Warkworth to Wellsford

Construction Water Management Design

Technical Report

July 2019

QUALITY ASSURANCE

Prepared by

Jacobs GHD Joint Venture in association with Ridley Dunphy Environmental Ltd. Prepared subject to the terms of the Professional Services Contract between the Client and Jacobs GHD Joint Venture for the Route Protection and Consenting of the Warkworth to Wellsford.

Revision history:

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
Final	Tony Cain	Graeme Ridley Justine Bennett		Brad Nobilo		05/07/2019

Quality information

Document title: Ara Tūhono Project, Warkworth to Wellsford Section; Construction Water Management Design Technical Report

Version: Final

Date: July 2019

Prepared by: Tony Cain and Roanna Salunga (GHD Limited)

Reviewed by: Graeme Ridley (Ridley Dunphy Environmental Limited) and Justine Bennett (GHD Limited)

Approved by: Brad Nobilo (GHD Limited)

File name: Construction Water Management Design Report_5July19_FINAL.docx

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GLOSSARY AND DEFINED TERMS

Refer to the Water Assessment Report for a master glossary and defined terms table.

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1 INTRODUCTION

1.1 Project background

The NZ Transport Agency (Transport Agency) is lodging a Notice of Requirement (NoR) and applications for resource consent (collectively referred to as “the Application”) for the Warkworth to Wellsford Project (the Project).

The Project involves the construction, operation and maintenance of a new four lane state highway. The route is approximately 26 km long. The Project commences at the interface with the Pūhoi to Warkworth project (P-Wk) near Woodcocks Road. It passes to the west of the existing State Highway 1 (SH1) alignment near The Dome, before crossing SH1 just south of the Hōteo River. North of the Hōteo River the Project passes to the east of Wellsford and Te Hana, bypassing these centres. The Project ties into the existing SH1 to the north of Te Hana near Maeneene Road. The proposed designation boundary and Indicative Alignment are shown in Figure 1.

For description purposes the Project has been divided into the following sections (as shown in Figure 1).

a) Southern Section: From the southern extent of the Project at Warkworth to the northern tunnel portal.

b) Central Section: From the northern tunnel portal to the Hōteo River (southern abutment.

c) Northern Section: From the Hōteo River (northern abutment) to the northern tie in with existing SH1 near Maeneene Road.

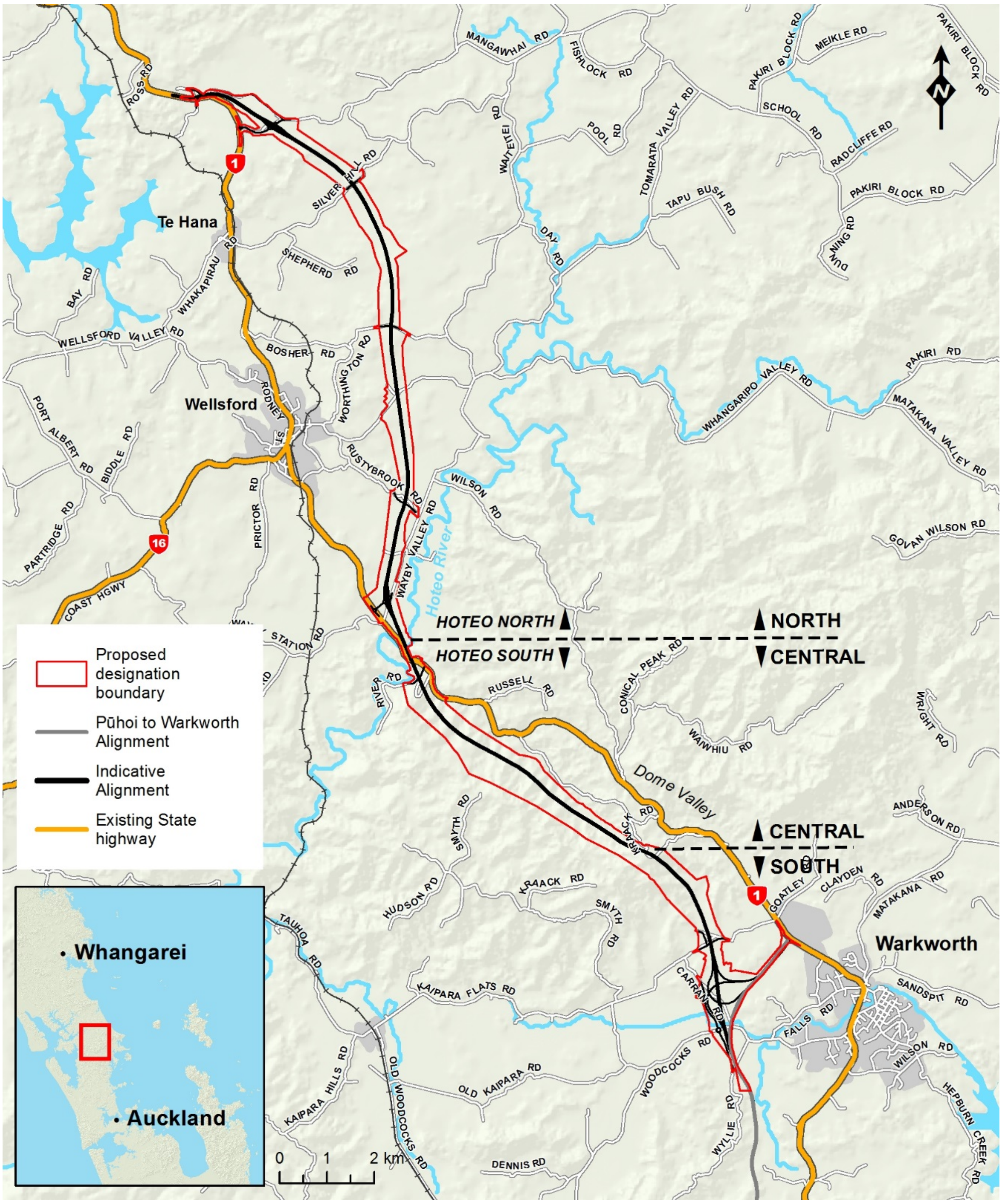


Figure 1 - Project Sections and Indicative Alignment

The proposed designation and freshwater catchments relevant to the Project are shown in Figure 2 below.

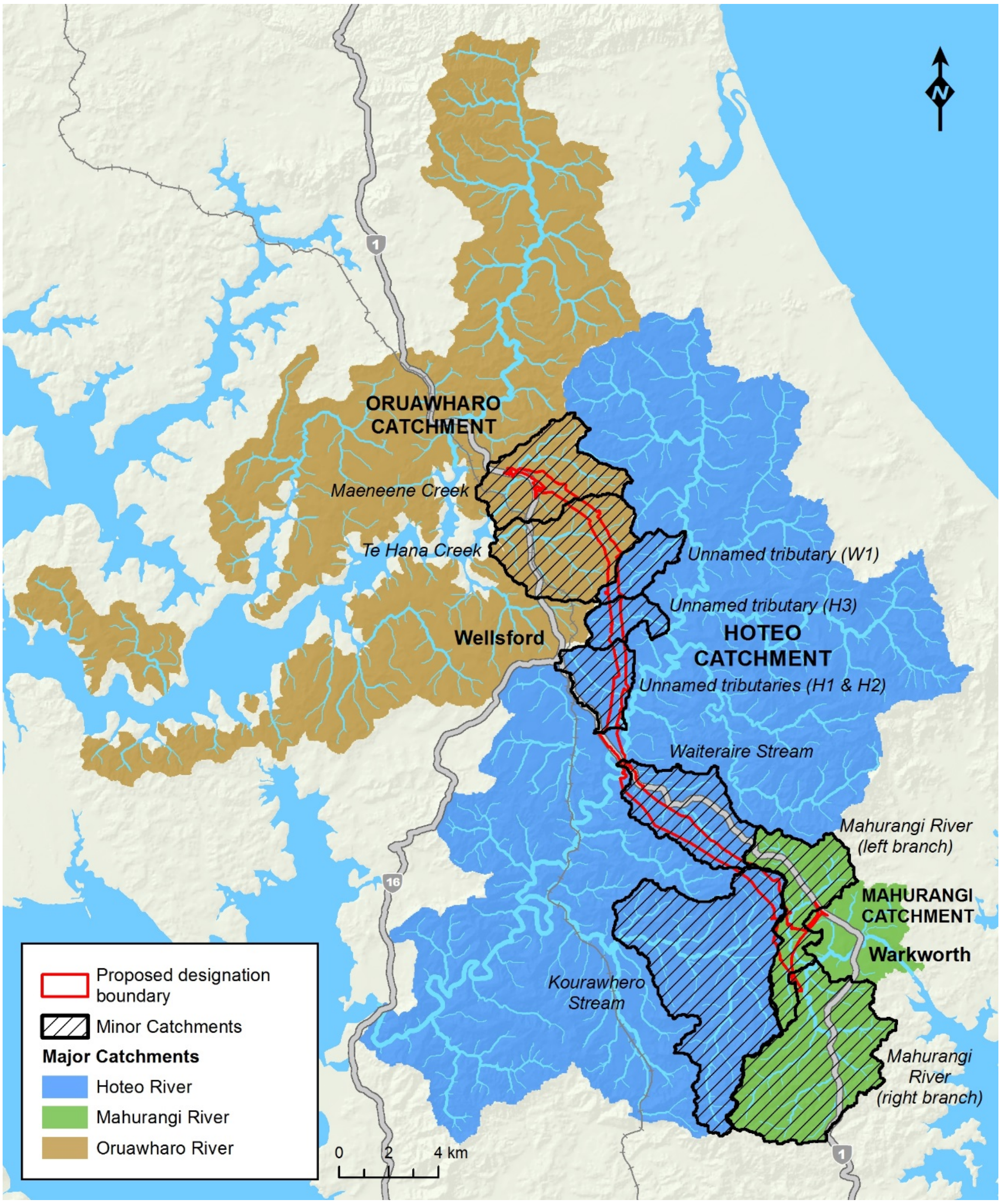


Figure 2 – Proposed designation boundary and freshwater catchments

1.2 Project features

The key features of the Project, based on the Indicative Alignment, are as follows:

a) A new four lane dual carriageway state highway, offline from the existing State Highway 1, with the potential for crawler lanes on the steeper grades.

b) Three interchanges as follows:

   i. Warkworth Interchange, to tie-in with the Pūhoi to Warkworth section of state highway and provide a connection to the northern outskirts of Warkworth.

ii. Wellsford Interchange, located at Wayby Valley Road to provide access to Wellsford and eastern communities including Tomarata and Mangawhai.

iii. Te Hana Interchange, located at Mangawhai Road to provide access to Te Hana, Wellsford and communities including Port Albert, Tomarata and Mangawhai.

c) Twin bore tunnels under Kraack Road, each serving one direction, which are approximately 850 metres long and approximately 180 metres below ground level at the deepest point.

d) A series of steep cut and fills through the forestry area to the west of the existing SH1 within the Dome Valley and other areas of cut and fill along the remainder of the Project.

e) A viaduct (or twin bridge structures) approximately 485 metres long, to span over the existing SH1 and the Hōteo River.

f) A tie in to existing SH1 in the vicinity of Maeneene Road, including a bridge over Maeneene Stream.

g) Changes to local roads:

i. Maintaining local road connections through grade separation (where one road is over or under the other). The Indicative Alignment passes over Woodcocks Road, Wayby Valley Road, Whangaripo Valley Road, Mangawhai Road and Maeneene Road. The Indicative Alignment passes under Kaipara Flats Road, Rustybrook Road, Farmers Lime Road and Silver Hill Road.

ii. Realignment of sections of Wyllie Road, Carran Road, Kaipara Flats Road, Phillips Road, Wayby Valley Road, Mangawhai Road, Vipond Road, Maeneene Road and Waimanu Road.

iii. Closing sections of Phillips Road, Robertson Road, Vipond Road and unformed roads affected by the Project.

h) Associated works including bridges, culverts, drainage, stormwater treatment systems, soil disposal sites, signage, lighting at interchanges, landscaping, realignment of access points to local roads, and maintenance facilities.

i) Construction activities, including construction yards, lay down areas for storage of materials and establishment of construction access and haul roads.

A full description of the Project including its current design, construction and operation is provided in Section 4: Description of the Project and Section 5: Construction and Operation of the AEE contained in Volume 1 and shown on the Drawings in Volume 3.

The Indicative Alignment is a preliminary alignment for a state highway that could be constructed within the proposed designation boundary. The assessment within this Construction Water Management Design Technical Report considers the effects of the Indicative Alignment, but also considers the sensitivity to effects if the alignment shifts within the proposed designation boundary when the design is finalised.

The final alignment for the Project (including the detailed design and location of associated works including bridges, culverts, stormwater management systems, soil disposal sites, signage, lighting at interchanges, landscaping, realignment of access points to local roads, and maintenance facilities), will be refined and confirmed at the detailed design stage.

1.3 Purpose and structure of this report

This Construction Water Management Design Technical Report (this Report) forms part of a suite of water related design and technical reports prepared for the Ara Tūhono – Pūhoi to Wellsford - Warkworth to Wellsford section (the Project).

These reports are listed below with a short description of each:

- **Water Assessment Report (WAR) –** This report contains a summary of the work carried out and assessment of water related effects associated with construction and operation of the Project.
- **Construction Water Management Design technical report (This report) –** This report contains indicative details of the proposed construction methodology, proposed erosion and sediment controls (ESCs), and other construction phase mitigation measures recommended to reduce and erosion and sediment laden stormwater discharges from entering the receiving environment during construction.
- **Operational Water Design technical report** – This report contains details of the operational stormwater management and other operational phase mitigation by design.
- **Water Quality technical report** – This report summarises water quality monitoring carried out by Auckland Council and for the Project.
- **Catchment Sediment Modelling technical report** – Sediment models have been developed to predict changes in sediment and water quality within receiving watercourses associated with the Project. This report summarises the modelling methodology and results.
- **Operational Water - Road Runoff technical report** – An assessment has been carried out to predict changes to water quality in relation to the Project and pollutants.
- **Flood Modelling technical report** – A model has been developed to predict any changes to flood risk associated with the Project. This report summarises any changes.
- **Hydrological technical report** – Catchment analysis has been developed to predict catchment wide hydrological changes associated with the Project. This report summarises predicted changes to the hydrological environment.

In addition to these reports there are two further assessment reports which consider water associated effects, these are:

- **Ecology Assessment Report**; and
- **Marine Ecology and Coastal Avifauna Assessment Report.**

This purpose of this report is to document the indicative design of the various construction water management (CWM) measures and procedures to be established prior to and during the construction of the permanent works, in order to inform the Water Assessment Report and the Assessment of Effects on the Environment (AEE). Figure 3 below summarises the relationship between each of the water related technical and assessment reports and the AEE.

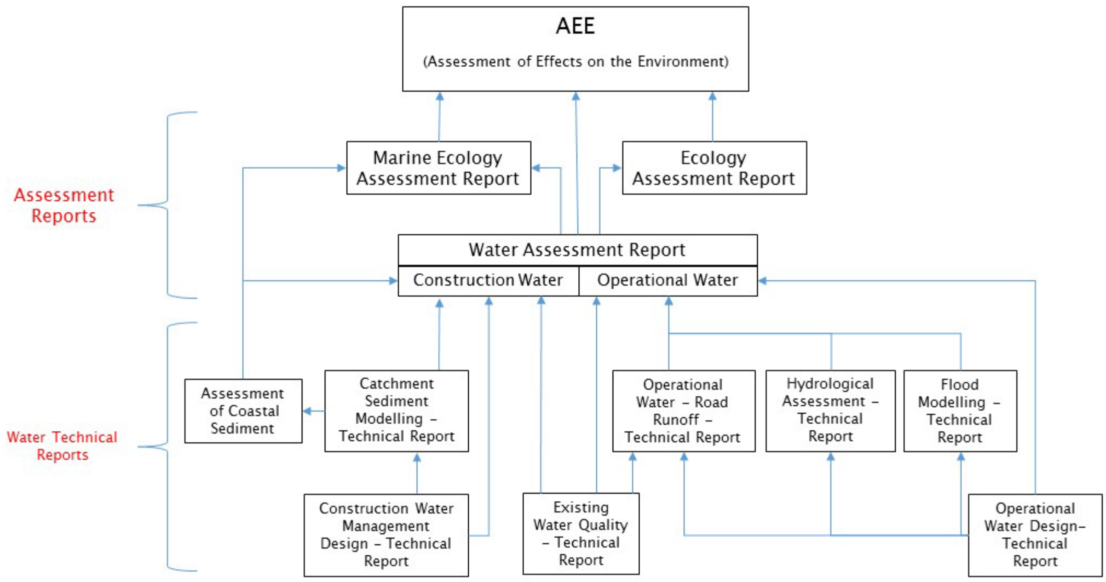


Figure 3 - Construction Water Management Design Technical Report – relationship to other reports

The structure of this Report is as follows:

- **Section 1** (this section) – We describe the purpose and the content of this report.
- **Section 2** – We describe the existing environment and the factors that influence construction water runoff, such as climate and rainfall, topography and geology.
- **Section 3** – We discuss the CWM design philosophy, the principles recommended for the Project and the CWM design guidelines and standards applicable to the Project.
- **Section 4** – We discuss the specific CWM indicative design response to the Indicative Alignment and the measures recommended to plan, design, operate and maintain the various CWM systems included in the Project.
- **Section 5** – We present our overall recommendations and conclusions made on the CWM design.

1.4 Overview and context of construction water management systems

In the context of the Project, CWM refers to the management of stormwater runoff from disturbed areas of the project during the construction period. For the operation of the

Project, operational stormwater flows are managed separately from the CWM and are discussed in the Operational Water Design Report.

Figure 4 provides a pictorial high level representation of how runoff from disturbed areas are managed and treated prior to discharge to the receiving environment during the construction phase of the Project. In summary:

- Rainfall onto disturbed areas of earth is conveyed to and collected in sediment retention devices, prior to discharge to streams and watercourses. These streams and watercourses subsequently drain to the estuaries and harbours.

- Rainfall onto adjacent areas (outside of the earthwork locations) will be diverted away from (or around) the works to minimise erosion of disturbed earth. If allowed to flow through the earthworks area, this surface water runoff would increase sediment generation. Hence, it is diverted away.

- Meanwhile, streams and watercourses that flow through the earthwork locations are diverted through or beneath the alignment using culverts or under bridges. In some instances, streams and watercourses will need to be diverted themselves away from the earthworks areas.

- In addition to these permanent stream diversions, the construction of culverts and other works in watercourses will require temporary stream diversions, to allow these works to be carried in an 'offline' environment. Temporary culverts may also be required to facilitate access to construction areas.

In some circumstances (not shown in Figure 2) the Project's earthworks will be undertaken within existing identified flood plain locations. This activity in itself is considered to be a diversion of surface water and is discussed in more detail in Section 5.3.13 of this report.

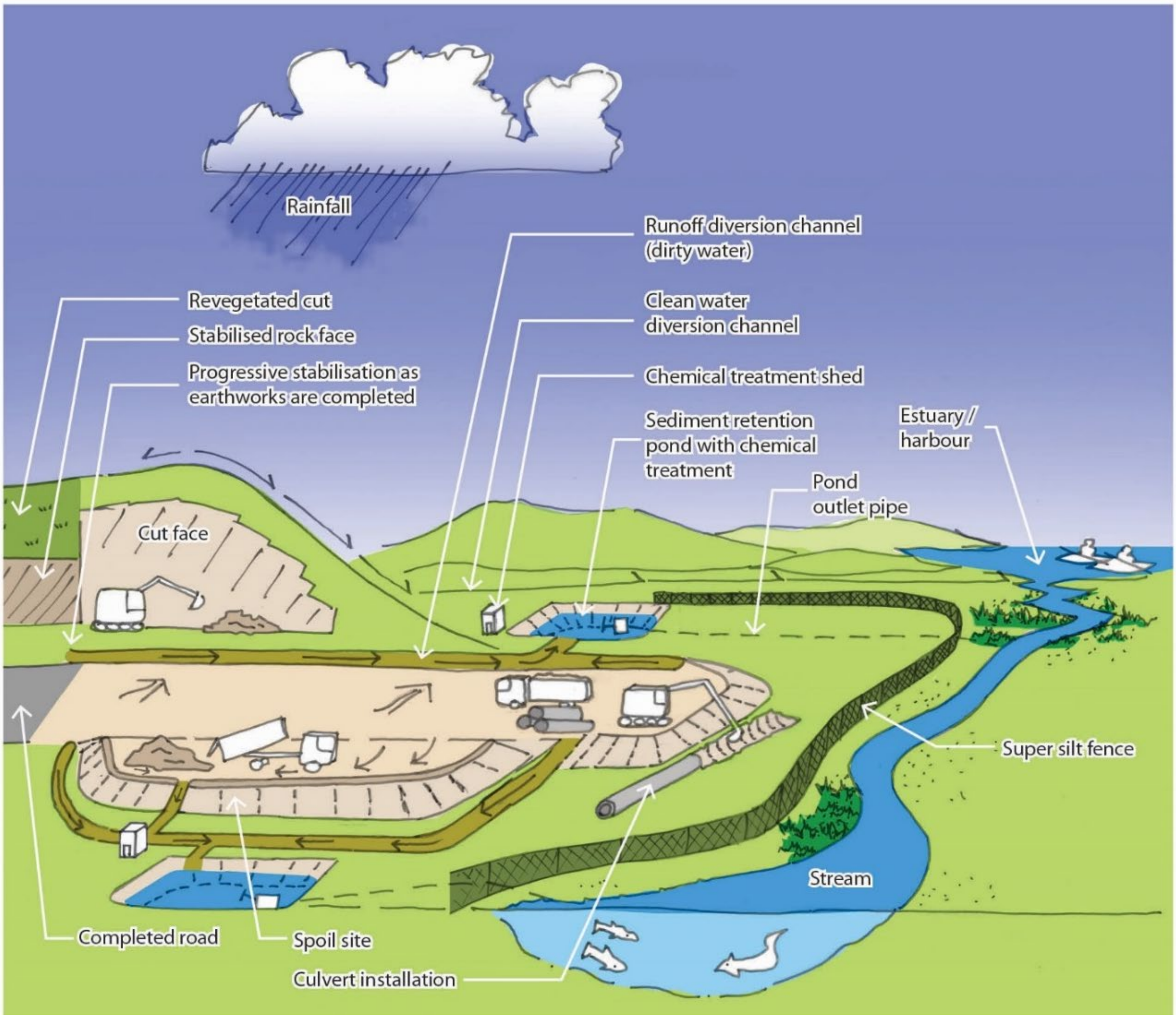


Figure 4 - Construction Water Management Systems and the environment

1.5 Construction sections

A high level construction methodology and a conceptual construction programme was developed for the Indicative Alignment of the Project and is described in section 5 of the AEE. This includes the following indicative earthworks volumes:

- Total Cut approximately 12.3M m^3, and;
- Total Fill approximately 9.6M m^3.
- Imported Material approximately 0.64 M m^3
- Surplus Material approximately 3.4 M m^3 to be disposed of within proposed soil disposal sites

The Project is split into three main construction sections (see Figure 1):

- **Southern Section:** southern tie-in with SH1 to Northern tunnel portal;
- **Central Section:** Northern tunnel portal to Bridge 11 over the Hōteo River; and
- **Northern Section**: Bridge 11 over the Hōteo river to the northern tie-in to SH1.

Due to the scale of the Project and geographic separation of the sections, it is likely that each section would be managed separately in terms of resources. Each section is likely to be constructed concurrently, with some co-ordination of programme activities and resources.

2 EXISTING ENVIRONMENT

In this section, we briefly describe the existing environment to provide a context for the Indicative Alignment and associated design. The section includes brief descriptions of the main river catchments, topography, geology, flooding and existing infrastructure. Additional detail relating to the existing environment can be found in the Water Assessment Report and the Water Quality Technical report.

2.1 Catchment description

Following the proposed designation from the south to the north, it begins in the Mahurangi River catchment, crossing the left branch of the river. The proposed designation then passes through the Hōteo River catchment, crossing many tributaries as well as the main channel of the Hōteo River near the existing SH1 crossing.

The proposed designation continues north and crosses two tributaries of the estuarine Oruawharo River, Te Hana Creek and Maeneene Creek, before tying back into the existing SH1.

The proposed designation and catchment boundaries discussed above are shown on Figure 2.

The Mahurangi River is the main tributary of the Mahurangi Estuary, a long estuary flowing southwards from Warkworth on the eastern coast. There are many small bays and estuaries along the sides of the estuary with two larger arms to the south. Many of the small bays and upper estuaries dry during the tidal cycle and are comprised of soft muddy sediment.

The Hōteo River drains to the southern part of the Kaipara Harbour.

Te Hana Creek and Maeneene Creek are tributaries of the Oruawharo River, which flows into the northern Kaipara Harbour.

The Kaipara Harbour is a complex drowned-valley enclosed estuary on the west coast of the Northland peninsula. The harbour is composed of intertidal flat and shallow sub-tidal habitats with deep channels following historic rivers. Sand barriers form north and south heads as well as tidal deltas, beach and dune systems.

2.2 Rainfall and CWM

An overview of the rainfall data for the Project area is addressed in the Catchment Sediment Modelling Report. The data was sourced from NIWA's High Intensity Rainfall Systems (HIRDS) and NIWA's Virtual Climate Station Network (VCSN).

From a CWM perspective, we do not consider any difference in rainfall patterns between the construction sections to be significant.

2.3 Topography

The topography across the Project area ranges between approximately 15-300 metres Above Datum (mAD), with slopes ranging from 0-50 degrees.

The topography of the Project area can be broadly divided into three distinct topographic areas depending upon the slope angle. The Southern Section from the lower Mahurangi River valley between Woodcocks Road and Philips Road and the Wellsford flats in the Northern Section of the proposed designation are generally flat. The Dome ranges in the south (including the Matariki forestry block in the Central Section) represent steeper hill country, with lower undulating hill country in the centre and northern extents of the Project.

The steep terrain within the central section of the Project results in much of the overlying soils being either unstable or highly susceptible to erosion when exposed to rainfall and reduced ground cover conditions following tree felling activities.

The details relating to slope angle and elevation along the Indicative Alignment are summarised in Table 1, and shown on Figure 5. This information is based on LIDAR.

Table 1 - Slope degrees and elevation

Section	Slope (degrees)	Elevation	Chainage
Southern	Generally 0-10°, minor hills of 10-18°	30-85 mAD	The alignment south of the Kourawharo River (47200-50800 chainage)
Central	10-50°, multiple peak and valleys	40-300 mAD	Kourawharo River crossing to the Hōteo River crossing (38200-47200 chainage)
Northern	Generally 0-10°, regular hills 10-21°, peaks up to 30°	15-110 mAD	Area to the north of the Hōteo River crossing (0-38200 chainage)

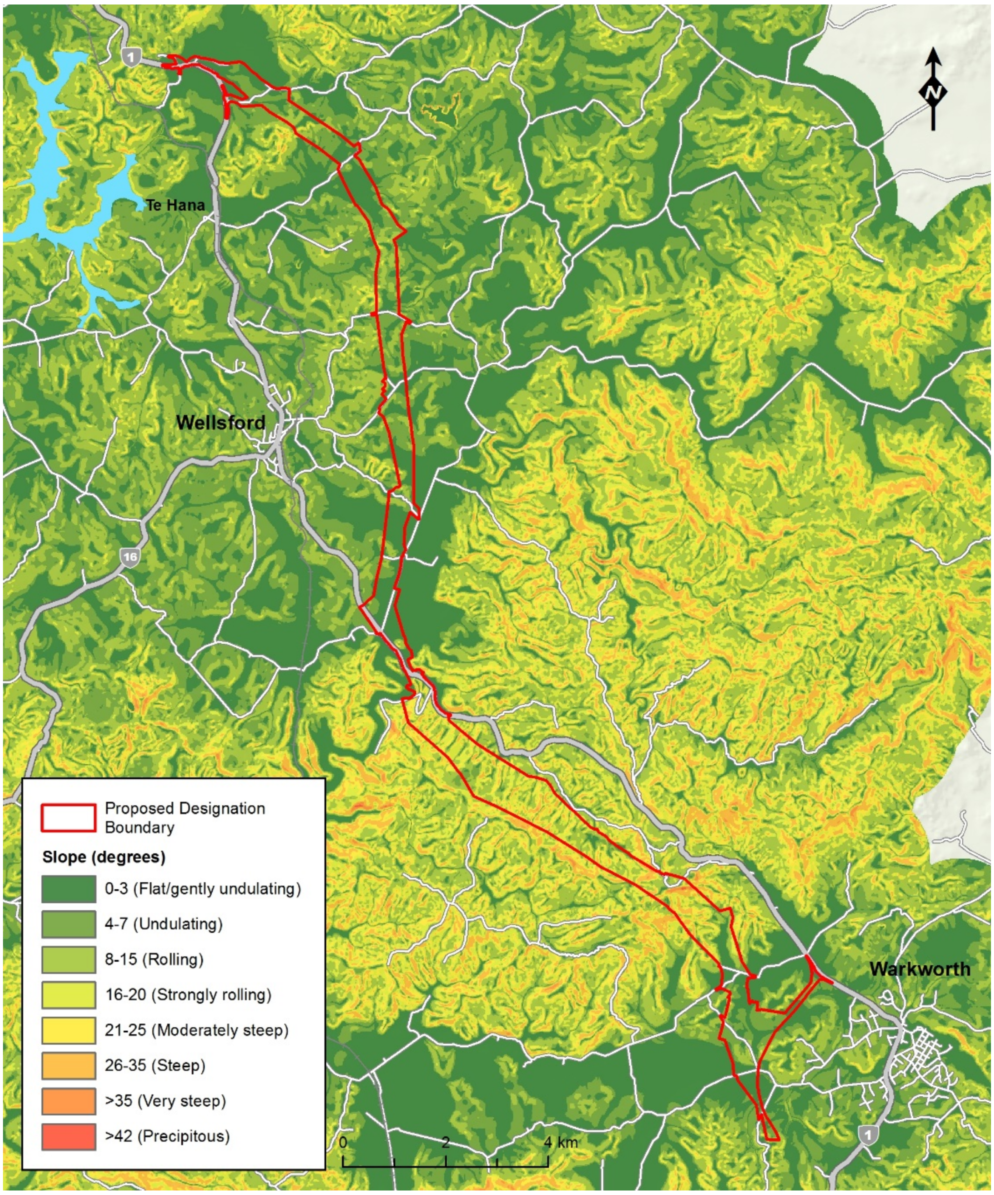


Figure 5 - Slope range (in degrees) in the Project area

Approximately 45% (139.5 ha) of the overall earthworks footprint area of the Indicative Alignment (310 ha) is steeper than 10 degrees, with approximately 30% (117.8 ha) of the overall earthworks footprint area being greater than 15 degrees.

For the purpose of this Report, "steeper areas" are defined as slopes over 10 degrees. We consider that 10 degrees is an appropriate threshold in a CWM context, as there is a higher risk of erosion generation on slopes of 10 degrees and greater.

A summary of the various slope classifications is provided in Table 2.

Table 2 - Slope classifications

Slope Classification (degrees)	Area within designation boundary (ha)	Area within earthworks footprint (ha)	Percentage of Total Area within earthworks Footprint
0 - 3	284.2	62.0	20%
3 - 6	227.36	49.6	16%
6 - 10	269.99	58.9	19%
10 - 12	99.47	21.7	7%
12 - 15	113.68	24.8	8%
15 – 18	71.05	15.5	5%
18 - 21	71.05	15.5	5%
21 - 24	56.84	12.4	4%
24 - 27	56.84	12.4	4%
27 - 30	56.84	12.4	3%
30+	113.68	24.8	8%
Total	**142**	**310**	

2.4 Geology

The Project area is predominantly underlain by sedimentary rocks of the Waitemata Group (Pakiri Formation) south of the Hōteo River, and the Northland Allochthon (formerly known as Onerahi Chaos) rocks to the north of the Hōteo River. A detailed description of the geology in the Project area is presented in the Section 3 of the AEE, and is indicated in Figure 6.

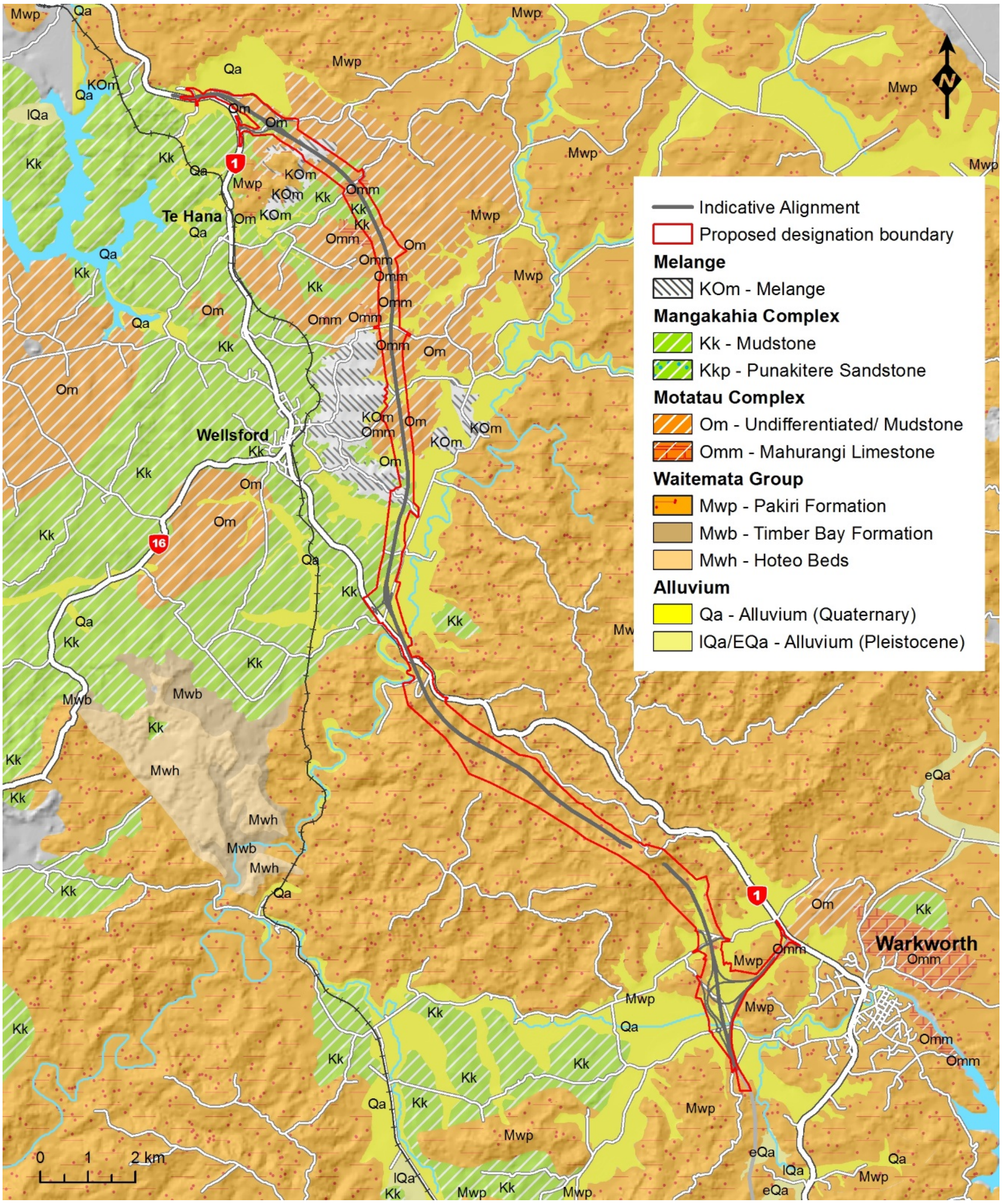


Figure 6 - Geological map for Warkworth to Wellsford

3 EROSION AND SEDIMENT CONTROL – KEY CONCEPTS AND GUIDELINES

3.1 Erosion and sedimentation process

Erosion occurs when the surface of the land is worn away (eroded) by the action of water, wind, ice or geological processes. Through the erosion process, soil particles are dislodged, generally by rainfall and surface water flow.

As rain falls, water droplets concentrate and form small flows. As this flow moves down a slope, the combined energy of the rain droplets and the concentration of flows has the potential to dislodge soil particles from the surface of the land. The greater the slope angle the greater the erosion potential of the slope.

Sedimentation occurs when these soil particles are deposited in a receiving environment. The amount of sediment generated depends on the erodibility of the soil, the energy created by the intensity of the rain event, the site conditions (for example the slope and the slope length), and the area of bare earth or unstabilised ground exposed to rainfall.

3.2 Key concepts

The following terms represent the key aspects of Construction Water Management:

- **Sediment generation** - this refers to the generation potential of the area in question and is based on slope, slope length, soils, rainfall and erosion control factors (such as those discussed in Section 4.2.1).
- **Sediment delivery** – this relates to the amount of eroded material that is not retained on site (i.e. in depressions and within the site's natural contours) prior to it entering any sediment treatment devices.
- **Sediment yield** – the amount of sediment that actually leaves the site and enters the receiving environment.
- **Sediment load** – the mass of sediment carried in suspension within rivers and marine waters.
- **Erosion control** is based on the practical prevention of sediment generation in the first instance. If erosion control measures and practices are effective then sediment generation will be minimised and the primary reliance on the sediment control measures is reduced.
- **Sediment control** refers to management of the sediment after it has been generated. It is inevitable that some sediment will be generated through land disturbance activities even with best practice erosion control measures in place. Sediment control measures are designed to capture this sediment to minimise any resultant sediment-laden discharges to waterways.

The receiving environment associated with the Project area includes a range of freshwater and marine systems with varying ecological and amenity values. These values are highlighted within the Water Assessment Report, Ecology Assessment Report and Marine Ecology and Coastal Avifauna Assessment Report.

It is essential that the ESC measures and practices implemented during the construction phase recognise these values, and manage the discharge of sediment accordingly.

High erosion risk areas are identified as those locations within a sediment control protection area which includes works:

- 100 m either side of a foredune or 100 m landward of the coastal marine area (whatever is the more landward of mean high water springs); or
- 50 m landward of the edge of a watercourse, or wetland of 1,000 m² or more.

In addition, areas of steeper slope angle (greater than 10 degrees) would also be considered as high risk areas due to the direct relationship between slope angle and erosion potential (i.e. the steeper the angle the greater the erosion potential).

The Ecology and Marine Ecology and Coastal Avifauna Assessment Reports discuss and identify, where relevant, areas of sensitivity where higher standards of ESC will need to be implemented.

In lower risk areas, sediment generation will arise from the bulk earthworks phase of the construction operation. Soil types, slopes and the construction methodology are all significant influencers on this sediment generation.

Potential effects of the discharges from earthworks in all locations will be managed through the implementation of appropriate ESC measures such as the implementation of limits on the extents of open areas of earthworks, providing super silt fences down slope of sediment retention devices to provide a last line of defence, regular and progressive stabilisation, increased frequency of inspection and maintenance of ESC measures and increased levels of monitoring.

In our experience, the Transport Agency has demonstrated a proven track record with respect to ESC associated with large infrastructure projects. Many of its previous projects have demonstrated the effectiveness of the Transport Agency's approach, which is based on the consenting authority's approval of Construction stage Erosion and Sediment Control Plans (CESCPs), or the equivalent, throughout the relevant projects. This track record has been previously illustrated through the Northern Gateway Toll Road, Hobsonville and the Waterview Tunnel projects and more recently the construction of the Pūhoi to Warkworth section of the Ara Tūhono Pūhoi to Wellsford project.

3.3 Overarching CWM approach and principles

Physical ESC measures and site management practices are used in combination to minimise the effects of earthworks on the receiving environment and CWM on the Project will be undertaken and implemented with a hierarchy and priority order as follows:

- **Prevention:** Excluding clean water runoff from entering the active work areas, therefore preventing clean water runoff from combining with excavated spoil and/or construction material and will require the use of clean water diversion (CWD) channels and/or bunds to divert runoff from the upstream side of the work area.
- **Capture:** Any sediment laden runoff generated within the working area will be captured through the use of dirty water diversion (DWD) channels and/or bunds on

the downstream side of the construction site which will direct sediment-laden runoff from the site to an appropriate sediment control device. Sediment capture will be implemented through one or more sediment control measures.

- **Minimisation:** Limiting the length of time and the extent of the area of exposed/disturbed soil to reduce the erosion potential to generate erosion. Timely stabilisation of exposed areas and the construction of impermeable areas will also reduce the potential for erosion to occur.

- **Staging and Sequencing of Works:** Construction activity will be carried out in stages and works within those stages will be sequenced to manage erosion and sedimentation. Working areas will be progressively stabilised as appropriate as the works progress.

In general, steep slopes with long slope lengths, generate a greater amount of energy and hence increase the risk of erosion. Any reduction of this energy through the use of erosion control measures will reduce erosion and hence any subsequent sedimentation.

With the above in mind, the ESC measures for the Project are to be designed to minimise the extent of soil erosion and capture and retain, to the fullest practical extent, the resultant sediment yield generated from the upstream construction zone.

In this regard, erosion control measures, such as those discussed in 4.2.1, will be given the highest priority in the establishment of ESC measures as these prevent sediment generation in the first instance.

The conceptual locations and types of ESC measures for the Project are indicated on the ES Series drawings within the drawings set and have been designed to take into account the highest level of control and treatment in accordance with industry best practice.

We have assessed that the documents listed in Section 3.4, provide an appropriate tool kit for the development of the ESC design undertaken to date. They also provide the best design approach for the Project, while providing the most practical approach in terms of constricted or constrained site conditions.

3.4 Erosion and sediment control guidelines

Auckland Council and the Transport Agency have both published guidelines relating to the design, construction and management of ESC measures on land disturbing activities. We list the key documents below.

- Auckland Regional Council Technical Publication No. 90 – Erosion & Sediment control Guidelines for Land Disturbing Activities in the Auckland Region (TP90) - which provides information on the appropriate use, design and construction of ESC practices for the Auckland region. TP90 is referenced in the AUP(OP).

- Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland Region; June 2016; Guideline Document 2016/005 (GD05); Auckland Council - which provides information on the appropriate use, design and construction of ESC practices for the Auckland region. GD05 has been published by Auckland Council as an update to TP90 and is designed to supersede TP90. However, the AUP(OP) refers to TP90 and the formal incorporation of GD05 requires a Plan Change to the

AUP(OP). We consider that the guidance in GD05 generally represents industry best practice and is therefore applicable for use in the design of the Project's ESC measures.

- Erosion and Sediment Control Guidelines for State Highway Infrastructure; September 2014 (*Transport Agency ESC Guidelines*) – The Transport Agency has developed and published a guideline for State highway infrastructure. The Transport Agency ESC Guideline was developed to assist roading practitioners with the selection and design of erosion and sediment control practices.

- Forestry Operations in the Auckland Region a Guideline for Erosion and Sediment Control; September 2007; Technical Publication 223 (TP223); Auckland Regional Council - TP223 provides a specific set of guidelines for earthworks and general land disturbing activities associated with forestry operations and builds on the concepts and guidance provided by TP90 or its replacement GD05 and is therefore applicable to plantation forestry clearance activities that may be associated with the Project.

We have reviewed all of the documents above and have determined that best practice to achieve the necessary environmental outcomes for the Project is represented, to varying degrees, within all of these guidelines.

Where the guideline documents present a range of design criteria, we have adopted the more onerous design criteria that are most protective of the environment for the design of the ESC measures presented in this report. Importantly this design criteria will need to be confirmed within the CESCPs where variations and design changes to these guidelines may be presented for implementation.

With respect to TP223 this is a forestry operation specific guideline. Engagement with Matariki Forest owners has identified that the forest harvesting within the proposed designation will be completed prior to the Project commencing. We have therefore adopted this as the base case assumption for our design purposes. We have included TP223 for completeness in our review of applicable design guidelines and to allow for any potential change to the current harvest programme. The design criteria we have adopted meet or exceed the requirements set out in TP223.

3.5 Key ESC design criteria

Table 3 below summarises the key ESC design criteria which have been used in the conceptual design of the ESC measures for the Project.

The Project and location specific design of the ESC measures will be confirmed through the development of the CESCPs which includes review and associated input from Auckland Council.

Table 3 – Key ESC design criteria

Device/methodology	Criteria
Erosion control measures	
Clean Water Diversions (CWD)	Clean water diversion channels and bunds will be designed to cater for the 1% AEP rainfall event unless otherwise detailed in CESCPs.

Device/methodology	Criteria
Construction staging and sequencing	Staging and sequencing are both important non-structural measures and will be implemented as necessary to achieve the any staging requirements (discussed in the Water Assessment Report). Detail of the staging and sequencing of works will be detailed within the CESCPs.
Contour drains	Contour drains will be designed and implemented in accordance with GD05.
Device location	All ESC devices should be located outside the 20 year ARI flood level unless no other viable alternative exists.
Dirty Water Diversions (DWD)	Dirty water runoff diversion channels will be sized to cater for the 1% AEP rainfall events unless otherwise detailed in CESCPs. Sediment sumps with a minimum volume of 2 m^3 to be installed in all DWDs. Sediment sumps will be required on all DWDs at intervals of 50m, with a capacity of 2m^3 per sump.
Pipe drop structures/flumes	Flumes will be used to safely transfer runoff from the top of batters to the bottom of the batter slopes.
Rock check dams	Rock check dams will be designed and implemented in accordance with TP90.
Stabilisation for erosion and dust management purposes	Progressive and rapid stabilisation of disturbed areas utilising top soil (where necessary) and seed, mulch, geotextiles and polymers will be ongoing throughout the Project. Stabilisation will be undertaken with three key purposes: • To achieve any required restrictions on the extent of open areas of earthworks; • To reduce the open area of higher risk locations to assist with a reduction in sediment generation; and • In response to the continuous improvement monitoring programme to address any potential effects or undesirable monitoring trends.
Stabilised entrance ways	Stabilised entrance ways will be established at all entry and exit points of the site.
Sediment control measures	
Construction Erosion and Sediment Control Plans (CESCPs)	CESCPs are to be submitted prior to the commencement of enabling works and Construction Work in the relevant sector. CESCPs will be prepared in accordance with the Project's overarching erosion and sediment control plan. The CESCPs will include the following as a minimum: • Contour information; • ESC measures for the works being undertaken within a particular construction area; • Chemical treatment design and details; • Catchment boundaries; • Location of the work;

Device/methodology	Criteria
	• Details of construction methods; • Contingency measures; • Design criteria, typical and site specific details of esc measures; • Identification of risk and details of this risk management; • A programme for managing non-stabilised areas; • The identification staff who will manage ESCs; • The identification of staff who monitor compliance with conditions; • A chain of responsibility for managing environmental issues; • Methods and procedures for decommissioning measures; and • Design details for managing the treatment, disposal and/or discharge of contaminants (e.g. concrete wash water).
Container impoundment systems	Container Impoundment Systems will be implemented as per Drawing ES-076. They will be based on a 3% volume criterion applied in relationship to catchment size and as such will apply to smaller catchment areas than DEBs and SRPs. Their primary purpose is for the initial earthworks in steep or constrained or constricted working areas prior to the formation of a SRP or DEB structures.
Decanting earth bunds (DEBs) and decant systems	All DEBs established will be based on a volume of 3% of the contributing catchment area and sized accordingly, subject to a to a maximum DEB catchment area of 3,000 m^2 unless varied within the CESCPs. All SRPs and DEBs will be fitted with floating decants. Decants will have a manual control mechanism (to prevent) outflow from the DEB during pumping activities to these structures.
Decommissioning of devices	Removal of devices will be in accordance with the CESCP and will only be undertaken once the catchment draining to them is considered to 80% stabilised or Auckland Council approval is granted for such removal.
Flocculation	Flocculation will be applied on all SRPs and DEBs based on an approved Chemical Treatment Management Plan (CTMP). Flocculation will be applied to all DEBs with a catchment area above 500 m^2, and all SRPs. For all contributing catchments over 2 ha in area, two flocculation sheds will be installed for the purpose of increasing the volume of flocculant available and also for reducing the risk of failure if one of the flocculation systems fails or has reduced performance. Manual batch dosing will be applied as required. Flocculant socks to be utilised as alternative and/or additional measures as required.
Non-structural measures	These elements include: • Manually raised decant devices on SRPs and DEBs; • Batch dosing of SRPs and DEBs with chemical flocculant where required;

Device/methodology	Criteria
	• Proactive monitoring and reporting programme (refer to Section 5 of the Water Assessment Report) • Risk identification and management accordingly; • Progressive stabilisation as works progress; and • Weather response.
Pumping activities	Pumping of sediment laden runoff and groundwater during construction will be to SRPs, DEBs, or to temporary sediment retention devices such as Container Impoundment Systems while also utilising grass buffer zones for "polishing" of any such discharges prior to the discharge entering the receiving environment.
Sediment retention ponds (SRPs)	All SRPs will be implemented based a 3% volume criterion applied in relationship to catchment size (i.e. 300 m^3 SRP volume per 10,000 m^2 of contributing catchment) All SRPS will be subject to a maximum catchment area of 50,000 m^2 unless varied within the CESCPs Baffles, decant pulleys and reverse slopes to be installed in all SRPs.
Streamworks	At all practical times these activities, and any associated works within these environments will be undertaken in an offline 'dry' environment. Fish spawning and migration periods will be avoided where practicable and managed accordingly. These periods are discussed in the Ecology Report.
Super silt fences and silt fences	All super silt fences and silt fences will be based upon the design criteria within TP90. SSF fabric will be installed with 200 mm of fabric upslope at the base of the trench. In areas all areas where sediment control devices are within 50 m of a watercourse, SSF will be utilised as a last line of defence such that if a failure of the primary control measure eventuates then the last line of defence will capture and treat such a discharge.

Whilst reference has been made to TP90, GD05 and the Transport Agency Standards, it is noted that some ESC measures proposed by the contractor may exceed the guidance provided in those documents, for example SSFs being used as a last line of defence and reverse slopes within SRPs. Such initiatives reflect the continued development of best practice in erosion and sediment control.

The CESCPs will need to be prepared in accordance with the principles, criteria and practices set out in the ESC guidance documents and furthermore, through the CESCP development process and subsequent design and construction phases of the Project, we recognise that there will be scope for innovation and alternative means of achieving the same or better environmental outcomes required for the Project.

ESC measures should be planned and finalised during the detailed design phase of the Project. The ESC measures should be constructed, maintained and monitored during the construction period in accordance with the principles and practices as outlined in this report.

Conceptual design drawings for the ESC for the Project are provided in the drawing set (ES Series).

3.6 Streamworks

Works within or adjacent to freshwater streams are also considered higher risk than earthwork activities due to the close proximity of the receiving environment and the associated increased potential for direct sediment effects.

Within the Project, streamworks will be undertaken in a manner that recognises this risk and the sensitivity of the receiving environment and where practical, streamwork activities and any associated works within these environments will be undertaken in an 'offline' environment. This will be based upon the temporary diversion of flows around the area of works or working immediately next to the stream with no formal stream diversion required.

In-stream works, where practicable, will need to avoid the fish spawning and migration periods (typically September to February), or as discussed in the Ecology Report, or where this cannot occur then fish relocation methodologies will be implemented.

Where such work needs to be undertaken during the main migration period, the section of stream in which the work will be undertaken will, under the supervision and management of the Project's Ecologist, be isolated (stop-nets at each end of the works section) and any resident fish caught and relocated downstream of the works area. The lower stop-net will be retained to prevent any fish migrating back upstream and into the works area.

4 OVERVIEW OF CONSTRUCTION WATER MANAGEMENT MEASURES

In this section, we discuss the various CWM measures and practices that can be used to reduce erosion and capture sediment generated during construction of the Project.

4.1 Structural and Non-Structural CWM measures

The primary focus for CWM measures is management of sediment generation at source though erosion controls. This source control will mean that less sediment laden runoff will need to be intercepted, treated and discharged from the sediment control measures.

With the above in mind, the CWM measures for the Project are designed to minimise the extent of soil erosion and capture and retain, to the fullest practical extent, any resultant sediment yield generated from the upstream construction zone.

In addition to the CWM structural practices, which include physical measures such as sediment retention ponds, the Project will also use a series of 'non-structural practices'. Non-structural practices focus on the various site management practices such as staging and sequencing of construction works, and providing an appropriate level of resourcing for environmental management and monitoring.

The non-structural measures are also considered crucial in avoiding significant environmental effects. Examples of structural (physical controls) and non-structural (site management practices) measures include:

Structural Examples

- ESC device installation;
- SRP Baffles;
- SRP decant pulleys; and
- Rainfall activated chemical treatment devices.

Non-Structural Examples

- Manual batch dosing of SRPs and DEBs with chemical flocculants during pumping operations;
- Significant pre- during - and post-rain inspections;
- Implementation of a continuous improvement monitoring programme; and
- As part of the CESCP process the selection of all discharge locations (and the timing) to the receiving environment to ensure sensitive areas and times are avoided.

4.2 Applicable ESC measures and site management practices

The design of the ESC measures and management practices discussed in this report are based on the conceptual construction sequencing discussed in Section 5 of the AEE.

We also note that the design of the ESC measures included in this report have been developed prior to a construction contractor being appointed to construct the Project and we consider that further discussion and approval of the ESC measures is required prior to construction and this will take place through the preparation of site and activity specific CESCPs, which take into account future refinements of the design and contractor innovation and working practices.

The CESCPs will take into account the various environmental and ecological values of the receiving environment and will then determine the most effective and appropriate form of CWM devices and management practices required to manage construction water (including erosion and sedimentation) on a site-by-site basis during the construction period. The proposed process of CESCP development is illustrated in Figure 7 below.

STAGE 1: Determine and/or confirm existing environmental and associated values (based on existing documentation and detailed site investigations)

STAGE 2: Review the Water Assessment Report, and Construction Water Design Report and confirm principles and practices to be applied

STAGE 3: Develop CESCPs as per the consent conditions and relevant ESC design guidelines and submit to Auckland Council (NZTA is applicant so will prepare the docs to comply with conditions – or contractor will on behalf). CESCPs will identify alternatives, specific water management measures, staff roles and responsibilities, monitoring requirements, methods and reporting procedures

Figure 7 - CESCP development process

Below is a summary of the key ESC devices and management practices, relating to erosion control and sediment control respectively, which are applicable to the construction phase of the Project.

4.2.1 Key erosion control measures

In general, the erosion control measures and practices (structural and non-structural) to be applied to the Project are indicated on drawing set ES Series and will be more specifically confirmed through the CESCP process. Typical measures are described as follows and design criteria are set out in section 3.5.

Construction staging and sequencing

The extent of exposed soil and length of time that an area is exposed directly influences the sediment yield leaving a particular area. Bulk earthworks and construction activities will be staged and sequenced in order to keep open areas to within acceptable limits allowing the construction to be carried out efficiently. Open earthworks areas will be progressively stabilised to reduce the potential for erosion to occur. The specific nature and extent of these open areas is discussed within the Water Assessment Report.

Clean and Dirty Water Diversions (CWD and DWD)

- CWDs and DWDs are diversion channels or bunds which provide for the controlled conveyance of runoff from the wider catchment (CWDs), and the construction areas (DWDs).

- CWDs will be used on the Project to prevent stormwater runoff from the undisturbed catchment above the works from entering the construction area.

- CWDs will be fully stabilised with either vegetation or geotextile cloth to prevent erosion of the channel.

- DWDs transfer sediment-laden water from construction areas to sediment retention devices (such as sediment retention ponds and decanting earth bunds) for treatment.

- DWDs will be stabilised dependent upon soil type and site slope for the specific area of works. If through the development of CESCPs, velocities are calculated that will result in erosion of the DWD itself, then stabilisation of the DWDs will be required.

- Sediment sumps will be required on all DWDs. These will capture sediment during a rain event and minimise the maintenance of the sediment retention pond forebays.

- A maintenance programme will be implemented during construction activity to remove the sediment deposited within the diversion channels.

Contour drains

Contour drains are temporary ridges or excavated channels, or a combination of the two, that are constructed to convey water across a slope at a minimum gradient. Contour drains effectively reduce the slope length and velocity of water flowing down disturbed slopes. Therefore, contour drains reduce the erosive power of runoff from disturbed surface, which in turn reduces sedimentation.

Rock check dams

Rock check dams are small dams made of rock aggregate or other non-erodible material constructed across a swale, channel or DWD. Rock check dams act as a control structure to reduce the velocity of flow within the channel and prevent scour of the channel surface.

Rock check dams also allow for some settlement of suspended solids within the channel.

Stabilisation for erosion and dust management purposes

Stabilisation is a key feature of the Project to reduce the erosion potential of disturbed earth. GD05 defines a stabilisation as *"the application of measures, such as vegetative or structural practices that will protect exposed soil and prevent erosion."*

Progressive and rapid stabilisation of disturbed areas will be ongoing throughout the Project. Mulch will include hay/straw and wood bark generated on site though the removal and mulching of existing vegetation as appropriate.

Stabilisation will particularly apply at stockpile areas and batter establishment to reduce both erosion and dust generation.

Mulching will typically apply up to slopes of less than 10 degrees, above which alternatives such as geotextile or polymers will need to be considered.

The development of the CESCPs will determine the specifics of this stabilisation technique and timing.

Stabilisation will be undertaken with three key purposes:

- To assist with the reduction of overall disturbed areas of earth, which will go some way towards achieving any open area limitations
- To minimise the open area extents in higher risk locations and to assist with a reduction in sediment generation; and
- In response to the continuous improvement monitoring programme to address any potential effects or undesirable monitoring trends.

Pipe drop structure/flume

Temporary pipe drop structures or flumes are constructed to convey construction runoff down a slope face without causing erosion of the slope and will be used to ensure no scour of these batters occurs.

Stabilised construction entrance way

Stabilised Construction Entrance Ways are a stabilised pad of aggregate placed on a filter base, and are located where construction traffic will exit or enter a construction site. Stabilised construction entrance ways are often used in conjunction with wheel washes.

Stabilised construction entranceways help to prevent site entry and exit points from becoming a source of sediment and also help to reduce dust generation and disturbance along public roads.

No vehicles will be allowed to leave the site unless tyres are clean, so that construction vehicles will not contribute to sediment deposition on public road surfaces.

4.2.2 Key sediment control measures

Sediment control on the Project will involve the interception and treatment of sediment-laden runoff from the various construction areas along the Project and will be established through the use of recognised sediment control measures and site management practices.

Wherever possible, sediment control devices will be located outside the 20 year ARI flood level, unless no other viable practical alternative exists.

Where, sediment control devices are required within the 20 year ARI flood plain, they will be designed to capture the minimum catchment area practicable and will be subject to an increased inspection and maintenance regime. Further discussion on works within the flood plain is made in section 5.3.13.

The general sediment control measures and principles to be used on the Project are as follows:

Sediment Retention Pond (SRP)

Treatment of construction runoff will be carried out to ensure that sediment is removed to the maximum extent possible from the construction runoff before being discharged to the receiving environment. Key design criteria are set out below:

- SRPs will be designed and constructed based on the extent of the contributing catchment and shall be designed with a minimum 3% volume criterion applied in relationship to catchment size (i.e. 300 m^3 SRP volume per 10,000 m^2 (1 ha) of contributing catchment) with an ideal length to width ratio of 3:1, but not exceeding 5:1

- Catchment areas to SRPs will be limited to a maximum of 5 ha unless the CESCP illustrates that a larger catchment area is applicable.

- SRP spillways will be designed and constructed to ensure that they safely pass the 1% AEP event flow with low velocity, which will reduce the risk of scour on the downstream side of the spillway.

- Forebays of SRPs will be established which are designed to capture the majority of the sediment entering the SRP. Any sediment that is not captured within the forebay area will be transferred into the main body of the SRP and will be captured through the provision of baffles within the SRP itself.

We note that as part of the SRP construction, we recommend that as part of the CESCP development the following activities are carried out:

- Check ground conditions through the use of bore holes to undertake a geotechnical assessment of the proposed SRP site;

- Determine the need or otherwise for a shear key establishment, or other geotechnical works, for the SRPs; and

- Remove any unsuitable material and confirm ground conditions as appropriate for SRP establishment.

SRPs will be fitted with floating decants with a mechanism to control outflow, such as a manual decant pulley system to be used during pumping activities to these structures.

Decanting Earth Bund (DEB)

Decanting earth bunds (DEB) are temporary berms or ridges of compacted soil, which are constructed to create impoundment areas where ponding of sediment-laden runoff can occur. DEBs provide time for suspended solids to settle out before the runoff is discharged to the receiving environment. Key design criteria are set out below:

- Unless otherwise specified within the CESCP, DEBs will be designed based on a volume of 3% of the contributing catchment area with a maximum contributing area not exceeding 0.3 ha, with an ideal length to width ratio of 3:1, but not exceeding 5:1

- All spillways from the DEBs will be constructed to safely pass the 1% AEP event flow with low velocity and therefore minimal scour potential.

- DEBs will be fitted with floating decants with a mechanism to control outflow such as a manual decant pulley system to be used during pumping activities to these structures.

Pumping activities

Wherever possible, gravity flow into the various sediment retention measures will be used in preference to pumping.

However, it may not always be possible to achieve gravity flow to sediment control devices during construction and floating decants will be fitted with a mechanism to control outflow, such as a manual decant pulley system, which will enable the decants to be raised during pumping activities to these structures.

The decants will only be lowered once an acceptable standard of discharge quality, not less than 100mm clarity, has been achieved.

The pumping rates and volumes to SRPs and DEBs will be controlled so that the total pump volume can be fully captured within the retention structure.

Pumping may also be required for other activities such as bridge construction where pumping of sediment-laden water may be required during foundation construction.

Pumping flows to SRPs and DEBs ensures that any sediment laden flows are discharged to a treatment device prior to entering the receiving environment.

Container Impoundment Systems (CIS)

In locations where SRPs or DEBs cannot be located due to slope, physical space, ground instability issues or other constraint, container impoundment systems (CIS) may be used.

CISs are typically shipping containers which have been sealed and retrofitted with a decant system to control discharges. CISs will also be subject to chemical flocculation.

It is expected that these systems will be used, as a temporary measure, primarily in the early stages of earthworks for small catchment areas prior to the ability to develop SRP structures.

Super Silt Fences (SSFs)

Super silt fences are fabric fences reinforced with stakes and netting backing. SSFs provide a physical barrier to flows leaving the area of earthworks.

The placement of SSFs will be based upon the criteria contained within TP90. SSFs will be used in those areas of work adjacent to, or in the immediate vicinity of, watercourses and ecologically sensitive areas.

To minimise the risk of failure for SSFs, the fabric will be installed with a minimum 200mm of fabric placed upslope at the base of the trench in accordance with figure 9-9 of the Transport Agency ESC Guideline, as shown on Figure 8.

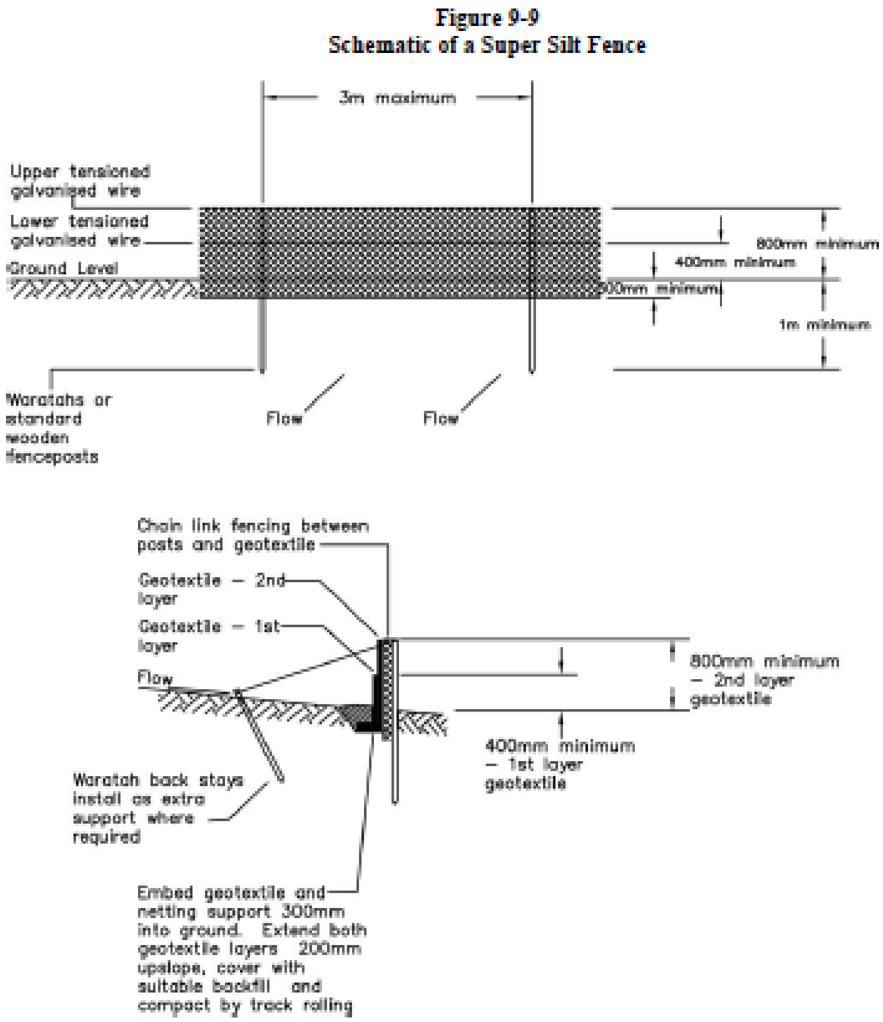


Figure 8 - Schematic of a Super Silt Fence

Flocculation

The fine-grained nature of the soils within the proposed designation would require sediment retention ponds and decanting earth bunds to receive flocculant treatment (flocculation), to maximise their efficiency. Flocculation is a chemical treatment method for coagulation and increases the retention of suspended solids from construction runoff in SRPs and DEBs.

Flocculant is added to the construction runoff flowing into a SRP or DEB via a rainfall activated system (flocculant shed) or via manual batch dosing.

All SRPs, DEBs and CISs will be chemically treated with a flocculant appropriate for the soil type and discharge location in a particular construction area and is discussed further in section 5.3.7. The bench testing of soils using a range of flocculants will be carried out during the CESCP development, which will include details of the flocculant type, dosing rate and floc shed roof area to be applied at specific locations.

4.2.3 Other CWM Measures

Permanent stormwater treatment devices

The Project will also include the installation of a number of permanent stormwater treatment wetlands for the treatment of stormwater runoff from impervious surfaces during the operational phase of the Project.

These treatment wetlands are illustrated in the SW series of the Volume 3 drawings set of the AEE.

Permanent stormwater treatment and detention devices could be installed early in the Project where the location of a SRP coincides with a permanent stormwater treatment device and the stormwater treatment device could be used on a temporary basis as a SRP to reduce ground disturbance.

These could then be converted to long term stormwater treatment devices at the completion of the earthworks activity within that sub-catchment.

No existing natural wetlands should be used for primary treatment of sediment-laden runoff from the construction phase.

Permanent stormwater cut off drains

The Project will also include for the construction of cut off drains at the top of cuts and bottom of fill locations to divert stormwater runoff from the upslope catchment away from the Project.

These cut-off drains will typically also be required at the same or similar locations as the CWDs required during the construction phase of the Project.

Cut-off drains will be designed to cater for a 1% AEP Rainfall event which is the same criteria required for the establishment of the CWDs.

Decommissioning of Devices

ESC measures should remain in place until such a time as Auckland Council approval is obtained or the catchment contributing to that device is stabilised. Once the contributing catchment is considered stabilised the ESC measure can be decommissioned. The decision process and procedure for this will be outlined within the CESCPs.

Non-Sediment Contaminants

There are also a number of non-sediment contaminants which generally consist of site and materials management measures that may directly or indirectly discharge into the receiving environment from site activity.

Potential non-sediment contaminants typically found on the construction site that may have an effect if accidentally released into the receiving environment and for ease of reference have been listed in Table 4 below.

Table 4 - Potential non-sediment contaminants

Product/work activity	Potential contaminants	Indicator	Non-visible potential contaminants
Adhesives	• Adhesives • Glues • Resins • Epoxy • PVC Cement	Oily sheen or discoloration from some products	• Phenols • Formaldehydes • Asbestos • Benzene and • Naphthalene
Asphalt paving	Hot and cold mix asphalt	Oil Sheen	Oil, petroleum distillates, Poly aromatic hydrocarbons
Cleaning products	Cleaners, ammonia, lye, caustic sodas, bleaching agents, chromate salts	Discolouration	Acidity/alkalinity
Concrete	Cement	Discolouration	Alkalinity (High pH)
Flocculants	Specific to flocculant used but can include pH and aluminium	Clarity	• Aluminium toxicity • pH
Sanitary waste	Portable toilets, disturbance of sewer lines	Discolouration, sanitary waste	Bacteria, Biological Oxygen Demand, Pathogens
Vehicle and equipment use	Equipment operation, maintenance, washing, refuelling	Oil sheen, sediment	Total Petroleum, hydrocarbons, coolants, benzene and derivatives

Storage and management of non-sediment contaminants

The management of these non-sediment contaminants will be subject to specific best management practice and industry guidelines. It is currently unclear as to the specific nature of these non-sediment contaminants and the associated volumes required during the construction of the Project is not currently known, however Table 5 below provides some generic guidance as to the expected management approach.

Table 5 - Potential non-sediment contaminants – management approach

Product/work activity	Management approach
Adhesives	• Store materials in an area that is not subject to rainfall contact • Use adhesives carefully and clean up any spilled material • Properly dispose of containers once they are empty
Asphalt paving	• Water runoff should discharge to a treatment system designed to capture hydrocarbons
Cleaning products	• Store materials in an area that is not subject to rainfall contact • Use adhesives carefully and clean up any spilled material • Properly dispose of containers once they are empty
Concrete	Refer to Section 5.3.15 of this report. • Concrete truck chutes, pumps and internals should only be washed out into formed areas awaiting installation of concrete or will be removed from site for cleaning in designated areas. • Unused concrete remaining in trucks shall be returned to the concrete batching plant • Hand tools should only be washed out into formed areas awaiting installation of concrete or removed from site for cleaning in designated areas.
Flocculants	Refer to Section 5.3.7 of this report. • Ensure the use of flocculants follows an approved flocculant management plan and industry best practice. • Regularly measure pH of the discharge from sediment retention devices.
Sanitary waste	• Place portable toilets away from site vehicle movement areas, to minimise risk that they will be knocked over • Service portable toilets regularly • Empty portable toilets before they are moved • Avoid breaking sanitary sewer lines that may exist on site
Vehicle and equipment use	• Fuel storage tanks shall be bunded to store a minimum of 100% of the tank's capacity. • Procedures and practices such as dedicated maintenance and service areas with appropriate measures for the collection of fluids and coolants shall be put in place to minimise or eliminate the discharge of lubricants, coolants or hydraulic fluids to the receiving environment • Have spill prevention and control measures and procedures in place, such as dedicated spill kits available at vehicle and equipment maintenance areas and all relevant site staff be trained in their use.

5 MANAGEMENT OF CONSTRUCTION ACTIVITIES

In this section we discuss the specific ESC controls and practices required to plan, design, operate, maintain and decommission ESC control devices during the Project construction period and for specific construction activities.

We have assessed these activities and measures in the knowledge of the Project conditions and are able to confirm the applicability of these measures, for those activities.

5.1 Overall ESC approach for the Project

One of the aims of this report is to determine the various ESC measures and devices that can be used in the construction of the Project and provide sufficient information to allow an assessment of effects that will result from construction activity to be undertaken. The proposed measures are discussed in the following sections and the effects are discussed further in the Water Assessment Report.

The development of the ESC measures discussed in this Report is based on:

- The conceptual construction programme and staging of works as set out in section 5 of the AEE;
- Viewing the construction of the Project in a holistic manner. The combined effects of the construction activity on the receiving environment, are considered as a whole and not in isolation from each other;
- Minimising the potential adverse effects on the receiving environment, by using measures that meet or exceed industry best practice guidelines;
- Developing CESCPs and undertaking pre-construction meetings for specific stages of construction and having regular 'toolbox' meetings on site with relevant personnel in attendance as part of the construction phase;
- Maintaining a register of control measures and 'As Built' information of key controls such as CWDs, DWDs, DEBs, SRPs, SSFs to allow for quick referencing, identification and understanding of function and location of the various ESC measures installed on site;
- Ensuring all ESC measures are structurally sound and have been checked and certified by a geotechnical engineer or ensure alternative ESC measures such as container impoundment systems, are employed;
- Including both Structural ESC Measures and Non-Structural ESC Measures within the ESC methodologies;
- Manually raising decant devices on SRPs and DEBs as required and during pumping operations. Pumping will often occur during dry periods and as such the rainfall activated chemical treatment systems will not be activated automatically. Raising

the decants will ensure no discharge and will assist with increasing sediment capture during dry weather periods; and

- The development of a continuous improvement monitoring programme, (refer to the Water Assessment Report), to inform the extent and environmental performance of construction activity on site and directing the work activity to directly influence and reduce the effect of sediment yield into the receiving environment.

5.2 Innovation

This report outlines the nature of the ESC measures that will be used within the Project. However, in some circumstances the design and implementation of ESC measures will go beyond current guidelines as best practice in this technical field is continually developing. As such these measures are referred to within this report as innovative measures. Some of the potential benefits of innovations are that they may improve environmental outcomes, pose less health and safety risk or reduce cost.

5.2.1 ESC innovations from other projects

The Long Bay development is discussed here as an example of innovation beyond the current guidelines. Similar to this Project, the development is taking place in relatively steep, clay based terrain and has a sensitive receiving environment (marine reserve in the case of Long Bay). Given the on site conditions there has been a high degree of focus on ESC.

With the emphasis on ESC, the Long Bay development has included the implementation of a number of innovative structural and non-structural ESC measures which are shown in Table 6.

Innovations have also been discussed with the team constructing the Pūhoi to Warkworth project and some of these are also outlined below.

Measures which could be applicable to the Project are also indicated in the table.

Table 6- ESC Innovations

Innovation on other Projects	Could be applied to the Project
Structural	

• SRP Baffles;
• SRP reverse slopes in base of ponds;
• SRP decant pulleys;
• Sediment sumps in all diversion channels;
• Installation of a last line of defence for all erosion and sediment controls; and,
• Rainfall activated flocculation devices for:
    • DEBs with a catchment area of between 500 and 3,000 m2; and
    • SRPs with a catchment area greater than 3,000 m2 with double flocculation sheds.
	All applicable

Innovation on other Projects	Could be applied to the Project
Non Structural	

• Manual batch dosing of SRPs and DEBs with chemical flocculants during pumping operations;
• Email and SMS notifications for ESC site and management staff in response to forecast rain events;
• Significant pre, during and post rain inspections;
• Educational 'Toolbox' meetings for all site staff on ESC measures; and
• Implementation of a continuous improvement adaptive monitoring programme including:
    • The continuous sampling and testing of water samples from selected SRP discharge locations;
    • If elevated levels of sediment are found within the sample, then site based investigations are carried out to determine the cause; and
    • Once the cause of elevated sediment levels has been determined, corrective actions including additional chemical dosing, restrictions on earthworks activity and stabilisation of open areas with mulch.
	All applicable

NX2 Stabilisation Trials	
• Stabilisation trials early in the construction process on various cut and fill locations. Monitoring the results of the water quality sampling to establish a direct link between earthworks activity, stabilisation techniques and their direct effect on sediment yields. • The use of soil stabilising agents (soil binders) prevent or reduce the movement of dust from disturbed soil surfaces that may create health hazards, traffic safety problems and offsite damage. Soil binders may also reduce the effect of raindrop erosion and therefore, minimise sediment runoff. However, the effectiveness of their use for this purpose has not yet been verified.	Dependent on results

With the exception of the stabilisation trials, the above measures have contributed to the overall success of the ESC approach for the Long Bay Development.

During the planning phase of the Pūhoi to Warkworth Project, the Further North Alliance team identified a number of, what were considered to be, innovative practices and lessons learned from other projects in relation to the establishment of ESC measures and practices. Their stabilisation tests are included in the table above.

However, the performance data generated during the construction phase of the Pūhoi to Warkworth Project has yet to be fully analysed and conclusions have yet to be reached on the performance of the innovative ESC measures relative to current guideline criteria.

Some of the other innovations currently being tested on the Pūhoi to Warkworth Project include:

- Trials for use of polymers to support stabilisation rather than traditional mulching. Trials have shown it to be more successful and consent conditions do not preclude it.

- Provision of automated monitors in a number of locations as required by the consent conditions.

- Sampling with telemetry trials/berley bomb snatch sampling/turbidity monitoring.

- Open Area Limits are being tracked through use of Drone flyovers and on ground measurement of open areas and stabilisation.

By the time the Project is constructed these and other methods may be well proven and suitable for use.

Table 6 indicates innovations that could be applicable to the Project. Where indicated we consider that these practices continue to be applicable and we also recognise that these innovative practices do not necessarily all fall within the current guideline documents.

We would therefore recommend that these practices be reviewed in the context of the value of the receiving environment and included in the development of the CESCPs prior to construction commencing.

While we consider that innovation will apply to all earthworks activity, those activities with an identified higher risk profile will be subject to more stringent management of both structural and non-structural measures. In particular, the implementation of a treatment train approach is a key element of consideration.

To ensure the identified ESC approaches and innovative practices are appropriate and applicable, we discuss below the specific ESC measures that can be applied on the Project.

5.3 Construction activity methodologies and CWM

This section includes the details of CWM measures and practices required to manage construction runoff from a variety of specific construction activities on the Project.

It should be noted that the works methodologies discussed below are conceptual in nature and have been developed to provide details of the various ESC measures and practices to be put in place to address erosion and sedimentation issues during the construction phase. It is noted that the various construction activities discussed below will be further developed and specific detail will be provided in the CESCPs, which will be produced by the principal contractor prior to construction works commencing.

We note however that we have 'tested' the methodologies within specific locations of the Project to ensure practicality and workability and have also assessed the transferability of the method to the same activity type within other Project locations. These "tested" methodologies are detailed below:

- For the tunnel construction; the construction of Bridge 11 and the establishment of the potential Soil Site between CH 41650 and CH 42000, we consider these area of work to be more complex and have developed site specific methodologies to provide confidence and certainty that the ESC measures can be implemented effectively during construction;

- Vegetation removal; it has been assumed that the plantation forestry will be felled prior to construction of the Project. However, the removal of other areas of vegetation form part of the overall land disturbing activity that needs to be undertaken for the Project. It is the first step that occurs and while the vegetation removal itself does not include earthworks activity there may be a number of associated earthworks activities such as tracking and skid site establishment;

- Prior to undertaking vegetation removal, the erosion and sediment control measures that will apply to the subsequent earthworks operation will be installed. This will result in some areas of initial disturbance which will be the subject of progressive stabilisation, using mulched tree vegetation, while diversion channels and retention structures are established;

- If vegetation removal is identified as a standalone activity, then specific CESCPs will be developed; and

- This part of the Project is relatively short term and the specific control measures to be employed will be fully detailed and designed within the CESCP for specific locations. We acknowledge that vegetation removal operations that will occur throughout the Project will be subject to the CESCP process and that this will provide an appropriate level of control.

We consider that the above process, methodology and controls can be effectively implemented on site during construction and specifically during construction during the CESCP process.

5.3.1 Stockpile establishment and management

A stockpile is a temporary store of material which is placed and stored prior to re-use or disposal. The majority of materials to be stockpiled on the Project will be topsoil, subsoil, and unsuitable material gained from the bulk earthworks operations, hardfill material such as crushed rock. Imported hardfill will also be stockpiled.

Stockpiles can become a source of sediment and dust and will need to be carefully managed to ensure there are no environmental effects resulting from these areas.

Stockpiles will be established throughout all sectors of the Project, the major ones being for the storage of topsoil and subsoil material for re-use during the establishment of the permanent landscaping for the Project. Surplus material and soil that is unsuitable for the construction of embankments will be disposed of in one of the identified soil disposal sites within the proposed designation. These are discussed in Section 5.3.2 of this report.

The establishment of stockpiles will be subject to the development of CESCPs. From an ESC perspective, the establishment of material stockpiles will have regard to the following to reduce the risk of sediment-laden runoff from entering the receiving environment.

Water Pollution

- ESC measures should be established and managed to minimise or prevent pollutant material entering waterways, and stockpiles should not be established below the level of the 20 year ARI flood extent;

- Stockpiles should not be established within 20 m of a permanent watercourse;

- CWDs will be established on the 'high' side of the stockpile to direct upslope runoff away from the stockpile area. This will prevent erosion of the base of the stockpile, which could affect the stability of the stockpile and induce a slip within the stockpiled material;

- DWDs will be established downslope of the stockpile and will discharge to a DEB; and

- SSFs will be established downslope of the stockpile to intercept and treat any sediment laden runoff from the stockpile prior to its discharge to the receiving environment.

Soil Disturbance and Erosion

- Erosion and sediment control measures will be implemented and maintained to prevent sediment from leaving the site. SSFs or DEBs will be provided on the 'low' side of the stockpile to ensure any sediment-laden runoff from the surface of the stockpile is treated prior to discharge;

- Material stockpiled for longer than one month will be stabilised using vegetative mulch or geotextile; and

- Stockpiles will not be established on ground with a slope greater than 5% unless a geotechnical assessment has confirmed suitability of the site for such a purpose.

Dust Management

- Construction dust management measures are set out in Section 6.1 of the Air Quality Report.

The specific location of temporary stockpiles has not been determined at this stage of the Project and will be confirmed and outlined within CESCPs. As part of the site visits undertaken and the design process, we have determined that there is adequate room available for stockpiles within the proposed designation, and that the above measures will be adequate to ensure effects of runoff from these features are only minor.

5.3.2 Soil disposal site establishment and management

Overview

Unsuitable and surplus material will be cut from the various cuttings zones within the Project and disposed of within various soil disposal sites and embankment widening works associated with the Project. The locations of the areas identified for the deposition of unsuitable material are indicated on the drawing set.

We note that the final soil disposal site locations and final volumes are yet to be determined for the Project and a large degree of value engineering will need to occur prior to implementation which could significantly reduce the spoil volumes. However, the construction section of the AEE indicates that up to approximately 85 ha of potential soil disposal sites have been identified.

Conceptually the ESC measures required during the establishment and management of the soil disposal sites will be similar to that required for the establishment of the various cut and fill zones proposed throughout the Project. The various activities would likely be as follows:

- Temporary and Permanent Stream Diversions (Discussed in Section 5.3.3 of this Report);
- Clearing vegetation and stripping of topsoil;
- Pumping of groundwater and surface water runoff (discussed in Section 5.3.6 of this Report).
- Construction of shear keys (Discussed in Section 5.3.6 of this Report);
- Haul Road and access road construction – (Discussed in Section 5.3.10 of this Report);
- Construction of Gully drains;
- Stockpiling of excavated material;
- Bulk Earthworks (Excavation and Filling operations);
  - Cut to Fill within the Site; and
  - Import of cut material to disposal site.
- Drying / Dewatering of unsuitable material.

The establishment and management of soil disposal sites will require site specific CESCPs to be prepared prior to works commencing within these areas.

Site Specific Methodology

To demonstrate that erosion and sedimentation can be managed effectively during the establishment of the soil disposal sites we have developed a conceptual ESCP for the indicative soil disposal Site between CH 41650 and CH 42000 which is discussed below.

A conceptual design of the CWM measures is presented on drawings ES-081 to ES-084. The conceptual design includes a conceptual staging of the works required to establish and manage the formation of the soil disposal site, stream diversion and road embankment and is described below:

Stage 1 (Drawing ES-081)

- Establish an access road within the designation to the location of the spoil site and culverts CH41850 and CH41750;
- Clear vegetation from the culvert locations and temporary stream diversion channels only;
- Construct a CWD (A1) and (A2) above the s soil disposal site location to prevent run-on water from the uphill catchment from entering the work area;
- Establish DWDs (B1, B1a and B2, B2a)) and DEBs (C1 to C3) to receive pumped flows from the stream culvert excavation works; and

- Construct the temporary stream diversion (D1 and D2) and temporary culverts across the access track offline from the existing stream to ensure works are carried out in a dry environment and provide any erosion protection measures require to stabilise the channels.

Stage 2 (Drawing ES-082)

- Once the temporary stream diversions are stabilised, flows from the existing stream can be transferred into the temporary Stream Diversions (E1 and E2);
- Once flows have been transferred to the temporary stream diversions, vegetation clearance of the soil disposal site area can commence;
- Construct Culverts CH41850 and CH41750;
- Construct the CWDs (F) to redirect stormwater runoff from the upstream catchment around the works area;
- Construct the SRPs F1 and F2, and SSFs G1 and G2;
- Establish DWDs along the toe of the embankment and connect to SRPs F1 and F2 of groundwater and surface water flows will be required during the construction of the gully drains, pumped flows will be discharged to SRPs F1 and F2;
- Remove topsoil and subsoils as required by the design beneath the road embankment;
- Construct Gully Drains and any subsoil drains required by the design; and
- Commence the placement of fill to the road embankment, ensuring that any stormwater runoff from the earthworked area discharges to SRPs F1 and F2.

Stage 3 (Drawing ES-083)

- Establish SRPs H1 to H4 and establish SSFs to act as a last line of defence;
- Construct a network of DWDs within the soil disposal site area, which will discharge to SRPs H1 to H4;
- Commence the placement of excavated material from the Project within the soil disposal site and spread within the soil disposal site uphill of the work area stabilised with mulch at the end of each working day;
- SRPs H1 to H4 are to discharge to the inlet of culverts CH41850 and CH41750;
- SRPs H1 to H4, will need to be relocated at higher elevations as the depth of spoil material increases in height during the filling operation; and
- Once complete the area will be planted and stabilised in accordance with the design and the permanent stream diversions will be constructed.

Stage 4 (Drawing ES-084)

- Once the soil disposal site area has been confirmed as being stabilised, work can commence of decommissioning the ESC measures discussed above; and
- Upon removal of the ESC measures, the flows in the temporary stream diversions can be transferred across into the permanent stream channel.

All works are effectively outside of the stream channel alignment with this in itself acting as the key to ensuring any construction effects relating to sedimentation are minimised to the fullest extent possible.

The conceptual construction sequence discussed above is a description of only one possible method of establishment of this soil disposal site and we have demonstrated that it can be managed effectively to control the effect of erosion and subsequent sedimentation and it is expected that site specific CESCPs will be produced for the establishment and management of the soil disposal site prior to construction commencing.

5.3.3 Temporary or permanent stream diversions

Stream diversions will be required during the construction of the Project to divert flows on a temporary basis to allow construction works to progress or provide access to an area.

They are also required on a permanent basis to divert the stream around or through a permanent feature of the Project such as an embankment, bridge or culvert. In both cases, the stream diversion will be necessary in order to establish an 'off-line' environment to allow construction works to be completed outside of the active stream channel.

The following discusses a conceptual sequence of works required to complete a temporary or permanent stream diversion:

- Excavation of the diversion channel will be carried out offline from the existing stream, so that excavation works can be carried out in a dry environment. A clay plug will be left in place at each end of the diversion channel to ensure that the existing stream cannot breach and flow through the new channel prior to it being stabilised;
- In the case of temporary stream diversions, the dimensions of the diversion will be such that it will have sufficient capacity to cater for the 20-year flow, in accordance with GD05. Permanent stream diversions will be established in accordance with the design. This will be detailed within the CESCP;
- Where the capacity of the diversion differs from the GD05 requirements this will be explained and justified within the CESCP;
- Stabilisation of the newly constructed diversion channel will be carried out to ensure it does not become a source of sediment. This will be achieved using geotextile fabrics, rip rap material or rock armour;
- Once the diversion channel is fully stabilised, the downstream clay plug will be removed to allow stream flows to enter the diversion channel. The upstream clay plug can then be removed allowing stream flows through the diversion channel;
- Removing the downstream clay plug first helps to reduce scour in the diversion channel by keeping some water within it when the upstream plug is removed;
- A non-erodible dam will then be placed within the original channel immediately downstream of the inlet to the diversion channel to divert flows into the diversion channel. A non-erodible dam will also be immediately placed at the downstream end of the original channel, upstream of the diversion channel outlet to prevent backflow into the construction area. Once the flows have been diverted and the dams placed, fish removal from the original channel can be completed. Construction activity can then take place within the original channel as required;

- The non-erodible dam will comprise the formation of a sand bag barrier with an impermeable lining to avoid seepage through the sand-bags. Clay will then be placed immediately behind the sand-bags to prevent water flowing through the sand-bag barrier and into the construction area;

- Any water remaining within the works area will be pumped to a DEB. Pumped, volumes will be minor and the decant within the DEB will be manually raised during the pumping process to allow for settlement of sediment and chemical treatment with flocculant if necessary;

- Once the original channel has been de-watered, construction activity (such as removal of weak and unsuitable material, filling, and culvert construction) within the original channel can then occur;

- CWDs will then be installed above the area of work to ensure that no stormwater runoff from the existing catchment outside of the works can enter the area during the construction period;

- Material excavated from the diversion channel will be placed in stockpiles away from the stream diversion and outside of the identified flood plain area;

- Although the works will not commence until a fine weather window is forecast, geotextile material will be available on site to cover any exposed areas in the event of an unexpected change in weather;

- The works will be staged such that if flood conditions are predicted the area can be fully stabilised in a few hours. Any sediment deposited within the newly formed channel will then be pumped and removed to a DEB;

- Once the works within the original channel have been completed, other appropriate controls, such as silt fences, will be installed below the area of works; and

- Once the new culvert has been constructed and the surrounding area stabilised then flows from the existing to the new channel and culvert can be transferred.

If rainfall occurs during the course of construction this will be managed as below. In the event of forecast rain, or before leaving the work area for more than 24 hours the following will occur:

- Any loose material that could enter a watercourse is to be removed from the work area, depending on the quality of the material this will be either to a soil disposal site or to a stockpile area;

- Where possible, all exposed areas will be covered with geotextile to ensure no flows overtopping the stream banks create scour issues. It is expected that this will be achieved through geotextile with the geotextile appropriately trenched in at the head and toe of the area;

- All existing and additional erosion and sediment control measures will be inspected, secured and maintained where required;

- Additional mulch and geotextile / polythene will be kept on site at all times to cover exposed areas and stockpiled material; and
- Extended working hours will be considered if it is believed significant benefit with regard to programme and environment impact is either required or possible.

A typical stream diversion and culvert construction methodology is outlined in GD05 Figures 121 to 124 that provides an indication of the construction process (summarised as Figure 9).

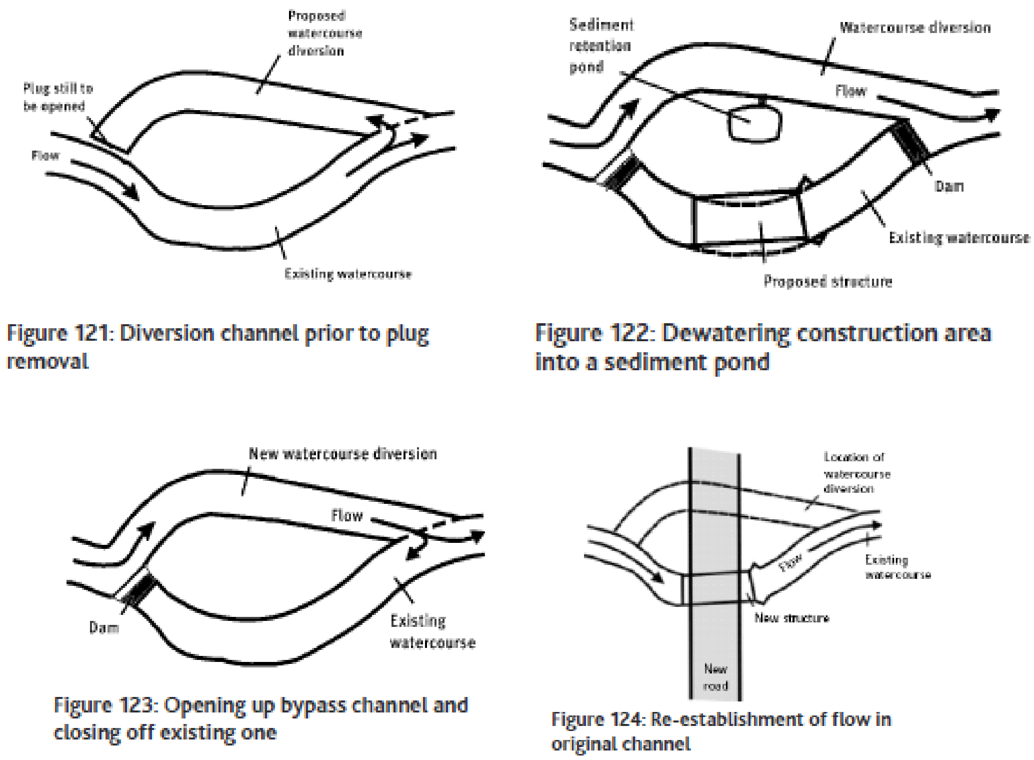


Figure 9 - Possible Stream Diversion options

We consider that the above process, methodology and controls can be effectively implemented on site during construction.

Where the pumping of flows around the work area is required this will be carried out in accordance with the methodology described in Section 5.3.6 of this Report.

5.3.4 Culvert construction

Temporary and permanent culvert construction will be required in a number of locations throughout the Project. Temporary culverts will be provided to allow construction vehicles to cross watercourses and overland flowpaths, and these temporary culverts will be removed when no longer needed.

As with the stream diversion methodology discussed in section 5.3.3 above it is important that the culvert construction activities are undertaken early in the construction program to ensure that the surrounding earthworks can be completed.

Fish migration and spawning are important considerations to be taken into account during the construction of culverts and stream diversions, these are addressed in the Ecology Assessment Report.

We note however that from a construction and operational perspective that as soon as the culvert is commissioned and stream flows are passed through the culvert then the operational considerations apply. This includes ensuring long term fish passage remains and that the hydrological design aspects of the Project are fully addressed.

Prior to undertaking the works at a particular culvert location, a specific construction methodology will be developed and will be detailed within the CESCP for the particular location.

Culverts and their associated stream diversions will generally be constructed within an offline location, isolated from the existing stream flows. A stream diversion will be required either prior to construction works commencing on the culvert or to direct flows into the culvert once construction works have been completed.

Where culvert installation or an extension is required within a stream channel, and it is not possible to divert the stream, the culvert works, (depending on stream flows and fish passage requirement) could be carried out either by bypassing the flows around the culvert footprint by establishing a stream diversion as discussed in Section 5.3.3 of this Report (e.g. Figure 10), or by pumping the flows around the culvert works areas as described below.

Figure 10 – Diversion of stream flows around the culvert work area

Pumping of flows from an existing stream will only be carried out in situations where it is not practical to construct a diversion channel.

The decision to pump as opposed to the installation of a diversion channel will be made by the Project team, and will form part of the CESCP, for that construction work area. This methodology and associated process is a common approach to works in stream channels and has been successful previously. The NGTR and works in the Long Bay catchment both illustrate the effectiveness of this approach.

Where pumping is to occur the operation will be carried out as follows:

- Place a temporary non-erodible dam within the existing stream channel upstream of the work area and install a pump approximately 5m upstream of the dam. The pump will pump flows upstream of the works around the work area and discharge them back into the existing watercourse downstream of the culvert works;

- Sand bags or similar will be used to impound flows for the pump. The inlet of the pump will be supported above the base of the stream and will contain a fish grill, to prevent fish from entering the pump intake structure;

- The pump flow rate will be equal to the expected dry weather flow for the particular stream;

- The Ecology Report provides for fish management measures. With the controls in place, any fish observed in any of the pools within the work area will be removed by hand netting and released downstream of the work area. Any fish or eels discovered during excavation will also be captured and released downstream;

- Initial excavation works will remove the vegetation from the work area followed by the excavation of any unsuitable material. This excavated material will be removed from the work area and disposed of within one of the identified potential soil disposal sites;

- Once all unsuitable and soft material has been removed from the extent of the culvert to be constructed, the area will be backfilled with the required amount of structural fill and the culvert along with all associated wingwalls, retaining walls and backfill will be constructed;

- Any other construction activity associated with the culvert construction, such as the placement of fill, will only be carried out once ESC measures such as super silt fences, CWDs DWDs, SRPs and DEBs have been put in place. When the works have been completed, any disturbed and exposed areas of bare earth will be fully stabilised through mulching or vegetation establishment;

- Once the necessary approval has been obtained from the Project ecologist, the pump and bund will be removed and the stream flows can then be passed through the new culvert structure; and

- Where an existing culvert is to be extended, a plywood bulkhead, or equivalent, with a flexible bypass pipe fixed into the bulkhead of the culvert will be installed. The bulkhead will be sealed into the base and sides of the existing culvert. If required a supplementary pump will be used to ensure a dry working environment. The flexible bypass pipe will be a sufficient length to allow low flows to discharge beyond the works area.

All culvert works

The following will be required for the construction of all culverts:

- Prior to any works commencing on the construction of a particular culvert a period forecast of dry weather sufficient to construct the culvert will be confirmed through appropriate weather monitoring system;

- Culverts are expected to be installed in sections and sections will be fully constructed and the immediate area stabilised at the end of each working day;

- Any water present within the work area will be pumped to a DEB which will be located away from, and discharge away from, the stream environment;

- On completion of the culvert extension, all plant, materials and labour will be demobilised and the site will be permanently stabilised in accordance with the CESCP for that work area; and

- Any rock armouring required for stabilisation purposes at the outlet of the culvert will be placed and accommodated as required.

In the event of high rainfall during the course of construction of the culvert, or prior to leaving the site for more than a 24-hour period, the following will occur:

- That any loose material that could enter a watercourse is to be removed from the flood plain of the stream;

- Any downstream sand bag barriers will be checked and, if required, removed;

- All existing sediment control measures will be inspected and secured and maintained where required should a significant rain event be forecast. The streambed in the location of the culvert will be fully stabilised to ensure no flows overtopping the upstream dams or bunds can create scour issues. It is expected that this will be achieved through geotextile membrane being appropriately trenched in at the head and toe of the work area; and

- Extend the working hours subject to compliance with relevant consent conditions, if it is believed to have significant benefit with regard to programme, forecast weather events and environmental impacts.

We consider that the above process, methodology and controls can be effectively implemented on site during construction.

5.3.5 Bridges

Overview

Bridges will be required to span across natural gullies, roads and watercourses.

Bridge construction will typically involve piling operations to form a stable foundation onto which precast reinforced concrete columns will be constructed.

Pre-cast and Pre-stressed concrete elements required for the construction of the bridges will be cast in a precast concrete construction yard and then transported to the particular bridge of viaduct location, where they will be placed in position. Once fixed in position the top slab will be poured in-situ to the required depth.

In some cases, construction of the bridge will involve establishing structures with sheet piling on either side of a stream system with no instream works required. The placement of a concrete slab over the stream without diverting the stream will complete the bridge structure. In these occasions ESC will be based around placement of controls below the sheet pile locations but above the stream bank profile.

To demonstrate that that construction of bridges can be carried out with effective environmental management including erosion and sediment control during construction, we have briefly discussed the ESC measures required at Bridge 11 below.

Site Specific ESC Methodology

Bridge 11 is a 490 m long multi-span structure which spans across the existing SH1, the Hōteo River, the Waitaraire Stream and the indigenous forest area near the Hōteo River east of SH1 and will be elevated above ground level by up to 14 m.

Section 5 of the AEE indicates that the configuration of the structure would be suited to segmental precast balanced cantilever construction using an overhead gantry, and this construction methodology was used in the construction of the Waiwera Viaduct on the NGTR project (see Figure 11).

From a CWM perspective the construction will need to consider a temporary crossing of the Waitaraire Stream and the Hōteo River, which can be achieved through the use of temporary "bailey bridges" to provide access for construction plant including piling rigs, cranes and support vehicles.

Staging platforms will be required and hardfill will be required to provide support for construction plant. The establishment of hard fill material within the construction zone will have the added benefit of providing a hard stabilised surface which will be resistant to erosion should flooding of the Hōteo River eventuate during the construction period.

Additional ESC measures will be required during the establishment phase of the Project and these will include the use of DEB's, SRPs and SSFs to ensure that sediment laden runoff is intercepted prior to being discharged to the receiving environment.

In addition, site management measures including weather watching and adjusting site operations to suit forecast and actual weather conditions.

The following is a description of the ESC measures that have been developed in response to the indicative design for Bridge 11. These ESC measures, whilst indicative in nature, demonstrate that the works required to construct the bridge piers can be carried out, whilst ensuring the effect on the environment will be less than minor.

The indicative design of Bridge 11 shows this to be a multiple 9 span bridge with 18 bridge piers required to support the bridge beams.

The bridge piers have been located to take cognisance off and minimise the vegetation clearance to also span across, the existing SH1, the Waitaraire Stream and the Hōteo River.

From review of the indicative design for Bridge 11, it is considered that given their close proximity to the receiving environments of both the Hōteo River and Waitaraire Stream that the establishment of access to, and construction of, Piers E and F would represent an elevated risk with respect to sediment discharges.

The following section describes, albeit at a conceptual level, the various ESC measures that could be provided during the construction of the Bridge Piers at this, or other sensitive locations. ESC measures developed on the indicative design of Bridge 11 are indicated on Drawings ES-086 and ES-087.

Access Establishment and Vegetation Clearance

Piers E and F are located within an area of existing native bush and a section of this vegetation will need to be cleared at each pier location in order to establish a working platform for construction plant and labour to access and construct the bridge piers.

Vehicle Access to Pier E, would be from the existing SH1 via the Spring Hill Farm Access track with the establishment of a new access track to the edge of the Waitaraire Stream. Where, given the depth of the stream (approximately 2.5m to 3m at this location) a temporary bridge (Bailey Bridge type structure) is proposed to cross over the stream to provide access to the area of vegetation required to be cleared.

Prior to the establishment of the new access track a supersilt fence will be constructed around the access track area to prevent sediment laden runoff from entering the Waitaraire Stream.

Once the supersilt fence has been erected works can commence on establishment of the access track, which will be undertaken using a cut and cover methodology whereby once the topsoil and subsoil have been removed down to the required depth, clean crushed rock aggregate will be placed and compacted to provide a stabilised surface on which construction plant and other vehicles can use to access the site.

Once the access track has been established, the temporary bridge structure can be lowered into place across the Waitaraire Stream.

Following the placement of the temporary bridge, works will commence on the removal of the vegetation within the location of Pier E. Vegetation clearance will be carried out by hand with established trees being felled to ground level and removed to stockpile areas to be processed into mulch for use as a stabilisation material within the Project area.

At this stage vegetation will be removed to ground level thereby leaving the area in a stabilised state until the various ESC measure can be established prior to excavation works commencing.

Working Area Establishment

The ESC measures required for the working area at Pier E are as follows:

1) The erection of a super silt fence around the working area, which will remain in place to act as a last line of defence against sediment laden water from being discharged to the Waitaraire Stream.
2) The construction of a Decanting Earth Bund at the lowest point of the site area.
3) The construction of Dirty Water and Clean Water Diversion Drains around the perimeter of the working area. Dirty Water Drains will discharge to the Decanting Earth Bund and Clean Water drains will discharge to the Waitaraire Stream.

Once the ESC measures have been established, work can commence on the removal of tree stumps, topsoil and subsoil to the required depth. Once complete, rock aggregate will be placed to a sufficient depth to provide a working platform for construction plant to undertake the works required to form the bridge piers at this location. The placement of the rock aggregate also provides a stabilised surface providing protection against erosion, thereby reducing the risk of sediment laden water from leaving the site.

All stormwater runoff from within the working area will be discharged to the Decanting Earth Bund for treatment prior to discharge to the Waitaraire Stream.

Upon completion of the pier works, disestablishment of the working area can commence, with the removal of the rock aggregate platform which will be replaced with topsoil, which will be seeded and/or planted and mulched in accordance with the design proposals.

The physical ESC measures will remain in place until the site has been confirmed as being 80% stabilised.

The same procedure would be followed for access to Pier F except access will be provided from the south directly off SH1

Figure 11 - A launching gantry placing segmental box girder sections on the Waiwera Viaduct

5.3.6 Pumping from excavations and shear keys

Pumping operations will be mainly required for the removal of groundwater from excavations such as those required to construct foundations for structures and trenches for pipelines. Dewatering of excavations will be required to allow construction personnel and equipment to undertake construction activities in a dry environment.

Excavations

Where pumping is required from excavations for foundations or trenches it will typically be carried out and managed as follows:

- The pump intake will sit on hard fill material, which will provide a filter media to ensure debris and larger particles are not sucked into the pump intake. The filter media will also act as an ESC pre-treatment system and will also reduce the risk of direct damage to the internal workings of the pump;

- If the discharge water quality is satisfactory with a minimum 100mm clarity, the pump discharge will be directly to a vegetated environment away from any watercourse;

- Where a suitable vegetated area is not available within the vicinity of the working area the discharge from the pump will be to a DWD and subsequently to a SRP or DEB; and

- If the water clarity is not satisfactory, pumping will be to a DEB or SRP and during pumping operations the decant of the DEB or SRP will be manually raised and will remain in that position until sufficient settlement of suspended solids within the discharged water has occurred.

Shear keys

A shear key is a geotechnical design feature that will be constructed in areas where the existing ground beneath the proposed road alignment requires improvement and strengthening to ensure the long-term stability of the road embankment (see Figure 12 for photograph of excavation).

There are a number of Shear Keys required along the Project and these are discussed in the Geotechnical Assessment Report.

The works required to construct shear keys will typically be:

- The excavation of material to a depth to be determined by a specific geotechnical design;

- The placement and compaction of durable rock fill within the excavation to form the shear key;

- Pumping operations will be required to remove groundwater and any surface water ingress into the excavation; and

- Excavated material from the shear key excavation will likely be classed as unsuitable material and will not be used as structural fill within earth embankments and will be removed from the work area to one of the identified potential soil disposal sites within the Project.

The depth required (in some cases in excess of 10 m) to construct a shear key will require the pumping operations to be managed carefully and will be carried out in stages as the excavation progresses. From an ESC perspective the pumping of groundwater and surface water ingress from shear keys will typically be carried out in the same way as described above.

Discharges from the pump will be directed to a SRP, or DEB. During the pumping operation, the decants within the SRP or DEB will be manually raised and will remain in that position until sufficient settlement of suspended solids within the discharged water has occurred.

If required, manual batch dosing of the SRP and DEB with chemical flocculant will be carried out to increase the level of sediment retention in the SRP or DEB. Once pumping operations have been completed and the sediment sufficiently settled out, the decants can be lowered and normal operation can resume.

We consider that the above process, methodology and controls can be effectively implemented on site during construction.

Figure 12 – Shear Key excavation

5.3.7 Chemical treatment of SRPs and DEBs (flocculation)

Flocculation is a method of increasing the retention of suspended solids from earthworks runoff. Flocculant is added to the inflows of a SRP or DEB via a rainfall activated system or by manual batch dosing.

The flocculant is a chemical additive which works by neutralising the negative charge of soil particles, thereby accelerating coagulation and increasing the rate of settlement of soil particles. The use of flocculation chemicals increases the efficiency of SRPs and DEBs and reduces the amount of sediment discharged to the receiving environment.

There are a number of flocculants available on the market, with Poly Aluminium Chloride (PAC) being widely used throughout the Auckland Region, there are also other alternatives available in the marketplace each varying in their effectiveness depending on the soil condition of the site.

We further note the successful use of PAC as a specific flocculant, has been endorsed fully by Auckland Council in their Technical Publication 227 (TP 227) and has achieved excellent water quality results throughout the majority of recent earthworks projects in the Auckland Region, with no reported residual effects.

Flocculation is a key structural management tool and with appropriately trained personnel managing and using this measure, it has proven to be a critical feature of successful ESC.

Further to the above, the proposed continuous improvement monitoring programme as discussed in Section 5 of the Water Assessment Report will include continuous monitoring to ensure that appropriate water quality is being achieved from the discharge of construction runoff and also that any residual effects are minor only.

Given the varying soil conditions through the length of the Project we would recommend that bench testing be carried out on various soil samples from the Project area using a range of available flocculants to determine the most appropriate type of flocculant and also the dosing rate that the flocculant is applied to the various ESC measures.

We consider that flocculation is a viable and effective method of management of sediment yield on the Project and we recommend that bench testing of be carried out during the development of the CESCPs.

5.3.8 Riprap placement

Riprap material is a permanent erosion protection measure and is most commonly used along stream banks and at culvert outlets. Riprap resists the erosive action of water flowing across the surface of a stream bank, which can lead to erosion or failure and collapse of the bank.

Riprap will be used on the Project in a number of locations as permanent erosion protection measures. This will typically be associated with the inlet and outlets of culverts, and also be used for stabilisation in stream diversions. From a temporary perspective riprap will be utilised to provide erosion protection at the outlet of the SRPs to be installed.

While placement of riprap is a relatively simple process we have outlined the methodology that will be used for the placement of a riprap within an existing stream environment and also discuss the ESC measures required.

A conceptual construction sequence for riprap placement in a stream channel is described below:

- A clear weather window will be established prior to commencing works on the riprap. Clearance of the stream bank can commence and will only be carried out to allow sufficient room for the riprap to be placed;

- A temporary flow diversion will be established to keep water away from the works during the placement of the riprap. The bank slope will be cleared of bushes, trees, stumps or other organic material, loose and soft material will be removed from the bank and a smooth, uniform surface formed;

- A separation layer of geotextile and a filter layer of stone will be placed and spread evenly across the extent of the riprap location, using an excavator; and

- The riprap material will be free of any silt, clay or organic material such as silt and will be carefully placed to the required depth. Larger rocks will be placed at the toe of the riprap and will be evenly distributed across its width.

The placement and use of riprap will be used widely on the Project and will not create any associated environmental effects.

5.3.9 Stormwater wetland establishment

A construction issue that is relevant to the operational water management is the timing of the switch from construction to operational water treatment devices. This is a practical issue when an operational stormwater treatment device is located at the same location as the construction water management device e.g. sediment retention pond for construction stage modified to a wetland for the long-term operational phase.

In these circumstances the same earthworks footprint will apply and the sediment retention device will simply be constructed as per normal construction techniques but with the outlet device incorporating the same outlet structure device as the permanent structure. It will continue to operate as a construction related device and once the criteria for operational implementation is met then the outlet will be changed to reflect operational requirements. Flocculation will be reconsidered and may no longer be necessary at this stage.

From our experience in other development projects we recommend that the operational water treatment devices will generally need to progress from the construction water management device when 80% of the catchment is in its permanent form e.g. stabilised by vegetation and roads sealed.

5.3.10 Access track and haul road establishment

Access tracks and haul roads will be required on the Project to transport plant machinery, personnel, materials, earth and fill material throughout and between construction zones on the Project.

All-weather access, access tracks and haul roads will be required and will be constructed using rock to form a stabilised surface. A typical detail of an access track can be seen in Figure 13 below and typical haul roads and dust suppression can be seen in Figure 14 and Figure 15 respectively.

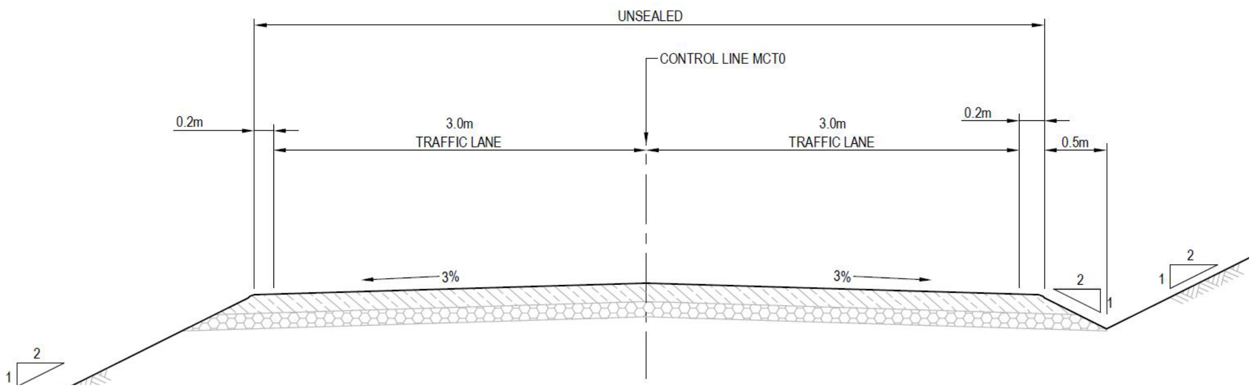


Figure 13 – Typical haul road detail

DWDs will be constructed on each side of the access track and haul road to receive runoff. These DWDs will discharge to the receiving environment via a DEB, or SRP, depending on the catchment size.

During the construction period water carts will be used to spray the access tracks and haul road with a fine spray to wet the surfaces to suppress dust. These haul roads are considered relatively simple to manage and can be treated as isolated areas of works with the associated ESCs in place.

Where haul roads form a component of the larger earthworks footprint the control measures will likely be incorporated into the wider site erosion and sediment control measures and the relevant CESCPs.

Figure 14 – Haul road in use

Figure 15 - Water cart dust suppression

5.3.11 Construction compounds and staging areas

The construction description in Section 5 of the AEE indicates that construction compounds will be required for the duration of construction and will be required for repairs, maintenance, re-fuelling of earthmoving equipment, lay down and storage areas for materials delivery, workshops, project offices, messing, and ablution facilities. They are likely to operate throughout the construction period.

Bridge staging will also be required for the assembly of launching gantries, lay down and storage areas for materials delivery, workshops, project offices and tool-box, messing and ablution facilities.

Construction compound water management measures

ESC devices to be used for the establishment and operation of construction yards will be as follows:

- Stabilised Construction Entrances will be established as the entry point to the proposed construction yard to reduce transfer of sediment onto the external road network;
- If necessary CWDs will be established at the perimeter of the site to intercept and divert offsite water and overland flow from the catchment uphill of the construction yard from entering the areas;
- DWDs will be constructed to intercept and divert runoff from the surface of the earthwork areas within the work area and will discharge it to a SRP to assist with removal of sediment from the runoff prior to discharging to the receiving environment;
- Super Silt fencing – These will be placed during the yard establishment phase of works if necessary;
- The construction yard establishment is recognised as a quick process whereby earthworks activity to establish the platform is completed as a single operation. The topsoil stripping and any subsoil stockpiles will be managed as per Section 5.3.1 of this Report and will be stabilised (likely with a mulch cover) immediately on establishment;
- Immediately on reaching grade the yard area will be stabilised with a 50 to 100mm thick layer of clean hard fill material. This has the purpose of achieving immediate stabilisation but also ensuring traffic movement to and from the site will not be a generator of any further sediment yields;
- The SRP will remain after the yard is stabilised and will act as an attenuation device for the short term operational aspect of the yard. This SRP will be sized in accordance with the requirements of GD05 and will provide for treatment during the earthworks activity while also providing water quality treatment and extended detention treatment for the impervious areas associated with the construction yard;
- In accordance with the Transport Agency ESC Standard the decant structure from the SRP will remain through the entire duration of the construction yard life with the decant design providing the required extended detention flow rates;
- The SRP will remain in place until the yard is no longer required and is returned to a vegetated or final land use state; and
- Drawing ES-071, (refer to drawing set ES series) provides a conceptual yard water management plan that will be implemented during the yard development process.

Further water management practices to be used in the operation of the construction yards during construction will be as follows:

- Vehicle movements and parking will only be within designated areas of hardstanding;

- Non-Sediment Contaminants (Chemicals, petroleum and solvent based) products are to be stored within appropriately designed bunded areas;

- Regular clearing of sealed hardstanding areas will be carried out using a road sweeper to remove deposited material from the surface that could become mobilised during rain events;

- All material stockpiles located within the yard confines will ensure treatment through the SRP; and

- Sediment will be removed from the SRP' associated with the individual construction yards when accumulated sediment exceeds 20% of the available storage volume for the particular device.

The specific detail of these yards will be highlighted within the CESCPs to be submitted prior to construction commencing.

We consider that the above process, methodology and controls can be effectively implemented on site during construction.

5.3.12 Overall earthworks

A series of conceptual erosion and sediment control plan drawings have been prepared for the Project and have been developed with reference to the construction section of the AEE and consequently the ESC measures proposed take into account the various construction activities discussed. A copy of the conceptual ESC drawings developed during the preparation of this Report are included in drawings set (ES Series).

A summary of the total earthworks volumes for the Project are summarised in Table 7.

Table 7 - Project earthworks volume summary

	Northern Section (m^3)	Central Section (m^3)	Southern Section (m^3)	Total
Year 1	500,000	800,000	200,000	1,500,000
Year 2	900,000	1,100,000	350,000	2,350,000
Year 3	900,000	1,100,000	350,000	2,350,000
Year 4	900,000	1,100,000	300,000	2,300,000
Year 5	900,000	1,100,000	300,000	2,300,000
Year 6	471,000	969,000	110,000	1,551,000
Total Earthworks	**4,571,000**	**6,169,000**	**1,610,000**	**12,350,000**

Whilst the construction methodology has been developed and highlights a number of discrete activities to be carried out during construction, it is recognised that a number of these activities are linked and are dependent on one another and these will need to be considered and written into the CESCPs prior to construction commencing.

Following the development of the conceptual ESCPs for the Project, we have demonstrated that through the implementation of a range of structural and non-structural ESC measures and practices, including the implementation of SRPs, DEB, CWDs, DWDs and chemical treatment, that erosion and subsequent sedimentation can be managed effectively throughout construction. Additional information on the sediment yield predicted to be generated for the Project is discussed in the Water Assessment Report.

5.3.13 Works within the flood plain

Sediment control devices will be located outside the 20 year ARI flood level, unless no other viable alternative exists. If sediment control devices are required within the 20 year ARI flood level, they will be designed to capture the minimum catchment area (0.3 to 5.0 ha) and will be subject to an increased inspection, monitoring and maintenance regime.

The operation of the sediment retention devices during the construction phase of the Project flooding has been considered, in particular during the design phase and works within the flood plain have been avoided as a first step.

However, given the extent of some of the flood plains, such as the Hōteo River, it is anticipated that there will be some works required to be undertaken within the identified flood plains, such as the construction of culverts and stream diversions, the placement of fill to embankments, the construction of bridge piers and foundations.

Where works are required within flood plains, the risk of sediment discharges reaching the receiving environment is higher during construction, and CWM measures will be established, operated and maintained to minimise this risk.

A number of measures that can minimise the risk of sediment discharges are listed below. We note that no one way will reduce the risk on its own or be applicable to construction activity, and consequently the preparation of CESCPs during construction will need to consider the following risk mitigation measures:

1) Undertake works during a dry weather window – This is particularly relevant in the construction of culverts, stream diversions and works adjacent to streams and watercourses and avoid working (and ensure site is stabilised) during forecast flood events for the area of concern.

2) Undertake increased levels of pro-active maintenance such as:

    a. Undertake Regular – (Daily, Weekly and Long-range) - weather monitoring;

    b. Programme construction and stabilisation works in response to forecast weather events;

    c. Regularly remove retained sediment from the sediment retention devices and should be cleaned out when sediment levels reach 10% of the normal operating capacity to ensure that retained sediment is not re-suspended in the event of an extreme rainfall event;

    d. Make necessary repairs to ESC devices regularly and especially prior to forecast rainfall events; and

e. Undertake pre and post rainfall event inspections of ESC measures

3) Provide stabilised flow paths for flood flows to bypass the working area.

4) Provide stabilised working platforms during construction around bridge foundations and piers adjacent to stream and watercourses.

5) Limit open areas of disturbed earth.

5.3.14 Tunnel establishment

Overview

The indicative design for the tunnel comprises of two oval parallel tunnel bores 15 m wide at the widest point. These will be excavated in weak to medium strength sedimentary rock as follows:

- The upper bench within the tunnel would be excavated using a track mounted roadheader. This machine has rotating cutting discs mounted within a shield at the end of a hydraulic boom.

- The lower section of the tunnel bore would be most efficiently excavated using a large rock milling machine. This machine has rotating cutting or milling discs mounted below the undercarriage which allows the machine to remove the rock in layers as the machine traverses along the bench.

The excavation will initially be temporarily supported by lattice girders, rock bolts and shotcrete. The permanent waterproof lining will consist of a drainage fleece, waterproof membrane and cast in situ unreinforced concrete.

The tunnel is proposed to have a longitudinal grade of up to 5% with the northern portal positioned higher than the southern portal. The preferred direction of drilling will therefore be from south to north, to allow gravity drainage of groundwater.

The conceptual construction methodology indicates that excavated material (approx. 200,000 m^3) would be loaded onto trucks and transported to and deposited in the Southern Construction Section and used as fill material for the construction of the Project.

Tunnelling ESC methodology

The construction of the tunnels will be underground, and therefore the works will not be exposed to wind or rainfall erosion. Therefore, sediment generation will be minimal.

The construction of the tunnels may result in groundwater seepage at bedding planes and any fault zones encountered along the length of the tunnels. To reduce the inflow of groundwater in these areas dewatering bores will be installed along the length of the tunnel. Ground water from the dewatering bores will be discharged to vegetated buffer zones prior to reaching the receiving environment.

Any groundwater seepage within the works will be drained along the length of the tunnel by channelling the flows along each side of the tunnel bore, these channel will then discharge to a sediment retention device.

Groundwater flows will inevitably flow across disturbed surfaces where they will pick up sediment from the tunnel floor. This sediment laden water will need to be treated prior by a sediment retention device such as an CIS, SRP or DEB prior to being discharged to the receiving environment.

Groundwater seepage within the tunnel will be channelled to a low point within the tunnel from where it will either flow by gravity or be pumped to the sediment retention device.

Prior to construction commencing CWM measures will be established and these will include:

- CWDs to divert clean stormwater runoff from the upstream catchment around the tunnel portals;
- Sediment retention devices including CISs, DEBs and/SRPs will be established downstream of the tunnel entrances. These sediment retention devices will treat any sediment laden water from the works area prior to discharge to the receiving environment.

  As the tunnel works are underground, they will not be exposed to rainfall and therefore rainfall activated treatment system will be ineffective in treating these sediment laden flows. Therefore, additional ongoing, monitoring of the sediment retention devices, combined with the manual raising of the decants and batch dosing of the sediment retention device will be required during the tunnelling works and treated water will only be discharged, by manually lowering the decants, when the water clarity within the Sediment retention device has a clarity of a minimum of 100 mm.
- If SRPs at the tunnel portals also receive flows from rainfall, then the SRP will be increased in size to cater for the additional volume of groundwater inflow and this will be confirmed as part of the CESCP process.
- The sediment retention device will also discharge to a vegetated buffer zone, prior to reaching the receiving environment.
- Material excavated from within the tunnel bores will be loaded onto trucks and transported along haul roads to be used as fill material within the Project's embankments.
- As soon as is practically possible, the permanent waterproof lining will be installed which as noted above will of a drainage fleece, waterproof membrane and cast in situ unreinforced concrete, and will minimise groundwater inflows into the tunnelling works.

5.3.15 Concrete work

Concrete works will be necessary for many of the bridges, viaducts, the tunnels and other ancillary structures within the Project.

During construction of the bridges, it is proposed to minimise the amount of in-situ concrete that will be required through the use of pre-cast elements which will be manufactured off site and transporting them to the work area as required.

Any cement contaminated water that does result from concrete placement, will require treatment before discharge. This will be achieved by either onsite treatment tanks with the water pH tested before discharge, or the water removed from site through the use of sucker trucks and transported offsite for treatment elsewhere.

Concrete placement will be carefully controlled to ensure no loss to the environment through the use of pumps and skips. Concrete truck wash and pumps be provided on site with a dedicated concrete wash facility, designed to accept such waste.

6 RECOMMENDATIONS

We make the following key recommendations for the management of construction water for the Project.

- A range of ESC measures have been proposed on the Project and we recommend that the final CWM utilised be confirmed through the use of CESCPs.

- That the ESC devices at all times achieve, as a minimum, best practice requirements which will result in the implementation of components of all available guidelines and other innovative and best practice techniques.

- That ESC measures will be based on the provision of both structural and non-structural measures with an emphasis placed on the non-structural management techniques along with a range of innovative ESC measures being implemented.

- The methodologies to be employed and written into the CESCPs for the various construction activities should follow the CWM principles as outlined in Section 4 and the methodologies outlined in Section 5 of this report.

- That CESCPs be developed before any construction activity takes place, to allow for contractor input and innovation.

- That a continuous improvement monitoring programme is developed and implemented on site during construction which will allow for an understanding of effectiveness of controls utilised and any ongoing water quality and ecological assessment during construction. Continuous improvement of the ESC methodologies will form an integral part of this monitoring programme.

- That risk be managed within the site CWM implementation and activities.

APPENDIX A: ESC PRINCIPLES (TP90 NZTA ESC GUIDELINES AND GD05)

TP90 – ESC Principles

erosion&sedimentcontrol

Guidelines for Land Disturbing Activities in the Auckland Region

These "Ten Commandments," summarise the ten principles to follow when preparing an Erosion and Sediment Control Plan.

1. Minimise Disturbance

Fit land development to land sensitivity.

Some parts of a site should never be worked and others need very careful working. Watch out for and avoid areas that are wet (streams, wetlands, springs), have steep or fragile soils or are conservation sites or features.

Bear in mind the *minimum earthworks strategy (low impact design)* – ideally, only clear areas required for structures or access.

Show all Limits of Disturbance on the Erosion and Sediment Control Plan (E&SCP). On site, clearly show Limits of Disturbance using fences, signs and flags.

2. Stage Construction

Carrying out bulk earthworks over the whole site maximises the time and area that soil is exposed and prone to erosion. "Construction staging", where the site has earthworks undertaken in small units over time with progressive revegetation, limits erosion.

Careful planning is needed. Temporary stockpiles, access and utility service installation all need to be planned. Construction staging differs from sequencing. Sequencing sets out the order of construction to contractors.

Detail both construction staging and sequencing in the E&SCP.

3. Protect Steep Slopes

Existing steep slopes should be avoided. If clearing is absolutely necessary, runoff from above the site can be diverted away from the exposed slope to minimise erosion. If steep slopes are worked and need stabilisation, traditional vegetative covers like topsoiling and seeding may not be enough – special protection is often needed.

Highlight steep areas on the E&SCP showing Limits of Disturbance and any works and areas for special protection.

4. Protect Watercourses

Existing streams, watercourses and proposed drainage patterns need to be mapped. Clearing is not permitted adjacent to a watercourse unless the works have been approved by the Auckland Regional Council. Where undertaken, work that crosses or disturbs the watercourse

Map all watercourses and show Limits of Disturbance and protection measures; show all practices to be used to protect new drainage channels; and indicate crossings or disturbances and associated construction methods in the E&SCP.

5. Stabilise Exposed Areas Rapidly

The ultimate objective is to fully stabilise disturbed soils with vegetation after each stage and at specific milestones within stages. Methods are site specific and can range from conventional sowing through to straw mulching. Mulching is the most effective instant protection.

Clearly define time limits for grass or mulch covers, outline grass rates and species and define conditions for temporary cover in the case of severe erosion or poor germination in the E&SCP.

6. Install Perimeter Controls

Perimeter controls above the site keep clean runoff out of the worked area – a critical factor for effective erosion control. Perimeter controls can also retain or direct sediment laden runoff within the site. Common perimeter controls are diversion drains, silt fences and earth bunds.

Detail the type and extent of perimeter controls in the E&SCP along with design parameters.

7. Employ Detention Devices

Even with the best erosion and sediment practices, earthworks will discharge sediment laden runoff during storms. Along with erosion control measures, sediment retention structures are needed to capture runoff so sediment generated can settle out. The fine grained nature of Auckland soils means sediment retention ponds are often not highly effective. Ensure the other control measures used are appropriate for the project and adequately protect the receiving environment.

Include sediment retention structure design specifications; detailed inspection and maintenance schedules of structures and conversion plans for permanent structures, in the E&SCP.

8. Get Registered

A trained and experienced contractor is an important element of an E&SCP. These people are responsible for installing and maintaining erosion and sediment control practices. On-site staff certified through the Auckland Regional Council Industry Education Programme can save project time and money, by identifying threatened areas early on and putting into place correct practices.

Contact Auckland Regional Council about registration. Include arrangements for a pre-construction meeting, regular inspection visits (including a pre-wintering meeting), and final inspection.

9. Make Sure the Plan Evolves

An effective E&SCP is modified as the project progresses from bulk earthworks to developed individual lots. Factors such as weather, changes to grade and altered drainage can all mean changes to planned erosion and sediment control practices.

Update the E&SCP to suit site adjustments in time for the pre-construction meeting and initial inspection of installed erosion and sediment controls, and make sure it is regularly referred to and available on site.

10. Assess and Adjust

Inspect, Monitor and Maintain Control Measures

Assessment of controls is especially important following a storm. A large or intense storm will leave erosion and sediment controls in need of repair, reinforcement or cleaning out. Repairing without delay reduces further soil loss and environmental damage.

Assessment and adjustment is an important erosion and sediment control practice – make sure it figures prominently in the E&SCP.

Assign responsibility for implementing the E&SCP and monitoring control measures as the project progresses.

4. Erosion and sediment control concepts

4.1 Key principle of erosion and sediment control

The overarching principle of erosion and sediment control on earthworks sites is to limit sediment transport and deposition. As a number of factors (e.g. rainfall intensity, soil composition) are beyond our control, it therefore falls to applying the most appropriate solution for the circumstances. As there are numerous devices at our disposal, the integration of as many concepts as possible provides the most effective erosion and sediment control on site (Georgetown County, 2006).

These concepts are typically formalised through the use of erosion and sediment control practices detailed in an Erosion and Sediment Control Plan (ESCP) prepared for the land disturbing activity.

4.2 Advantages of erosion and sediment control

With careful pre-planning, erosion and sediment controls usually result in many on-site advantages in addition to protecting the environment.

Environmental benefits include:

- Reduced risk of damage to aquatic ecosystems,
- Improved appearance of the site and downstream waters,
- Reduced water treatment costs,
- Reduced blockage of drains, and
- Less mud dropped or washed onto roads.

On-site benefits can typically include:

- Improved drainage and reduced site wetness as a result,
- Less dust problems,
- Improved working conditions,
- Reduced downtime after rain,
- Less stockpile losses,
- Reduced clean-up costs,
- Earlier works completion, and
- Less chance of public complaints.

4.3 Concepts and principles of erosion and sediment control

Implementation of erosion and sediment controls is required to avoid, remedy or mitigate the effects of earthworks on the receiving environment. To ensure that erosion and sediment controls are effective and cost efficient, an understanding of the basic principles of erosion and sediment control is required, as is ensuring that erosion and sediment control practices are considered and carefully managed throughout the project's planning, design and construction phases (Environment Canterbury, 2007).

State highway project's construction timeframes may take longer to construct than other types of construction projects, and the resulting longer operational life of many erosion and sediment controls, requires a stronger emphasis on some management concepts (Department of Environment and Climate Change NSW, June 2008), particularly:

- The control of upper catchment water,
- Separation of clean from dirty water,
- Protecting the land surface from erosion, and
- Preventing sediment from leaving the site.

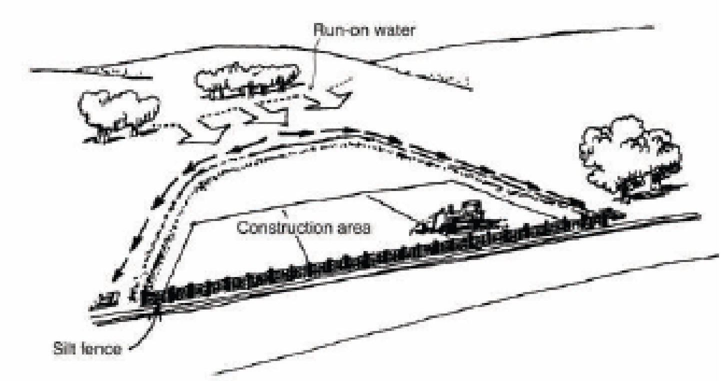
The following concepts are therefore relevant when designing an erosion and sediment control plan for a state highway project site.

4.3.1 Control upper catchment water

Upper catchment water is runoff from above the area of disturbance that would normally flow through the site. The key consideration in reducing the contributing catchment is to control this clean water by interception, diversion and safe disposal to a location below the area of disturbance as shown in Figure 4.1.

Reducing the area of the catchment contributing to water flowing through the site will reduce the volume of water to be treated thereby minimising the sizing of any controls.

Figure 4.1
Diversion of clean water from above the site (Goldman et al 1986)



4.3.2 Separate clean from dirty

Clean water is water that has not flowed through disturbed areas whilst discharges from disturbed areas are considered to be dirty water. Minimising the volume of water that is required to be treated by a sediment control device saves space and money. Furthermore clean water (upper catchment water that does not flow through the disturbed area) has not been contaminated by sediment, therefore does not require treatment. Practices to achieve this are outlined in Section 7 of this standard.

Diversion separating the clean water from the dirty water

4.3.3 Reduce the area available for erosion

To minimise the rates of soil loss, techniques as outlined in section 8 of this standard will assist however, protecting the land surface from erosion can be as simple as:

- Project design taking into account terrain limitations,
- Project scheduling to known climatic and soil variations,
- Minimising land clearance,
- Limiting areas of disturbance, and
- Progressively stabilising disturbed areas (e.g. grassing and mulching)

Erosion Control – Mulching

4.3.4 Minimise sediment from leaving the site

Sediment laden water (dirty water), as discussed in previous sections, can have a variety of impacts if not managed in accordance with best practice. Therefore it is imperative that a suite of controls are used on state highway construction projects. Sediment controls should be selected taking into account the site constraints and receiving environment, and steps should be taken to ensure that the controls are integrated with the permanent features of the project. Refer to the practices outlined in section 8.

Sediment Control Practices

4.4 The role of erosion and sediment controls

Erosion and sediment controls have different roles on an earthworks site. Erosion controls seek to minimise any sediment from being mobilised whilst sediment controls attempt to remove sediment from suspension once entrained. The analogy of erosion controls (fence at the top of the cliff) whilst sediment controls (ambulance at the bottom of the cliff) is applicable in describing their roles.

Any ESCP should place initial emphasis on erosion control although in many circumstances this may not be achievable.

4.4.1 Efficiency vs effectiveness of practices

The ability of an erosion and sediment control practice to prevent sediment from being transported or to remove sediment once entrained is a measure of its efficiency. This efficiency (as a %) can be represented as the volume removed when measured against the volume of sediment that arrives at the practice. Depending on a range of factors the removal efficiency can range from 50% to 75%.

Efficiency should not be confused with effectiveness. The effectiveness of a specific practice takes into consideration other factors such as the timing, cost, sensitivity of receiving environment and placement location of the device. For example, a sediment retention pond placed in an area that receives little or no water is still an efficient practice but is not an effective measure for that particular site.

4.5 The treatment train

A treatment train comprises a series of best management practices and/or natural features, each planned to treat a different aspect of pollution prevention, that are implemented in a linear fashion to maximise pollutant removal. This approach is directly applicable to the control of sediment on state highway projects.

Erosion and sediment control measures should generally be planned to link functionally to form a "treatment train" with each measure having a specific role within the framework of surface water management, soil protection and stabilisation, and sediment capture. This approach can be a combination of structural (e.g. sediment ponds, hydroseeding) and non-structural (e.g. earthworking season) practices.

This approach needs to be considered during the early phases of project planning, and followed through to the completion of the project. Section 5 of this document will detail how to select the appropriate tools to ensure that this approach occurs.

4.6 Principles to follow

These ten principles (best practice principles) build upon the previous concepts and provide guidance for erosion and sediment control through the planning, construction and maintenance phase of a project

4.6.1 Minimise disturbance

Fit earthworks, construction techniques and methodologies to land sensitivity. This may be difficult from a state highway perspective where space is limited but the concept should always be considered.

Some parts of a site should never be worked and others need very careful working. Watch out for and, if practicable, avoid areas that are wet (streams, wetlands and springs), have steep or fragile soils or are conservation sites or features.

Bear in mind a minimum earthworks strategy and only clear areas required for structures or access.

Show all limits of disturbance on the ESCP. On site, clearly show the limits of disturbance using fences, signs and flags.

Highway Construction Site – Minimising Disturbance

4.6.2 Stage construction

Carrying out bulk earthworks over the whole site maximises the time and area that soil is exposed and prone to erosion. "Construction staging", where the site has earthworks undertaken in small units over time with progressive revegetation, limits erosion.

Careful planning is needed. Temporary stockpiles, access and utility service installation all need to be planned. Construction staging differs from sequencing. Sequencing sets out the order of construction to contractors. Detail both construction staging and sequencing in the ESCP.

4.6.3 Protect Steep Slopes

Where possible avoid existing steep slopes. If clearing of steep slopes is necessary, runoff from above the site can be diverted away from the exposed slope to minimise erosion. If steep slopes are worked and need stabilisation, traditional vegetative covers like

Flume Installed to Protect Steep Slope

topsoiling and seeding may not be enough - special protection is often needed.
Highlight steep areas on the ESCP showing limits of cisturbance and any works and areas for special protection.

4.6.4 Protect watercourses

Existing streams and watercourses, and proposed drainage patterns need to be mapped. Resource consent may be required for clearance works adjacent to a watercourse.

Map all watercourses and show all limits of disturbance and protection measures in the ESCP. Also, the ESCP should show all practices to be used to protect new drainage channels. Indicate crossing or disturbances and associated construction methods in the ESCP.

Sediment Discharge as a Result of Not Protecting the Watercourse

4.6.5 Stabilise exposed areas rapidly

An important objective is to fully stabilise disturbed soils with vegetation after each stage and at specific milestones within stages. Methods are site specific and can range from conventional sowing through to straw mulching. Mulching is the most effective instant protection.

In the ESCP clearly define time limits for grass or mulch application, outline grass rates and species and define conditions for temporary cover in the case of severe erosion or poor germination.

Rapid Stabilisation

4.6.6 Install perimeter controls

Perimeter controls above the site keep clean runoff out of the worked area - a critical factor for effective erosion control. Perimeter controls can also retain or direct sediment laden runoff within the site. Common perimeter controls are diversion drains, silt fences and earth bunds.

Detail the type and extent of perimeter controls in the ESCP along with the design parameters for those controls.

Types of Perimeter Controls

4.6.7 Employ detention devices

Even with the best erosion and sediment practices, earthworks will discharge sediment laden runoff during storms. Along with erosion control measures, sediment retention structures are needed to capture runoff so sediment generated can settle out. Sediment retention ponds are often not highly effective in areas with fine grained soils. In those areas it is necessary to ensure the other control measures used are appropriate for the project and adequately protect the receiving environment.

Sediment Retention Pond

Include sediment retention structure design specifications; detailed inspection and maintenance schedules of structures and conversion plans for permanent structures, in the ESCP.

4.6.8 Experience and training

A trained and experienced contractor is an important element of an ESCP. Contractors are individuals responsible for installing, maintaining and decommissioning erosion and sediment control practices.

Critical on-site staff should go through an erosion and sediment control training programme that may be available either locally or elsewhere in New Zealand. The NZTA also has an e-learning module on erosion and sediment control in development. Better knowledge can save project time and money, by allowing for identification of threatened areas early on and putting intc place correct practices.

Making arrangements for a pre-construction meeting, regular inspection visits, and final inspection is also important.

4.6.9 Make sure the plan evolves

An effective ESCP is modified as the project progresses from bulk earthworks to permanent drainage and stabilisation. Factors such as weather, changes to grade and altered drainage can all mean changes to planned erosion and sediment control practices.

Update the ESCP to suit site adjustments in time for the pre-construction meeting and initial inspection of installed erosion and sediment controls, and make sure it is regularly referred to and available on site.

4.6.10 Assess and adjust

Inspect, monitor and maintain control measures.

Undertaking Maintenance of a Sediment Retention Pond

Assessment of controls is especially important following a storm. A large or intense storm will leave erosion and sediment controls in need of repair, reinforcement or cleaning out. Repairing without delay reduces further soil loss and environmental damage.

Assessment and adjustment is an important erosion and sediment control practice - make sure it figures prominently in the ESCP.

Assign responsibility for implementing the ESCP and monitoring control measures as the project progresses.

The ESCP should also be integrated with the Contractor's Social and Environmental Management Plan, therefore, reducing duplication in the site specific environmental aspect management plans.

4.7 Bibliography

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Georgetown County, Storm Water Management Design Manual, November 2006.

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A2.0 Fundamental principles of erosion and sediment control

The following ten fundamental principles of ESC provide best practice guidance for minimising the adverse effects of erosion and sedimentation through the planning, construction and maintenance phases of a project. These should be followed when preparing and implementing an ESC Plan:

1. Minimise disturbance

Consistent with the concepts of water sensitive design (WSD – formerly referred to as low impact design) in Auckland Council guideline GD04, the identification and retention of existing site attributes should be incorporated into project designs, and earthworks should be minimised to the greatest extent practicable.

Land development should be fitted to land sensitivity and where possible, disturbance should avoid steeper slopes and other features such as streams and wetlands.

For any development, the total area of earthworks should be the minimum necessary to achieve the design outcome (including temporary works). The area of earthworks exposed to erosion at any given time should also be minimised through staging and progressive stabilisation.

All limits of disturbance should be shown on the ESC Plan. On-site limits of disturbance should be clearly shown using fences, signs and flags.

2. Stage construction

Carrying out bulk earthworks over the whole site maximises the time and area that soil is exposed and prone to erosion. By only exposing those areas that are required to be exposed for active earthworking at any one time, the duration of exposure and risk of erosion/sediment discharge can also be minimised. 'Earthworks staging', where the site has earthworks undertaken in smaller units over time with progressive revegetation, limits erosion.

Careful planning is needed. Temporary stockpiles, access and utility service installation all need to be planned. Earthworks staging needs to be planned in conjunction with the overall construction sequencing to ensure that it accommodates the contractor's requirements.

Earthworks staging and sequencing should be detailed in the ESC Plan.

3. Protect slopes

If slopes are worked and require stabilisation, simple vegetative covers like topsoiling and seeding may not be immediately effective and additional measures may be required. These are described in Section E3.0 of Part 2 - Practices.

Disturbance of existing slopes should be avoided wherever possible, particularly steep slopes which have a higher risk of erosion. Clean water runoff from above the site must be diverted away from the exposed slopes to minimise erosion.

Slopes should be highlighted on the ESC Plan, as well as limits of disturbance and any works and areas requiring specific protection.

4. Protect watercourses

Existing streams, watercourses and proposed drainage patterns need to be mapped. Earthworks and the removal of vegetation beside or within streams (including intermittent streams), wetlands and the coast, typically require consents from Auckland Council. The Council should be consulted on these matters prior to finalising project designs.

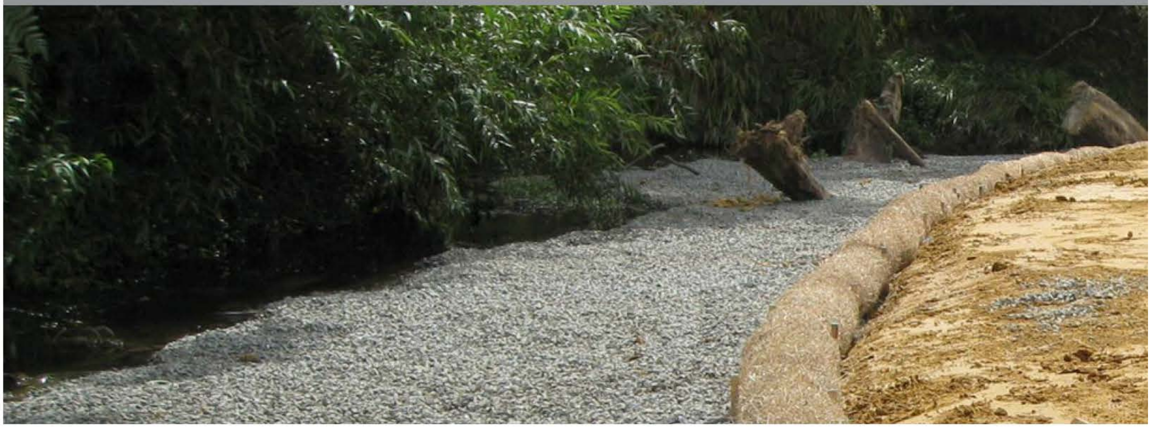
All watercourses, limits of disturbance and protection measures should be mapped on the ESC Plan. In addition, all practices to be used to protect new drainage channels should be marked, as well as crossings, disturbances and associated construction methods.

Further advice on works within a watercourse is provided in Section G of Part 2 – Practices.

5. Rapidly stabilise exposed areas

Disturbed soils should be progressively stabilised with vegetation, mulch, grassing or other stabilising methods after each earthworks stage and at specific milestones within stages. Available stabilisation methods are site specific and are described in Section E3.0 of Part 2 - Practices.

Time limits for grass or mulch covers should be clearly defined in the ESC Plan along with conditions for temporary cover (in the case of severe erosion) or poor germination.



6. Install perimeter controls and diversions

Perimeter controls and diversion measures help separate 'clean water' from outside the area of disturbance from 'dirty water' that has flowed through the disturbed area. Minimising the earthworks catchment by diverting clean runoff away from the works area is a critical erosion control measure. It also reduces the size of sediment control devices necessary for any given works area. Perimeter and diversion controls can also retain or direct sediment-laden runoff within the site. Common controls are diversion drains and earth bunds. These are detailed in Section E2.0 of Part 2 – Practices.

The type and extent of perimeter or diversion controls should be outlined in the ESC Plan, along with design parameters.

7. Employ sediment retention devices

Even with the best ESC practices, earthworks will discharge sediment-laden runoff during and immediately following storms. Along with erosion control measures, sediment retention devices are needed to capture runoff so sediment generated can settle out and be retained on site. These are detailed in Section F1.0 of Part 2 – Practices.

The fine-grained nature of Auckland soils means sediment retention ponds will usually require flocculant treatment (flocculation) to maximise their efficiency. All sediment retention devices must be sized and maintained in accordance with the guideline, and must be appropriate for any given location within a site.

The ESC Plan should include sediment retention device design specifications, detailed inspection and maintenance schedules of structures, and conversion plans for permanent structures.

8. Get trained and develop experience

A trained and experienced contractor is an important element of an ESC Plan, considering contractors are generally responsible for installing and maintaining ESC practices. Trained and experienced staff can save project time and money through proactive construction and maintenance of ESCs. Staff should be encouraged to become experienced in ESC. Key staff should also be assigned to provide that role, so that the appropriate level of experience and supervision is provided for each new project.

9. Adjust the ESC Plan as needed

An effective ESC Plan is modified as a project progresses from bulk earthworks to a fully developed site. Factors such as weather, changes to grade, altered design including drainage and formation of roads can require changes to initial ESC design.

The ESC Plan should be updated to suit site adjustments in time for the pre-construction meeting and initial inspection of installed ESCs. The Plan must also be regularly referred to and available on-site. Prior to the commencement of works, consideration should be given to how the site will change throughout the project, and how the ESC Plan will need to evolve.

Note: For consented sites, adjustments to the ESC Plan may require sign-off from Council.

10. Assess and adjust your ESC measures

ESC measures need to be inspected, monitored and maintained.

Inspection and maintenance of controls is especially important prior to and following a storm event. A large or intense storm can leave ESC measures in need of repair, replacement, reinforcement or cleaning out. Maintaining and repairing measures as soon as possible after a storm event will maximise the ongoing efficiency of the measures and minimise adverse environmental effects.

Assessment and adjustment is an important ESC practice –it must figure prominently in the ESC Plan. It is also important to assign responsibility for implementing the ESC Plan and monitoring control measures as the project progresses.