an early

activity and use it as a construction stormwater treatment device. A wet pond is proposed rather than a wetland due to the varying and potentially high sediment loading from construction yards, which can be detrimental to the effectiveness of a wetland (for further discussion, refer to section 7.2.3). The most practical option for temporary stormwater treatment is to construct a wet pond, with the same geometry as that of the proposed permanent wetland.

7.9.3 Best Practicable Options

Construction Device 6A – Temporary Meola Wet pond

The proposed wet pond CD6M is shown on Drawing 20.1.11-3-D-D-350-111 (Appendix A). The key operating levels and volumes are summarised in Table 7.9. The WQV for catchment 6A is 264m³ 100% of which will be stored, included in the permanent volume of water in the wet pond. The wet pond is larger than it needs to be, as it has been sized as the treatment device for the operation phase for the larger motorway catchment.

Table 7.9: Wet pond Design Geometry for CD6A – Temporary Meola Wet Pond

| Parameter | Elevation (mRL) | Area (m ²) | Volume (m ³) |
|--|-----------------|------------------------|--------------------------|
| Wet pond Invert | 8.0 | 479 | - |
| Normal Water Level | 8.5 | 759 | 309 |
| Extended Detention Level | 8.8 | 1379 | 674 |
| Maximum water level during 20 year ARI event | 9.0 | 1482 | 933 |

7.10 Sector 7

7.10.1 Description

The construction works for Sector 7, the GNR Underpass Tunnel, occur below ground and within the proposed construction yards. The catchment for temporary stormwater treatment in Sector 7 consists of the proposed Construction Yard 7, in the vicinity of the Bored Tunnel northern portal (shown on Drawings 20.1.11-3-D-D-350-113 and 20.1.11-3-D-D-350-114, Appendix A). In addition, to enable construction works to be carried out a section of GNR will be temporarily realigned. This is likely to involve more than one different alignment for different stages of the works. Runoff from both the realigned section of GNR, and Construction Yard 7 will require treatment. In addition, provision to discharge treated water from the tunnel construction is proposed.

Treatment devices for the Sector 7 temporary catchments will discharge to the downstream reach of Oakley Creek. We consider that attenuating and therefore delaying the peak flows from the local motorway catchment

would potentially increase the peak flow in Oakley Creek due to coincidence with peak flows from further up the catchment. For this reason attenuation of flows from Sector 7 is not proposed. However extended detention is proposed for the Construction yard, to protect the stream from erosion.

The extent of the catchments for Sector 7 temporary treatment devices CD7A and CD7B are shown on Drawings 20.1.11-3-D-D-350-113 and 20.1.11-3-D-D-350-114 (Appendix A).

7.10.2 Options Considered

Construction Device 7A

The runoff from the diverted GNR section can be collected and conveyed to one point using a traditional kerb and channel system. Therefore wet ponds or cartridge filters were considered. The ground profile in the area is steep and space is limited (making wet pond construction difficult), and because the location of the treatment device will change more than once, cartridge filters were selected. Either StormFilter or UpFlo filters would be suitable. The discharge would be back into the existing Great North Road stormwater system.

Construction Device 7B

Cartridge filters, a wetland or a wet pond were considered to treat runoff from the construction yard in Sector 7. The device will also treat water from the tunnel construction. A wetland was selected as the BPO because the vegetation and organic content of the wetland will act as a pH buffer and provide polishing for the already treated tunnel water.

7.10.3 Best Practicable Options

Construction Device 7A –GNR Diversion Cartridge Filter

The proposed CD7A is shown on Drawing 20.1.11-3-D-D-350-113 (Appendix A). The diversion of the road will occur over two stages. The key operating parameters are summarised in Table 7.10. During Stage 1 the additional impervious area created by the diversion is only 200m, and therefore it is not practicable to provide stormwater treatment for this.

Table 7.10: Cartridge Filter Vault Design Summary for CD7A

| Parameter | Cartridge Filter CD7A Stage 1 | Cartridge Filter CD7A Stage 2 |
|---|-------------------------------|-------------------------------|
| Increased impervious area (m ²) | 200 | 3800 |
| Number of Cartridges | - | 8 |
| Approximate Vault Area (m ²) | - | 6.9 |
| Outlet Level (RLm) | - | 14.5 |

Construction Device 7B – Northern Portal East Wetland

The proposed CD7B is shown on Drawings 20.1.11-3-D-D-350-113 & 114 (Appendix A). The catchment area serviced by CD7B is 1.51 ha. The WQV is 327m³.

Treated water from the tunnelling works (estimated to be 300m³ per day) will be discharged through this pond. To account for this an extra 300m³ has been added to the permanent volume of water in the wet pond. The permanent volume of water in the wetland will be half of the WQV plus the provision for tunnel water, with the remaining half of the WQV captured and released slowly as part of the extended detention volume. The key operating levels and volumes are summarised in Table 7.11.

CD7B will be used for the management of tunnel water during construction. Water management during construction will have two phases, although these may overlap:

1. During excavation the tunnels will be dewatered to an erosion and sediment discharge control device consisting of modified containers used for treatment of tunnel water. For details refer to Technical Report No G.22 *Erosion and Sediment Control Plan*. Tunnel water will be then discharged to CD7B and CD9A for water quality polishing. The daily volume is estimated at 300m³/day at each portal, and has been allowed for by increasing the permanent storage volume of CD7B by this amount.
2. After excavation is complete and the tunnels are lined, the seepage to the tunnel is estimated to be 16.4m³/day, which will be pumped to CD7B or to CD5B. During the operation phase this tunnel water is pumped to TD5F.

Table 7.11: Wetland Design Geometry for CD7B – Temporary Northern Portal East Wetland

| Parameter | Elevation (mRL) | Area (m ²) | Volume (m ³) |
|--|-----------------|------------------------|--------------------------|
| Wet pond Invert | 6.0 | 264 | - |
| Normal Water Level | 7.0 | 823 | 463 |
| Extended Detention | 7.5 | 964 | 949 |
| Maximum water level during 20 year ARI event | 7.7 | 1020 | 1126 |

7.11 Sector 8

7.11.1 Description

The construction works for Sector 8, Avondale Heights Tunnel, will be underground and no stormwater treatment is required, other than the management of treated tunnel water that is described for Sectors 7 and 9. For details of the tunnel water management and treatment refer to Technical Report No G22 *Erosion and Sediment Control Plan*.

7.12 Sector 9

7.12.1 Description

The construction works for Sector 9 are the SH20 surface motorway and trench approach to the tunnel southern portal. The catchment for temporary stormwater in Sector 9 is the area requiring permanent stormwater treatment (SH20 from Ch 150 to the tunnel portal, the Christ the King site and the Maioro Interchange overbridge plus on and off ramps) with the addition of the four proposed construction yards in the vicinity of Alan Wood Reserve (shown on Drawings 20.1.11-3-D-D-350-117 and 20.1.11-3-D-D-350-118, in Appendix A). In addition, provision needs to be made for treated water from the tunnel construction. The discharge of construction stormwater in Sector 9 is to Oakley Creek where flooding is a recognised issue. Therefore attenuation of peak flows is required. It is proposed to limit post development peak flows to predevelopment levels for the 2 year, 10 year and 20 year ARI events during the construction phase (refer to section 7.3.1 for further explanation).

The catchments for Sector 9 temporary stormwater treatment are shown on Drawings 20.1.11-3-D-D-350-117 to 119 (Appendix A).

- Temporary catchment 9A is formed by the Construction Yard 8 – Alan Wood Park.

- Temporary catchment 9B is formed by the Construction Yard 9 – Alan Wood Park, and tunnel water and groundwater inflows after pre-treatment by an erosion and sediment control device, will also be directed to the temporary treatment device for catchment 9B.
- Temporary catchment 9C is the same as that for the permanent device TD9A and includes the impervious surface (SH20 Ch 1110 to the southern tunnel portal), with the addition of Construction Yard 10 - Alan Wood Park.
- Temporary catchment 9D is formed by the boundaries of Construction Yard 11- Hendon Park, Construction yard 12 – Valonia St and the catchment for permanent device TD9B (all impervious work areas between SH20 Ch 150 and 1110, and the Christ the King site).

7.12.2 Options Considered

Wetlands or wet ponds are the only options for treating runoff from the temporary stormwater catchments in Sector 9 due to the requirement to provide attenuation. The potentially high and variable sediment loading from construction yards can reduce the effectiveness of vegetated devices. Wet ponds have been selected as the BPO for this reason as well as for their durability and ease of construction. However, wetlands are the BPO when water inflows include those from construction processes involving concrete such as tunnel water and concrete batching plants as wetlands can buffer pH (refer to Section 7.3.1 for a discussion on BPO considerations for temporary stormwater treatment devices).

For compatibility with permanent devices, temporary devices CD9B and CD9C will be located in the same places as TD9A and TD9B respectively, with similar contouring to the proposed permanent wetland contouring. The outlet details for each will be adjusted to suit the temporary treatment requirements.

7.12.3 Best Practicable Options

CD9A – Southern Portal Yard Wet Pond

The proposed CD9A is shown on Drawing 20.1.11-3-D-D-350-117 (Appendix A). The catchment serviced by CD9A is Construction Yard 8 with an area of 0.95ha. The key operating levels and volumes are summarised in Table 7.13. The WQV is 197m³. The permanent volume of water in the wetland will be at least half of the WQV. The flood attenuation performance is summarised in Table 7.12. These values show that the peak flows are slightly larger than the predevelopment, this is because the whole area is Type A – Volcanic soils and has a CN of 39. However, across all four construction devices, sufficient attenuation is provided for in Sector 9.

Table 7.12: Peak flows for CD9A - Southern Portal Yard Wet Pond

| Parameter | 2 year ARI | 10 year ARI | 20 year ARI |
|---|------------|-------------|-------------|
| Pre-development catchment peak inflow | 0.02 | 0.05 | 0.06 |
| Post development catchment peak inflow | 0.12 | 0.19 | 0.23 |
| Post development wetland peak outflow | 0.01 | 0.05 | 0.07 |
| Attenuated peak flow as percentage of pre-development peak flow* ¹ | 75% | 105% | 110% |

*¹ Attenuated peak flow as a percentage of pre-development peak may vary as dependent on detailed design, Design criteria is for the post development peak outflow to be less than the pre-development peak outflow.

Table 7.13: Wet pond Design Geometry for CD9A –Southern Portal Yard Wet Pond

| Parameter | Elevation (mRL) | Area (m ²) | Volume (m ³) |
|--|-----------------|------------------------|--------------------------|
| Wetland Invert | 36.0 | 225 | - |
| Normal Water Level | 36.5 | 304 | 132 |
| Extended Detention Level | 37.3 | 465 | 443 |
| Maximum water level during 20 year ARI event | 37.9 | 742 | 750 |

CD9B – Vent Building Wetland

The proposed CD9B is shown on Drawing 20.1.11-3-D-D-350-117 (Appendix A). The catchment serviced by CD9B is Construction Yard 9 with an area of 1.34ha. The key operating levels and volumes are summarised in Table 7.15. The WQV is 445m³. The permanent volume of water in the wetland will be half of the WQV plus 300m³ (provision for tunnel water) with the remaining half of the WQV captured and released slowly as part of the extended detention volume. The flood attenuation performance is summarised in Table 7.14, which demonstrates that peak flows are attenuated to predevelopment levels for the 2 year, 10 year and 20 year ARI events.

Table 7.14: Peak flows for CD9B - Vent Building Wetland

| Parameter | 2 year ARI | 10 year ARI | 20 year ARI |
|---|------------|-------------|-------------|
| Pre-development catchment peak inflow | 0.02 | 0.06 | 0.09 |
| Post development catchment peak inflow | 0.16 | 0.27 | 0.32 |
| Post development wetland peak outflow | 0.02 | 0.05 | 0.07 |
| Attenuated peak flow as percentage of pre-development peak flow* ¹ | 74% | 82% | 84% |

*¹ Attenuated peak flow as a percentage of pre-development peak may vary as dependent on detailed design, Design criteria is for the post development peak outflow to be less than the pre-development peak outflow.

Table 7.15: Wet pond Design Geometry for CD9B –Vent Building Wetland

| Parameter | Elevation (mRL) | Area (m ²) | Volume (m ³) |
|--|-----------------|------------------------|--------------------------|
| Wetland Invert | 36.0 | 277 | - |
| Normal Water Level | 36.9 | 827 | 438 |
| Extended Detention Level | 37.3 | 941 | 839 |
| Maximum water level during 20 year ARI event | 37.9 | 1442 | 1439 |

CD9C- Temporary Alan Wood Wetland

The catchment, location and design for CD9C will be similar to that for TD9A (the permanent wetland), with Construction Yard 10 adding to the catchment area, and restricting the area available. The catchment area serviced by CD9C is 3.34ha. The proposed CD9C is shown on Drawing 20.1.11-3-D-D-350-117 (Appendix A). The key operating levels and volumes are summarised in Table 7.17. The WQV is 692m³. The permanent volume of water in the wetland will be 439m³ with the remaining volume for water quality treatment captured and released slowly as part of the extended detention volume. Groundwater inflow to the southern portal trench will also be pumped to CD9A. The flood attenuation performance is summarised in Table 7.16, which demonstrates that peak flows are attenuated to predevelopment levels for the 2 year, 10 year and 20 year ARI events.

Table 7.16: Peak flows for CD9C - Temporary Alan Wood Wetland

| Parameter | 2 year ARI | 10 year ARI | 20 year ARI |
|---|------------|-------------|-------------|
| Pre-development catchment peak inflow (m ³ /s) | 0.06 | 0.16 | 0.20 |
| Post development catchment peak inflow (m ³ /s) | 0.39 | 0.65 | 0.76 |
| Post development wetland peak outflow(m ³ /s) | 0.04 | 0.11 | 0.15 |
| Attenuated peak flow as percentage of pre-development peak flow* ¹ | 66% | 71% | 72% |

*¹ Attenuated peak flow as a percentage of pre-development peak may vary as dependent on detailed design. Design criterion is for the post development peak outflow to be less than the pre-development peak flow.

Table 7.17: Wet pond Design Geometry for CD9B – Temporary Alan Wood Wetland

| Parameter | Elevation (mRL) | Area (m ²) | Volume (m ³) |
|--|-----------------|------------------------|--------------------------|
| Wetland Invert | 37.3 | 275 | - |
| Normal Water Level | 38.1 | 982 | 439 |
| Extended Detention Level | 38.9 | 1404 | 1392 |
| Maximum water level during 20 year ARI event | 39.8 | 1846 | 2850 |

CD9D – Temporary Valonia Wet Pond

The proposed CD9D is shown on Drawing 20.1.11-3-D-D-350-118 (Appendix A). The catchment area serviced by CD9D is 15.29ha. The key operating levels and volumes are summarised in Table 7.19. The WQV for temporary catchment 9D is 2347m³. The permanent volume of water in the wetland will be 1499m³ with the remaining volume for water quality treatment captured and released slowly as part of the extended detention volume. The flood attenuation performance is summarised in Table 7.18, which demonstrates that peak flows are attenuated to predevelopment levels for the 2 year, 10 year and 20 year ARI events.

Table 7.18: Temporary Device 9C – Temporary Valonia Wet Pond

| Parameter | 2 year ARI | 10 year ARI | 20 year ARI |
|---|------------|-------------|-------------|
| Pre-development catchment peak inflow (m ³ /s) | 0.43 | 1.00 | 1.30 |
| Post development catchment peak inflow (m ³ /s) | 1.27 | 2.33 | 2.82 |
| Post development wetland peak outflow (m ³ /s) | 0.20 | 0.72 | 1.00 |
| Attenuated peak flow as percentage of pre-development peak flow* ¹ | 46% | 72% | 77% |

*¹ Attenuated peak flow as a percentage of pre-development peak may vary as dependent on detailed design. Design criterion is for the post development peak outflow to be less than the pre-development peak flow.

Table 7.19: Wet pond Design Geometry for CD9C –Hendon Wet pond

| Parameter | Elevation (mRL) | Area (m ²) | Volume (m ³) |
|--|-----------------|------------------------|--------------------------|
| Wetland Invert | 41.0 | 2727 | - |
| Normal Water Level | 41.4 | 4784 | 1499 |
| Extended Detention Level | 42.1 | 5822 | 5209 |
| Maximum water level during 20 year ARI event | 42.9 | 7032 | 10206 |

Provision for overland flow paths

The SH20 motorway alignment in Sector 9 intersects with existing overland flow paths draining from the Hendon Avenue vicinity. Swales have been proposed to convey flows in this area around the area of the motorway in cut, and the tunnel portal, to discharge to Oakley Creek during the operational phase of the Project. The BPO to provide for overland flow in this area during construction is to construct the proposed permanent drainage swales at the beginning of the construction period.

7.13 Stormwater Management for Concrete Batching Plants

7.13.1 Introduction

The Project will require the installation and use of two concrete batching plants during the period of construction. The concrete batching plants are required to supply shotcrete to the tunnel for liner construction and will be located at the northern and southern portals, in construction yards 6 and 10, respectively.

The runoff and waste water from these concrete batching plants will require extra treatment due to the high sediment loads and elevated pH; thus the runoff will need to be treated separately to that from the construction yards. The concrete batching yard will comprise of the “at risk” or “dirty” areas of the site whilst the remainder of the construction yard including the aggregate storage area, any covered storage of additives and general vehicle movement areas will be the “clean” areas.

Dirty water will be managed by reusing as much of that water as possible for concrete production. The waste water from the concrete batching plant, e.g. the truck washdown, and the runoff from the plant yard will be treated and stored onsite before either being reused or routed through construction yard stormwater wetlands for further water quality polishing prior to discharge. The storage/reuse tank will consist of a container modified for the removal of sediment and pH correction.

The runoff from the clean area will drain to the temporary stormwater treatment device for that particular construction yard for treatment (refer Section 7.8 for Construction yard 6 and Section 7.12 for Construction yard 10).

Full details of the concrete batching plant operations are described in the Concrete Batching and Crushing Plant Management Plan (CBCPMP) (Appendix F).

7.13.2 Methodology

For the southern portal concrete batching plant, dirty water consisting primarily of runoff will be contained onsite and stored in tanks. Excess dirty water will be pumped to the treatment devices to be used for treatment of tunnel water in the trench. The water will then be discharged through construction yard stormwater treatment wetlands for further water quality polishing prior to discharge.

The southern portal batching plant will be located within construction yard 10, which is adjacent to the motorway “trench”. The concrete trucks will be loaded within the motorway trench itself, with the concrete poured from the batching plant located above, outside the trench. Therefore, the site will have two dirty areas, comprising the concrete batching plant itself, as well as the truck loading area within the trench. The concrete batching plant will be located on a concrete pad, which will drain to the storage/reuse tank. Excess dirty water will be pumped to the tunnel water treatment device (located in the trench near the tunnel portal). The truck loading area within the trench will drain directly to the tunnel water treatment device. The truck load areas will also operate a truck wash-out area which will also be contained. A diagram of the southern portal layout is shown in Figure 7.1 below.

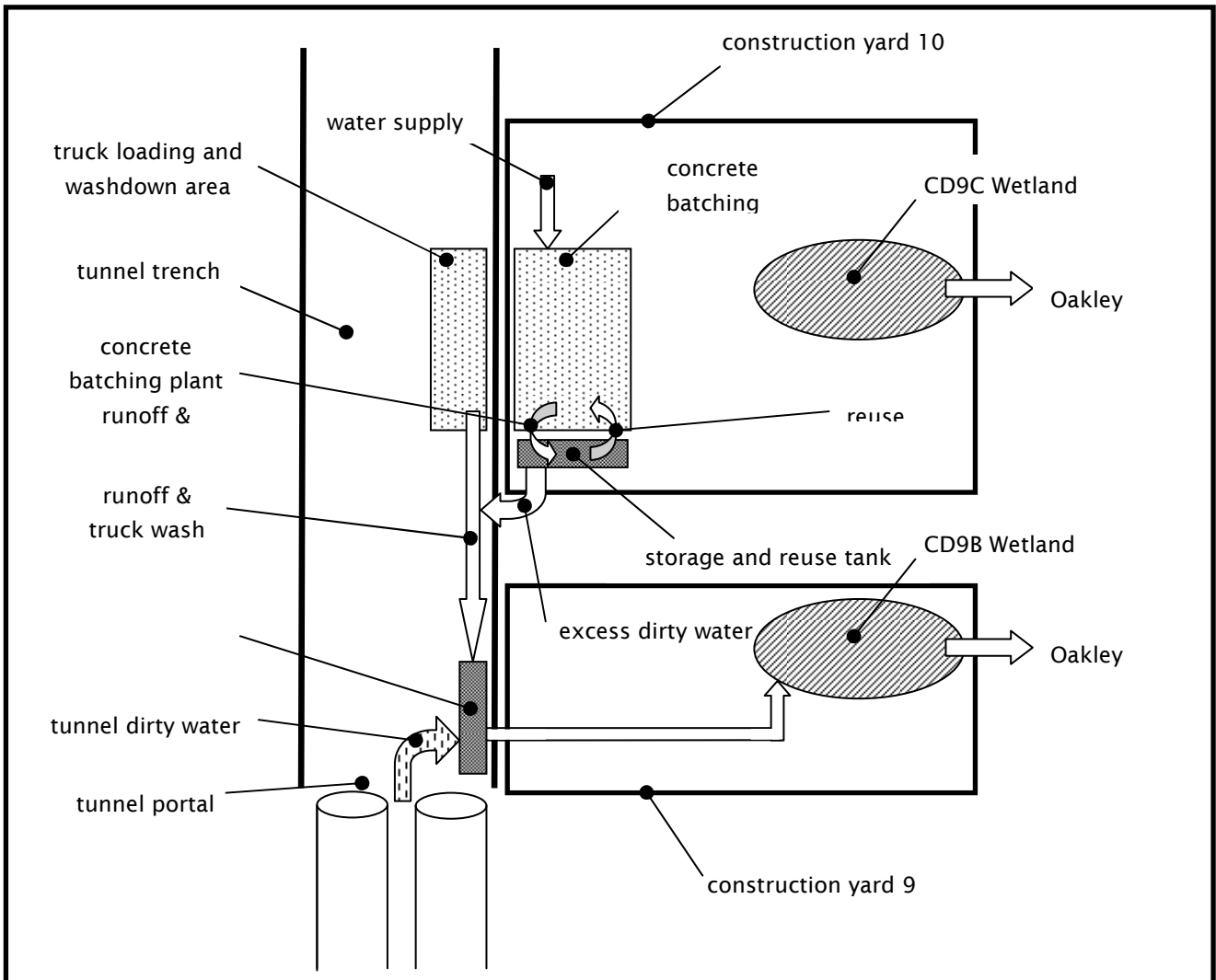


Figure 7.1: Southern portal concrete batching plant water process diagram

The northern portal will be located in construction yard 6 and will have a single dirty area, comprising the concrete batching plant itself as well as the truck loading area. The water from the concrete batching plant and the runoff from the plant yard, including the truck loading and washdown areas, will be treated and stored onsite in the storage/reuse tank before either being reused or discharged through the construction yard stormwater ponds.

7.13.3 Best Practicable Option

The size of the pads for the concrete batching plants will be 20m by 20m. This concrete pad will contain the mixing plant, the aggregate hoppers, cement silo, truck loading area and a truck washdown area. The pad will be surrounded by a mountable kerb to redirect runoff to the storage/reuse tank. The truck washdown area will be contained with a separate drain with grit and aggregates traps which will then connect to the treatment and

storage tank. A drawing of the concrete batching yard is shown in Drawing 20.1.11-3-D-D-365-211 (Appendix A).

The treatment tanks will be two converted 40ft containers which have been split into segments. The tanks will have multiple stages to allow sediment to settle out. The tanks will have a forebay containing 32m³ of water, dead storage of up to 62m³ of for normal use and will have an additional available storage of 40m³ to contain runoff from a 100mm rainfall event. In the event that a storm event larger than 100mm occurs, the tanks will be pumped to the tunnel water treatment devices and construction stormwater ponds for additional treatment before discharging into the receiving environment. A drawing of the treatment tanks is shown in Drawing 20.1.11-3-D-D-365-212.

Drawings showing possible locations for the northern and southern concrete batching plants can be found in Plan set F.2, Drawing No. 20.1.11-3-D-C-913-106 and 20.1.11-3-D-C-913-110 (also in CBCPMP, Appendix F). A stormwater monitoring programme is proposed for the concrete batching plants, refer to the CBCPMP (Appendix F). This will include continuous turbidity and pH monitoring of stormwater discharges at the point of discharge to the natural environment.

7.14 Flood Effects during Construction

Flooding of construction work areas during the construction phase is undesirable as potentially contaminants from these areas can be washed into the watercourse and discharged into the receiving environment. For this reason proposed construction working areas are located out of the 100 year ARI flood plain, with the exception of Construction Yard 7 in Hendon Park. It is proposed to provide a bund to exclude this area from the 20 year ARI flood plain, and restrict activities in this work yard to exclude stockpiling of spoil and granular materials. Refer also to Technical Report No G.22 *Erosion and Sediment Control Plan* for management methodology for works in the flood plain.

7.15 Summary Assessment of Effects of Stormwater Discharge Construction Phase

An assessment of the effects of the stormwater aspects of the Project during the construction phase has been carried out. This section provides a summary of the stormwater quality and quantity treatment outcomes for the proposed temporary stormwater system design to meet assessment criteria set out in relevant planning documents (summarised in Table 4.1). A discussion of the BPO selection process and influence of relevant planning objectives and policies on the proposed design is outlined in Section 6.2 and 7.3.

In addition to the assessment provided in the this section, the effects of stormwater and in particular residual contaminants (after treatment) and change in stormwater flows, are assessed in the following reports:

- Waterview Connection Project: Technical Report No G.6 *Assessment of Freshwater Ecological Effects*
- Waterview Connection Project: Technical Report No G.11 *Assessment of Marine Ecological Effects*
- Waterview Connection Project: Technical Report No G.4 *Assessment of Coastal Processes*

7.15.1 Water Quality Treatment

During the construction phase, stormwater generated is likely to be higher in suspended sediments than that generated during the operation phase, but lower in other pollutants such as heavy metals and hydrocarbons. The stormwater will be generated from the areas of motorway under construction and from construction yards. While these areas are temporary, they still have the potential for adverse environmental effects, so water quality treatment is to be provided where practicable.

The criterion that water quality treatment design is measured against is the requirement to remove at least 75% of TSS loads on an average annual basis for any additional impervious areas, and for any areas for which treatment is currently provided. This is the level of treatment required by the PARP:ALW to minimise the potential effects of stormwater discharge on the environment. Design guidance for devices that achieve this standard is contained within TP10. Subsequent planning documents for the Auckland region adopt TP10 in relation to stormwater.

Stormwater treatment during construction is proposed using stormwater management measures in accordance with TP10. However, for some areas such as motorway widening, there are low levels of pollution generation, and no viable options for stormwater treatment for the construction period. In these areas the BPO has been to retain erosion and sediment discharge control measures. In all areas the permanent stormwater treatment measures will be in place and operational before the road is open for public vehicular traffic.

In areas of SH16 to be widened there is little existing stormwater treatment for the existing motorway. The motorway widening has created the opportunity to provide stormwater treatment for not just the additional impervious surface, but also the existing impervious areas of the motorway. In these areas the overall level of treatment during motorway operation will be much higher than existing, so there is an enhancement in these areas of the stormwater treatment. This is considered to provide some mitigation for the lack of stormwater treatment for motorway widening areas during construction.

Table 7.20 summarises the existing and additional impervious areas within the Project for each of the Sectors, and summarises the areas for which removal of 75% of TSS loads on an average annual basis will be achieved during construction. Where temporary stormwater catchments change throughout the construction phase, an assessment of the likely average area with treatment provided has been made. The construction yards for each Sector have been reported in the table separately from the rest of the motorway catchment as these areas have high contaminant generation potential and variability, and will be reinstated to clean water catchments before the operational phase of the Project. The minimum level of treatment is 75% removal of TSS for the additional impervious areas, and maintaining treatment for those existing areas for which treatment is currently provided. Stormwater quality treatment of existing impervious areas, for which treatment is not currently provided, helps to mitigate the potential effects of stormwater discharge to the environment and is considered to be a Project enhancement. Where there are areas of pervious surface, the runoff from which cannot practically be separated from that of the impervious motorway, these areas have been added to the new stormwater systems, and the treatment devices proposed are sized accordingly.

Across the Project there are 22.25ha of additional impervious areas of motorway catchment proposed for the construction phase of the Project, of which it is proposed to provide treatment for 15.73ha or 70.7%. In addition, there are 16.93ha of area proposed for construction yards, 100% of which will be treated. There is in

total 33.49ha of existing motorway for which treatment to TP10 standards was consented for 9.9%, and it is proposed to maintain or provide treatment to TP10 standards for approximately 21.7% of these areas during construction.

Table 7.20: Summary of Motorway Catchment Areas with Water Quality Treatment during Construction Phase

| Sector | Existing Impervious | | | Additional Impervious | | Total | |
|---|---------------------|------------------------------|-------------------------------|-----------------------|-------------------------------|--------------|-------------------------------|
| | Area (ha) | Percentage currently treated | Percentage proposed treatment | Area (ha) | Percentage proposed treatment | Area (ha) | Percentage proposed treatment |
| Sector 1 – Motorway catchment | 8.05 | 1.7 % | 0 % | 3.67 | 11.3 % | 11.72 | 4.4 % |
| Sector 2 – Motorway catchment | 1.45 | 0 % | 0 % | 0.72 | 0 % | 2.17 | 0 % |
| Sector 3 – Motorway catchment | 3.88 | 0 % | 13.6 % | 1.47 | 0 % | 5.35 | 9.9 % |
| Sector 4 – Motorway catchment | 8.37 | 13.9 % | Ranges from 18% to 70% | 3.40 | 100% | 11.77 | Ranges from 35% to 100% |
| Sector 5 – Motorway catchment | 6.62 | 30.3% | 30.3% | 3.43 | 100 % | 10.05 | 54% |
| Sector 6 – Motorway catchment | 4.08 | 0 % | 0 % | 1.07 | 0% | 5.15 | 0 % |
| Sector 7 – Motorway catchment | na | na | na | na | na | na | na |
| Sector 8 – Motorway catchment | na | na | na | na | na | na | na |
| Sector 9 – Motorway catchment | 1.04 | 0% | 100% | 8.49 | 100% | 9.53 | 100% |
| Total Project Motorway Catchment | 33.49 | 9.87% | 21.67% | 22.25 | 70.72% | 55.74 | 41.25% |

Table 7.21: Summary of Construction Working Catchment Areas for Water Quality Treatment during Construction Phase

| Sector | New Impervious Construction Working Catchments | |
|---|--|-------------------------------|
| | Area (ha) | Percentage proposed treatment |
| Sector 1 - Yard 1 | 4.20 | 100 % |
| Sector 2 | na | na |
| Sector 3 - Yard 2 | 0.37 | 100 % |
| Sector 4 | na | na |
| Sector 5- Yards 3 & 4 | 7.78 | 100% |
| Sector 6- Yard 5 | 1.22 | 100% |
| Sector 7- Yards 6 & 7 | 1.90 | 100% |
| Sector 8- | na | na |
| Sector 9- Yards 8, 9, 10, 11 & 12 | 4.99 | 100% |
| Total Project Construction Catchment | 20.46 | 100% |

By adopting a BPO approach to stormwater treatment during the construction phase to meet the requirements of the Proposed Auckland Regional Plan: Air, Land and Water for all of the new impervious areas, the effects from stormwater discharge on the receiving environment have been minimised. The effects of residual contaminants and change in stormwater flows are assessed in Technical Report No G.6 *Assessment of Freshwater Ecological Effects* and Technical Report No G.11 *Assessment of Marine Ecological Effects*.

7.15.2 Erosion Control

The criterion for erosion control requires that all outfall discharges that are likely to cause scour at the outfall incorporate erosion control measures. For many of the temporary treatment devices, which will be adapted to permanent devices for the operational phase, it is proposed to construct the outfall configuration proposed for the permanent device.

Energy dissipation and erosion control measures are proposed at all treatment device outfalls for the construction phase of the Project. A summary of the treatment devices and proposed erosion control measures is shown in Table 7.22 below. For a discussion of the merits of each measure and a BPO discussion refer to Section 6.2.2.

Through provision for erosion control measures at all outfalls, the potential adverse effects on the surrounding environment from erosion or scour at discharge points during the construction phase of the Project have been avoided.

Table 7.22: Summary of Stormwater Outfalls for Construction Phase and Erosion Control Measures

| Treatment Device | 20 yr ARI peak discharge (m ³ /s) | Receiving Environment | Proposed Erosion Control Solution |
|--|--|---|--|
| CD1A : Yard 1 (Orangahina Park) Wet pond | 1.19 | To swale along Te Atatu EB on-ramp and into Whau River at western bridge abutment | Rock lined swale (ALD 200mm x 10m long) |
| CD3A : Patiki Rd off ramp cartridge filter | 0.06 | North of Rosebank Domain into the CMA | Ø300mm outlet pipe, wing wall and rock revetment apron (ALD 100mm x 3m long) |
| CD3B : Rosebank Rd off ramp cartridge filter | 0.03 | East of Rosebank Peninsula into Whau River tidal flats | Ø300mm outlet pipe with flap valve, wing wall and rock revetment apron (ALD 100mm x 2m long) |
| CD3C : Rosebank Rd on-ramp cartridge filter | 0.06 | North of Rosebank Peninsula into east of Pollen Island into CMA | Ø300mm outlet pipe with flap valve, wing wall and rock revetment apron (ALD 100mm x 3m long) |
| CD3D : Yard 2 (Patiki) Wet pond | 0.09 | West of Rosebank Peninsula into Whau River tidal flats | Ø300mm outlet pipe, wing wall with rip rap rock apron (ALD 100mm x 4m long) |
| CD4A : Eastbound outer sand filter trench | 0.036 | Northern side of causeway at 60m centres into the CMA | Ø225mm outlet pipe onto rock revetment apron |
| CD4B : Eastbound inner sand filter trench | 0.027 | Northern side of causeway at 120m centres into the CMA | Ø225mm outlet pipe onto rock revetment apron |
| CD4C : Eastbound 3m grassed filter strip | 0.36l/s per metre wide strip | Northern side of causeway as sheet flow | Rock revetment apron |

| | | | |
|---|-------|--|--|
| | | into the CMA | |
| CD4D : Westbound inner sand filter trench | 0.035 | Southern side of causeway at 100m centres into the Waterview Estuary | Ø225mm outlet pipe onto rock revetment apron |
| CD4E : Westbound outer sand filter trench | 0.050 | Southern side of causeway at 100m centres into the Waterview Estuary | Ø225mm outlet pipe onto rock revetment apron |
| CD5A - Temporary Contractors' West Interchange Wet pond | 0.360 | Existing Ø700mm culvert | Ø450mm outlet pipe onto existing Ø700mm culvert |
| CD5B - Temporary Waterview Park Wet pond | 1.570 | Oakley Inlet | Ø600mm outlet pipe into Ø3000 stilling manhole and rip rap rock apron |
| CD6A - Temporary Meola Wet pond | 0.585 | Meola Creek | Ø1350mm outlet pipe into existing wing wall/headwall |
| CD7A - Temporary GNR Diversion Cartridge Filter | 0.095 | Existing Great North Road stormwater system | Ø375mm outlet pipe into existing system |
| CD7B - Temporary Northern Portal East Wet pond | 0.370 | Oakley Creek | Ø525mm outlet pipe into Ø1050 stilling manhole and rip rap rock apron |
| CD9A - Southern Portal Wet pond | 0.680 | Oakley Creek | Ø300mm outlet pipe into Ø1050 stilling manhole and rip rap rock apron |
| CD9B - Vent Building Wet pond | 0.080 | Oakley Creek | Ø300mm outlet pipe onto rip rap rock apron |
| CD9C- Alan Wood Wet pond | 0.190 | Oakley Creek stream realignment C | As per permanent case: Ø450mm outlet pipe with wing wall and rip rap rock apron (ALD 100mm x 1.2m long) |
| CD9D - Valonia Wet Pond | 1.000 | Oakley Creek stream realignment B | As per permanent case: Ø600mm outlet pipe with wing wall and rip rap rock apron (ALD 500mm x 4200m long) |

7.15.3 Water Quantity Treatment

Attenuation of peak flows has been provided within treatment devices which discharge to Oakley Creek during the construction phase of the Project. Attenuation within the wetlands is proposed by providing storage, and detailing outlet configurations. The proposed treatment devices would limit the 2 year, 10 year and 20 year ARI post-development events to not be greater than the corresponding peak flows for pre-development events. This outcome reduces peak flows to meet the requirement of clause (i) of the assessment criteria (Refer to Section 6.11.3).

An assessment of the potential benefit of providing attenuation of construction peak flows to discharge to Meola Creek was undertaken. It was found that attenuating, and therefore delaying the peak flows from the local motorway catchment, would increase the peak flow in Meola Creek due to coincidence with peak flows from further up the catchment, due to the discharge point being within the lower reaches of the stream. Therefore, not providing attenuation within the Meola wetland is the BPO approach.

The volume of stormwater runoff for post-development events has been minimised as far as possible by limiting impervious catchment sizes for the Project. The adoption of a tunnel for much of the alignment minimises the impervious area of surface motorway. Infiltration to ground was considered as an option for stormwater quantity treatment, however this is not considered practicable for the flow rates generated by the subcatchments. In this way clause (ii) of the assessment criteria has been met (Refer to Section 6.11.3).

The criterion applied to minimise erosion of the downstream stream channel where discharges are to a stream environment is set by the TP10 as the controlled release of the runoff generated in a rainfall event of 34.5mm, over a 24 hour period. This is known as 'extended detention'. Extended detention has been provided for all stormwater discharges to stream environments within the Project, minimising the potential for erosion of the downstream channel in these environments.

The criteria for stormwater quantity treatment have been met by the proposed treatment devices. A summary of the water quantity criteria achieved by each of the proposed construction stormwater treatment devices is summarised in Table 7.1.

7.15.4 Overland Flow

Provision of overland flow paths is an assessment criterion in the ARC PARP:ALW, (refer to Section 6.11.4). Existing stormwater overland flow paths will be maintained during construction. In Sector 9 overland flow paths for the 100 year ARI rainfall event intersect the proposed SH20 motorway alignment, and in this area it is proposed to construct the proposed permanent overland flow diversion swales before excavation of the motorway alignment.

In this way the criterion to avoid potential effects on the environment from overland flow is met.

7.15.5 Aesthetics and Odour

The criterion to assess the effects of aesthetics and odour is defined in the RMA Section 107 as follows;

“...a consent authority shall not grant a discharge permit...

...if after reasonable mixing, the contaminant or water discharged (either by itself or in combination with the same, similar, or other contaminants or water), is likely to give rise to all or any of the following effects in the receiving waters:

- c. The production of any conspicuous oil or grease films, scums or foams, or floatable or suspended materials:*
- d. Any conspicuous change in the colour or visual clarity:*
- e. Any emission of objectionable odour:”*

The stormwater generated from the areas of motorway under construction and from construction yards will be treated to remove 75% TSS and associated pollutants, as detailed in Table 7.1. Areas that are not to be treated have a lower risk of stormwater pollution and will be managed by a continuation of erosion and sediment control measures. By these controls, and after mixing, no conspicuous change to the receiving waters is expected. Similarly, no emission of objectionable odour is expected. The AMA report no complaints or problems with odour from stormwater treatment devices on the Auckland Motorway network (pers. comms. Peter Mitchell, AMA). Therefore, there are no adverse environmental effects expected due to aesthetic changes or odour from stormwater discharges.

8. Effects Assessment: Streamworks

The proposed SH20 motorway alignment in Sector 9 crosses the existing Oakley Creek alignment a number of times in Hendon Park and Alan Wood Reserve. For a description of Oakley Creek in the vicinity of the Project refer to Section 5.9.

Consideration of the effects on the Oakley Creek were taken into account during selection of the proposed SH20 alignment (refer to the Assessment of Environmental Effects). The proposed alignment intersects the stream alignment at approximately SH20 Ch 1060m, requiring a stream crossing of the motorway. Downstream of this point three sections of realignment of the stream course, and four sections of stream rehabilitation are proposed. The realignments are necessary where the stream course clashes with the proposed surface motorway alignment, or proposed sports grounds.

In these areas the existing stream is channelised in many portions with manmade basalt rock walls. The proposed stream realignments and rehabilitations are based on a naturalised channel form, and will increase and enhance the aquatic and terrestrial habitat, and make the stream more amenable and accessible to the public. In addition, the proposed Project structures interact with the 100 year ARI flood plain, and this is to be mitigated by hydraulic design to ensure that effects of flooding are minimised.

The approach to streamworks was developed and is expressed in the Western Ring Route: Oakley Creek Re-alignment and Rehabilitation Guidelines (appendix in Technical Report No G.11). These guidelines were developed by Project ecologists, landscape architects and engineers and propose a set of integrated principles for ecological function, landscape values and stream hydraulics.

During design of the streamworks, the following objectives were incorporated:

- To preserve the function of the flood plain and not exacerbate flood effects elsewhere
- To mitigate the effects of the motorway on the stream and in fact enhance the stream hydraulics, ecology and amenity
- To ensure the 100 year ARI flood flow does not compromise the SH20 carriageway
- To ensure an extreme rainfall event such as the 2500 year ARI event can be managed while minimising risk to human life and infrastructure.

Refer to Section 3.4 for a description of the streamworks design methodology. Section 8.1 presents the BPO proposed streamworks design. Section 8.2 outlines some of the alternatives considered and Sections 8.3 and 8.4 provide an assessment of effects of the streamworks, and of the effects of the Project on Oakley catchment flooding respectively. Section 8.5 outlines the requirements for flood management in extreme events.

For the construction methodology refer to Technical Report No G.22 *Erosion and Sediment Control Plan*.

For the ecological assessment of the Oakley Stream realignments refer to Technical Report No G.6 *Assessment of Freshwater Ecological Effects*. This report focuses on the design process, describing the proposed solution and the hydraulic effects.

8.1 Proposed Streamworks

8.1.1 Outline

The proposed Oakley Creek streamworks for the Project involve;

- Oakley Creek SH20 Bridge located at approximately SH20 Ch 1060m and associated realignments of Oakley Creek and the Stoddard Road tributary. The works include the enabling abutments for the future rail corridor bridge and the cycleway bridge immediately downstream of the motorway bridge.
- Construction of SH20 motorway in areas of Oakley Creek floodplain.
- Realignment of the creek for three discrete lengths in Alan Wood Reserve; Stream realignments A, B & C.
- Rehabilitation of the stream in four reaches, upstream of, downstream of and between the proposed realignment sections; stream rehabilitations A, B, C & D. Rehabilitation will include removing constructed stone walls, increasing channel cross-section to improve flood conveyance capacity, and enhancement of habitat and amenity values. Rehabilitation is included to provide continuity between realigned sections. These are expected to form part of the offset mitigation for streamworks.
- Realignment of the Stoddard Road tributary to be undertaken when necessary in the future for railway development.
- Retention of the Goldstar property (25 Valonia Street) for use for stormwater treatment and active recreation (sports fields). Floodplain storage that would have otherwise have been lost to consented development will be maintained.
- Construction of the cut and cover tunnel adjacent to Oakley Creek (SH20 Ch 3860 to 3900), over a short reach in Oakley Reserve, necessary to support the southbound cut and cover tunnel structure (Sector 7).

These works are described in detail in the following Sections.

8.1.2 Oakley SH20 Bridge

Where the SH20 alignment intersects with Oakley Creek at approximately SH20 Ch 1060 and approximately Oakley Creek Ch 5900, a motorway bridge is proposed. Refer to Drawings 20.1.11-3-D-D-330-210 (Appendix A).

The channel below the bridge will consist of a low flow channel 5m wide by 1m high, with 1:1 side slopes, and a high flow channel 12m wide with vertical sides in the form of the bridge abutments walls. The channel will need to be stabilised with rock or an alternative erosion resistant liner, as the area will be in the light and rain shadow of the bridge, so stabilisation with vegetation is not viable. Natural substrates will be used in the channel base for aquatic habitat. Fish passage will not be affected by the bridge.

The required bridge span is 12m refer to Drawing 20.1.11-3-D-S-635-200 (Appendix A) for details. Two bridges are proposed- a road bridge 38m wide and a rail bridge 10.5m wide, the latter being constructed at the time of the railway. It is proposed that the continuous abutment walls (for both bridges) are constructed as part of the Project. The soffit of the bridge is proposed to be a minimum of 0.6m above the 100 year ARI flood level.

A cycleway bridge will be constructed immediately downstream of the Oakley SH20 bridge. The cycleway bridge will be designed with span and soffit levels which do not impede the hydraulics of Oakley Creek during normal or flood flows.

8.1.3 Proposed Realignment and Rehabilitation

The proposed stream works that are located in Sector 9 are shown in Figure 8.1 and summarised in Table 8.1. For details refer to Drawings 20.1.11-3-D-D-330-210 (Appendix A).

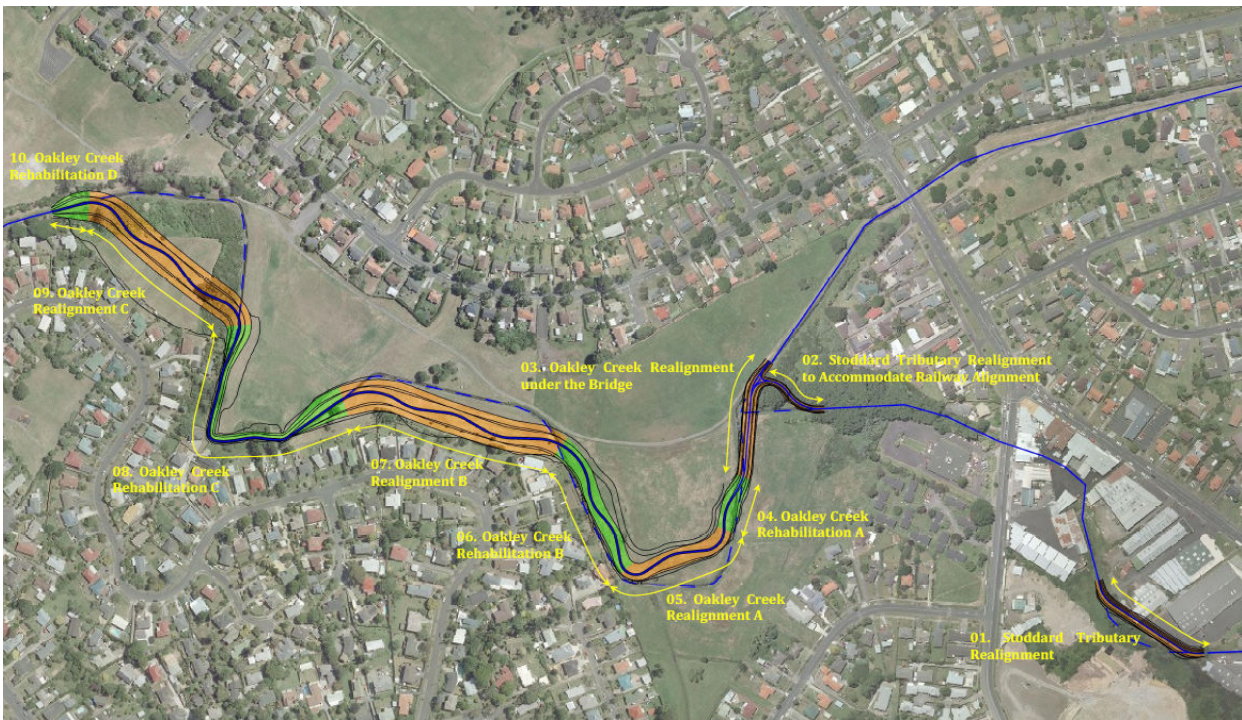


Figure 8.1: Proposed realignment and rehabilitation of Oakley Creek and Stoddard Road Tributary

Table 8.1: Summary of realignment and rehabilitation of Oakley Creek and the Stoddard Road Tributary

| Number (refer Fig 8.1) | Stream Section | Existing Creek Length (m) | Proposed Stream Length (m) | Change in Length (m) | Stream rehabilitation Typology*1 |
|------------------------------|--|---------------------------------|----------------------------------|-------------------------|---|
| 1 | Stoddard Tributary Realignment | 138 | 127 | -11 | Typology B |
| 2 | Stoddard Tributary Realignment to Accommodate Railway Alignment | 79 | 71 | -8 | Typology B |
| 3 | Oakley Creek Realignment under the Bridge | 125 | 124 | -1 | Inlet channel as Typology B. Plus Bridge Section. |
| 4 | Oakley Creek Rehabilitation A | 49 | 48 | -1 | Typology B/E |
| 5 | Oakley Creek Realignment A | 148 | 114 | -34 | Typology B/E |
| 6 | Oakley Creek Rehabilitation B | 135 | 141 | +6 | Typology E |
| 7 | Oakley Creek Realignment B | 230 | 214 | -16 | Typology B |
| 8 | Oakley Creek Rehabilitation C | 228 | 228 | 0 | Typology C/D |
| 9 | Oakley Creek Realignment C | 287 | 220 | -67 | Typology B |
| 10 | Oakley Creek Rehabilitation D | 31 | 31 | 0 | Typology A |
| | Total | 1450 | 1318 | 132 | N/A |

*1 Typologies are based on Western Ring Route: Oakley Creek Re-alignment and Rehabilitation Guidelines (appendix in Technical Report No G.11) and are described in the Section 8.1.2

8.1.4 Realignment Typologies

The proposed typologies for the realignments and rehabilitations were developed in the Western Ring Route: Oakley Creek Re-alignment and Rehabilitation Guidelines (appendix in Technical Report No G.11). The typologies describe how different stream reaches will be rehabilitated depending on the existing environment, whether the section is realigned and/or rehabilitated and other constraints/environmental considerations such as creation of a local wetland.

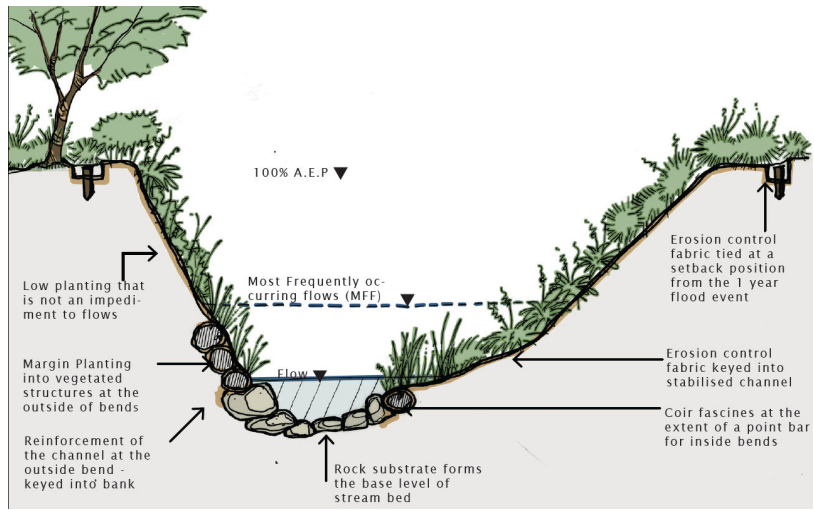
Table 8.2: Typologies for realignment and rehabilitation of Oakley Creek and Stoddard Road Tributary (from Oakley Creek Re-alignment and Rehabilitation Guidelines (Boffa Miskell, 2010))

| Typology | Description | Sketch |
|---|---|--------|
| Rehabilitation of Natural Stream Channel - Typology A | Rehabilitation of existing stream including biotechnical stabilisation of banks, riparian planting restoration of habitats. | |

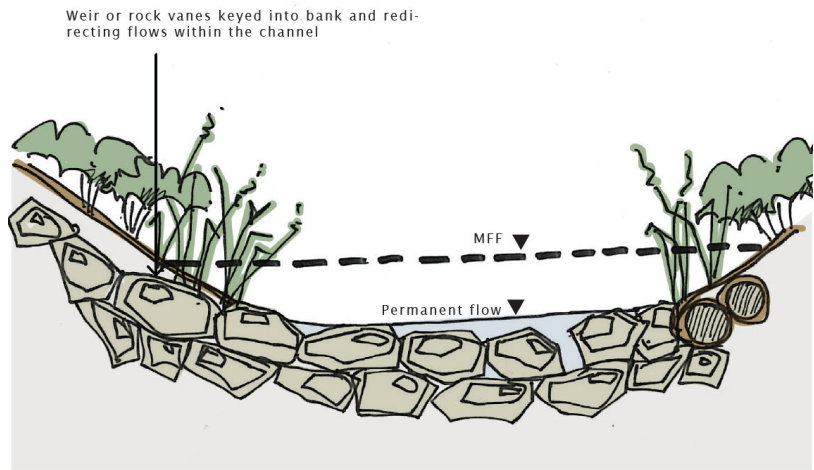
Realigned Stream Channel - Typology B

Realignment of stream using a naturalised channel consisting of meander, riffle-run-pools sequences.

Indicative Pool Section

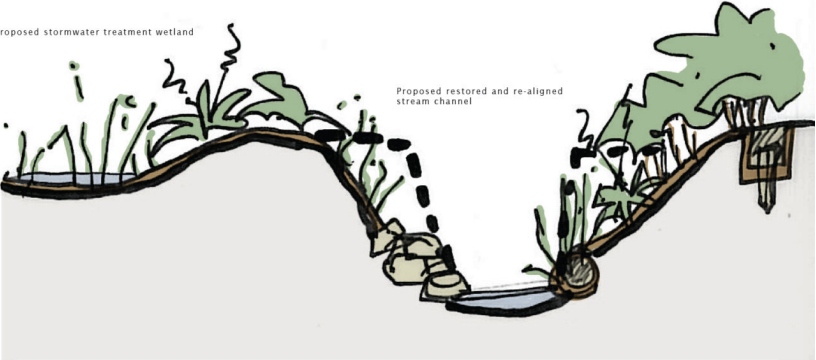


Indicative Riffle Section



Indicative Run Section

| | | |
|---|--|--|
| | | |
| <p>Channel Rehabilitation (Remove Walls) - Typology C</p> | <p>Rehabilitation in areas where existing channel is constrained within straight basalt walls. Rehabilitation utilises biotechnical treatments to restore a natural stream bank profile. Use of rock to create meanders and flow variations. Riparian planting on restored stream banks.</p> | |
| <p>Channel Rehabilitation (Maintain Walls) - Typology D</p> | <p>Keep the basalt walls on the outside bends and in areas of high velocity and flow energy. Retained walls also provide example of this heritage</p> | |

| | | |
|---|---|--|
| | <p>element. Reduce height of inside walls to increase flood capacity.</p> | |
| <p>Channel Rehabilitation (Wetlands) - Typology E</p> | <p>Similar to Typology C, but in areas adjacent to wetlands design and plant for continuous riparian area between stream and wetland.</p> |  |

8.1.5 Realignment Details

The detailed plans and cross sections for the proposed realignments and rehabilitation are shown in Drawings 20.1.11-3-D-D-330-210 to 219 (Appendix A). The typical plan form of the proposed naturalised realignment channel is shown on Drawings 20.1.11-3-D-D-330-201, with the cross sections on Drawings 20.1.11-3-D-D-330-202 (Appendix A). Features of the proposed realignment design include:

- A low or normal flow channel which meanders in plan within the stream banks.
- In-stream heterogeneity via riffle-run-pool, riffle sequences and complexity via rock placement.
- Cross sectional profile that resembles a natural staged channel, including a permanent flow channel, with stream banks based on the two year event.
- Bed material consisting of cobbles. Infilling of naturally occurring silts into deeper pool areas is expected.
- Floodplains and berms to hold the 100 year ARI flood flow with a minimum freeboard of 0.5m within the realignment cross section.
- Planting of stream banks and floodplain to provide stream shading to reduce in-stream macrophytes, improve stream hydraulics, enhance aquatic habitat and contribute to slope stabilisation.
- Visual and physical public access to the stream.

The proposed stream realignments and rehabilitations are based on a naturalised channel. A meander type channel is proposed with run-riffle-pool sequences. A low gradient stream such as Oakley Creek would tend to meander if left to nature (Shields et al 1996). Meanders are observed in the downstream section of Alan Wood Reserve although these may be influenced by geological features, as basalt strongly influences channel alignment in this area. The proposed meander ratio (arc length [half wavelength] divided by channel width) ranges from 3.5 to 4.5 which is at the lower end of the range observed in nature of 4-9 (Shields et al 1996), but greater than those observed in the downstream section of Alan Wood Reserve.

Run-riffle-pool sequences combined with the meander will provide heterogeneity to the flow and add complexity to the aquatic environment. The channel is low gradient typically at 0.3%, so there is a limit to the number of riffles (which are flat weir type structures) than can be placed in the stream. These are proposed every one or two inflection points, where the flow crosses over into the start of another arc. Pools naturally form on the outside of bends and these will be created with some local deepening of the channel in these areas. The proposed channel types are suitable for the expected fish species, being long and short fin eel. Fish passage will not be affected by the proposed stream realignments.

The materials to be used will be natural. Basalt material from the existing basalt walls will be recovered (where sequencing allows) and used to form erosion protection at the toe of banks, riffles and rock placed elsewhere in the channel for interest and additional flow complexity. Biotechnical engineering techniques will be used where possible using fascines or compost socks, soil lifts and geotextiles fabric in combination with planting.

8.1.6 Construction of the cut and cover tunnel in Oakley Reserve

The proposed cut and cover tunnel is in close proximity to Oakley Creek over a short reach in Oakley Reserve, SH20 Ch 3860 to 3900 (Sector 7), refer to Drawings 20.1.11-3-D-D-300-114 (Appendix A) for location.

Figure 8.2 below shows a section through this area at SH20 Ch 3880. The cut and cover tunnel is required at this location because of the shallowness of the tunnel vertical alignment and ground conditions. The impact of the cut and cover tunnel on the floodplain has been mitigated by lowering the top level of the cut and cover tunnel, which reduces the covering fill on the creek side. This requires an earthworks cut of up to 5m deep and a retaining wall adjacent to Great North Road.

The cut and cover tunnel requires a small amount of fill in the Oakley Creek floodplain to cover the structure. The cross section of fill in the floodplain has an area of approximately 9m² at Ch 3880, or an estimated volume of 360m³ based on a 40m length. This is a relatively small volume and the Oakley Creek floodplain at this location is wide, so this reduction in the floodplain volume will not significantly affect water levels. Furthermore, there are no buildings or infrastructure in the vicinity of the proposed activity that would be affected by minor changes to flood water levels.

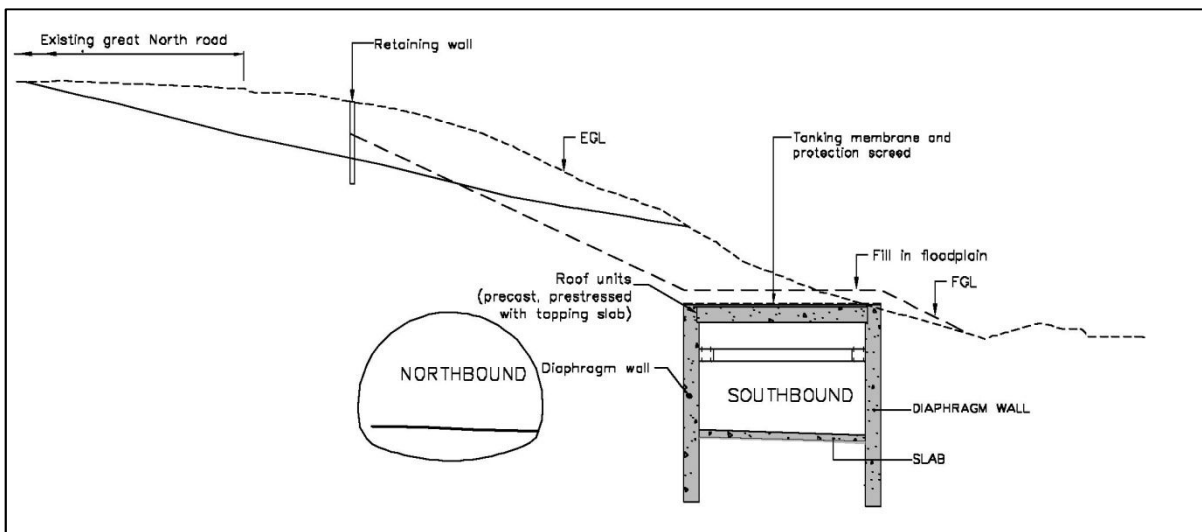


Figure 8.2: Cut and cover adjacent to lower Oakley Creek at SH20 Ch 2880.

8.1.7 Flood Protection Works

The Project will implement flood protection works for the motorway and tunnel in Sector 9. Refer to Drawing 20.1.11-3-D-D-330-210 (Appendix A) for indicative positions. These will be designed in accordance with the design approaches/standards detailed in Table 8.3. Design approaches/standards are recommended at this stage rather than absolute levels because decisions are still to be made regarding flood management in the Oakley Catchment by Auckland City Council/Metrowater. Refer to Section 8.5 for development of these design approaches/standards, which was based on the flood risk and modelling of likely design scenarios.

Table 8.3: Design approach for flood protection works

| Area | Approach |
|--|---|
| Northern side of Motorway (Hendon Avenue area of Alan Wood Reserve) | Set motorway levels or design flood defences for expected 100 year ARI flood level plus 500mm freeboard (provided that 2500 year ARI event can be conveyed within the freeboard). |
| Southern side of Motorway upstream of cascade in Oakley Creek for Alan Wood Reserve and Goldstar Property areas (Including Valonia Wetland, Realignments A and B and Rehabilitations A and B sections) | |
| SH20 Bridge | As above but 600mm freeboard to bridge soffit. |
| Southern side of Motorway downstream of cascade in Oakley Creek (in the vicinity of Realignment C, and ensuring protection of the southern portal) | Set flood defences above backwater from railway overland flow path (considering 2500 year ARI events and culvert blockage) with 500mm freeboard. |

8.2 Options Considered

The following sub sections outline some alternative options that were considered for various aspects of streamworks design, and the reasoning behind the solution outlined above being selected as the Best Practicable Option.

8.2.1 Stream Crossing and Realignment Options

A number of options were considered and evaluated for the streamworks required for the motorway crossing of Oakley Creek and the stream realignments in the Alan Wood Reserve area (Sector 9). These were as follows:

Option 1 - Stream realignment along the northern side of the motorway

The option of realigning Oakley Creek to run along the northern side of the motorway with a culvert/bridge at Ch 1200, or along the full length of motorway past the southern portal was considered but rejected for the following reasons:

- A principle of the Western Ring Route: Oakley Creek Re-alignment and Rehabilitation Guidelines (appendix in Technical Report No G.11) was to limit the extent of stream re-alignment to the extent practicable. A diversion of Oakley Creek along the northern side of would be longer than other options and therefore contrary to this principle.
- The realignment of Oakley Creek along the northern side of the motorway would be excavated in basalt and there would be greater risk of leakage from the stream effecting low flows in Oakley Creek and potentially increasing groundwater inflows to the motorway trench (approach to the portal).
- Stormwater drainage that discharges currently to Oakley Creek (to the south of the motorway) would be disconnected from the realigned Oakley Creek located north of the motorway. This would include a major catchment from Valonia Street, so an open drain or piped system would need to be constructed to collect these stormwater systems to divert them to the relocated Oakley Creek.
- The realigned stream would be separated from the existing flood storage area within the Goldstar property (refer to Figure 8.3 for location).

Option 2 - Realignment of stream within Goldstar property

This option involved a culvert/bridge at Ch 1100 for the motorway crossing of Oakley Creek (refer to Figure 8.3). The stream would be realigned adjacent and parallel to the motorway. The realignment would be similar to a realignment that has already been consented as part of development plans for the Goldstar property (refer to Figure 8.2 for location). The advantages include:

- Good hydraulic performance by shortening and steepening the stream result in lower water levels during floods.

The disadvantages include:

- This option would be contrary to the principle in the Western Ring Route: Oakley Creek Re-alignment and Rehabilitation Guidelines (appendix in Technical Report No G.11) of limiting the extent of stream re-alignment to the extent practicable.
- Loss of stream length would have an adverse ecological impact.



Figure 8.3: Option 2 - Realignment of stream within Goldstar property

Option 3 - Stream remaining in existing channel through the Goldstar property

This option involves the construction of a culvert/bridge and maintaining the existing channel through the Goldstar property (refer to Figure 8.4). Realignment of the stream under and upstream of the bridge is necessary to provide an alignment which will be hydraulically suitable for the proposed motorway, and for potential realignment of the stream in the Goldstar property, if this was carried out in the future as part of the development of that property. This option has the advantage that:

- It minimises the stream re-alignment by the Project, which is consistent with the principle established in the Western Ring Route: Oakley Creek Re-alignment and Rehabilitation Guidelines (appendix in Technical Report No G.11). However, the baseline is the stream diversion as per Option 2, as this has consent as part of the Goldstar development.



Figure 8.4: Option 3 - Stream remaining in existing channel through the Goldstar property

Option 4 - Proposed streamworks

The proposed streamworks solution as described in section 8.1 was selected as it enabled an integrated solution that achieved an optimal outcome in terms of the environment, flood management and active recreation for this area. The elements of this integrated solution include:

- Stream realignment/rehabilitation best meets the objectives of the Western Ring Route: Oakley Creek Re-alignment and Rehabilitation Guidelines (appendix in Technical Report No G.11). This stream realignment/ rehabilitation achieves the best environmental outcome of any of the options, by preserving the greatest length of Oakley Creek and providing a naturalised channel. This assumes that diversion of the stream parallel to the motorway would eventually occur should the residential development of the Goldstar property proceed, but that purchase of the property by the NZTA will instead enable the preservation of most of the stream length.
- Location of the stormwater wetland TD9B within the Goldstar property is the best practicable location, refer to Section 6.10.2 for the BPO analysis. The alternate equivalent location (that was also out of the

100 year ARI flood plain) was north of the motorway adjacent to Hendon Avenue, which required the acquisition of a number of properties (refer to Chapter 11.10.5, Part D of the AEE for further detail).

- Provision of two sports fields for active recreation compensation, refer Chapter 11.10.5 and the Assessment of Open Space Mitigation, Chapter 22.2, Part D of the AEE.
- Preservation of flood storage within the Goldstar property, which would have otherwise been lost as the consented development proposed to raise ground levels to above the flood level. The NZTA proposes to set the sports field level at approximately the 10 year ARI flood level, so that for larger flood events the sports fields are temporarily flooded. Preservation of this flood storage is considered to be Project betterment (compared to the consented Goldstar development).

The proposed integrated solution requires purchase of the Goldstar property.

8.2.2 Motorway Stream Crossing Options

Two options were considered for the SH20 motorway crossing of Oakley Creek; a box culvert or a bridge. For the proposed stream realignment (option 4) the motorway crosses Oakley creek at about Ch 1060m. The culvert option would require three box culverts consisting of one 3.5m wide by 2.5m deep concrete box culvert for normal flow and in parallel two 3.5m wide by 2.0m deep concrete box culverts with inverts 0.5m higher for flood flows. The bridge span would require a road bridge 38m wide with a span of 12m, the channel below consisting of a low flow channel 4m wide by 1m high, with 1:1 side slopes, and a high flow channel 12m wide with vertical sides in the form of the bridge abutments walls.

Table 8.4 below compares the culvert and bridge options against a number of criteria to assess their suitability for use.

Table 8.4: Oakley Creek culvert/bridge assessment criteria (- negative, + positive)

| Parameter | Culvert (3 culvert arrangement) | | Bridge | |
|-----------------------|---------------------------------|--|--------|--|
| | Assess | Comment | Assess | Comment |
| Cost | | Baseline | - | Only slightly more expensive (2 %). |
| Hydraulic Performance | - | Intermediate walls affect hydraulic performance and increase head losses. | + | Clear span under bridge allows greater hydraulic efficiency. |
| Affects of blockage | | Blockage risk low due to upstream culvert. | + | Blockage risk low due to upstream culvert, but still less than culvert due to greater open area |
| Ecological benefits | - | Stream habitats can be created within culverts, although additional cost is required to achieve this. There will be no vegetation growth within the culvert. | + | Better ecologically as fully natural creek bed. Vegetation growth will be limited due to reduced light and rain shadow from bridge decks. |
| Safety | + | The flood culverts could create an unsafe place. Pedestrian access into flood culverts could be mitigated by grills with floats so that they would rise automatically during floods. | - | The under bridge area could create an unsafe place, although the area would be more open and visible than culverts. Access to the under bridge area could be discouraged by materials, e.g. rock, but less easily prevented. |

The bridge option was selected as the best practical option due to its greater hydraulic efficiency, lower risk of blockage, and environmental benefits.

8.2.3 Realignment Cross Section Options

The design realignment typologies were developed with input from hydraulic, ecological and urban design experts. The principles of design are documented in the Western Ring Route: Oakley Creek Re-alignment and Rehabilitation Guidelines (appendix in Technical Report No G.11). The preferred cross section is a naturalised channel as described in Sections 8.1.4 and 8.1.5.

Alternative stream channels include basalt block walls channels (similar to existing), rock lined channels or concrete channels. All of these options were rejected for ecological reasons, as they do not offer the opportunities for improved aquatic habitats as the proposed naturalised stream channel.

8.2.4 Options for Increasing Conveyance

An option was considered to increase the capacity of the Bollard Avenue high flow culvert which conveys Oakley Creek under New North Road and the existing western line railway, as during the 100 year ARI flood this culvert flows full and there are back water effects further upstream.

Modelling using the T&T floodplain model (refer Section 3.4.2) was carried out assuming a duplication of the existing Bollard Avenue high flow culvert to evaluate the potential benefits. Simulated peak water levels immediately upstream of the culverts decrease, with the extra culvert in place. This would be beneficial in

terms of flood water levels in the vicinity of the southern portal. However the effects are limited to downstream of the natural cascade formed at by approximately motorway Ch 1450.

The cost of installing a duplicate culvert at Bollard Avenue would be high, and the benefits of doing so are not significant to the Project, and therefore do not justify this action. However, if Auckland City Council/Metrowater decides to implement catchment upgrades that increase peak flows through this reach, the duplication of the culvert should be considered.

8.3 Assessment of Effects – Streamworks

This section provides an assessment of effects for the streamworks against the assessment criteria set out in relevant planning documents and summarised in Table 4.2. A description of the proposed streamworks and the BPO selection process is outlined in Sections 8.1 and 8.2, respectively.

The assessment in this section focuses on hydraulic issues. The primary document for the assessment of effects due to the streamworks is the Technical Report No G.6 *Assessment of Freshwater Ecological Effects*. Flooding issues are addressed in Section 8.4.

The constructability and effect of the streamworks during the construction period is outlined in Technical Report No G.22 *Erosion and Sediment Control Plan*.

Groundwater effects are assessed in Technical Report No G.13 *Assessment of Ground Settlement Effects*.

8.3.1 Stream bed morphology

The assessment criterion is to (refer to Table 4.2):

Avoid, remedy or mitigate significant adverse changes to a river/stream bed morphology.

The existing Oakley Creek within Alan Wood Reserve (refer Section 5.9.3 for details) has basalt geology in places along the true right bank, and Tauranga Group geology in places along the true left bank, with weathered soils that are susceptible to erosion. Oakley Creek has a relatively low gradient (~0.3% slope), channelised in the majority of the area to be affected with basalt rock walls. Reaches of the stream that are not channelised are steeply incised. Bed materials include a combination of cobble, bedrock and soft bottom substrates. Sedimentary and basalt rock appear in places. A feature of the stream in this area is a cascade formed by basalt bedrock where the stream invert drops approximately 2m at approximately motorway Ch 1450m.

The proposed stream realignments will consist of cobble materials. Naturally sourced silt material is expected to be deposited in pool areas creating a variable bed type. Riffles will be formed with basalt rock across the base of the stream. The cascade which is the principle natural feature will be preserved. Therefore the proposed stream bed morphology is expected to change significantly and there are not expected to be adverse environmental effects.

Groundwater interactions with the creek are detailed in the Technical Report No G.7: *Assessment of Groundwater Effects*. An issue considered is the potential for leakage from the creek to the ground. Stream realignment A will be through similar geology to the existing alignment with mixed basalt, alluvium and Tauranga Group materials. Stream realignments B and C will be more in the Tauranga Group materials than the current stream alignment that is at the basalt/ Tauranga Group interface. For these reason leakage from the stream is no more likely than the current situation.

During construction, the cuts for stream realignments should be geologically mapped, permeability tests undertaken and consideration given to liner material if leakage different to that estimated are causing worse effects than considered in Technical Report No G.7: *Assessment of Groundwater Effects*. These procedures are included in the Groundwater Management Plan, part of the Technical Report no. G.21 Construction Environmental Management Plan.

8.3.2 Flow hydraulics

The assessment criterion is to (refer to Table 4.2):

Avoid, remedy or mitigate significant adverse changes to flow hydraulics.

The change to a natural channel type for streamworks reaches is likely to be beneficial to the flow hydraulics. The meander pattern and riffle-run-pool sequences that are proposed will add complexity to the flow hydraulics compared to the existing basalt rock wall channels. Riparian planting will increase the roughness of the channel compared to the existing basalt rock walls, which will slow the flows. These changes will have a positive effect on flow hydraulics and will be beneficial to aquatic fauna.

The areas of the stream affected by the Project shorten in length by 10% to 1318m (refer to Table 8.1). The changes in channel slope that result from the channel realignments are summarised in Table 8.5. The shortening of the stream at these sections locally increases the stream slope but only by a small amount. The slope for the channel realignments are typically less than the average slope of Oakley Creek in the lower catchment of 1%, which occurs in similar geology. Therefore, the slight change in slope is not considered significant, and is not likely to results in any adverse effects. An assessment of the changes to flow hydraulics for flood events is provided in Section 8.4.2.

Table 8.5: Changes to channel slope for channel realignments

| Stream section | Existing Creek Length (m) | Proposed Stream Length (m) | Existing Stream Slope | Proposed Realignment Slope |
|--------------------------------|---------------------------|----------------------------|-----------------------|----------------------------|
| Stoddard Tributary Realignment | 138 | 127 | 0.62% | 0.68% |
| Oakley Creek Realignment A | 148 | 114 | 0.68% | 0.47% |
| Oakley Creek Realignment B | 230 | 214 | 0.28% | 0.33% |
| Oakley Creek Realignment C | 287 | 220 | 0.24% | 0.43% |

Sediment

The assessment criterion is to (refer to Table 4.2):

Avoid, remedy or mitigate permanent adverse effects on the surrounding environment from the deposition of sediment, including the effects on ecological values and physical processes within the river or stream, and the potential to cause or exacerbate erosion or deposition within the river/stream or on adjacent land.

Sediment during construction will be managed in accordance with Technical Report No G.22 *Erosion and Sediment Control Plan*.

The stream realignment areas will be fully stabilised prior to diversion of Oakley Creek into the new channels. The stream bed will be stabilised with cobbles and will have riffles constructed from basalt rock (that will serve the additional function of grade control, preventing bed erosion). Basalt may be use in areas susceptible to erosion such as the toe of banks. Banks will be stabilised with geotextile and planted to ensure that they are resistant to erosion. The natural channel in the lower Oakley Creek is mostly free of erosion in those areas where vegetation has been re-established.

8.3.3 Ecological Habitat

The assessment criterion is to (refer to Table 4.2):

Avoid remedy or mitigate significant adverse changes to ecological habitat including

- *maintaining the passage of fish and other aquatic organisms both up and down stream*
- *enabling the colonisation of the diverted river or stream by aquatic flora and fauna following the completion of the diversion activities*
- *enabling the restoration or enhancement of wetlands, or areas of indigenous vegetation or the habitats of indigenous fauna in any river/stream*
- *not resulting in the permanent loss of any habitat of a rare or endangered species.*

The proposed stream realignments and rehabilitations will have a positive effect on the environment as a natural channel form is proposed to replace most of the existing basalt rock wall channel. The streamworks proposed for the Project will have net ecological, environmental and recreational benefits by providing greater access to the stream, better ecological habitats, and more vegetation than currently exists in these reaches. These aspects are covered in Technical Report No G.6 *Assessment of Freshwater Ecological Effects*.

8.4 Assessment of Effects - Flooding

This section provides an assessment of the effects of flooding issues associated with the Project and its streamworks design to meet assessment criteria and policies set out in relevant planning documents as summarised in Table 4.3.

Extensive hydraulic modelling has been carried out by Tonkin & Taylor for the NZTA initially as part of the design process, and subsequently by AECOM for Metrowater/NZTA using the catchment model (refer to Section 3.4.2) and AECOM (2010a) Oakley Creek Flood Management – SH20 Options Modelling Report (Appendix C). The modelling assumptions, parameters and methodology are summarised or referenced in Section 3.4.

100 year ARI rainfall was used to simulate flood events with adjustments for climate change and maximum probable development of the catchment (refer to Section 3.2), resulting in a conservative estimate of likely flood levels.

The modelling results were used to:

- assess the existing situation
- refine the design of the streamworks and works in the floodplain to find the BPO
- assess the effects of the Project on flooding

- ensure the proposed streamworks design can accommodate potential catchment management options being considered to alleviate flooding in the upstream catchment by Metrowater
- as a basis of design for flood protection.

The scenarios that were considered are summarised in Table 8.6. Scenarios for “existing” and “with motorway” are the basis for the effects assessment in this section. The “with motorway” scenario is the essentially the Project. The “with motorway” model includes:

- MIKE21 digital terrain updated to include all aspects of the design included Maioro Interchange, motorway pavement surface, creek realignments and rehabilitations, Oakley SH20 bridge and tunnel portal
- MIKE11 creek model updated to reflect creek realignments and rehabilitations
- Catchments affected by the Project were revised to represent the proposed motorway catchments and stormwater treatment wetlands (with flood attenuation) and changes to drainage (Hendon Avenue swale and Culverts).

The other sensitivity scenarios are for “pass forward” flows, “2500 year ARI rainfall” and “culvert blockage” are discussed in Section 8.5 and are considered for the design of flood protection.

Table 8.6: Summary of modelling scenarios

| Scenario | Hydrology | Richardson Road (Oakley Ch 5640) | Model Name ^{*1} | Purpose |
|---------------------------------|---------------|----------------------------------|--|--|
| Existing | 100 year ARI | 32.92 | Base Existing 100 Year Event with Climate Change (Figure 1) | Assess effects (refer Sections 8.4.1 and 8.4.2) |
| With motorway | 100 year ARI | 32.79 | Base Future 100 Year Event with Climate Change (Figure 2) | Assess effects (refer Sections 8.4.1 and 8.4.2) |
| With motorway, pass forward | 100 year ARI | 51.37 | Pass Forward 100 Year Event with Climate Change (Figure 3) | Sensitivity - Future proof (refer Section 8.4.3) |
| With motorway, culvert blockage | 100 year ARI | 32.79 | Future 100 Year Event with Climate Change Downstream Culverts 50% Blocked (Figure 5) | Sensitivity - Design consideration for tunnel flood protection (refer Section 8.4.3) |
| With motorway | 2500 year ARI | 40.02 | Future 2500 Year Event (Figure 6) | Sensitivity - Design consideration for tunnel flood protection (refer Section 8.4.3) |
| With motorway, pass forward | 2500 year ARI | 61.76 | Pass Forward 2500 Year Event (Figure 7) | Sensitivity - Design consideration for tunnel flood protection (refer Section 8.4.3) |

*1 Model names and figure numbers refer to flood extent plots in Appendix C

8.4.1 Flooding Effects

The assessment criteria for flooding effects are to (refer to Table 4.3):

Not give rise to flooding of adjacent land or exacerbate existing flooding.

- *does not cause flooding, in a 100 year ARI storm, of a habitable floor level in any dwelling;*
- *extent occupies flood storage volume below the 100 year ARI flood level.*

The results are discussed in relation to peak water levels, flood extents, habitable floors affected, and volume of floodplain occupied in the subsequent paragraphs. Figures showing peak water levels and flood extents are presented to illustrate the effects.

Peak water levels during the 100 year ARI interval rainfall event

Figure 8.5 below shows a long section of the Oakley Creek invert, with simulated 100 year ARI peak water levels for the existing case and the with motorway case. Table 8.7 summarises water levels at key locations. Peak water levels give an indication of the extent of flooding for each case, because the higher the water level the greater the extent of flooding.

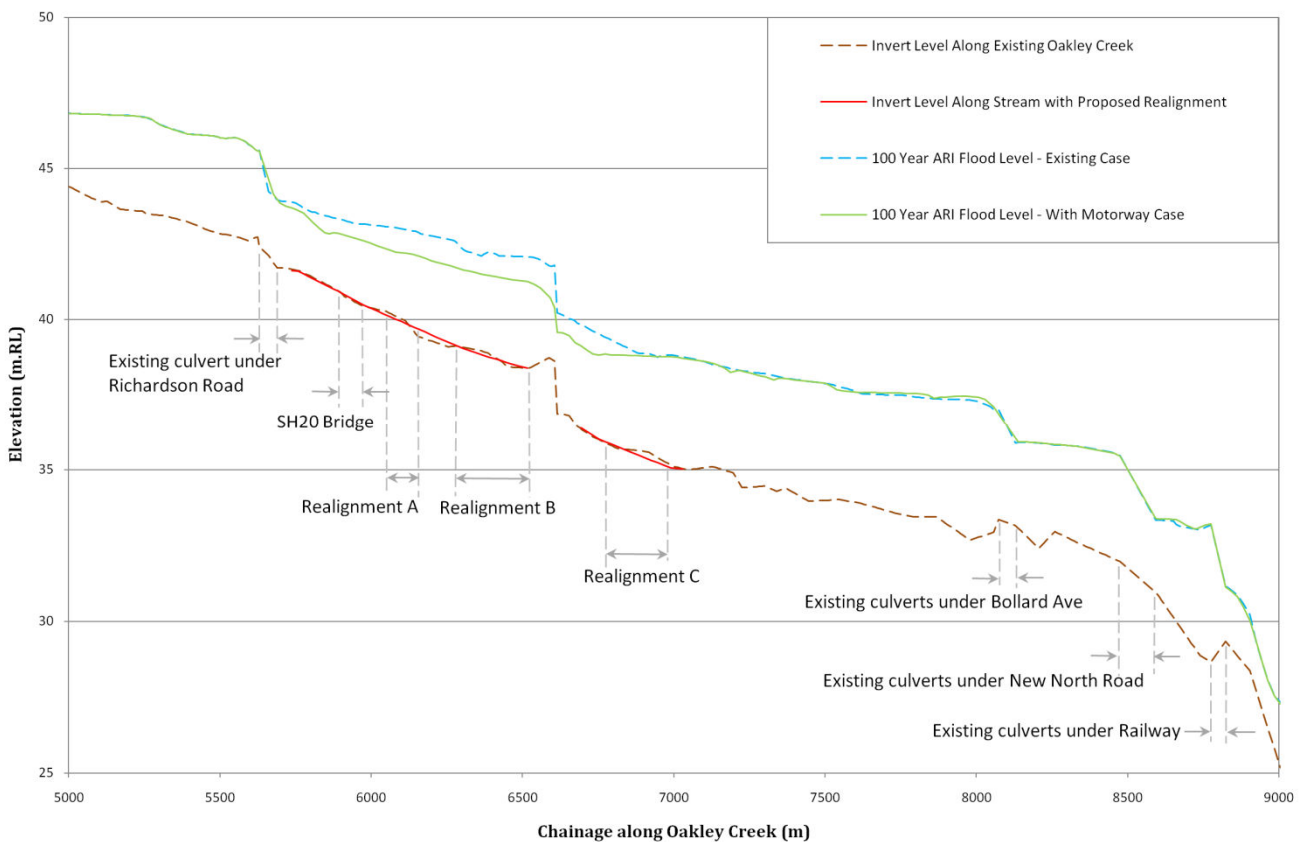


Figure 8.5: Maximum 100 year ARI Water Levels for Existing and With Motorway

Water levels for the two cases are the same upstream of Richardson Road, as is expected, as the models are the same in this area. From just upstream of the proposed SH20 bridge crossing through to Realignment C water levels are lower for the with motorway case than the existing case. This reach includes the SH20 Bridge, and realignment sections A and B, rehabilitation sections A, B and C. The sudden drop in Oakley Creek bed level at Ch 6615 is the naturally occurring cascade, which is preserved in the proposed streamworks.

The lower peak water levels are primarily due to greater hydraulic capacity and in-channel flood storage for the proposed realignments and rehabilitation sections, compared to narrower existing basalt block wall channels. The slightly shorter stream lengths (due to the realignments that increase the slope of the stream, refer to

Table 8.5), may slightly increase flow velocities and lower water levels (refer to Figure 8.11). Although these changes will be partially offset by the higher roughness for the naturalised channels (n=0.04 used compared to 0.0375 for existing).

The proposed streamworks including the SH20 Bridge do not increase upstream flood levels, so there is no adverse effect on upstream flooding. The lowering of flood levels through the proposed stream works will be beneficial to neighbouring properties and local drainage systems in the area.

Downstream of Realignment C, from approximately Oakley Creek Ch 6900 to Bollard Avenue, the water levels are reasonably similar for the existing and with motorway cases, with a local water level increase of 150mm upstream of Bollard Avenue (refer to Table 8.7). Downstream of Bollard Avenue including downstream of the Railway culverts the differences are negligible: within the range of +30mm to -30mm, which is smaller than the model accuracy limits. The effect of these increases is discussed in relation to habitable floor levels below.

Table 8.7: 100 year ARI flood levels at key locations

| Location | Chainage along Oakley Creek (m) | Existing (mRL) | With Motorway (mRL) | Difference (m, +increase) |
|-------------------------------------|---------------------------------|----------------|---------------------|---------------------------|
| Upstream of SH20 Bridge | 5910 | 43.27 | 42.81 | -0.46 |
| Realignment A (Goldstar) | 6112 | 42.98 | 42.20 | -0.78 |
| Realignment B | 6423 | 42.11 | 41.41 | -0.70 |
| Realignment C | 6917 | 38.88 | 38.78 | -0.10 |
| Upstream of Bollard Avenue culverts | 7998 | 37.30 | 37.45 | +0.15 |
| Upstream of New North Road culverts | 8446 | 35.57 | 35.56 | -0.01 |
| Upstream of Railway culverts | 8775 | 33.18 | 33.21 | 0.03 |
| Downstream of Railway culverts | 8824 | 31.17 | 31.14 | -0.03 |

Flood extents during the 100 year ARI interval rainfall event

Flood extents simulated for the existing and with motorway scenarios are illustrated in Figures 8.6 and 8.7 respectively. Water that is modelled within the MIKE11 component of the model that represents flow in the main channel is not shown, which is why areas close to the stream invert are not shown as flooded. Only water in the MIKE21 component of the model that represents the floodplain area outside the main channel is shown. The purpose of the drawings is to show any differences between the scenarios, which are most likely towards the outer extents of the modelled flood plain.

As can be seen in Figures 8.6 and 8.7, the flood extents are very similar both upstream of the Richardson Road and downstream of the Project streamworks, for the existing and with motorway cases. From Richardson Road through the Project streamworks reach, the flood extents for the 100 year ARI event are less extensive for the with motorway case compared to the existing case, corresponding to the lower peak water levels due to the increased conveyance capacity within the proposed streamworks. The extent of the floodplain in Alan Wood Reserve also changes, due to the differing geometry and ground profile of the proposed motorway structures.

In summary, the Project slightly reduces flood extents upstream of the SH20 motorway bridge, and more significantly reduces flood extents through the streamworks reach. In general, more of the peak flow is contained within the channel extents, and less overflows to surrounding reserve land and properties, resulting in an overall positive environmental effect of the Project on flood extents.

Affected properties and habitable floor flooding during the 100 year ARI interval rainfall event

Flooding is a widespread issue in the catchment, particularly the areas surrounding Underwood and Walmsley parks. Flood hazard mapping has been undertaken by AECOM (2010c). The key results from AECOM (2010c) for the area between Richardson Road and the existing western line railway are shown in Appendix C.

The reduction in flood extent has benefits to properties along Valonia Street, Whittle Place, Methuen Road (large improvement) and Hendon Avenue. Refer to Appendix C Figures 1 and 2 for flood maps that also show property boundaries and street names.

In the Project area AECOM (2010d, Appendix C) have identified two properties with habitable floors predicted to be within 500mm of the flood level during the 10, 50 and 100 year ARI flood events for the existing situation. These houses at 33 Valonia Street and 33 Whittle Place that have 0.4m and 0.3m freeboard, respectively, for the 100 year ARI flood event. At this location the 100 year ARI flood level is predicted to be reduced by 0.78m due to the Project, so the habitable floors of these houses would no longer be at risk.

In the downstream area, from Bollard Avenue to the Railway, AECOM (2010d) predict property and floor flooding of a number of properties for the existing situation. Four properties have been identified with habitable floors as either being within 500mm of modelled flood levels, or at risk of inundation, during the 10, 50 or 100 year ARI flood events for the existing situation. These are houses at 1254 New North Road, 1260 New North Road, 1248-1250 New North Road and 21A Bollard Avenue. At these locations the 100 year ARI flood level is predicted to be essentially unchanged (0.01m decrease predicted) for the with motorway case, so the

risk to habitable floors of these houses will not change due to the Project. The feature affecting flood levels at this location is the capacity of the culvert under New North Road.

The only location where the 100 year ARI flood level is expected to increase due to the Project is upstream of the Bollard Avenue culverts (low flow and overflow culverts see Table 5.3). An increase of 150mm is predicted for the with motorway case compared to the existing case. AECOM (2010c) do not identify any habitable floors in this area that are at risk of flooding. A number of properties, with boundaries along Oakley Creek will experience a higher peak water level during the 100 year ARI flood. However because the banks are steep and the houses are higher than the predicted peak flood levels, the effects will be no more than minor.

The only building identified as being adversely affected is the basement garage of 12A Bollard Avenue. The flooding depth in the garage for the with motorway case is 1.32m, compared to the existing case of 1.19m, for the 100 year ARI event with MPD and climate change. The effect of the Project is an increase in flooding depth of 130mm, within a garage that is already predicted to flood severely. Flooding of the basement garage at 12A Bollard Avenue is understood to have occurred in the past (pers. comms Metrowater). Considering that flooding of this basement garage already occurs to a substantial depth, the increase in flood depth is considered to be minor effect.

In summary, a number of habitable floors have been identified as at risk of flooding in the Project area by AECOM (2010d). The Project reduces the flood risk for two houses, and leaves it unchanged for four other houses. No additional habitable floor levels are put at risk due to the Project. The extent of flooding reduces due to the Project for properties along Valonia Street, Whittle Place, Methuen Road (large improvement) and Hendon Avenue. Minor adverse effects are experienced due to an increase in flood level for properties upstream of the Bollard Avenue culvert, including one basement garage that also floods severely for the existing case.

The Project streamworks will provide a net benefit in terms of peak flood levels and extents. The adverse effect of increased peak water level in the garage of 12A Bollard Avenue is mitigated by reductions in flood risk for two houses, and the reduction in total flood extent within the Project area.

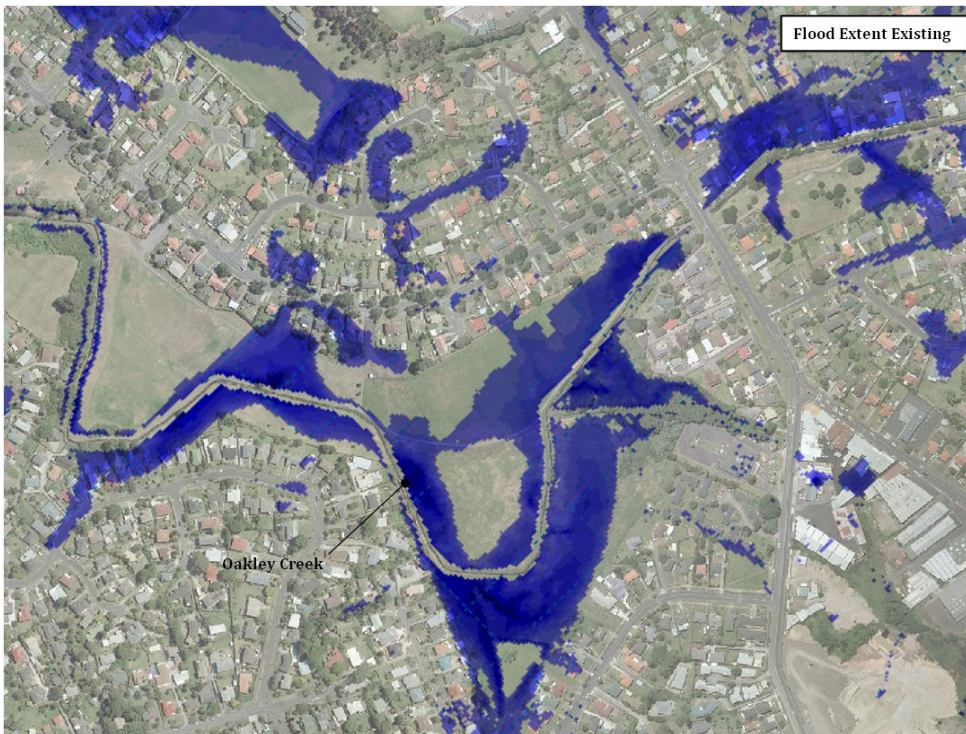


Figure 8.6a: Flood extents for the existing, 100 year ARI scenario (upstream area)

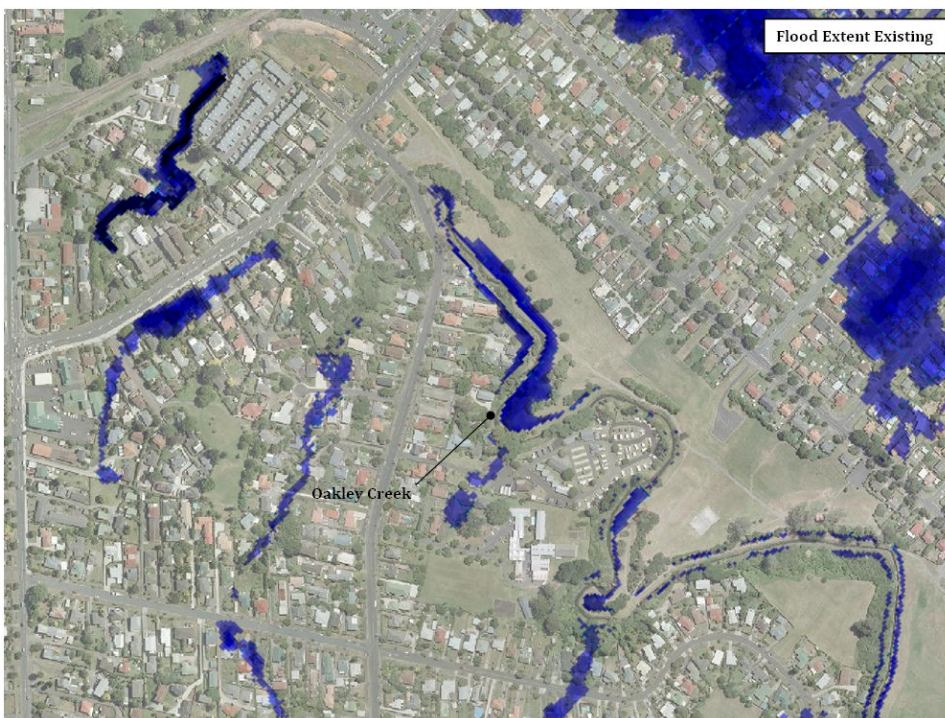


Figure 8.6b: Flood extents for the existing, 100 year ARI scenario (downstream area)

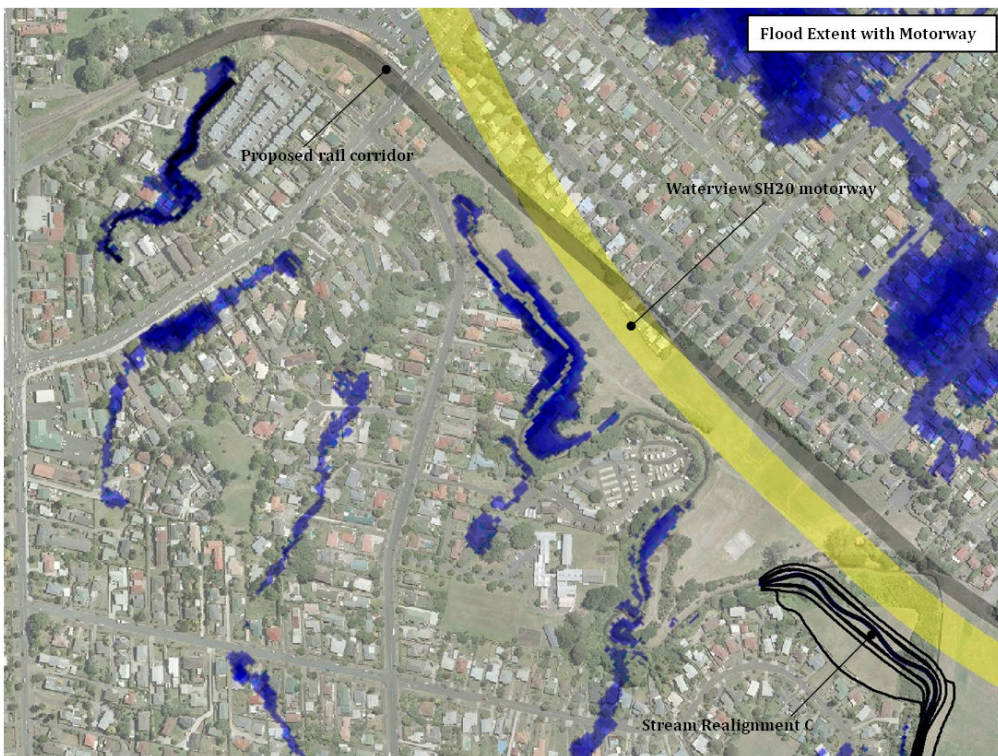


Figure 8.7a: Flood extents for the with motorway, 100 year ARI scenario (upstream area)

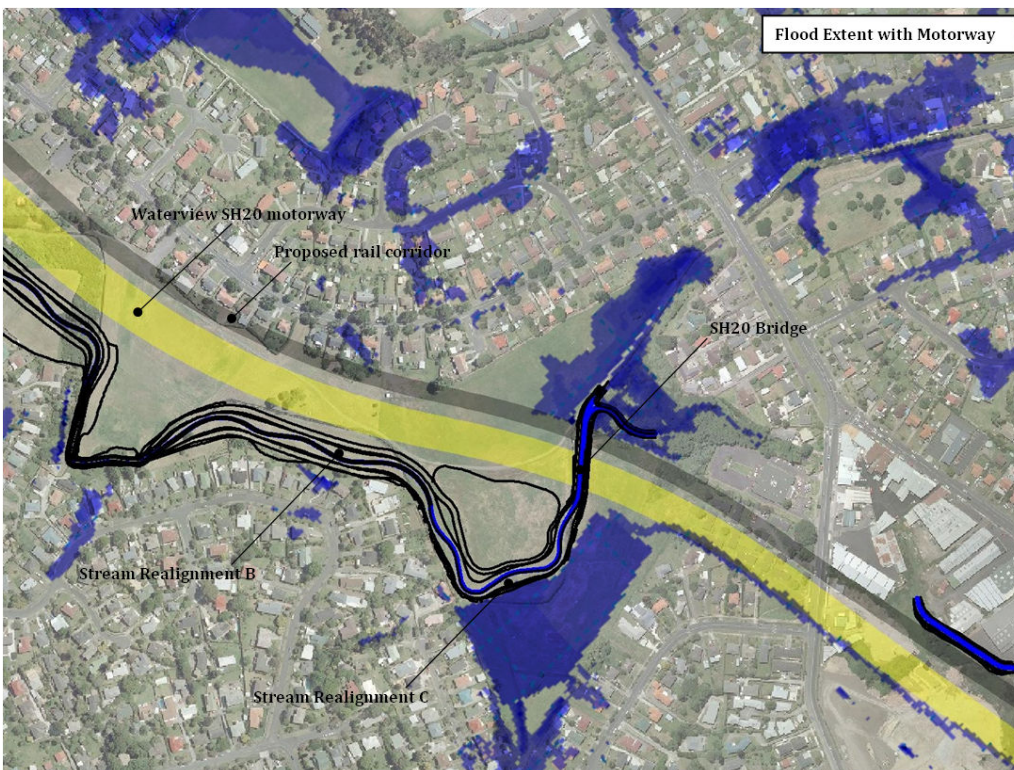


Figure 8.7b: Flood extents for the with motorway, 100 year ARI scenario (downstream area)

Extent of works occupying the 100 year flood plain

A criterion for consideration of flooding effects is the volume within the 100 year floodplain that is no longer available for flood storage during an event, due to the Project. The motorway and rail corridor footprint occupy 9,331 m³ of the floodplain in Alan Wood Reserve for the existing scenario for the 100 year ARI event.

A comparison has been made of the flood storage utilised in the 100 year ARI design event in the Alan Wood Reserve area for both the existing case and the with motorway case. The existing flood storage is 79,400 m³ compared to 47,600 m³ for the with motorway case, resulting in a net decrease in flood storage of 31,800 m³. This is despite the channel storage increasing from 18,400 m³ to 27,200 m³. The reduction in net storage occurs mostly from reduction in flood water level.

The reduction in net storage would be greater if it wasn't for the preservation of flood storage within the Goldstar property which amounts to 8,000 m³. This would be available as part of the Project if the Goldstar property was to be purchased, and the low lying land is to be used for sports field and will be allowed to flood in events exceeding the 10 year ARI. The consented development plans for the Goldstar property allowed for the land to be raised, which would have caused the loss of flood storage in this area. This is considered partial mitigation for loss of flood storage.

8.4.2 Hydrological Effects

The criterion for hydrological effects is that the proposal does not create adverse hydrological effects, specifically by increasing downstream flow rates (refer Table 4.3):

- *Avoid adverse hydrological effects*
 - *does not increase downstream flows and thereby worsen flooding in downstream areas.*

Peak flow rates and velocities were evaluated to assess the hydrological effects of the proposal. Figures 8.8, 8.9 and 8.10 show flow hydrographs for the existing and with motorway scenarios at the Richardson Road culvert (upstream of the Project area), at a point between Realignment B and C (within the Project area) and upstream of the Bollard Avenue culvert (downstream of the Project).

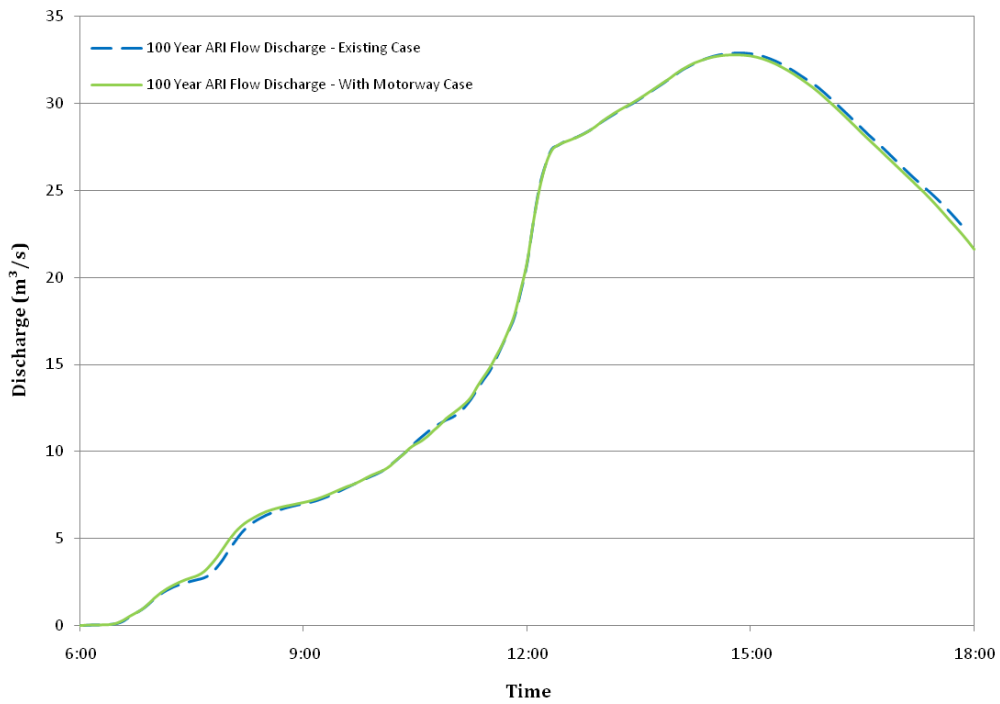


Figure 8.8: Existing and with motorway flow hydrographs for 100 year ARI flood event at Richardson Road culvert (upstream of Project, Stream Chainage 5675)

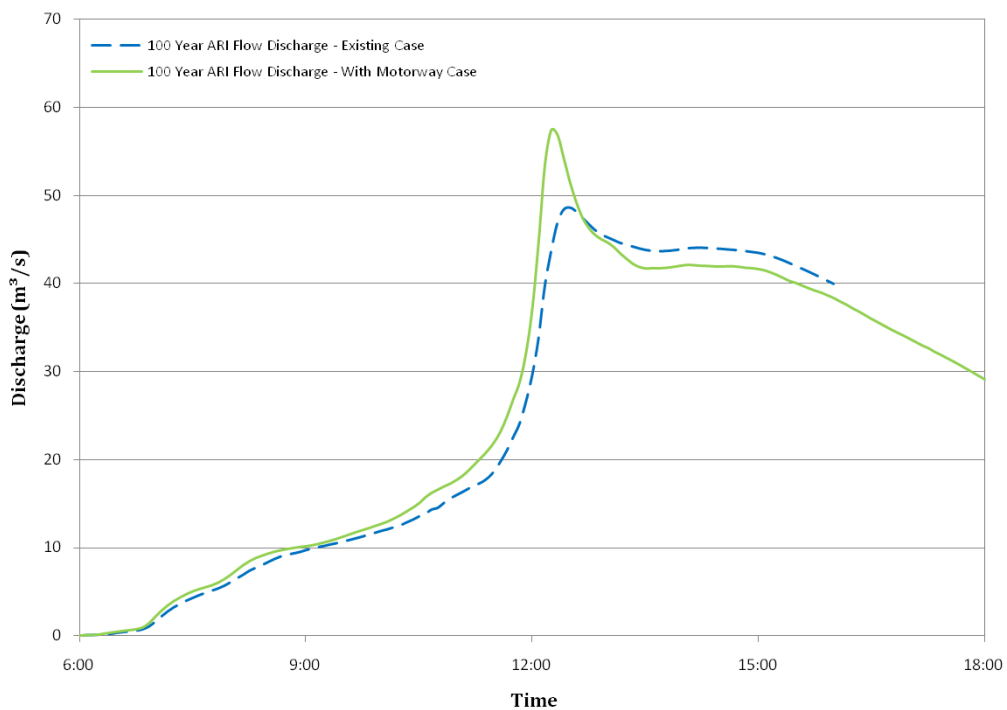


Figure 8.9: Existing and with motorway flow hydrographs for 100 year ARI flood event at location between stream realignments B and C (within Project, Stream Chainage 6755)

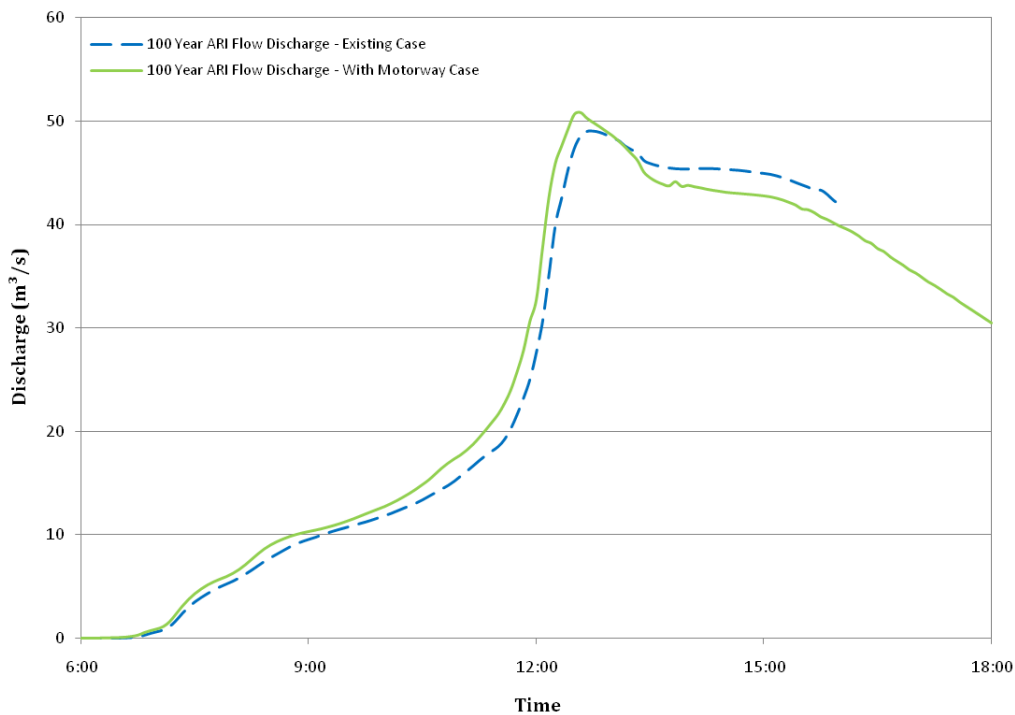


Figure 8.10: Existing and with motorway flow hydrographs for 100 year ARI flood event at location upstream of Bollard Avenue culverts (downstream of Project, Stream Chainage 7973)

Figures 8.8, 8.9 and 8.10 show that there is an increase in peak flow rate due to the Project, but that most of the additional flow is attenuated by the time the flow reaches the Bollard Avenue culverts. The cause of the additional flow is considered to be due to the reduction in storage in the Project area. At Bollard Avenue the peak flow increases from approximately 49m³/s to approximately 50.7m³/s, an increase of 3.3%. This results in slightly higher headwater level at the entrance to the Bollard culverts (refer to Table 8.7) as discussed previously.

The first flood peak is due to inflows from the Stoddard Road tributary. It has been ignored for the comparison because it includes changes made due to the already consented Maioro Interchange works.

Figure 8.11 shows a stream long section with maximum velocities for the existing and with motorway cases plotted for comparison.

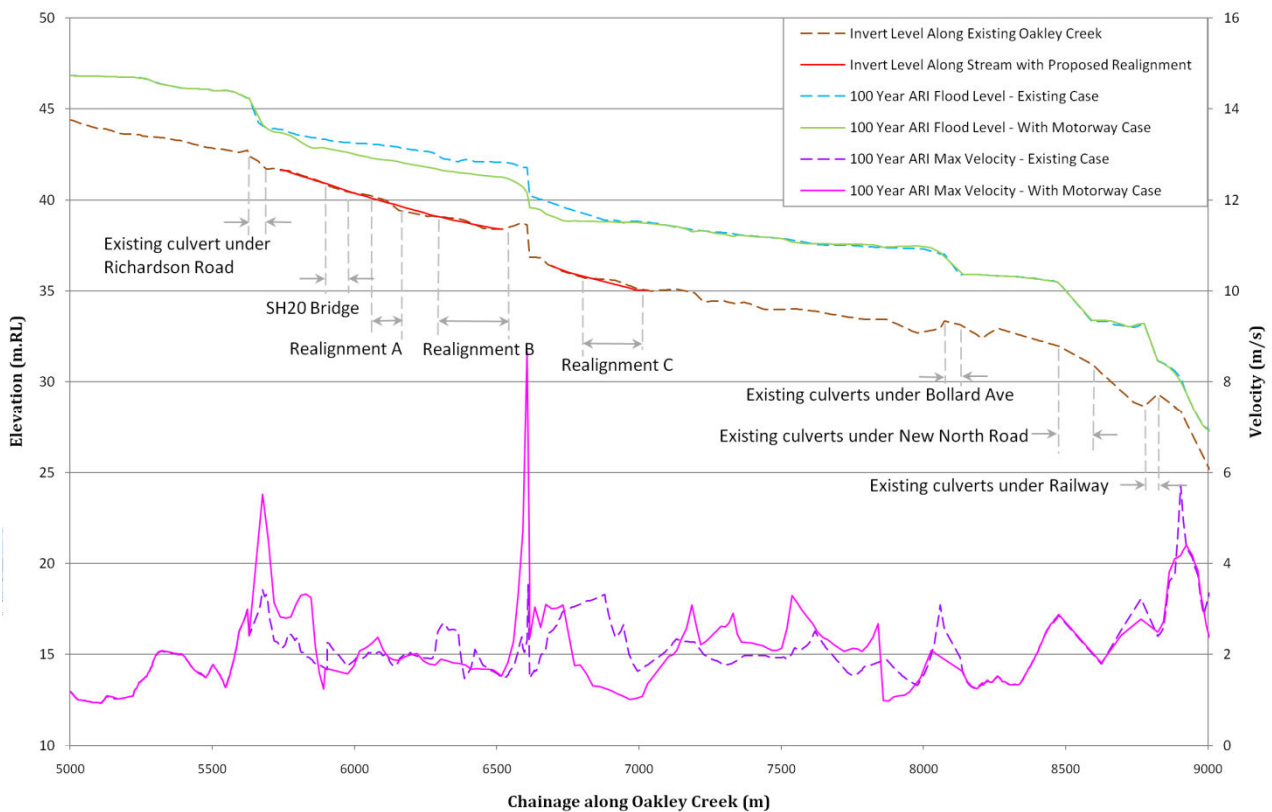


Figure 8.11: Existing and with motorway maximum velocities for 100 year ARI

Figure 8.11 shows mixed results for velocity. There are local increases in velocity at the proposed SH20 Bridge. Then between the SH20 Bridge and the cascade, including realignments A and B and rehabilitations A and B, there is no significant difference in velocity. At the cascade, the with motorway case shows a spike in velocity, which should be investigated further at the detailed design stage and is most likely to be a modelling issue. Immediately, downstream of the cascade the velocities are higher for the with motorway case, which can be explained by higher flows through a similar channel to the existing form. Through realignment C the velocity decreases due to the wider channel shape with higher roughness. Downstream of the Project areas the velocity is slightly higher than the “existing” case due to the higher flows for the with motorway case.

The entire length of the reach is subject to rehabilitation works, which will be designed for the expected velocities. The expected maximum velocities of 2-3m/s can be tolerated by natural channels and the use of biotechnical engineering techniques to stabilise the channel banks will be suitable (Hewlett et al, 1987).

Areas of higher velocity will be designed with additional erosion protection. The bridge cross-section will be stabilised with rock or alternative erosion resistant liner. Stabilisation of the bridge cross-section with vegetation is not viable because of light and rain shadow from the bridge deck. In the area downstream of the cascade, including the outside of the bend, the basalt rock walls will be maintained as these good provide erosion resistance in this high energy zone.

It is noteworthy that the channel slopes in the Alan Wood Reserve have generally low slopes. This is due to the basalt flows from the Mount Albert eruption, which choked the valley in this area. Downstream of the existing

western line railway the lower Oakley Creek channel has a steeper gradient of approximately 1% and is in a natural state without hard erosion protection. This supports application of a naturalistic channel in Alan Wood Reserve where the channels will be mostly flatter (refer to Table 8.5).

The works will consist of creating the typologies detailed in Table 8.1 and outlined in the Western Ring Route: Oakley Creek Re-alignment and Rehabilitation Guidelines (appendix in Technical Report No G.11). Features of the typologies that contribute to protecting the reach from erosion include geotextile layers, planting, and rock placement, as well as consideration of slope angles. The guidelines were developed by Project ecologists, landscape architects and engineers, and include provision for peak flows and the attendant velocities through the stream works sections.

Therefore there are no adverse hydrological effects expected from the proposed design, other than the increases in flood levels upstream of the Bollard Avenue culvert that have previously been mentioned.

8.5 Flooding Protection for Motorway

In addition to the requirement for design of the motorway and streamworks to minimise the effects on the environment including flooding (refer to Section 8.3 and 8.4), it is also a NZTA requirement that the motorway be protected from flooding. Flooding of SH20 in Alan Wood Reserve (Chainage 900 to 1900) presents a particular hazard due to the risk of flood water entering the tunnels from the southern portal. The focus of this section is the design of measures to protect the motorway from flooding.

Flood protection will be provided by a combination of flood bunds and flood walls, for indicative locations refer to Drawings 20.1.11-3-D-D-300-117 and 118 (Appendix A).

8.5.1 Design Philosophy

The approach to flood management is outlined in the Technical Report No G.27 *Stormwater and Streamworks Design Philosophy Statement*, and the key criteria are:

- The Project will be developed to have a negligible effect on the 100 year ARI flood flows and levels in the Oakley catchment assuming the ACC maximum probable catchment development scenario.
- Opportunities to reduce flood levels shall be considered in conjunction with Metrowater for mutual benefit of lower motorway alignment and reduction in habitable floor flooding.
- The motorway level at the outer edge of lane line shall have 500mm freeboard to the 100 year ARI flood level. The 100 year flood level shall include for maximum probable development and climate change to 2090.
- The tunnels shall be protected from flooding from Oakley Creek or overland flow, during the 100 year ARI rainfall event. Measures to protect the tunnel from flooding, and/or manage the consequences should flooding occur during more extreme rainfall events shall be implemented with the 2500 year ARI rainfall event being considered as the design storm. Refer to the Waterview Connection Stormwater

and Streamworks Concept Design Report (Tonkin and Taylor 2010) for more information on this design event.

8.5.2 Scenarios

A number of scenarios were modelled to support the design of flood protection measures. These are summarised in Table 8.6 and are detailed below.

Pass forward flow – Design compatibility with possible future catchment upgrades

A comprehensive catchment study of the Oakley Creek catchment has been undertaken by AECOM for Metrowater/ACC independent of the Project. The objectives of the study were to develop flood hazard maps and options for flood management in the catchment. The modelling has shown that a significant number of habitable floors are at risk for the study's design rainfall event; the 50 year ARI event. Flood management options have been identified and presented to Metrowater. A decision has not been made on which option will be developed and implemented.

One of the options being considered involves a number of flood management options to relieve flooding upstream of Richardson Road by "passing forward" flow to downstream areas (refer to AECOM (2010c) in Appendix C). This option involves increasing conveyance in channel and through culverts (including the Richardson Road culvert). The "pass forward" option will result in higher peak flows through the Project area. Given that catchment upgrades of some form are likely to be implemented during the design life of the Project, and of the proposed options the "pass forward" option would result in the greatest peak flows through the SH20 Project area, an assessment has been carried out of the "pass forward" scenario to determine whether the proposed design is compatible with this possible, future flood management option.

The pass forward management option represents the maximum peak flow likely to be experienced in Oakley Creek in the vicinity of the Project. The hydrological assumptions are the same for this scenario as the previous scenarios. Therefore modelling the pass forward, 100 year ARI peak flow represents a conservative assessment. The pass forward 100 year ARI peak flow at Richardson Road (upstream of the Project area) is 51.37m³/s, a potential increase of 18.45m³/s (56%) above the existing 100 year ARI peak flow of 32.9m³/s (Table 8.6).

The proposed streamworks design and the flooding assessment (Sections 8.4.1 and 8.4.2) has been for the 100 year ARI without pass forward option catchment modifications because at this stage there is uncertainty over which, if any, of the upstream flood management options will be implemented. Over sizing of streamworks to focus on the effects of one potential management option did not represent the best practicable option. The objectives of modelling the pass forward flow are to show that the proposed design can accommodate these flows without flooding the motorway, and can be adjusted if necessary at the detailed design stage, when a decision is made on the catchment management options.

2500 year ARI rainfall event

The 2500 year ARI design storm was selected for flood protection of the tunnel portal areas to ensure large scale inundation of the tunnels with potentially catastrophic consequences does not occur. There are no

regulations in New Zealand for flood protection of road tunnels. Guidance was taken from design loadings from the Transit Bridge Manual and the AS/NZS 1170 Structural Design Actions. Inundation of the tunnels would be equivalent to the failure of a Level 3 importance structure for a significant period of time with risk to life. Therefore the most relevant comparisons are for Ultimate Limit State criteria of Level 3 structures. These criteria are shown in Table 8.8 below, and indicate a rainfall event of 2500 year ARI is appropriate as the design event.

Table 8.8: Relevant Hazard Criteria

| Document | Application | Criteria/Standard (year ARI) |
|--|--|--|
| Transit Bridge Manual | Importance level 3 Routes- Ultimate Limit State | 2500 flood |
| AS/NZS 1170 Structural Design Actions | Ultimate Limit State (failure of structure), Importance Level 3 | 2500 (wind or EQ 100yr design life) 1000 (wind or EQ 50yr design life) 500 (snow 100yr design life) 250 (snow 50yr design life) |

100 year ARI flow with 50 % blockage

The sensitivity to flooding due to blockage of downstream culverts was assessed by this scenario. 50% blockage of the cross-sectional area of the Bollard Ave, Railway, New North Road and Bollard Overflow culverts was assumed. This simulates the possibility that during major flood events these culverts may get blocked by debris or vegetation that is conveyed by flood waters but is unable to pass through the culvert. If these culverts in the vicinity of Bollard Avenue become partially blocked, it follows that peak water levels upstream may increase significantly. The maximum water level that can be reached is the level of the existing western line railway because at this level flow will overflow the railway and discharge without impediment to the lower section of Oakley Creek.

8.5.3 Scenario results

An Oakley Creek long section of the simulated peak water levels for each of the scenarios above is plotted in Figure 8.12. Water levels at key locations are shown in Table 8.9. The flood extent plots for each scenario are included in Appendix C. Each of the scenarios and their implications for design are discussed in subsequent paragraphs.

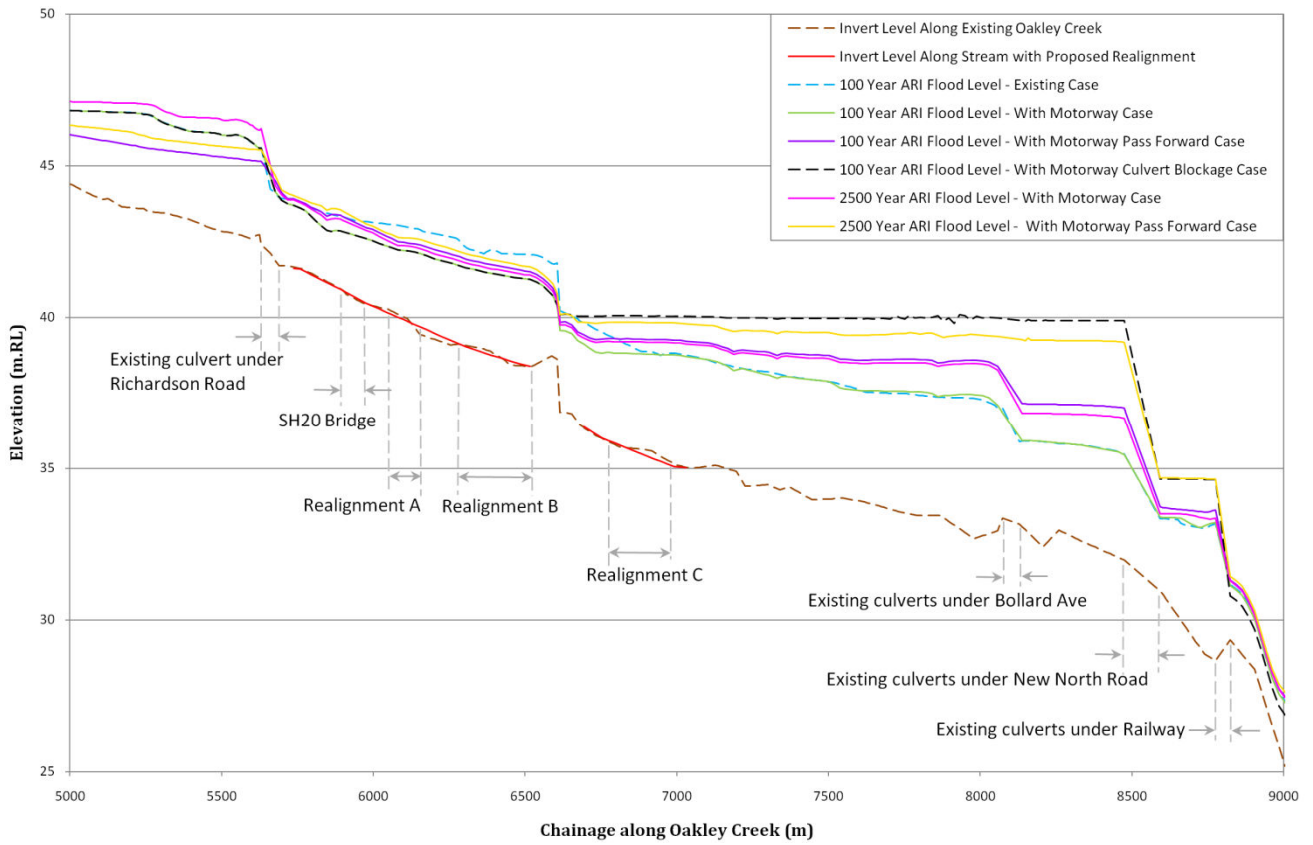


Figure 8.12: Flood Water Levels for all Scenarios

Table 8.9: Flood levels (mRL) at key locations [difference to 100 year, motorway – base case]

| Location | Chainage along Oakley Creek (m) | 100 year Existing | 100 year Motorway (base case) | 100 year Motorway Pass forward | 100 year Motorway Blockage | 2500 year Motorway | 2500 year Motorway Pass forward |
|-------------------------------------|---------------------------------|-------------------|-------------------------------|--------------------------------|----------------------------|--------------------|---------------------------------|
| Upstream of SH20 Bridge | 5910 | 43.27 | 42.81 | 42.85 [+0.04] | 42.81 [0.00] | 43.21 [+0.40] | 43.52 [+0.71] |
| Realignment A (Goldstar) | 6112 | 42.98 | 42.20 | 42.42 [+0.22] | 42.20 [+0.16] | 42.36 [+0.16] | 42.62 [+0.42] |
| Realignment B | 6423 | 42.11 | 41.41 | 41.67 [+0.26] | 41.41 [0.00] | 41.52 [0.11] | 41.83 [+0.42] |
| Realignment C | 6917 | 38.88 | 38.78 | 39.27 [+0.49] | 40.05 [+1.27] | 39.18 [+0.40] | 39.83 [+1.05] |
| Upstream of Bollard Avenue culverts | 7998 | 37.30 | 37.45 | 38.58 [+1.13] | 40.04 [+2.59] | 38.48 [+1.03] | 39.42 [+1.97] |
| Upstream of New North Road culverts | 8446 | 35.57 | 35.56 | 37.05 [+1.49] | 39.90 [+4.34] | 36.72 [+1.16] | 39.21 [+3.65] |
| Downstream of Railway culverts | 8775 | 33.18 | 33.21 | 33.62 [+0.41] | 34.63 [+1.42] | 33.35 [+0.14] | 34.66 [+1.45] |
| Upstream of Railway culverts | 8824 | 31.17 | 31.14 | 31.31 [+0.17] | 30.80 [-0.34] | 31.29 [+0.15] | 31.44 [+0.30] |

Pass forward flow – Design compatibility with possible future catchment upgrades

The modelling results for pass forward flows show decreases in water levels upstream of Richardson Road as is the objective of this flood management option. In the Project area, the water levels for the pass forward scenario are higher than for the motorway base case (100 year ARI, with motorway scenario) as is expected due to the higher flows for the pass forward scenario, but are still lower than for the existing 100 year ARI scenario. The exception is at the downstream end of the Project area, in stream realignment C, where the higher pass forward flows cause an increase in water levels compared to the motorway base case, as a result of the backwater effects of the Bollard Avenue culverts.

If pass forward options were implemented by Metrowater/ACC it may be necessary to modify the proposed stream works in the following ways:

- Raise the soffit of the proposed SH20 motorway bridge over Oakley Creek
- And/or increase the span of the proposed SH20 motorway bridge over Oakley Creek
- Increase conveyance and flood storage within the proposed Realignment Sections

- Provide for increased culvert capacity at Bollard Avenue.

2500 year ARI rainfall event

The modelling results for the 2500 year ARI rainfall event show increases in water levels compared to the motorway base case as is expected due to the higher flows. These increases can be accommodated within the 500mm freeboard proposed for flood defences for the 100 year ARI event.

The 2500 year ARI rainfall event with the pass forward flood management option causes larger increases in water levels (+1.05m) at realignment C (adjacent to the southern tunnel portal) and for the downstream area including Bollard Avenue to the railway culverts. The significant increase in water levels is partially due to the backwater from the Bollard culverts during flows of this magnitude. The design of flood defences must consider the long term flood management plan for Oakley Creek.

100 year ARI flow with partial blockage of Culverts

The scenario including blocked culverts was modelled as a sensitivity check for the design. It was assumed 50 % blockage by area of Bollard Ave, Railway, New North Road and Bollard Overflow culverts.

The significant effects of this scenario are observed downstream of the cascade. For this scenario, water heads-up to the level of the existing western line railway before flowing along the railway line, crossing the railway embankment opposite the Pak 'N' Save supermarket, and discharging without impediment to the lower section of Oakley Creek (refer to Figure 5, Appendix C).

The ramification of this scenario is that the southern tunnel portals are at risk of flooding due to increased water levels resulting from blockage of downstream culverts. The tunnel portal is only at risk from this scenario adjacent to Stream Realignment C, which has a length of approximately 220m. Elsewhere, naturally occurring high ground levels between the stream and the motorway alignment prevent flooding of the tunnel portal.

The overland flow path sets a maximum flood water level that is resilient to extreme floods, blockages and flood management scenarios.

8.5.4 Proposed Flood Management

The flood water levels are shown in Figure 8.13 for SH20 Ch. The design proposed approach to flood protection is detailed in Table 8.10. Design approaches/standards are recommended at this stage rather than absolute levels because decisions are still to be made regarding flood management in the Oakley Catchment by Auckland City Council/Metrowater. The indicative locations of flood protection bunds and walls are shown on Drawings 20.1.11-3-D-D-300-117 and 118 (Appendix A).

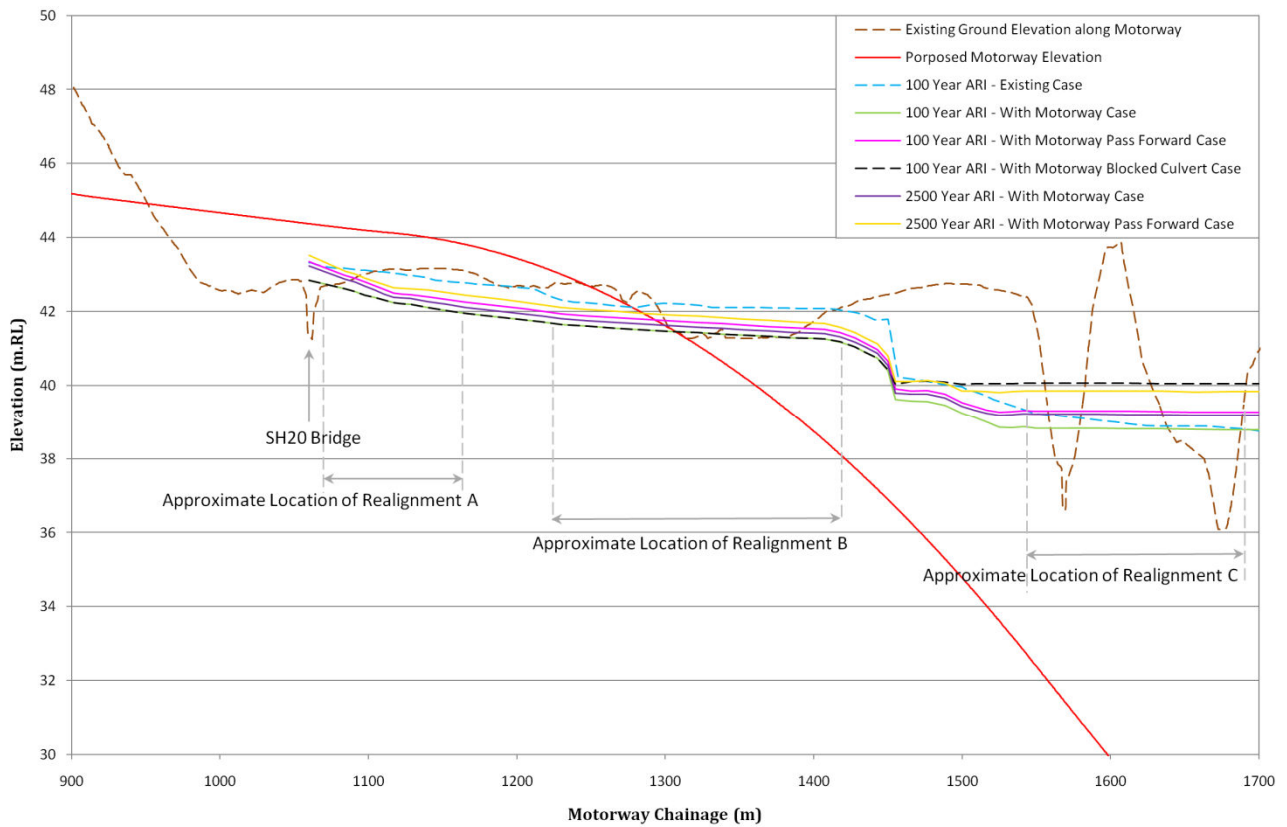


Figure 8.13: Flood Water Levels for all Scenarios (Motorway Ch)

Table 8.10: Rationale for design approach to flood protection works

| Area | Approach | Rationale |
|--|---|--|
| Northern side of Motorway (Hendon Avenue area of Alan Wood Reserve) | Set motorway levels or design flood defences for expected 100 year ARI flood level plus 500mm freeboard (provided that 2500 year ARI event can be conveyed within the freeboard). | <ul style="list-style-type: none"> • 100 year ARI flood level includes climate change and MPD. • 100 year ARI flood level to include for preferred catchment management option (may be pass forward). • 2500 year ARI event to be conveyed in freeboard. • Levels may be affected by blockage scenario because of significant water level increases in channel upstream of the cascade. • 100 year ARI water level plus 500mm is typical standard for NZTA. • 2500 year ARI water level is considered because of the risk to life and infrastructure from tunnel flooding. |
| Southern side of Motorway upstream of cascade in Oakley Creek for Alan Wood Reserve and Goldstar Property areas (Including Valonia Wetland, Realignments A and B and Rehabilitations A and B sections) | | |
| SH20 Bridge | As above but 600mm freeboard to bridge soffit. | NZTA Bridge Manual requirement. |
| Southern side of Motorway downstream of cascade in Oakley Creek (in the vicinity of Realignment C, and ensuring protection of the southern portal) | Set flood defences above backwater from existing western line railway overland flow path (considering 2500 year events and blockage) with appropriate freeboard. | <ul style="list-style-type: none"> • Maximum possible water level is set by the overland flow path across the existing western line railway (which sets maximum water levels during the blockage scenario). • The level of the railway line is higher than 100 year and 2500 year ARI flood events for any pass forward or other scenario. • 100 year ARI water level plus 500mm is typical standard for NZTA. • 2500 year ARI water level is considered because of the risk to life and infrastructure from tunnel flooding. • Freeboard level to be set as appropriate for confidence levels in modelling, and dynamic effects. |

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