PART D: DESCRIPTION OF THE PROJECT

7. Operation of the Project

Overview

The Main Alignment has been designed to an expressway standard, which comprises a minimum of four lanes with continuous median separation. Direct access to and from the Main Alignment will not be permitted, except via three new interchanges and the northern and southern tie-ins. At all interchanges the Main Alignment will go over the connecting roads. Along some parts of the Main Alignment where grades will be steeper, crawler lanes have been provided for slow moving vehicles (e.g. heavy vehicles). The Kenepuru Link Road has been designed as a State highway with strictly controlled direct access. The Porirua Link Roads have been designed to local road standards.

The Project involves approximately 112 stream crossings by either bridges (14) or culverts (98). All bridges have been designed so there are no piers in the wetted stream channel. Culverts and bridges will include necessary erosion protection. The Project will require the permanent realignment of some streams. In total, approximately 6.5km of stream will be realigned.

A range of options are proposed for the treatment of cut slope and fill embankments. The three main options are reinforced soil embankments, mechanically stabilised earth walls (typically around bridges) and soil nail walls. Indicative landscaping has been developed for finished cut and fill slope faces.

Stormwater runoff will be collected and treated using wetlands and proprietary treatment devices.

7.1 Introduction

In this chapter the operation of the Project is described. Specifically, the following aspects are described:

- the design philosophy (Section 7.2);
- road design (Section 7.3);
- traffic services (Section 7.4);
- interchanges (Section 7.5);
- pavements and surfaces (Section 7.6);
- walkways, cycleways and bridleways (Section 7.7);
- permanent access tracks for maintenance activities (Section 7.8);
- cut and fill slopes (Section 7.9);
- bridges (Section 7.10);

- vertical retaining walls (Section 7.11);
- noise attenuation (Section 7.12).
- culverts and erosion control and protection structures (Section 7.13);
- permanent stream realignment (Section 7.14)
- operational drainage and stormwater treatment (Section 7.15); and
- landscaping (Section 7.16).

The information provided in this chapter should be treated as being indicative only and is intended to provide sufficient detail on the Project to assess the potential environmental effects and to identify any necessary measures to avoid, remedy, or mitigate these effects, where appropriate. Through subsequent phases of the Project, the design will be further refined. This will be undertaken within the scope of the conditions which will have been put in place to manage the environmental effects. Prior to construction, the Project will be subject to the outline plan process.

7.2 Design philosophy of the Project

Detailed information about the design philosophy of the Project is contained in the relevant technical reports in Volume 3 in relation to:

- roading design (Technical Report 1)
- structures (**Technical Report 2**); and
- geotechnical engineering (**Technical Report 3**).

This section provides a summary of the key design elements of the Project.

7.2.1 Design objectives

In accordance with the Wellington RoNS programme, the broad design objective for the Main Alignment is to construct and operate a road to an expressway standard. The Kenepuru Link Road and the Porirua Link Roads will serve as local link roads and have therefore been designed to local road standards, although it is noted that the Kenepuru Link Road will be a State highway.

7.2.2 Road capacity

The level of service (LOS) is a qualitative measure of the capacity of a road to convey motor vehicles. The LOS is related to the quality of service available to a given traffic flow (volume) and ranges from LOS A to LOS F. LOS A represents the best quality of service, permitting drivers to drive unimpeded at free-flow speed. LOS F represents heavily congested conditions, where queuing and delays result.

For the Main Alignment, LOS C has been selected as an appropriate minimum performance level for the 2026 design year, as it was considered an acceptable balance between cost and service. LOS C represents stable flow, but with most drivers somewhat restricted in their freedom to select their desired speed and to manoeuvre within the traffic stream.

A higher LOS was considered inappropriate, because the associated increase in cost was not commensurate with the associated performance improvement, and would fail to meet the NZTA's objective of providing a cost-optimised route. Similarly, a lower LOS was considered inappropriate, because of the likelihood of the Main Alignment failing to deliver the required safety and reliability objectives. It would also be extremely disruptive and expensive to retrofit significant lengths of the Main Alignment if additional capacity was required in the future.

Predicted traffic volumes are such that, for a minimum LOS C, a total of four lanes (two in each direction) are required along the entire length of the Main Alignment.

7.2.3 Geometric design

The geometric design standards for this Project are based on the following standards and guidelines:

- the NZTA Draft State Highway Geometric Design Manual (SHGDM);
- the Manual of Traffic Signs and Markings: Part III Motorways (MOTSAM);
- the Austroads: Guide to Traffic Engineering Practice: Part 6 – Roundabouts;
- the Austroads: Rural Road Design Guide; and
- the Austroads: Urban Road Design Guide.

The SHGDM specifies minimum horizontal and vertical design speeds for dual carriageway State highways. For expressways, the horizontal design speeds are 110km/hr, 100km/hr and 80km/hr for flat, rolling and mountainous terrain, respectively. The Main Alignment will go through a combination of mountainous, rolling, and flat terrain (as defined in the SHGDM) at different points in the route. A varying design speed along the Main Alignment would be difficult to achieve in the areas of mountainous terrain as the road will have long straight lengths with limited opportunity to introduce tighter curvature to control speed. Where steeper grades may reduce vehicle speeds (particularly for heavy vehicles) crawler lanes have been provided. This is discussed further in Section 7.2.8 of this report.

As such, a 100km/hr horizontal design speed was considered to be appropriate for the entire Main Alignment. Under the SHGDM it is good design practice for the vertical design speed to be at least 10km/hr higher than the horizontal design speed. As such, a vertical design speed of 110km/hr was considered to be appropriate for the entire Main Alignment.

A design speed of 50km/hr was considered appropriate for the Kenepuru Link Road and the Porirua Link Roads.

7.2.4 Route security

It is generally recognised that Wellington City will be cut off from the rest of New Zealand following a large earthquake and perhaps a large storm event, as both the existing SH1 and SH2 routes and the North Island Main Trunk Line (NIMT) are vulnerable and likely to be closed for many weeks. A major concern is that this transport disruption would seriously impede Wellington's ability to recover after such an event. The Project represents a unique opportunity to improve regional and national route security by reducing the vulnerability of SH1 between Linden and MacKays Crossing. As such, a major driver in the development and design of the Project has been to reduce the vulnerability of SH1 to natural hazards, particularly earthquakes and landslides.

Avoidance of natural hazards is the optimal response to the risk they pose. However, for a significant piece of linear infrastructure, such as the Main Alignment, this is not always possible. Specifically in relation to active faults, it is accepted that some crossing of these faults (and associated splinter faults) will be required for the Main Alignment. On this basis, the approach has been to minimise the number of times faults are crossed. Where it is necessary to cross an active fault, the method of crossing has been carefully considered to minimise the potential damage risk. In general this has meant that crossing active faults with structures, such as bridges or tunnels, has been avoided. Instead, the preference for crossing active faults has been:

- embankments, where access after a rupture event (and potential 3m to 5m horizontal movement) can be reinstated within days; or
- cuttings, where embankments are unfeasible.

A key tenet of the design philosophy is that the road does not collapse, and limited access can be restored quickly in the event of a major earthquake.

Improvements on earlier proposals for the Main Alignment include:

- the removal of significant viaducts to increase the route's resilience to earthquake damage, revisions to road geometry to improve the alignment, particularly in terms of avoiding geological hazards and ecologically sensitive areas and reducing effects on existing streams; and
- enhanced route security through changes to cut and fill slopes in line with the results of detailed geotechnical assessments.

7.2.5 The regional road network

Once operational, the Main Alignment will become the main arterial road between Wellington City and the Kapiti Coast. Part of the existing State highway network (SH1 between Linden and MacKays Crossing and SH58 to the west of the Main Alignment) will likely become local road.

The Main Alignment will serve the wider Wellington region and will be easily accessible from all the main urban centres, namely:

- Wellington City, via existing SH1 at Linden;
- western Porirua, via the Kenepuru Link Road;
- eastern Porirua, via the Porirua Link Roads and the SH58 Interchange with existing SH58;
- the Hutt Valley, via the SH58 Interchange with existing SH58; and
- the Kapiti Coast, via existing SH1 at MacKays Crossing.

7.2.6 Traffic volumes

Traffic volumes for the Project have been modelled for 2026, 2031 and 2041. Table 7.1 shows the estimated traffic volumes for 2026 at a number of key points along the proposed new roads.

Table 7.1: Estimated traffic volumes for the Project

Mid-point	Estimated traffic volume (vpd, weekday)
MacKays Crossing to Pauatahanui Interchange	22,300
Pauatahanui Interchange to James Cook Interchange	20,000
James Cook Interchange to Kenepuru Interchange	18,900
Kenepuru Interchange to Tawa (tie-in with existing SH1)	18,300
Kenepuru Link Road	13,000
Waitangirua Link Road	3,300
Whitby Link Road	3,400

7.2.7 Travel speeds

The Main Alignment between Linden and MacKays Crossing will be approximately 27km long and will have a speed limit of 100km/hr. Travelling the Main Alignment at the speed limit will take approximately 17 minutes.

For heavy vehicles, travel speeds will be lower along some parts of the Main Alignment, because of the gradient of some sections. Where gradient will result in a significant travel speed difference between heavy and light vehicles, crawler and auxiliary lanes will be provided. Figure 7.1 shows the gradient of the Main Alignment and predicted travel speeds for heavy vehicles. It also shows where crawler / auxiliary lanes will be provided to account for reduced speeds by heavy vehicles.

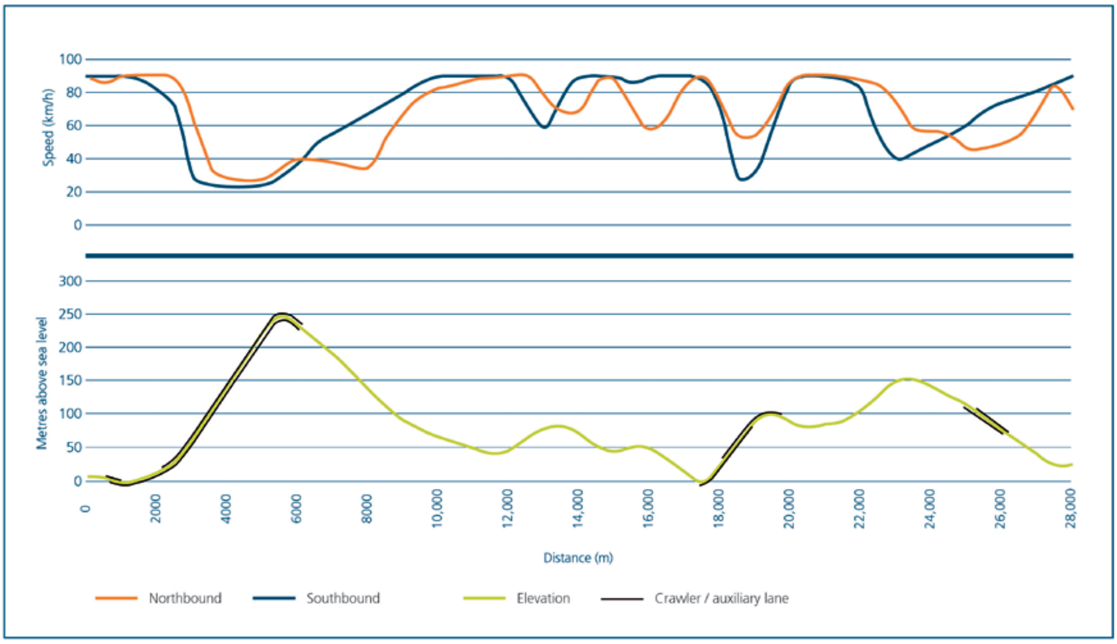

Figure 7.1: Longitudinal profile of the Main Alignment showing the predicted heavy vehicle travel speeds and the location of crawler / auxiliary lanes

7.2.8 Crawler and auxiliary lanes

Crawler lanes are additional lanes provided for slow moving vehicles where their speed has been reduced because of a steep grade. Auxiliary lanes are extensions to on or off ramps where the grades are such that slow moving vehicles are not able to accelerate to their normal operating speed within the traffic stream, or where they must decelerate early from their normal operating speed.

Currently, crawler and auxiliary lanes are proposed in the following sections:

- between MacKays Crossing and the northbound connection from existing SH1 (auxiliary lane);
- between MacKays Crossing and just south of Wainui Saddle at approximately 6,000m in both the northbound and southbound carriageways (crawler lanes);
- between the SH58 Interchange and the James Cook Interchange (auxiliary lane);
- northwards from the Kenepuru Interchange:
- from the Kenepuru Interchange to approximately 25,000m in the northbound (ascending) carriageway (auxiliary lane); and
- from approximately 25,900m to the Kenepuru Interchange in the southbound (descending) carriageway (auxiliary lane).

7.2.9 Escape ramps

The descent northbound from the summit of the Wainui Saddle has a gradient of approximately 8% and a right hand curve towards the bottom of the descent. The curve starts approximately 2.7km downhill from the summit. It is proposed that an emergency escape ramps and an arrestor bed[67] will be provided for downhill vehicles. No other gradients are considered long enough or steep enough to warrant construction of an arrestor bed.

7.2.10 Brake check areas

A brake check area for both north and south bound traffic on the Main Alignment is proposed just south of the summit of the Wainui Saddle (at approximately 5,600m). This will allow both north and south bound vehicles (but predominantly heavy vehicles) to check their brakes before commencing their descent from the Wainui Saddle.

Brake check areas are not considered necessary anywhere else along the Main Alignment.

67. An arrestor bed is an area of deep gravel or similar (directly next to the downhill carriageway) that allows a vehicle that is not able to stop normally due to brake failure or loss of engine power to safely come to a halt, and be able to be retrieved safely without impacting on other traffic. Suitable advanced warning signage would alert drivers to the presence of, and distance to, the arrestor bed.

7.3 Road design

The form of the proposed road is shown in the road layout plans **GM01-21** which should be read in conjunction with this section. The bridges and subways referred to in this section can be viewed on the plans **S01-29**.

7.3.1 Main Alignment

The Main Alignment will be approximately 27km long and has been designed to the following general specifications:

- four lanes (two lanes in each direction with continuous median barrier separation);
- rigid access control;
- grade separated interchanges;
- minimum horizontal and vertical design speeds of 100km/hr and 110km/hr respectively;
- maximum gradient of 8%; and
- crawler lanes in some steep gradient sections to account for the significant speed differences between heavy and light vehicles.

7.3.1.1 Section 1: MacKays Crossing

This section is approximately 3.5km long, and extends from the tie-in at the existing MacKays Crossing Interchange on SH1 to the lower part of the Te Puka Stream valley. The Main Alignment will connect to the existing SH1 at approximately 700m. The first 700m is the existing State Highway 1 alignment which is a grade separated interchange providing access across the NIMT. Any alteration to the existing MacKays Crossing Interchange will be minor.

This section of the Main Alignment will provide for three lanes in the northbound carriageway from 700m and from 2,100m in the southbound carriageway. Southbound traffic will be able to exit the Main Alignment at approximately 1,250m. This exit will pass under the Main Alignment at approximately 1,800m and will connect to the existing SH1 heading south towards Paekakariki. Traffic heading northbound from Paekakariki will be able to join the Main Alignment from a connection at approximately 1,200m.

A subway at approximately 2,000m (Bridge 2) will provide vehicular access across the state highway to three properties. This subway will also provide access across the Main Alignment for pedestrians, cyclists and stock. For the rest of this section heading south, the carriageway will be three lanes in both directions as it rises up the Te Puka Stream valley. At approximately 2,900m there will be an arrestor bed adjacent to the northbound carriageway for any out of control vehicles heading downhill. This section finishes at 3,500m.

7.3.1.2 Section 2: Wainui Saddle

Section 2 starts at approximately 3,500m and will continue climbing for about 2km to the top of the Wainui Saddle at approximately 262m above sea level (at about 5,500m). This will be the highest point of the Main Alignment. Just south of the Wainui Saddle summit (at about 5,600m), there will be a brake check area for both northbound and southbound carriageways. Slightly further south, at approximately 6,000m, three lanes in each direction will be reduced to two lanes in each direction. Section 2 finishes at 6,500m.

7.3.1.3 Section 3: Horokiri Stream

This section is approximately 3km long and extends from the southern end of the Wainui Saddle to the northern end of Battle Hill Farm Forest Park (BHFFP). For the entire length of this section, the Main Alignment will run generally parallel to the Horokiri Stream. From 6,500m to approximately 8,550m the Main Alignment will be to the west of the Horokiri Stream, while from 8,550m to 9,500m it will be to the east of the stream. As the Main Alignment runs parallel to the stream it will cross a number of its minor tributaries which generally run perpendicular to the Horokiri Stream and the Main Alignment.

Over this section, the Main Alignment will cross the Horokiri Stream once, with a bridge at 8,540m (Bridge 4). The section finishes towards the northern boundary of the BHFFP, at approximately 9,500m.

7.3.1.4 Section 4: Battle Hill

This section is approximately 3km long and extends from the northern boundary of the BHFFP to the Pauatahanui Golf Course. Shortly after the Main Alignment enters the BHFFP from the north it crosses over the Horokiri Stream with a bridge at approximately 9,720m (Bridge 6). Over the remainder of this section the Main Alignment will follow the Horokiri Valley floor which widens from north to south through the BHFFP.

Access across the Main Alignment for park users will be provided by a subway located at approximately 10,500m (Bridge 7). This will provide a connection between the eastern and western parts of the park for pedestrians, cyclists and stock. The Main Alignment will continue south from the BHFFP boundary towards the Pauatahanui Golf Course. At about 11,750m it will cross the Horokiri Stream with a bridge (Bridge 8). Access across the Main Alignment will be available underneath this bridge. The section finishes at 12,500m where there will be a subway providing pedestrian and stock access across the Main Alignment (Bridge 10).

7.3.1.5 Section 5: Golf Course

This section is approximately 3km long, and extends from north to south through rural land adjacent to the Pauatahanui Golf Course and Flightys Road. The Main Alignment will cross a number of small tributaries along this section but there will be no major stream crossings requiring bridges. At approximately 14,000m an underpass will provide access across the Main Alignment for two lots to the west of the Main Alignment. In conjunction with this, existing Flightys Road will be extended northwards by approximately 800m, broadly following an existing right-of-way (ROW) off the end of Flightys Road.

This will ensure that access is still available to properties to the east of the Main Alignment that currently use this ROW.

7.3.1.6 Section 6: State Highway 58

This section is approximately 3km long and starts at 15,500m. The SH58 Interchange will be located at approximately 17,500m. At this interchange the Main Alignment will be elevated above a roundabout which will provide access to and from the Main Alignment for traffic travelling in both directions on existing SH58. Immediately south of this interchange, at approximately 17,690m, there will be a bridge (Bridge 15) across the Pauatahanui Stream.

At approximately 18,250m the Main Alignment will widen to provide three lanes in each direction. This section finishes at approximately 18,500m.

7.3.1.7 Section 7: James Cook

This section starts just south of the SH58 Interchange, at approximately 18,500m. Three lanes will be provided for both the northbound and southbound carriageways. The James Cook Interchange will be located at approximately 19,500m. This will be a dumbbell interchange with the Main Alignment being elevated above the local road connections. These roads will provide access to the Main Alignment in both directions to and from the Porirua Link Roads. In the vicinity of this interchange, the number of lanes in each direction on the Main Alignment will be reduced from three to two. This will occur at approximately 18,900m in the northbound carriageway and at approximately 19,500m in the southbound carriageway. From the James Cook Interchange, the Main Alignment will continue southwards for a further 2km. This section finishes at approximately 21,500m.

7.3.1.8 Section 8: Cannons Creek

This section begins at 21,500m and is approximately 3.4km long. Throughout this section the Main Alignment will run along the eastern side of Duck Creek valley, and across an undulating, weathered greywacke plateau between Duck and Cannons Creeks.

There will be four major bridges in this section:

- a 140m long bridge starting at 21,555m, crossing a tributary of Duck Creek (Bridge 17);
- a 150m long bridge starting at 21,860m, crossing a tributary of Duck Creek (Bridge 18);
- a 160m long bridge starting at 22,780m, crossing a tributary of Duck Creek (Bridge 19); and
- a 260m long bridge starting at 23,550m, crossing Cannons Creek (Bridge 20).

These bridges will follow the horizontal alignment of the Main Alignment. This section finishes at 24,900m.

7.3.1.9 Section 9: Linden

This section is approximately 2.8km long. From the start of the section at approximately 24,900m, a third lane will be provided in the northbound carriageway heading uphill.

There will be two bridges:

- a 70m long bridge starting at 25,795m, crossing an unnamed stream that flows into the Onepoto Inlet of the Porirua Harbour (Bridge 21); and
- a 110m long bridge starting at 26,010m, crossing an unnamed stream that flows into the Onepoto Arm of the Porirua Harbour (Bridge 22).

The Kenepuru Interchange will be located at approximately 26,700m. This interchange will involve the Main Alignment being elevated above a roundabout which will connect to the Kenepuru Link Road.

South of the Kenepuru Interchange, the Main Alignment will continue downhill to where it will tie into the existing SH1 along the Tawa straight at Linden. For traffic joining the Main Alignment in a northbound direction, the carriageway will be elevated and will pass over the existing southbound SH1 carriageway. Traffic continuing to Porirua will be able to do so by taking the left lane exit from the existing SH1.

7.3.2 Kenepuru Link Road

The Kenepuru Link Road will provide a connection from the Main Alignment to western Porirua. This link road will provide a connection from the Kenepuru Interchange to Kenepuru Drive and will be approximately 600m long. There will be a roundabout at the intersection with Kenepuru Drive. The Kenepuru Link Road will be a State highway (limited access road) designed to the following standards:

- two lanes (one in each direction);
- design speeds of 50km/hr;
- maximum gradient of 10%;
- limited access only; and
- crawler lane.

The Kenepuru Link Road will run under the existing SH1 (which will be raised slightly) and will be bridged over the NIMT and Porirua Stream (Bridge 28).

7.3.3 Porirua Link Roads

The Porirua Link Roads will connect the Main Alignment to the eastern Porirua suburbs of Whitby and Waitangirua. The Porirua Link Roads will be local roads designed to the following standards:

- two lanes (one in each direction);
- design speeds of 50km/hr;

- maximum gradient of 10%;
- some side access will be permitted;
- provision for cyclists and pedestrians.

The Waitangirua Link Road will be approximately 2.5km long and will run from the western side of the James Cook Interchange to the existing intersection of Niagara Street and Warspite Avenue. This will be a signalised intersection. The Waitangirua Link Road will cross five waterways. The most significant of these will be a crossing of Duck Creek requiring a box culvert (Bridge 29).

The Whitby Link Road will be approximately 900m long and will run from the existing roundabout at the intersection of James Cook Drive and Navigation Drive to the Waitangirua Link Road. The new intersection of the proposed Waitangirua and Whitby Link Roads will be an unsignalised T-intersection with traffic from the Whitby Link Road giving way to Waitangirua Link Road traffic.

7.4 Traffic services

Traffic services include features such as:

- permanent road signs (including variable message signs);
- road lighting;
- road markings; and
- barrier protection.

The traffic services that are to be in place when the Project initially opens to traffic will be considered and finalised during the specimen design phase and will be designed in accordance with the relevant standards at the time the Project is constructed. Throughout the life of the Project, it is anticipated that traffic services will be renewed and upgraded as required, to ensure the continued safe and efficient operation of the State highway.

Design of all road signs and markings will be in accordance with the appropriate versions at the time of:

- the manual of traffic signs and markings (MOTSAM); and
- Land Transport Rule: Traffic Control Devices.

Lighting design for the Main Alignment will comply with AS/NZS 1158:2005 (Standards New Zealand and Standards Australia, 2005) to a V3 category, or whatever equivalent standard applies at the time the Project is constructed. This is the appropriate standard for an expressway with no property accesses and carrying large volumes of traffic at high speeds. Provision has been made for lighting at interchanges and between closely spaced interchanges as follows:

- from MacKays Crossing south to the tie in to the existing SH1 near Paekakariki;
- between SH58 and the James Cook Interchange; and
- between the Kenepuru Interchange and the tie-in to existing SH1 at Linden.

Lighting is not currently proposed for the Porirua Link Roads.

All barrier protection will be designed in accordance with the appropriate versions at the time of the following standards:

- the Transit NZ M/23:2000 Guide for Road Safety Barrier Systems;
- NZS 3114:1987 Concrete Surface Finishes;
- AS/NZS 3845:1999 Road Safety Barrier Systems;
- the NCHRP Report 350 - Recommended Procedures for the Safety and Performance Evaluation of Highway Features (NCHRP 350);
- the State Highway Geometric Design Manual (SHGDM); and
- the Transit NZ Bridge Manual, September 2004 Revision.

7.5 Interchanges

There will be three interchanges on the Main Alignment:

- the SH58 Interchange with existing SH58;
- the James Cook Interchange with the Porirua Link Roads; and
- the Kenepuru Interchange with the Kenepuru Link Road.

For all three new interchanges, the Main Alignment will be elevated above the connecting roads.

7.5.1.1 SH58 Interchange

The SH58 Interchange will be located at approximately 17,500m on the Main Alignment where existing SH58 crosses the Main Alignment. The Main Alignment will be elevated approximately 7m above the new roundabout which will connect to existing SH58 to the east and west of the Main Alignment allowing vehicles to join or exit the Main Alignment in both directions. To the east, a new access road will provide access to five properties and St Joseph's Church. To the west, a new road between the new SH58 Interchange roundabout and the existing SH58 roundabout will be formed. The existing part of SH58 between the new interchange and the existing roundabout will become a cul-de-sac, providing access to two existing residential properties and the Pauatahanui Substation.

7.5.1.2 James Cook Interchange

The James Cook Interchange will be located at approximately 19,500m on the Main Alignment. It will be a dumbbell shaped formation allowing vehicles to join or exit the Main Alignment in both directions. The western side of the dumbbell formation will connect to the Waitangirua Link Road.

The dumbbell formation has been selected because of the lower vehicle operating speeds associated with this formation, as compared to a regular roundabout formation. This lower operating speed is desirable at this interchange because it is situated at the connection between the local road network (with a speed limit of 50km/hr) and the State highway network (with a speed limit of 100km/hr).

7.5.1.3 Kenepuru Interchange

The Kenepuru Interchange will be located at approximately 26,750m on the Main Alignment. The Main Alignment will be elevated over a new roundabout which will connect to the proposed Kenepuru Link Road to the west. Both north and south-bound traffic will be able to join or exit the Main Alignment at this interchange.

7.6 Pavements and surfacing

Final design of the pavement will be undertaken during the detailed design phase of the Project. Design will be based on the Austroads Pavement Design Manual 2004 (Austroads, 2004), its accompanying supplement for light traffic, and the 2007 Transit New Zealand supplement to the Austroads Pavement Design Manual (Transit, 2007) or whatever appropriate relevant standards apply at the time.

This detailed design phase will consider factors such as:

- predicted traffic volumes and proportion of heavy vehicles;
- predicted seal design life;
- the type of pavement being sealed; and
- existing road surface types, where the carriageway connects to the existing road network.

In general terms the pavement design will be based on a flexible granular pavement in a 100km/hr rural road setting. Predicted traffic volumes of up to 25,000 vehicles per day distributed over four traffic lanes indicate that a chipseal type surface is likely to be the most appropriate as the default surface.

There will be areas where chipseal may not be suitable, such as locations where:

- high turning stresses occur on interchange roundabouts; or
- short lengths of different pavement surfaces would provide inconsistent surface friction and surface appearance; or
- to sensibly tie-in with existing surfacing types and maintenance regimes.

Where high stresses are likely to occur from braking and accelerating at interchange roundabouts, it is currently proposed to use a structural asphaltic concrete pavement and surface.

The entire length of the Main Alignment will be surfaced with chipseal, with the exception of the southern end (from 25,300m to the tie-in at Linden) which is likely to be surfaced in open graded porous asphalt (OGPA).

For the three interchanges along the Main Alignment (State Highway 58, James Cook and Kenepuru) the roundabout is currently proposed to be surfaced in stone mastic asphalt while the interchange slip lanes will be chipseal.

The Kenepuru Link Road is currently proposed to be surfaced with OGPA. The first 500m of the Waitangirua Link Road (i.e. closest to the connection with Warspite Avenue) is also currently proposed to be surfaced with OGPA while the remaining length to the connection with the James Cook Interchange will be chipseal. The Whitby Link Road is currently proposed to be surfaced with asphaltic concrete.

7.7 Walkways, cycleways and bridleways

7.7.1 Main Alignment

In accordance with its intending status as a motorway, the Main Alignment will not be able to be used by pedestrians, cyclists or horse riders. Provision for these transport groups has been made where it is practicable. Where the Project is likely to impact on existing tracks, new tracks have been proposed in order to mitigate these effects.

New tracks to mitigate the effects on existing tracks are proposed:

- re-alignment of the Transmission Gully Puketiro loop track at Battle Hill Farm Forest Park to provide access across the Main Alignment (under Bridge 7) to reinstate connectivity;
- a new track along Lanes Flat to provide access across the Pauatahanui Interchange (access will be provided under Bridge 15) to reinstate connectivity and to provide access to Lanes Flat; and
- re-alignment of existing tracks underneath Bridge 19 and the Cannons Creek bridge (Bridge 20) to provide access across the Main Alignment within Belmont Regional Park to reinstate and improve connectivity and to mitigate for effects on the existing registered walkway in Belmont Regional Park.

In other instances the Project has created some opportunities to improve the connection between existing tracks. Where practicable, the NZTA has attempted to realise these opportunities. It should be noted, however, that these improved connections are not required either for the Project itself or as mitigation for the adverse effects of the Project. The NZTA proposes to construct the following tracks which will be available for public use:

- a track connecting Queen Elizabeth Park to BHFFP, running up the Te Puka Stream valley to the Wainui Saddle and down the Horokiri Stream valley to BHFFP;
- north and south bound cycle lanes from Paekakariki (existing SH1) to Queen Elizabeth Park.

The new tracks identified above will use part of the land which is required for the Project. The proposed new and re-aligned tracks are discussed further and shown in the Urban and Landscape Design Framework (**Technical Report 23**).

7.7.1.1 Underpasses providing access for walkers, cyclists and horse riders

Underpasses will be provided at the following locations in order to provide access for walkers, cyclists and horse riders:

- at BHFFP under Bridge 7, as part of the realigned Transmission Gully Puketiro loop track; and
- at the SH58 Interchange, access will be provided under Bridge 15.

7.7.2 Kenepuru Link Road

Pedestrians and cyclists will not be able to use the Kenepuru Link Road as this road will only operate to link vehicles to the Main Alignment. Provision for pedestrians and cyclists will be made, however, at the newly created intersection with Kenepuru Drive, which currently forms part of the regional cycling network. The roundabout at this intersection has been designed to incorporate an underpass to allow safe use by cyclists travelling along Kenepuru Drive and pedestrians crossing Kenepuru Drive.

7.7.3 Porirua Link Roads

As local roads, the Porirua Link Roads will be available for use by pedestrians and cyclists. Cyclists will be able to ride on the road, while footpaths will be provided for pedestrians. This is consistent with the adjoining local road network and the long term intention for the Porirua Link Roads to service residential infill. The intersection of the Waitangirua Link Road with existing Warspite Avenue and Niagara Streets will be signalised with a dedicated pedestrian phase at the crossing. The connection of the Whitby Link Road with existing James Cook and Navigation Drives will be a roundabout with provisions for pedestrian movements.

PCC also has a long term aspiration for a pedestrian and cycle route along Duck Creek into the Belmont Regional Park. This will require a dedicated crossing point along the proposed Waitangirua Link Road to be provided. Provision for an at-grade crossing has been made. The final form of this crossing would be agreed in consultation with key stakeholders and interested parties.

7.8 Permanent access tracks for maintenance activities

Permanent access tracks will be constructed to provide long term access to the State highway. This is required for on-going maintenance of the road, including the maintenance of bridges and culverts. In some locations this track will also provide access to other assets such as electricity transmission lines.

The permanent access track is shown in the plans **AC01-21** but the two proposed track will be:

- a track running parallel to the Main Alignment from the bottom of the Te Puka valley to approximately 12,000m (just south of BHFFP); and
- a track running parallel to the Main Alignment from the James Cook Interchange (at 19,500m) to Takapu Road (approximately 24,250m).

7.9 Cut and fill slopes

The topography of the area means that significant cuts and fills will be needed along most parts of the Project. The form and treatment of these slopes is an important aspect of the Project. Generally throughout the Project:

- cut slopes will generally be between 22° and 35° and will have the first bench at 15m and then benches at 10m intervals thereafter; and
- for steeper cut slopes some form of additional stabilisation measures will be used, such as soil nailing.

The currently anticipated general cut slope configurations are detailed in Table 7.2.

Table 7.2: Cut slope configurations

Location (approximate SV in m)	Cut slopes	
	Slope (°)	Slope form
300 to 2,400m	22	3m wide benches with 15m initial rise and 10m thereafter.
2,400 to 2,850m	40	3m wide benches with 15m initial rise and 10m thereafter.
2,850 to 5,800m	35	3m wide benches with 15m initial rise and 10m thereafter.
5,800 to 8,700m	35	3m wide benches with 15m initial rise and 10m thereafter.
8,700 to 12,500m	25	3m wide benches with 15m initial rise and 10m thereafter.
12,5000 to 17,500m	25 - 35	3m wide benches with 15m initial rise and 10m thereafter.
17,500 to 17,900m	No cut slopes.	
17,900 to 23,300m	35	3m wide benches with 15m initial rise and 10m thereafter.
23,300 to 27,300m	35	3m wide benches with 15m initial rise and 10m thereafter.

Fill slopes are currently proposed to be either:

- 1V: 2H (approximately 25º); or
- 1V: 1H (approximately 45º) with reinforced soil embankments.

All fill faces will be treated and/or vegetated to minimise erosion.

Plans **GM36- 84** show the profile of the proposed cut and fill slopes in cross section.

7.9.1 Cut slopes

An integrated approach of considering cut slope stability, earthquake performance and rock fall management has been used in the design (including type and height), of the cut slopes along the route. Consideration of these approaches has resulted in the development of the cut slope design configurations detailed in Table 7.2.

The standard approach for the Project has been for a 45° (1H: 1V) cut slope with the first bench at 15m and then benching at 10m intervals thereafter for higher slopes. Benches are generally 3m wide. For a cutting of approximately 60m this creates a slope form, like that shown in Figure 7.2.

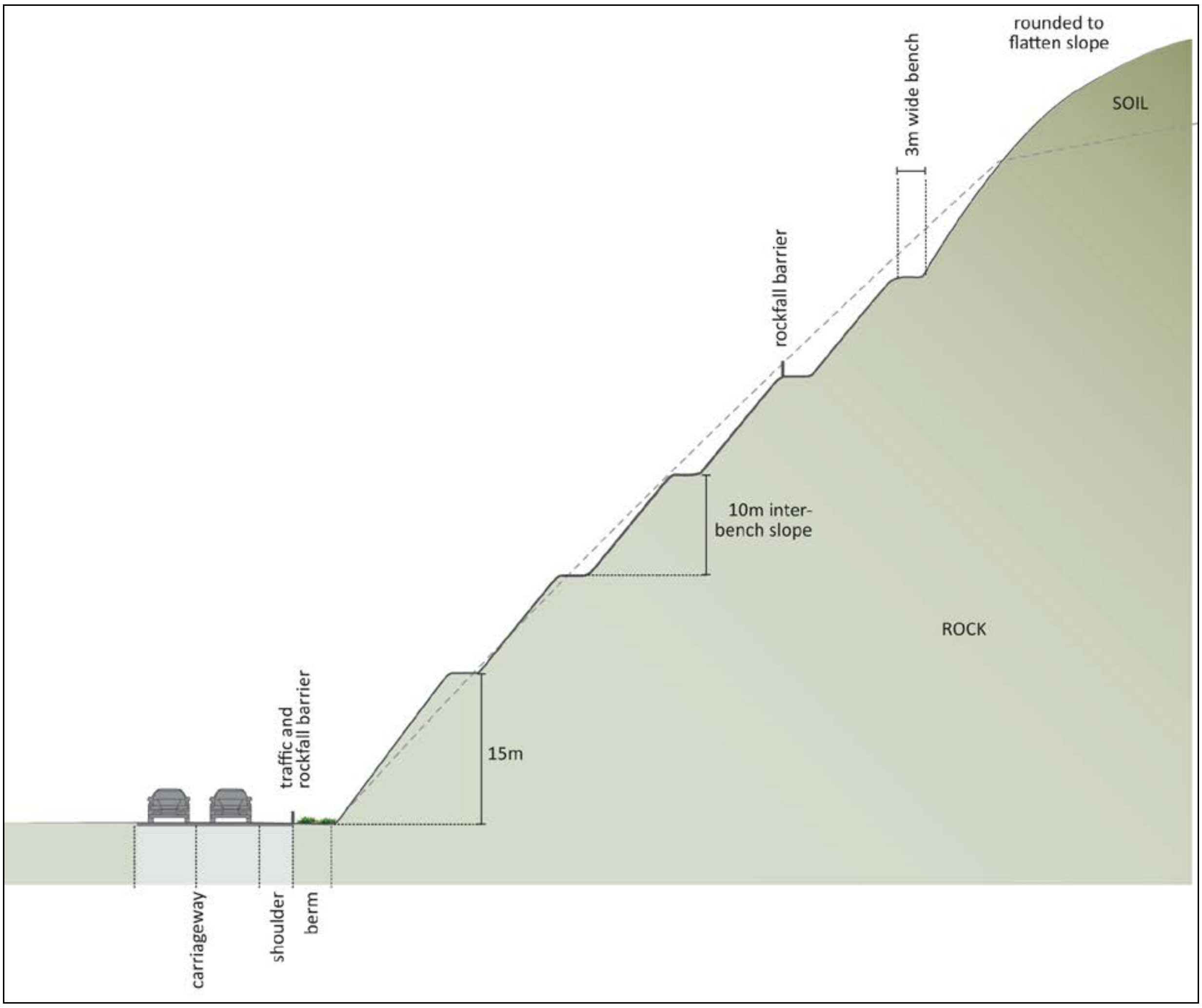

Figure 7.2: Typical form of a benched cut slope

Cut faces will typically be planted with grasses and/or shrubs. Where necessary, rock fall barriers will be installed at the side of the carriageway and/or on benches.

Where steeper cut slopes or additional stabilisation measures are needed, soil nail walls will be used.

7.9.1.1 Soil nail walls

Soil nail walls may be used where additional stabilisation of cut faces is needed. This will generally be in areas where particularly steep cuts are necessary (e.g. for cut slopes of 45 or greater). Soil nails installed into the cut face help to stabilise the face.

Soil nail walls may be needed for some cut faces at the following locations:

- some of the cut slopes in the upper Te Puka valley; and
- the higher (more than 10m) cut faces along parts of Section 3 of the Main Alignment.

7.9.2 Fill slopes

The primary consideration in the design of the fill slopes is the ability to adequately support the carriageway. Most fill slopes are between 22° and 26° with continuous batter slopes (i.e. no benches). For most areas, this form provides adequate structural support for the carriageway and can be planted in grasses and/or scrubs to reduce erosion and improve stability and visual aesthetics.

Where steeper fill slopes are desirable, reinforced soil embankments are likely to be used.

7.9.2.1 Reinforced soil embankments

Reinforced soil embankments (RSE) are proposed to enable fill embankments to be constructed with steeper slopes of 45°. Steeper slopes help to reduce the footprint of fill embankments which reduces the intrusion into streams (and hence the degree of stream realignment required), particularly the Te Puka and Horokiri streams.

RSE will be constructed using a variety of soils from cuttings along the Project. Appropriate fill slopes have been considered based on the performance of precedent slopes in similar soils in the region, and stability analyses. RSE with a face slope not exceeding 45° have been chosen, as they have the ability to be constructed like normal slopes, but incorporating geogrid reinforcement layers (made of high density polyethylene) and without the need for temporary or permanent facing. This will accommodate displacement without significant damage in strong earthquake shaking. This is desirable, given that RSE may be located close to, and in some sections straddling, the Ohariu and associated splinter fault south of the Wainui Saddle. As evident in Figure 7.3, RSE are similar in appearance to standard fill slopes but have increased stability.

Although the Figure 7.3 above is of an unvegetated RSE, all RSE used for the Project will be vegetated with grass and/or low-lying shrubs as significant tree root systems can destabilise the RSE. RSE will be used in the following parts of the Project:

- some of the fill slopes in the upper Te Puka valley; and
- the steeper (45°) fill slopes along parts of Sections 4 and 8 of the Main Alignment.

Figure 7.3: Example of a reinforced soil embankment under construction. Over time the slope face would be expected to re- vegetate

7.10 Bridges

The Project will involve the construction of 29 bridges. Five of the bridges will form part of the interchanges while the remaining 24 are required to take all or part of the carriageway across one or more of the following obstacles:

- existing SH1;
- access roads and local roads;
- streams and gullies; or
- the NIMT railway line.

It is currently considered that six different types of bridges are likely be used for the Project:

- underpass structures;
- pre-stressed concrete hollow core bridges;
- pre-stressed concrete super 'T' bridges;

- steel 'I' girder bridge;
- post-tensioned box structures; and
- box culverts.

Table 7.3 contains further details about each of these types of bridges, including illustrative examples of existing similar structures. More detailed information about the location and form of all the bridges (including a schedule of bridges) is contained in **Technical Report 2** and the plans **S01- 29**.

Table 7.3: Bridges currently proposed for the Project

Structure type	Description	Illustrative example
Underpass	Underpasses will be used to provide access beneath the Main Alignment for the existing SH1 near the northern tie-in and for access roads and tracks in a number of locations. They will between 6 and 13 metres wide and the walls will generally be made of pre-cast concrete.	
Pre-stressed concrete hollow core bridge	Pre-stressed concrete hollow core bridges are proposed where spans of up to 25m are required. They are a simple bridge form with deck units, which are typically supported on reinforced concrete cap beams founded on bored concrete piles.	

Structure type	Description	Illustrative example
Pre-stressed concrete super 'T' bridges and beam and slab bridge	Pre-stressed concrete super 'T' bridges are proposed where spans of between 25 and 35m are required. And bridge 27 is abeam and slab bridge. Both have a similar form to hollow core bridges but are able to provide greater span lengths.	
Steel 'I' girder bridge	Steel composite bridges are proposed where spans of between 35 and 60m are required. These types of bridges are proposed in a number of locations, particularly where large spans are desirable due to steep topography and/or the need to avoid structures in sensitive waterways.	

Structure type	Description	Illustrative example
Post-tensioned box structure	Post-tensioned box structures are proposed for spans greater than 60m. This is proposed for the bridge over Cannons Creek (Bridge 20).	
Box culvert	A single cell box culvert is proposed for a crossing of Duck Creek by the Waitangirua Link Road (Bridge 29). This crossing requires higher reserves of hydraulic capacity than could be provided by a pipe culvert. It will likely be constructed from in-situ or pre-cast concrete, or a combination of both. It has been designed to allow easy clearing of debris.	

Table 7.4: Schedule of proposed bridges (Schedule B)

Bridge	Location	Obstacle crossed	Bridge type	Special features	Spans	Length (m)	Width (m)
1	1,800m	Main Alignment over existing SH1	Hollow core deck underpass	Integral abutments	1	11.8m	110.4m
2	1,900m	Main Alignment over access road	Hollow core deck underpass	Integral abutments	1	13m	39.75m
3	2,730m	Main Alignment over Te Puka Stream	Steel 'I' girder bridge	Two separate bridge structures. One under northbound and southbound carriageways	N/B and S/B – 2 spans.	N/B 75.6m S/B 59.6m	N/B 13.5m S/B 13.5m
4	8,540m	Main Alignment over Horokiri Stream	Hollow core bridge	Integral abutments	1	27.4m	21.85m
5	9,300m	Main Alignment over access road	Reinforced concrete underpass	-	1	6.9m	27.8m
6	9,720m	Main Alignment over Horokiri Stream	Super 'T' bridge	Integral abutments	1	31.6m	21.80m
7	10,500m	Main Alignment over access road	Reinforced concrete underpass	-	1	5.8m	28.20m
8	11,750m	Main Alignment over Horokiri Stream	Hollow core bridge	Integral abutments & piers	3	67.2m	21.85m
9	N/A	Access road over Horokiri Stream	Hollow core bridge	Integral abutments	1	26m	5.775m
10	12,600m	Main Alignment over access road	Reinforced concrete underpass	-	1	6.9m	34.81m
11	12,840m	Main Alignment over access road	Reinforced concrete underpass	-	1	6.9m	24.8m
12	13,965m	Main Alignment over access road	Reinforced concrete underpass	-	1	6.9m	32m
13	17,400m	Main Alignment over SH58 Interchange	Hollow core bridge	Integral abutments	1	22.2m	21.85m
14	17,520m	Main Alignment over SH58 Interchange	Hollow core bridge	Integral abutments	1	22.2m	21.85m

Bridge	Location	Obstacle crossed	Bridge type	Special features	Spans	Length (m)	Width (m)
15	17,690m	Main Alignment over Pauatahanui Stream	Super 'T' bridge	Integral abutments	3 single span decks	32m	2 @ 10.5m 1 @ 21.80m
16	19,500m	Main Alignment over James Cook Interchange	Super 'T' bridge	Integral abutments	1	27.6m	24.3m
17	21,555m	Main Alignment over Duck Creek	Steel 'I' giver bridge	Base isolated bridge deck	3	142m	21.8m
18	21,860m	Main Alignment over Duck Creek	Steel 'I' giver bridge	Base isolated bridge deck	4	147m	21.8m
19	22,780m	Main Alignment over Duck Creek	Steel 'I' giver bridge	Base isolated bridge deck	4	162m	21.8m
20	23,550m	Main Alignment over Cannons Creek Gully	Post tensioned concrete box bridge	Balanced cantilever bridge form.	3	263.4m x 2 no.	2 x 11m
21	25,795m	Main Alignment over stream and gully	Steel 'I' girder bridge	Two separate bridge structures. One under northbound and southbound carriageways	N/B – 3 spans. S/B – 2 spans	N/B 71.4m S/B 53.4m	N/B 13.5m S/B 11m
22	26,010m	Main Alignment over stream and gully	Steel 'I' girder bridge	Two separate bridge structures. One under northbound and southbound carriageways	N/B – 3 spans. S/B – 3 spans	99.9m N/B & S/B	13.5m N/B & S/B
23	26,660	Main Alignment over Kenepuru Interchange	Hollow core bridge	Integral abutments	1	16m	21.85m
24	26,720m	Main Alignment over Kenepuru Interchange	Hollow core bridge	Integral abutments	1	16m	21.85m
25	27,015m	Main Alignment over existing SH1	Steel box girder bridge	Base isolated bridge deck	3	129m	varies 11m – 16.6m
26	27,510m	Main Alignment over Collins Ave	Hollow core deck underpass	Integral abutments	1	18.6m	36.25m

Bridge	Location	Obstacle crossed	Bridge type	Special features	Spans	Length (m)	Width (m)
27	N/A	Existing SH1 over the Kenepuru Link Road	Pre-stressed beam and slab on pre-cast concrete walls	Day lighting of bridge deck at portals	1	16.7m	123m
28	N/A	Kenepuru Link Road over NIMT railway	Super 'T' bridge	Integral piers.	4	121.5m	13m
29	N/A	Waitangirua Link Road over Duck Creek	Box culvert	-	1	5m	55.7m

7.11 Vertical retaining walls

Mechanically stabilised earth (MSE) walls are currently proposed to be used where vertical retaining walls are needed. These will typically be used for bridge abutments, around interchanges and may be used where walls are needed to support carriageways on steep slopes. The walls comprise metal straps or geotextile grid reinforcement embedded in the fill to provide stability. They are typically faced with patterned concrete panels which provide a more attractive finish, as shown in Figure 7.4.

Figure 7.4: Example of an MSE wall with concrete panel facing

MSE walls are a more attractive and cost-effective solution where vertical walls are required. They are widely used throughout the region's State highway network.

For the Project, they will be used for the following applications:

- the abutments of some bridges;
- around the ramps for all three interchanges and the tie-in to SH1 at Linden; and
- to support a length of the carriageway for the Kenepuru Link Road.

Two other types of retaining walls could also be used in some areas, being:

- continuous bored pile walls; and
- soldier piled walls.

These types of walls could be used where:

- very poor ground is encountered in cuttings requiring particular robust retaining solutions; or
- where top down construction is the constructor's chosen method of bridge construction (possibly around bridges 26 and 27).

7.12 Noise attenuation

Noise barriers are currently proposed in the following areas:

- a 2m high noise bund along the western (northbound) carriageway of the Main Alignment adjacent to the properties at Flightys Road (total length of approximately 378m);
- a 2m high noise barrier along the southern side of the Waitangirua Link Road at the proposed new intersection with Warspite Avenue adjacent to the marae (total length of approximately 150m);
- a 2 – 2.5m high noise barrier along the eastern (southbound) carriageway of the Main Alignment at the Linden tie-in (total length of approximately 532m, not continuous);
- a 2 – 3m high noise barrier along the western (northbound) carriageway of the Main Alignment at the Linden tie-in (total length of approximately 572m, not continuous);
- a 2 - 3m high noise barrier along the eastern (southbound) carriageway of the Main Alignment adjacent to the properties at 37 Apple Terrace - 56A Huanui Street (total length of approximately 151m); and
- a 2m high noise bund along the western (northbound) carriageway of the Main Alignment adjacent to the properties at 86 - 92 Tremewan Street (total length of approximately 100m).

The noise barriers are shown in the plans **GM01-21**. The assessment of noise effects and mitigation options are detailed in Chapter 16 of this report.

7.13 Culverts and erosion control and protection structures

The Project involves 98 permanent culverts for road crossings. Additional crossings by bridges have been detailed in Section 7.10. For most the length of the Main Alignment, the road will run parallel to the main channel of streams. In general, culverts are currently proposed for the small crossing of stream tributaries (which are often ephemeral) while bridges are currently proposed for larger crossings of the main channel of streams.

The design and selection of culvert forms was influenced by a number of factors, including:

- the hydraulic behaviour of the stream;
- Culverts should be capable of conveying the critical duration 10% annual exceedance probability (AEP) rainfall storm event without water rising above the top of the pipe (pipe soffit).
- The road surface level should be at least 500mm above design stormwater levels for a 1% AEP storm event.
- the ecological values of the stream;
- Fish passage should be provided where new culverts will impede the movement of fish.

The design of the culverts has also taken into account likely future development within the catchments and climate change. This will ensure that the culverts will be sized appropriately for their full life. Culverts will predominantly be flush-jointed pre-cast concrete pipes of standard sizing. For culverts handling large flow volumes, alternate designs have been considered.

Table 7.5 outlines the culverts required for the Project and their indicative position is shown in the plans **DR01- 21**. The lengths specified are only the length of the actual culvert itself. Each culvert will include erosion control and protection structures of up to 20m upstream and downstream of each culvert. These structures are described in Section 7.13.2 of this report.

In addition to the culverts required for the crossing of stream by a road, it is proposed to replace eight existing culverts in Duck Creek that current act as barriers to fish passage. The replacement of these existing culverts with countersunk culverts to allow fish passage is part of the proposed ecological mitigation measures (refer to the draft Ecological Management and Monitoring Plan in Volume 5 for further details). These eight existing culverts are labelled as DM (Duck mitigation) on plans **DR16 and DR17**.

Table 7.5: Culverts currently proposed for the Project (Schedule A)

Culvert ID	Location (m)	Length (m)	Diameter (mm) or box culvert dimensions (m)	Type of fish passage required
Wainui Stream catchment				
W1	1,525	155	1,050	Standard design
W2	1,630	109	1,050	Standard design
W3	2,100	96	Two 3m (W) x 2.5m (H) box culverts	Standard design
W4	2,250	95	900	Standard design
Te Puka Stream catchment				
T3	3,075	91	1,050	None
T4	3,300	69	600	New design
T5	3,475	56	1,050	None
T6	3,725	58	600	None
T7	3,900	72	900	None
T8	4,025	85	1,050	None

Culvert ID	Location (m)	Length (m)	Diameter (mm) or box culvert dimensions (m)	Type of fish passage required
T9	4,300	85	1,050	None
T10	4,475	93	1,200	Standard design
T15	4,575	84	600	None
T11	4,775	80	600	None
T12	4,875	65	1,050	None
T13	5,025	58	1,050	None
T14	5,200	245	900	None
Horokiri Stream catchment				
H2	5,375	266	1,050	Standard design
H3	5,650	51	1,050	New design
H4	5,825	72	1,050	New design
H5	5,930	69	750	None
H6A	6,075	61	600	None
H6B	6,150	54	600	None
H7	6,275	84	1,350	Standard design
H8	6,400	73	600	None
H9	6,575	57	900	None
H10	6,625	58	600	None
H11	6,675	80	750	None
H12	6,850	64	900	None
H13	7,050	72	900	None
H14	7,250	93	600	None
H15	7,400	96	1,200	New design
H16	7,675	68	1,200	New design
H17	8,000	64	900	None
H18	8,150	44	1,050	New design
H19	8,375	51	900	New design
H21A	8,850	50	1,200	None
H22	9,000	45	900	None
H23	9,150	33	600	None
H24	9,325	64	3m (W) x 2.5m (H) box culvert	Standard design
H26	9,925	52	600	None
H27	10,175	74	600	None
H29	10,550	66	900	None
H30	10,750	74	600	None
H31	10,800	74	600	None
H32	11,125	73	600	None
H33	11,250	63	900	None
H34	12,025	41	600	None
H35	12,125	49	900	None
H36	12,200	96	900	None
H37	12,400	81	750	None

Culvert ID	Location (m)	Length (m)	Diameter (mm) or box culvert dimensions (m)	Type of fish passage required
Ration Stream catchment				
R2	13,000	33	750	None
R3	13,100	89	1,050	Standard design
R4	13,250	50	600	None
R5	13,400	113	600	None
R6	13,450	86	600	None
R7	13,550	136	3,000	Standard design
R8	13,900	74	1,600	Standard design
R9	13,950	72	750	None
R10	14,775	125	2,100	Standard design
R10A	14,650	110	600	None
R11	15,075	133	1,200	None
R12	15,350	126	600	None
R13	15,600	109	1,200	Standard design
R14	15,800	153	900	None
Collins Stream catchment				
C1	16,125	88	750	None
Pauatahanui Stream catchment				
Pa1	16,625	107	1,200	None
Pa2	16,875	81	1,200	Standard design
Pa3	17,000	55	600	None
Pa4	17,175	63	600	None
Pa5	17,350	128	600	None
Pa6	17,475	40	1,050	Standard design
Pa6A	17,475	40	1,050	None
Pa8	18,225	52	1,200	None
Pa9	18,450	78	600	None
Duck Creek catchment				
D1	19,950	195	600	None
D2	20,100	141	600	None
D3	20,200	128	600	None
D4	20,375	113	600	None
D5	20,525	74	600	None
D6	20,600	154	600	None
D7	20,650	164	1,600	Standard design
D8	21,000	119	1,050	New design
D9	21,225	167	1,200	New design
D10	21,425	109	1,050	None
D13	22,450	62	600	None
D14	22,700	76	1,350	Standard design
D16	23,050	49	600	None
D17	19,550	62	600	None

Culvert ID	Location (m)	Length (m)	Diameter (mm) or box culvert dimensions (m)	Type of fish passage required
Duck Creek catchment (for the Porirua Link Roads)				
D19	Porirua Link Roads	45	600	None
D20	Porirua Link Roads	70	600	None
D21	Porirua Link Roads	46	600	None
D22	Porirua Link Roads	63	600	None
D23	Porirua Link Roads	91	900	None
D24	Porirua Link Roads	95	750	None
D25	Porirua Link Roads	48	600	None
D26	Porirua Link Roads	44	600	None
Duck Creek catchment (existing perched culverts to be replaced to provide fish passage)[68]				
DM1	N/A	10	Replace as existing	Standard design
DM2	N/A	10	Replace as existing	Standard design
DM3	N/A	10	Replace as existing	Standard design
DM4	N/A	10	Replace as existing	Standard design
DM5	N/A	10	Replace as existing	Standard design
DM6	N/A	15	Replace as existing	Standard design
DM7	N/A	15	Replace as existing	Standard design
DM8	N/A	12	Replace as existing	Standard design
Kenepuru Stream catchment				
K2	24,475	39	600	None
K3	24,625	82	600	None
K4	24,700	53	600	None
K5	24,850	72	900	None
K6	24,875	67	600	None
K7	25,100	83	975	None
K8	25,200	49	600	None
K9	25,325	54	1,200	New design
Porirua Stream catchment				
Po2	26,200	73	600	None
Po3	26,325	84	825	None
Po4	26,425	115	900	None
Po5	26,775	149	1,200	None
Po6	27,000	140	975	None

7.13.1 Providing fish passage

Of the culverts for the crossing of a stream by the road, 27 have been identified as requiring fish passage[69]. Fish passage has been determined on the basis of the need to mitigate potential adverse

68. As part of the freshwater mitigation measures it is proposed to replace eight existing perched culverts in the Duck Creek with culverts allowing fish passage. Refer to Chapter 22 of this report and **Technical Report 11** for further details.

69. This number of 27 does not include the replacement of the eight perched culverts in Duck Creek which are considered separately.

effects on freshwater ecology (as detailed in Chapter 22 of this report). For stream crossings not involving structures in the streambed, (i.e. all the bridges except the box culverts), it has been assumed that fish passage will not be affected.

Two methods of providing fish passage are proposed at this stage, depending on culvert and catchment characteristics. The most common design solution for culverts requiring fish passage is to bury the culvert pipe to maintain a constant wetted base. In this situation culverts have been oversized to allow for burial of the inverts up to 300mm (listed as '*standard design*' in Table 7.5). Where this has not been appropriate due to ecological or topographical factors, an alternative fish passage solution will need to be considered (listed as '*new design*' in Table 7.5).

7.13.2 Erosion control and protection structures

Erosion control and protection structures are structures located upstream and downstream of culverts. They are designed to ensure the on-going functioning of culverts by reducing the likelihood of debris blockages and/or erosion of the stream beds.

7.13.2.1 Inlet debris structures

Culvert inlets are susceptible to blockage from debris carried by water flowing down stream channels. Avoiding blockage of the culvert entrance is critical to maintaining the flow capacity of the structure. This will be achieved by creating a debris screen and stilling basin immediately upstream of the inlet structure by excavating the existing stream channel. The stilling basin will slow the velocity of the water in the channel allowing some of the suspended debris that passes through the screen to fall out of suspension before entering the culvert barrel. The stilling basins have been designed for ease of construction and to provide smooth hydraulic transitions. Standard pre-cast wingwall structures at the culvert inlet will also perform this function by directing flow into the culvert barrel.

A coarse debris screen will be installed upstream of the stilling basin. The coarse debris screen will be made up of a series of solid stakes driven into the stream bed. These stakes will be spaced so that debris large enough to block the culvert barrel will be stopped at the screen. The screen will be placed at an angle of 120 degrees to the direction of flow so that floating debris will be driven to one side of the channel by the force of the flow, allowing the other side to remain clear and able to accommodate the full flow.

Both the debris screens and stilling basins will need to be regularly maintained to ensure long term effectiveness. Both will need to be periodically cleared of accumulated debris so that the system does not become so full of debris that it fails.

7.13.2.2 Outlet structures

Excessive outlet velocities can result in significant erosion of stream channels and sizeable scour holes immediately downstream of culverts. To protect downstream channels and reduce water velocity immediately downstream of each culvert, erosion control structures will be installed. In most cases these will be either:

- a rip rap stilling basin and apron; or
- a baffle apron.

Both of these options can be equally effective at controlling culvert outlet velocity. Baffle aprons are a highly engineered structure and generally require a smaller footprint than a rip rap stilling basin with apron. A rip rap stilling basin provides a resting place for migrating fish and has a more natural appearance. For these reasons a rip rap stilling basin is the preferred option where fish passage is required.

The location and preliminary design details of all culverts are detailed in the maps and drawings contained in plans **DR01- 21**. Further information about the design and performance of culverts is also contained in **Technical Report 14**.

7.14 Permanent stream realignment

The Project requires a number of permanent stream realignment. For the purposes of this description of the Project, stream realignment is classified as a diversion of a surface water body not exclusively associated with the crossing of a stream (either by bridge or culvert). This is consistent with the term in the Regional Freshwater Plan[70]. Once water is diverted into the newly created stream channel, the old stream bed can be reclaimed. Stream realignment is typically required to avoid fill embankments.

The permanent stream realignments proposed are:

- realignment of parts of the upper Te Puka Stream to the east through the Te Puka Stream valley;
- realignment of parts of the upper Horokiri Stream to the east through the upper Horokiri Stream valley;
- realignment of parts of the lower Horokiri Stream to the west through the lower Horokiri Stream valley;
- realignment of parts of the Ration Stream to the east;
- realignment of parts of the Pauatahanui Stream to the east and to the west, approximately 500m north of Lanes Flat;
- realignment of the Pauatahanui Stream to the north through Lanes Flat;
- realignment of part of the Pauatahanui Stream to the east, immediately south of Lanes Flat;
- minor realignment of small sections of the Kenepuru Stream; and
- realignment of the Porirua Stream to the southeast around the Kenepuru Interchange and Kenepuru Link Road area.

In total, approximately 6.6km of stream will be realigned, as detailed in Table 7.6.

70. E.g. Rule 47 of the RFP allows for the temporary diversion of water associated with the placement and use of a river crossing. While the stream crossings required for the Project are being applied for under Rule 49, the temporary diversion of water provided for in Rule 47 is still applicable.

Table 7.6: Proposed permanent stream realignment

Catchment	Total length of stream realigned (m)
Wainui Stream	91
Te Puka Stream	1,867
Horokiri Stream	1,013
Ration Stream	896
Pauatahanui Stream	1,829
Duck Creek	221
Kenepuru Stream	169
Porirua Stream	474
TOTAL	**6,560**

The plans **DR01- 21** show the location and form of proposed stream realignments.

7.15 Operational drainage and stormwater treatment

This section contains a description of the drainage and stormwater treatment currently proposed for the on-going operation of the Project. Drainage and stormwater treatment (i.e. erosion and sediment control) needed for the construction of the Project is described in Chapter 8 of this report.

The operational drainage and stormwater treatment design for the Project has been driven by two key requirements:

- ensuring that stormwater does not inhibit the safe and effective operation of the Project; and
- ensuring that the potential adverse environmental effects associated with stormwater are mitigated.

7.15.1 Drainage

Adequate pavement drainage is fundamental to the satisfactory performance of the road pavements. Subsoil drains will be used, where required, to ensure that pavements can drain effectively. A minimum subsoil drainage depth of 1.5m will be provided.

The proposed stormwater collection and conveyance system will be designed so that no more than 4mm of water depth occurs across the traffic lanes for a 5% annual exceedance probability event, 10 minutes duration storm event. Stormwater will be collected and conveyed to catchpits. From these, stormwater will be conveyed to the treatment devices.

7.15.2 Stormwater treatment

The stormwater treatment currently proposed for the Project aims to avoid adverse effects on water bodies and has been guided by the following publications:

- the Regional Freshwater Plan for the Wellington Region (1999);

- the NZTA's Draft Stormwater Treatment Standard for State Highway Infrastructure (2010); and
- Auckland Regional Council's Stormwater Treatment Devices: Design Guidelines Manual (2003) (known as TP10).

The target standard considered as acceptable for long term treatment of stormwater from the Project has been set at removal of 75% of total suspended solids (TSS). This level of removal is considered best practice within existing standards and is known to remove the great proportion of heavy metal solids.

The proposed stormwater treatment system will use two main treatment methods:

- wetlands; and
- proprietary treatment devices.

7.15.2.1 Wetlands

Constructed wetlands are highly effective treatment systems and are capable of removing 77% of influent TSS as well as significant quantities of dissolved heavy metals such as copper, zinc and phosphorous. Wetlands are also capable of providing flow attenuation, flood protection, public amenity and habitat for aquatic life and wildlife. For these reasons, wetlands are the preferred treatment option, where practicable. One of the main requirements for wetlands is sufficient space. The steep nature of many areas has prevented the more widespread use of wetlands throughout the Project.

Five specific areas along the Main Alignment are considered appropriate for wetlands. These areas are detailed in Table 7.7 and marked on the plans **DR01- 21**.

Table 7.7: Proposed wetlands

Wetland #	Location	Approximate location	Length of the Main Alignment treated	Approximate size of wetland (m^2)
1	MacKays Crossing - Te Puka	940m	0m to 2,100m	1,980
2	Horokiri Valley	7,550m	5,550m to 7,550m	1,920
3	Battle Hill Farm Forest Park	10,200m	8,600m to 10,200m	1,650
4	Horokiri Valley south	11,200m	10,200m to 11,800m	1,980
5	SH58 Interchange	17,500m	15,600m to 17,700m	1,650

The areas currently proposed for wetlands will provide stormwater treatment for approximately 34% of the length of the Main Alignment.

7.15.2.2 Proprietary treatment devices

Proprietary treatment devices have few site constraints and can therefore be used in almost any area of the Project. They will be used wherever stormwater treatment via wetlands is not possible. The steep topography of much of the Project area prevents the use of wetlands. Accordingly, proprietary devices are proposed to be used for a significant proportion of the Project.

In total, 26 proprietary treatment devices are proposed along most of the length of the Main Alignment. The proposed location of the devices is shown in the plans contained in **Appendix 15.U** of **Technical Report 15.** The devices have been proposed adjacent to culverts or bridges so that treated runoff from the device can be efficiently discharged into natural waterways. The devices are also located at the low-point of every sub-catchment to ensure that all runoff is captured and treated.

7.16 Landscaping

Considerable landscaping will be undertaken as part of the Project. It will serve a number of purposes, including:

- helping to integrate the Project into the landscape;
- assisting to mitigate the visual and landscape effects of the Project;
- assisting to mitigate the ecological and stormwater effects of the Project; and
- helping to stabilise batter slopes and reduce erosion and sediment runoff.

The specific landscaping measures proposed are detailed Chapter 25 of this report and shown in the plans **LA01- 21**. Broadly, the following roadside landscaping is proposed:

- amenity planting on the cut and fill faces around MacKays Crossing;
- revegetation of the cut and fill faces through the Te Puka Stream valley, Wainui Saddle, Horokiri Stream valley and Battle Hill;
- a mixture of revegetation and grassing of the cut and fill faces though the golf course section to the SH58 Interchange;
- amenity and ecological planting around the SH58 Interchange;
- a kanuka corridor from the SH58 Interchange to just south of the James Cook Interchange;
- amenity planting around the James Cook Interchange;
- a mixture of revegetation and grassing of the cut and fill faces from the James Cook Interchange to the Kenepuru Interchange;
- amenity planting around the Kenepuru Interchange and the Kenepuru Link Road;
- revegetation of the cut and fill faces along the Whitby Link Road; and
- revegetation of the cut and fill faces of the upper half of the Waitangirua Link Road and grassing of the cut and fill faces of the lower half of the Waitangirua Link Road.

Additional landscaping is also proposed for other areas, such as stream restoration and surplus fill sites.