Project Number: 2-A0012.00

State Highway 1 and State Highway 29 Intersection Upgrade

Stormwater Assessment Report

19 August 2021

150 YEARS IN AOTEAROA

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Disclaimers and Limitations

This report (**Report**) has been prepared by WSP exclusively for Waka Kotahi NZ Transport Agency (**Client**) in relation to an application for a notice of requirements and regional resource consents (**Purpose**) and in accordance with our contract with the Client dated May 2020. The findings in this Report are based on and are subject to the assumptions specified in the Report. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

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Glossary of Abbreviations

Abbreviation/acronym	Term
AEE	Assessment of Effects on the Environment
AEP	Annual Exceedance Probability
ARI	Average Recurrence Interval
BPO	Best Practicable Option
CC	Climate Change
CEMP	Construction Environment Management Plan
ESC	Erosion and Sediment Control
ESCP	Erosion and Sediment Control Plan
GIS	Geographical Information System
ha	Hectares
km	Kilometres
km^2	Square Kilometres
L/s	Litres per second
m	Metres
m^2	Square Metres
m^3	Cubic Metres
MPDC	Matamata-Piako District Council
NES	National Environmental Standard
NES Freshwater	Resource Management (National Environmental Standards for Freshwater) Regulations 2020
NPS	National Policy Statement
NPS Freshwater	The National Policy Statement for Freshwater Management 2020
RMA	Resource Management Act 1991
SWDC	South-Waikato District Council
WRC	Waikato Regional Council
WRP	Operative Waikato Regional Plan

1 Executive Summary

The State Highway 1 (SH1) and State Highway 29 (SH29) Intersection Upgrade Project (the Project) is challenging for stormwater management due to the natural topography and geological characteristics. The goal of the stormwater component of the Project has been to avoid creating heavily engineered solutions, but instead to seek water-sensitive features that are sympathetic to the rural environment.

The Project has the potential to create stormwater-related effects on the receiving environment, both short-term and long-term. This Assessment of Environmental Effects (AEE) identifies potential effects as a result of the Project including:

1. Effects on water quality *(short–term)*
2. New impervious surface leading to increased and faster runoff *(long–term)*
3. Increased flooding *(long–term)*
4. Effects on water uses *(long–term)*
5. Watercourse diversions *(long–term)*
6. Increased scour or erosion (both short and long-term)

The proposed scheme will introduce more impervious surface area leading to more surface runoff. Therefore, post-developed surface flow volumes are expected to experience a minor increase for both the Waikato and Waitoa catchment. The minor modification to catchment delineation at the Karapiro leg and Tirau Leg is considered to have a negligible effect to water catchment volumes for the Waikato or Firth of Thames water allocation.

Effective and resilient stormwater management will be achieved during construction and operation of the Project by implementing a series of treatment wetlands, swales, watercourse diversions, culverts and implementing an erosion and sediment control plan (ESCP). Most drainage infrastructure is in the (existing or future) road reserve and these mitigation measures will ensure that the receiving environment is not negatively impacted by the Project.

A variety of best practicable option (BPO) mitigation measures have been proposed. Provided the proposed mitigation measures are implemented the stormwater aspects of the Project will have a neutral or net positive environmental effect (this positive effect arising from traffic shifting from predominantly untreated to treated roads).

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2 Introduction

2.1 Purpose and scope of this report

This report forms part of a suite of technical reports prepared for Waka Kotahi NZ Transport Agency (Waka Kotahi) for the State Highway 1 (SH1) and State Highway 29 (SH29) Intersection Upgrade Project (the Project). The purpose of this Report is to inform the Assessment of Effects on the Environment Report (AEE) and support two Notices of Requirement (NoRs) for alterations to designations to Matamata-Piako District Council (MPDC) and South-Waikato District Council (SWDC) and applications for regional resource consents to Waikato Regional Council (WRC).

A full description of the NoRs and regional resource consents required for the Project is provided in Section 4 of the AEE. A full description of the background and need for the Project is provided in Section 2 of the AEE.

2.2 Structure of this technical report

This technical report follows the following structure:

1. An introduction to the Project and its context;
2. An identification of the proposed stormwater mitigation measures; and
3. An identification and consideration of the residual effects remaining after mitigation.

This report addresses both short-term (construction-related) and long-term (operational) effects.

3 Project Description

3.1 The Project

The Project is the construction and operation of a new two-lane roundabout connecting SH1 and SH29, north-west of the existing intersection of SH1 and SH29 at Piarere. The key components of the Project are:

a) A two-lane roundabout with a 60m diameter central island.

b) Realignment of parts of the SH1 and SH29 approaches to connect to the new roundabout.

c) The roundabout will be elevated approximately 3.5m above the existing ground level to provide for cycle and pedestrian underpasses.

d) A stormwater management system, including a wetland, wetland and planted swales and a discharge structure and associated rip rap armour.

e) Construction activities, including a construction compound, lay down area and establishment of construction access.

A full description of the Project including its current design, construction and operation is provided in Section 6 of the AEE and shown in the Project Drawings in Volume 4: Drawing Set.

The final design of the Project (including the design and location of ancillary components such as stormwater treatment devices), will be refined and confirmed at the detailed design stage. Table 3-1 below provides selected metrics to provide a sense of the scale of the proposed work:

Table 3-1: Proposed roundabout – provisional construction estimates

Component	Provisional estimate
Total site area (including existing road corridor)	198,750 m^2
Total earthworks footprint	79,000 m^2
Indicative construction duration	Up to 18 months
Topsoil strip/stockpile/re-spread	24,000 m^3
Imported fill	90,000-95,000 m^3
Granular pavement and surfacing	45,000m^3

3.2 Context and existing environment

A site visit has been undertaken to land on the eastern side of SH29. Access to the land on the western side of SH29 has not been granted, therefore this analysis is based on roadside observation, information available online and previous assessment within the area.

3.2.1 Land use

The existing land use surrounding the site is classified as *High Producing Exotic Grassland* based on the *LCDB v5.0 - Land Cover Database version 5.0, Mainland New Zealand* (LRIS, 2019). The land within the proposed designation is occupied by farmland for pastoral use (see Figure 3-1).

Figure 3-1: Existing land use (LRIS, 2019)

3.2.2 Existing stormwater infrastructure

Existing stormwater infrastructure serving the site[1] and surrounding area are shown in **Appendix A**.

There are five existing highway culverts within the Project area:

Piarere Leg (SH29)

- The existing DN375[2] culvert conveys flow from the farm drain on the western side of SH29 to the roadside drain on the eastern side of SH29.
- The existing DN750 culvert conveys flow from the farm drain to the roadside drain on the eastern side. This culvert does not pass under the road.

Karapiro Leg (SH1 north)

- The existing DN450 culvert conveys flow from the northern side of SH1 to the roadside drain on the southern side of SH1 to the Waikato River.

Tirau Leg (SH1 South)

- The existing cross culvert DN400 conveys flow from the eastern side of SH1 to the roadside drain on the western side.

[1] "Site" and "Project Area" are used interchangeably in this report to refer to the area included in the proposed designation together with the adjacent state highways.
[2] DN – nominal diameter

- The discharge from the culvert flows to the western roadside drain and then over-land to the Waikato River.

Because of the flat nature of the area and successive diversions and drain cleaning, the bed level of the culverts for all these legs is not necessarily an indication of flow direction. It is even possible that water flows in different directions at different times.

3.2.3 Topography and landscape

The site is located on a terrace at an elevation of approximately RL 102m. Figure 3-2 shows the contours provided on the WRC (GIS) online mapping server (2021). The Waikato River (Lake Karapiro) situated below the terrace has a surface level of RL 53m.

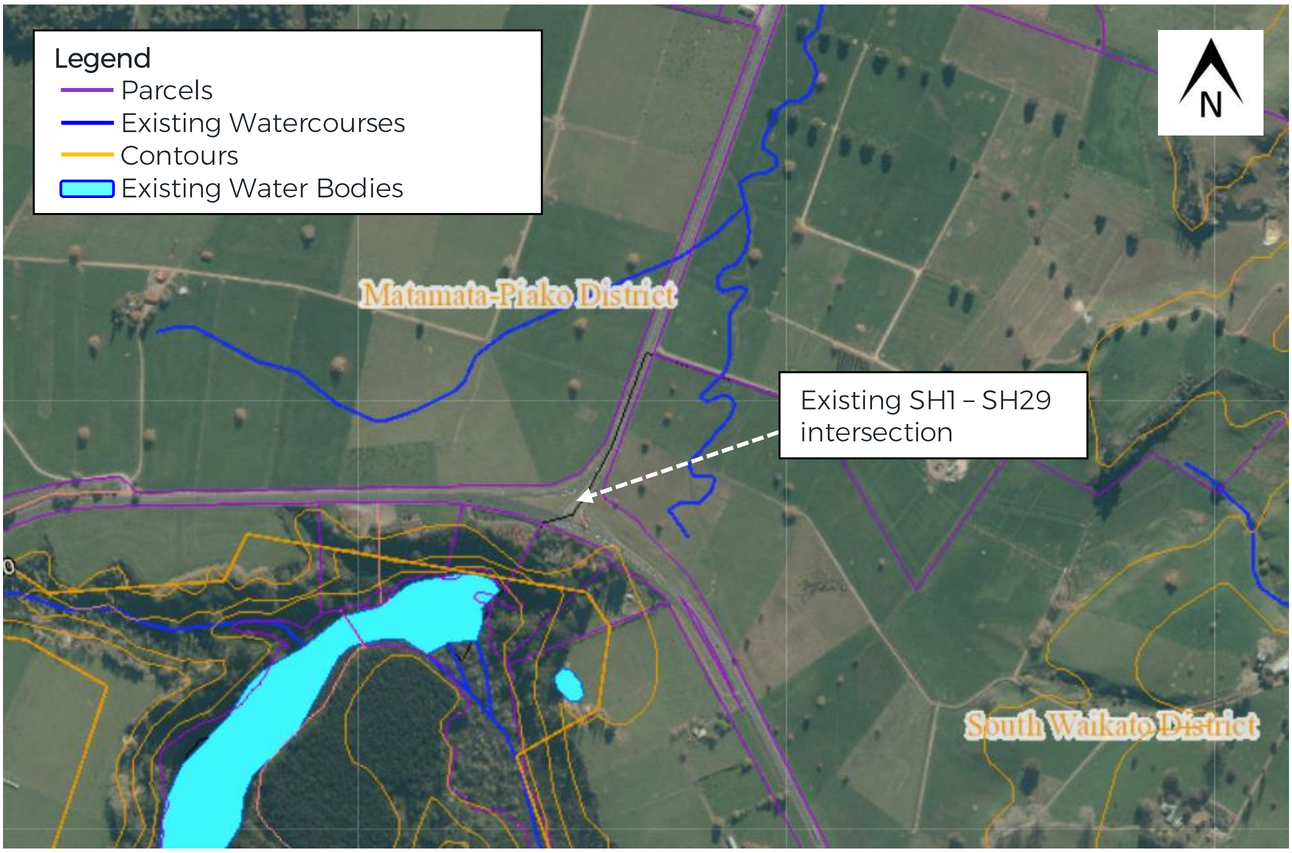

Figure 3-2: Existing topography (WRC, 2021)

Figure 3-3 shows the levels of the site based on the ground model produced from 2016 LiDAR. Both LIDAR and GIS data sources present the same ground levels across the site.

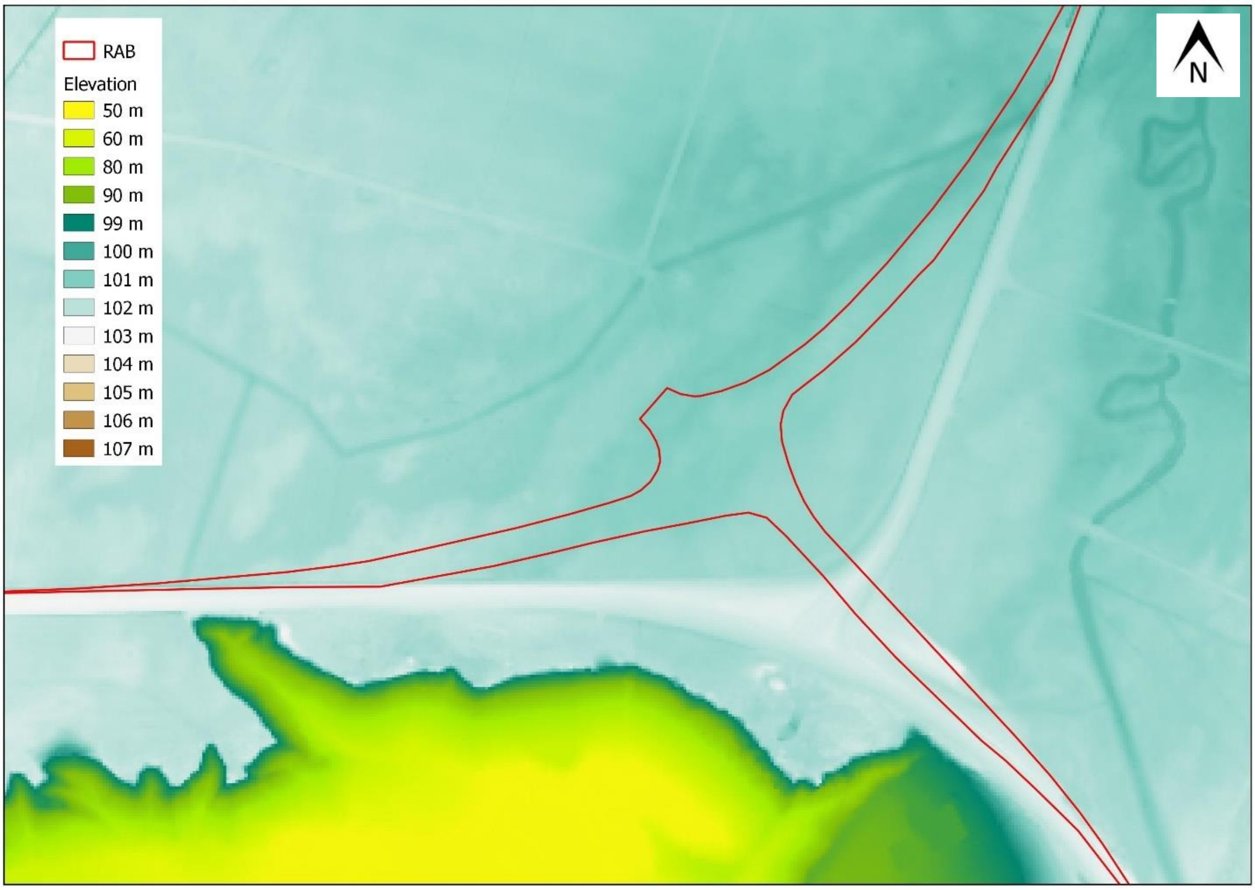

Figure 3-3: Ground model based on 2016 LiDAR

3.2.4 Geology

The generally flat land in the Project area is cross-bedded pumice sand, silt and gravel with interbedded peat. This type of soil is classified as *Q3a* and is a part of the Tauranga Group (Figure 3-4). Commonly known as the Hinuera Formation, this soil is highly variable and does not have a consistent percentage of sand, silt and clay, though it is typically expected to comprise approximately 60% sand, 30% silt and 10% clay.

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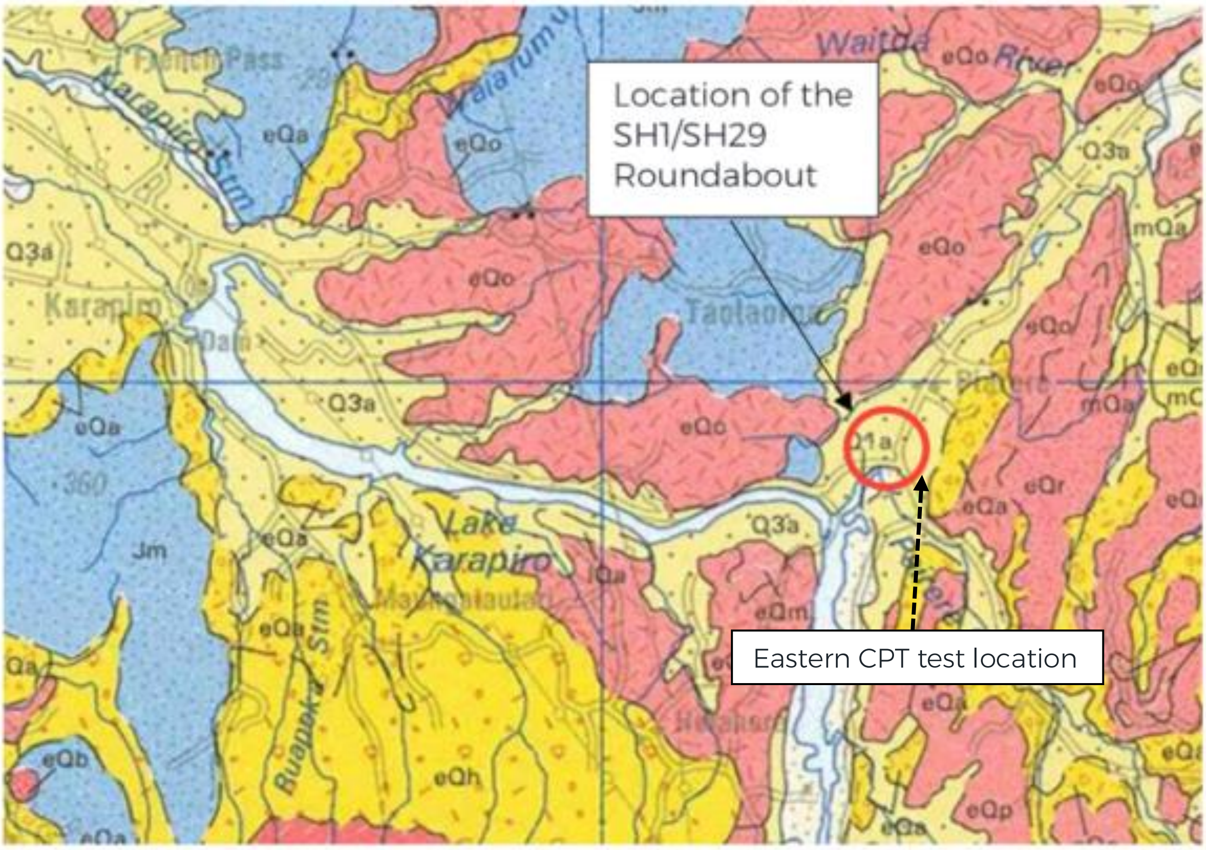

Figure 3-4: Regional geology of the area – excerpt from the GNS Science Map 5 Rotorua

3.2.5 Hydrogeology

The regional groundwater table is relatively deep and is likely to be in the order of 10 m or more below ground level and drawn down in proximity to the gully features. Available historic ground investigation data in the immediate vicinity of the site comprising hand augers (0.9m to 2.0m bgl) and a borehole (25m bgl) did not encounter groundwater.

Perched water tables in the area may be relatively continuous at higher levels and may generate significant seepage from gully and terrace faces. It is also possible that temporary perched groundwater could exist during or shortly after high rainfall events.

A CPT (cone penetration test) installed on 14 March 2021 on the eastern side of SH29 (25m bgl) did not encounter groundwater (location shown on Figure 3-4).

Further investigation and testing will be required during the detailed design phase to confirm the groundwater levels on the western side of the site. This will inform the infiltration capacity of the ground and feasibility of soakage as a means of stormwater disposal.

3.2.6 Drainage Catchments

The existing road corridors lie at the watershed of two catchments, the Waitoa River, which drains north to the Firth of Thames, and the Waikato River, which drains north-west to the Tasman Sea.

3.2.7 Catchment description and values

The existing road corridors are primarily located near the upper limit of the Waitoa River (Figure 3-5).

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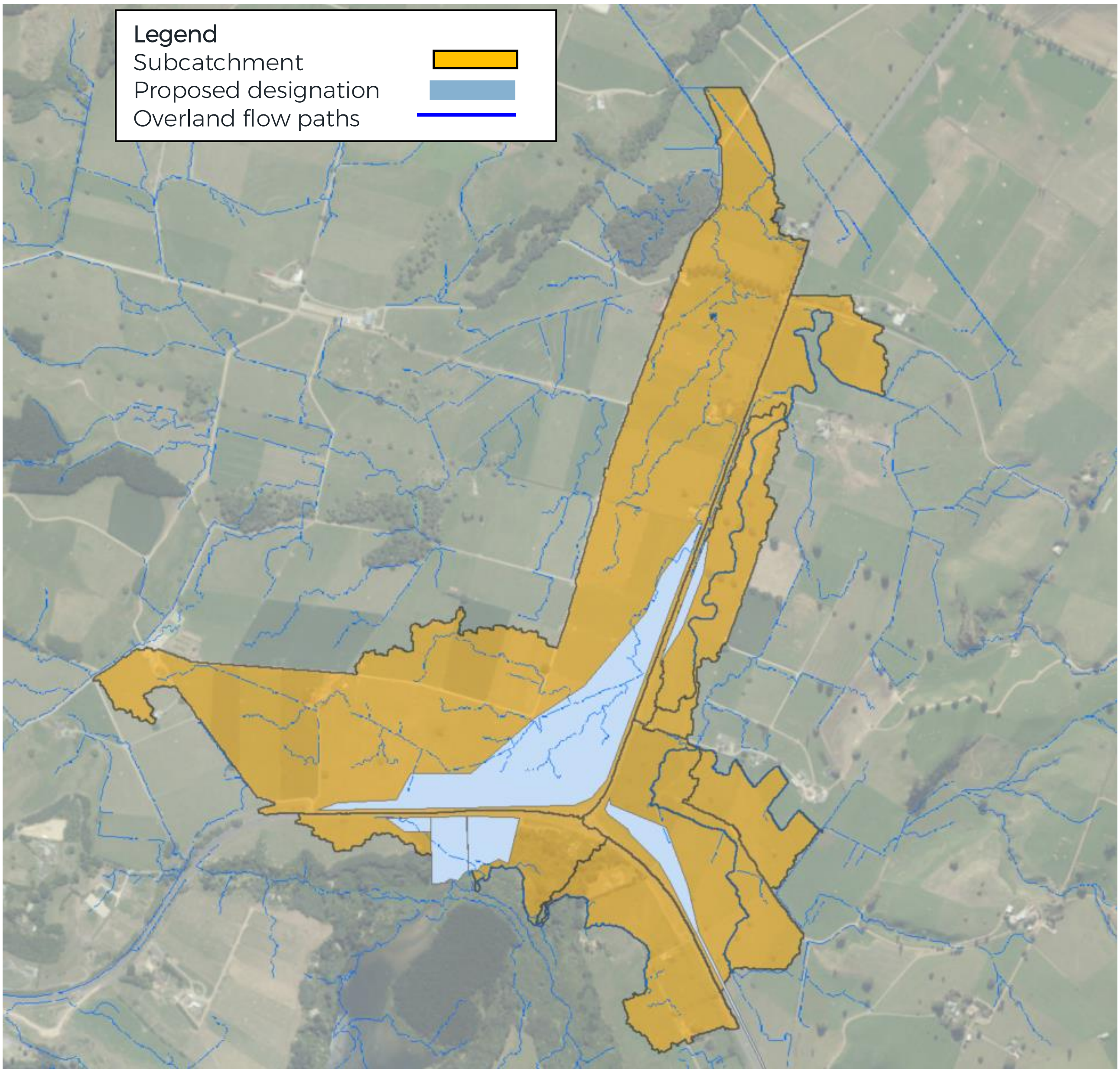

Figure 3-5: Existing flow paths and sub-catchments

3.2.8 Water quality

The surrounding area of the site is occupied by rural land use. These farms have highly modified ephemeral watercourses, so the water quality is expected to be consistent with a grazed catchment where there is virtually no riparian fencing or vegetation to provide shading along the flow paths. As the watercourses are at the upper end of the catchment, it is expected that they are dry most of the year.

3.2.9 Flooding

Inspection of historical aerial photography and contour data indicates that at least part of the catchment north of SH1 is discharged to the Waikato River – incised channels indicate steep, erodible soils, and potentially significant flow has occurred at some stage (*Figure 3*-6).

The eastern side of the SH29 intersection originally flowed towards the Waitoa River in a meandering channel. The historic construction of SH1, and creation of farm drains on the northern side of SH1 have altered the natural drainage patterns in the area. All these factors paint a picture showing the Waikato/Waitoa catchment boundary is ambiguous and may have changed more than once in the past.

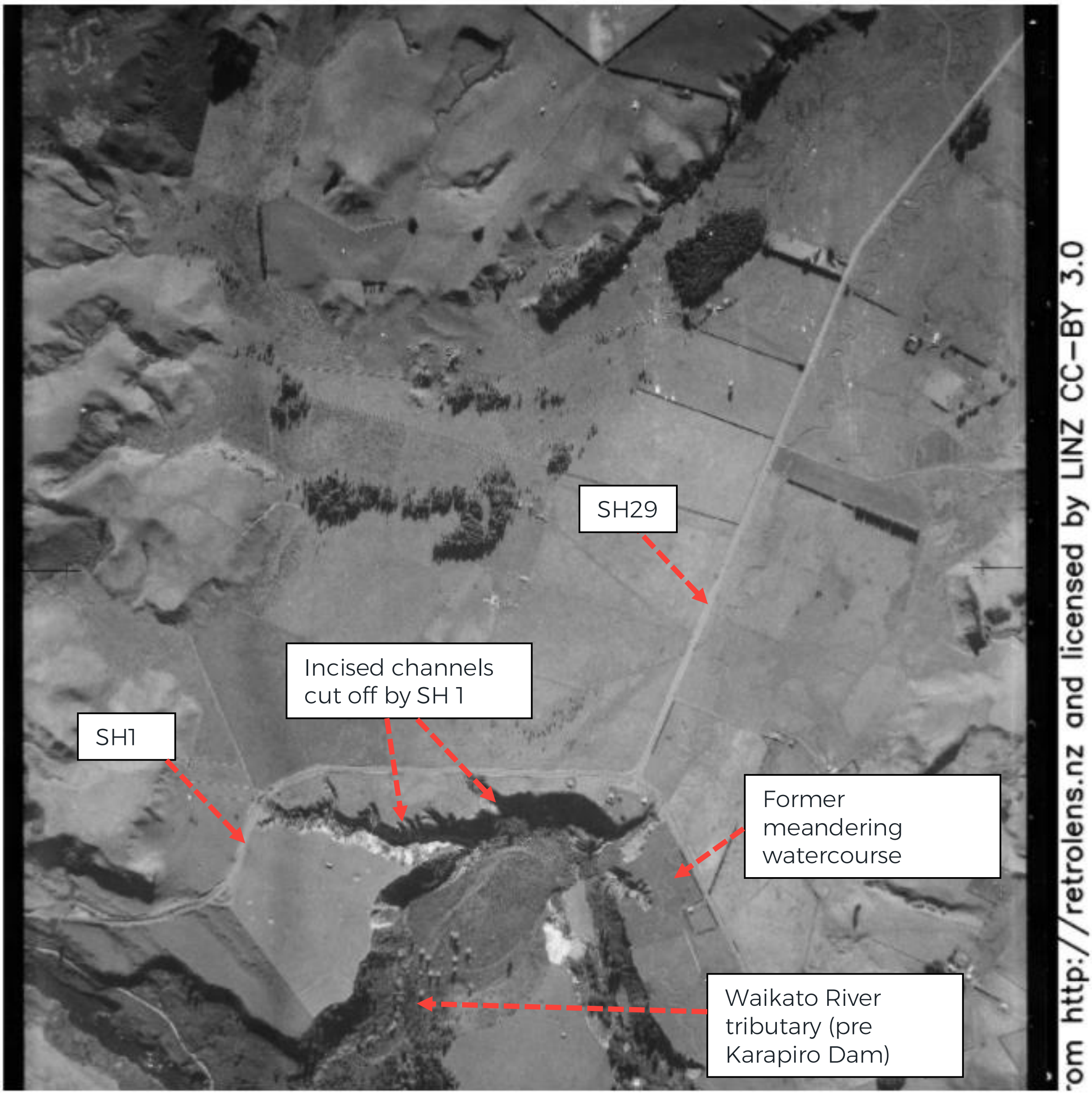

Figure 3-6: Aerial Photography, June 1943 of interchange site (source: retrolens.co.nz)

Currently, ephemeral watercourses near the intersection of SH1 and SH29 flowing towards the Waitoa River have capacity for low flow events less than the 2-year ARI (Annual Recurrence Interval).

Small culverts associated with the drainage of SH1 currently pass minimal flow towards the Waikato River. The valley of the Waitoa River forms a wide flood plain in major storm events. When rainfall exceeds the capacity of these ephemeral watercourses, a wide, shallow floodplain stores and conveys water to the north.

Figure 3-7 shows the flood depth within the site for the baseline scenario (i.e. without the Project) for the 1 in 100-year Average Recurrence Interval (ARI) event with climate change (CC) allowance. The majority of the existing road corridor has between 0.05m and 0.5m of flooding.

While there are no settlements in the immediate vicinity of the Project site, there are isolated farm buildings surrounding the existing road corridor. Table 3-2 shows the properties that are predicted to be within the floodplain in the 1 in 100-year ARI CC scenario without the Project. While the buildings lie within the flood plain their floor levels have not been surveyed, so it isn't yet possible to state whether they are actually flood-prone.

Table 3-2: Buildings predicted to be within floodplain (1 in 100-year ARI + CC).

Address	Existing predicted flood elevation (without Project) (1 in 100-year ARI)
Piarere Hall (5920 State Highway 29)	100.79 mRL
5969B State Highway 29 – building 1	101.93 mRL
5969B State Highway 29 – building 2	101.92 mRL
1833A Tirau Road, Karapiro – building 1	102.82 mRL
1833A Tirau Road, Karapiro – building 2	102.70 mRL
1833A Tirau Road, Karapiro – building 3	102.68 mRL
1833A Tirau Road, Karapiro – building 4	102.40 mRL

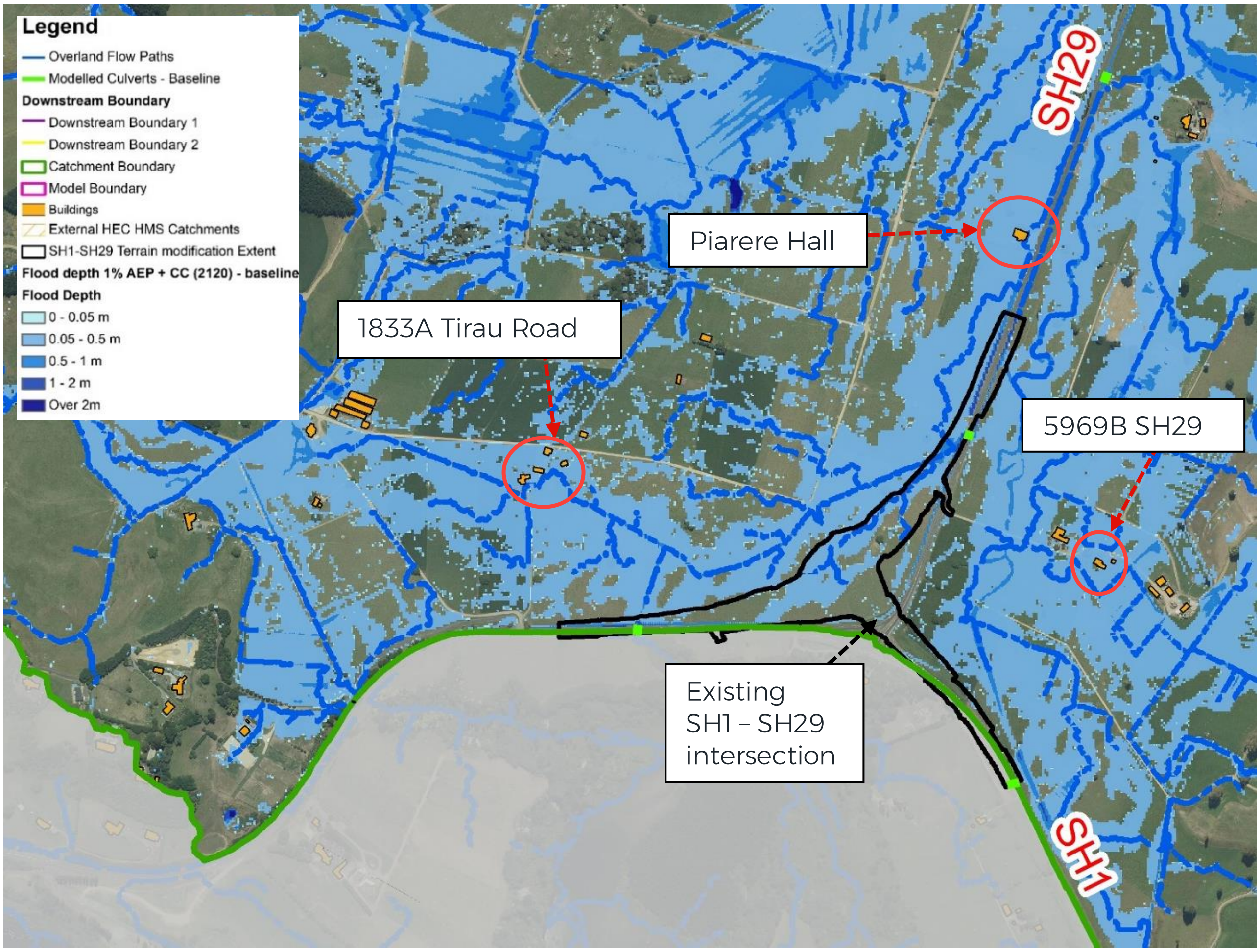

Figure 3-7: Flood depth map – baseline scenario 1 in 100yr ARI CC (2120 RCP6.0)

3.2.10 Ecology

Refer to the *State Highway 1 and State Highway 29 Intersection Upgrade, Assessment of Effects on Environment Ecology* (WSP, 2021) (Ecology Assessment) for details on the existing ecological environment of the site.

4 Stormwater Mitigation Measures

The following sections describe how the Project's stormwater management concept has been designed to avoid or minimise potential stormwater-related effects. As is common with projects of this nature it is not economically practicable to eliminate every last effect in its entirety so a Best Practicable Option (BPO) approach has been adopted. The BPO approach is the underlying philosophy under-pinning WRC's stormwater and erosion and sediment control guidelines.

Environmental effects associated with the Project can be categorised into short-term effects that occur during construction/earthworks activities, and long-term effects that occur during operation and maintenance of the highways. Sections 4.2 and 4.3 cover the best practice mitigation measures that will be applied for short term and long-term effects.

4.1 Applicable Standards

The SH1/SH29 intersection design will be based on Waka Kotahi's guidelines and standards, and WRC's Stormwater Guidelines, including the following:

1. *New Zealand Fish Passage Guidelines* (NIWA, 2018);
2. *National Policy Statement for Freshwater Management* (New Zealand Government, 2020);
3. *Erosion & Sediment Control Guidelines for Soil Disturbing Activities TR2009/02* (Waikato Regional Council, 2009);
4. *Waikato stormwater management guideline, TR2020/07* (Waikato Regional Council, 2020);
5. *P46 Stormwater Specification* (Waka Kotahi, 2016);
6. *Waikato stormwater runoff modelling guideline, TR2020/06* (Waikato Regional Council, 2020);
7. *Stormwater Treatment Standard for State Highway Infrastructure* (NZTA, 2010);
8. *Erosion and Sediment Control Guidelines for State Highway Infrastructure* (NZTA, 2014); and
9. *Environment Waikato Best Practice Guidelines for Waterway Crossings* (Waikato Regional Council, 2006).
10. *Climate Change Predictions for New Zealand*. Ministry for the Environment, 2018

4.2 Proposed stormwater management for construction effects

Short-term effects arise as a result of construction/earthworks activities. This section will describe the proposed stormwater management practices to mitigate the short-term effects.

4.2.1 Erosion and Sediment Control

Stormwater flowing over the work site can cause short-term flooding, mobilise sediment, and carry it off-site into surrounding streams and tributaries, the Waikato River and Waitoa River. Such sediment-laden runoff reduces water quality, and as it settles out, it can smother the base of the water body, suffocating aquatic life.

Sediment mobilisation on the Project will be mitigated via erosion and sediment control (ESC) practices that are consistent with WRC's guideline *Erosion & Sediment Control Guidelines for Soil Disturbing Activities TR2009/02* (Waikato Regional Council, 2009). Management of construction activities around watercourses should be is a particular priority for the contractors.

An indicative Erosion and Sediment Control Plan (ESCP) is attached as Appendix B. It is recommended that the appointed contractor be required to review and build on this indicative ESCP. The updated ESCP should include the following:

(i) Details of all principles, procedures and practices that will be implemented to undertake erosion and sediment control to minimise the potential for sediment discharge from the site;

(ii) The design criteria and dimensions of all key erosion and sediment control structures;

(iii) A site plan of a suitable scale to identify;

- The locations of waterways;
- The extent of soil disturbance and vegetation removal;
- Any "no go" and/or buffer areas to be maintained undisturbed adjacent to watercourses;
- Areas of cut and fill;
- Locations of topsoil stockpiles;
- All key erosion and sediment control structures;
- The boundaries and area of catchments contributing to all stormwater impoundment structures;
- The locations of all specific points of discharge to the environment; and
- Any other relevant site information.

(iv) Construction timetable for the erosion and sediment control works and the bulk earthworks proposed;

(v) Timetable and nature of progressive site rehabilitation and re-vegetation proposed;

(vi) Maintenance, monitoring and reporting procedures;

(vii) Rainfall response and contingency measures including procedures to minimise adverse effects in the event of extreme rainfall events and/or the failure of any key erosion and sediment control structures;

(viii) Procedures and timing for review and/or amendment to the ESCP; and

(ix) Identification and contact details of personnel responsible for the operation and maintenance of all key erosion and sediment control structures.

Based on the indicative ESCP, sediment control measures to be implemented on site may include up to nine sediment ponds. The construction site will be demarcated by a network of clean water bunds and silty water channels to effectively keep clean water out and dirty water inside the cordon. Silt fences will be used to cordon off smaller areas (generally less than 3 hectares), as well as to provide extra protection around watercourses and culvert entries.

Because soil will be trucked to the site, a stabilised construction entrance and, if required, a wheel wash facility will be constructed at each point where heavy vehicles will leave the site, as shown on the ESCP.

The Universal Soil Loss Equation (USLE) is an empirical formula which estimates soil loss from erosion prone areas. The formula estimates a site sediment yield figure that is applied to evaluate risk of the site in terms of sheet erosion (as distinct from channel erosion[3]). USLE calculations have been carried out for the site indicating that without proper mitigation during construction there is potential for 4,934 tonnes of soil that could be lost over the 18-month construction period without mitigation measures. A further 22 tonnes could be mobilised during the two-month re-establishment phase (Table 4-).

[3] Sheet and rill erosion involve mobilisation and transport of soil particles due to rainfall impact and runoff from the surface of the land. Channel erosion involves bank and bed erosion of watercourses due to the action of moving water.

With best-practice sediment controls implemented in accordance with the *Erosion & Sediment Control Guidelines for Soil Disturbing Activities TR2009/02* (Waikato Regional Council, 2009), the release of sediment from the Project will be limited to approximately 617 tonnes over the same period, with a further 3 tonnes over the 2-month vegetation re-establishment phase (refer Table 4-1).

The sediment yield is at the low end for earthworks sites of this nature, principally because the site is essentially flat. Note that these with-mitigation estimates are conservative i.e. sediment quantity is likely to be lower, as the calculations assume the maximum surface slope for the full construction duration, whereas the final surface profile will only be achieved near the end of the works. For this reason, and because the soils are not expected to be highly dispersive, chemical treatment of sediment ponds is not being recommended. Refer to **Appendix C** for USLE calculations.

Table 4-1: Potential Sediment Generation with and without mitigation

	Potential Sediment Generation Without Mitigation (tonnes)	Potential Sediment Generation with Comprehensive Sediment Control Measures (tonnes)
During construction phase	4,934	617
During re-establishment	22	3
Total	**4,956**	**620**

4.2.2 Fuel or Chemical Spill Management

It is recommended that on site refuelling of plant and equipment close to waterways is prohibited. Refuelling will only be permitted on a specially prepared area of hard standing. Therefore, it is recommended that the Construction Environmental Management Plan (CEMP) that the appointed contractor will be required to prepare, shall include procedures for the refuelling and maintenance of plant and equipment to avoid discharges of fuels or lubricants to watercourses. The CEMP shall also include measures to address the storage of fuels, lubricants, hazardous and/or dangerous materials, along with contingency procedures to address emergency spill response(s) and clean up.

4.2.3 Diversion of overland flows

Temporary diversion drains that can convey the 1 in 20-year ARI flows will be put in place during construction. Wherever possible, temporary bunds will not be placed where they impede the natural drainage paths. The proposed earthworks primarily consist of fill, so ponding of excavations is not expected to be an issue.

4.3 Proposed stormwater management for operational effects

Long-term effects expected to occur during the operation of the road are described below along with the proposed mitigation methods.

4.3.1 Water Quality Treatment and Stormwater Collection and Conveyance

The creation of impervious surfaces causes stormwater to be discharged at a faster rate, and in greater volumes. **Error! Reference source not found.**4-1 shows a plan of the existing and future impervious surface as part of the proposed roundabout.

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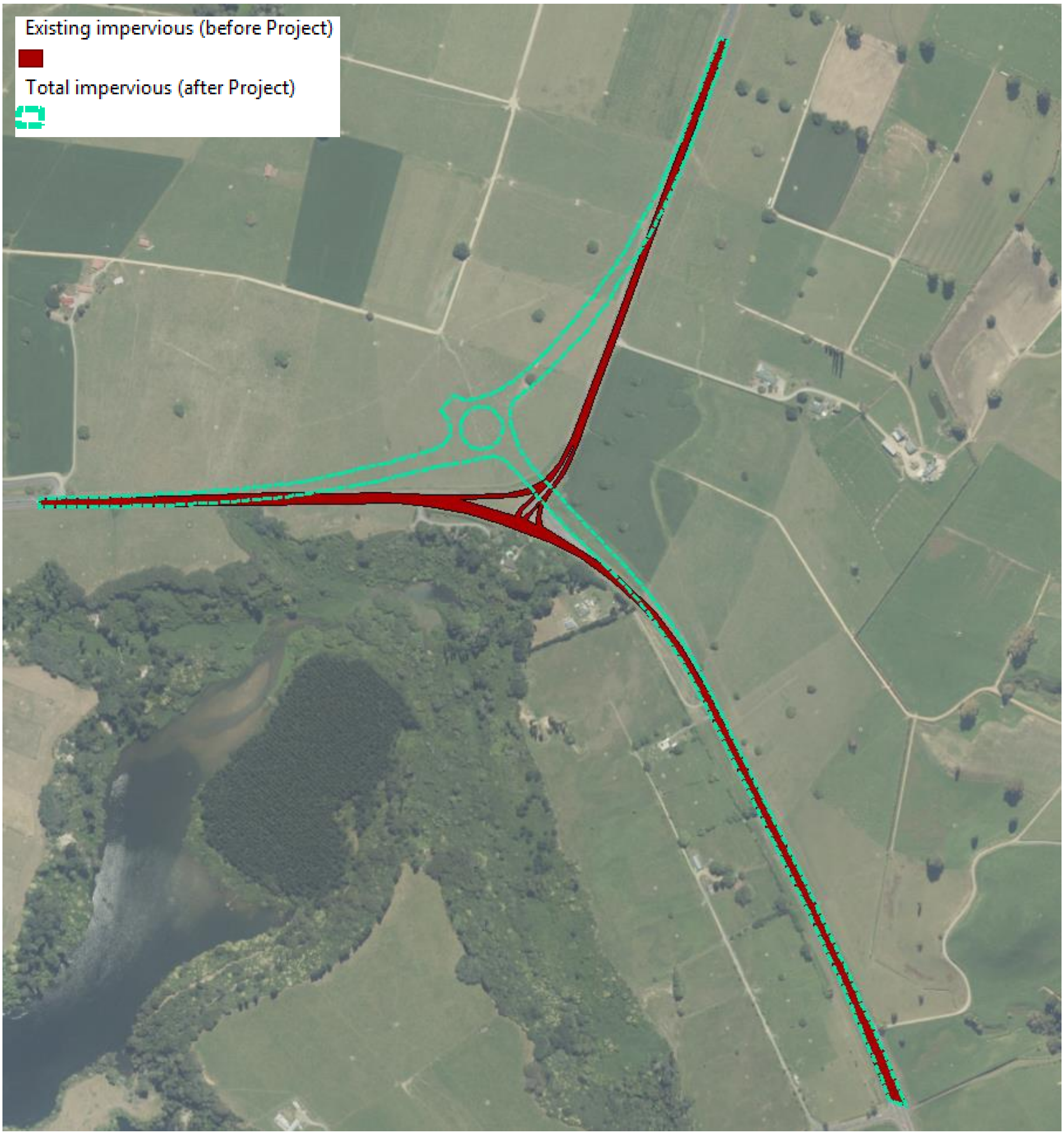

Figure 4-1: Existing and additional impervious surface

Table 4-2 shows the existing and future impervious surface values. For the project there will be approximately 11,000m^2 of additional impervious surface. Figures of impervious surfaces are approximations only and will be confirmed once the detailed design of the roundabout is completed.

Table 4-2: Indicative existing and future impervious surface (provisional figures)

Stage	Area (m²)
Existing impervious surface (before Project)	30,790
Total impervious surface (after Project)	41,876
Additional impervious surface	**+ 11,086**[4]

This increase in discharge has the potential to cause flooding and increase the rate of erosion within the receiving watercourses. Filling within a natural flow path or stream will reduce the cross section of the watercourse, potentially increasing flood risk within the site and upstream. For this project watercourses and drains will not be infilled unless an equivalent alternative waterway is provided. Removal of flood storage through the filling of natural flood plains can also lead to increased flooding.

Some flood plain filling will be unavoidable with construction of the roundabout. Accordingly, hydraulic modelling was undertaken to understand the potential flood effects of the Project on the wider catchment. A Project scenario (including the proposed RAB) was modelled to determine the flooding effects of the Project. Figure 4-2 shows the items incorporated into Project scenario.

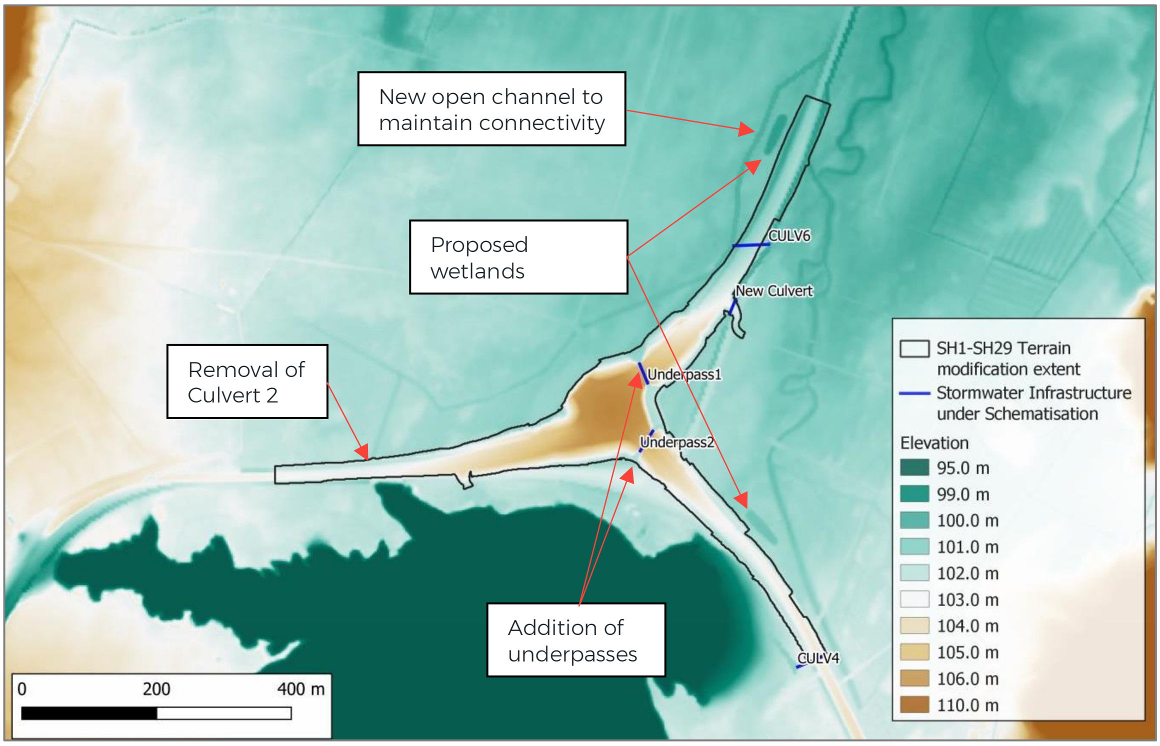

Figure 4-2: Digital Elevation Model and Stormwater Infrastructure Schematisation

Figure 4-3: Flood depth map – scheme scenario 1 in 100yr ARI CC (2120 RCP 6.0)

[4] This figure may increase dependant on future reuse of current carriageway for local access and shared path purposes.

shows the flooding extent for the Project scenario for the 1 in 100-year ARI + CC storm.

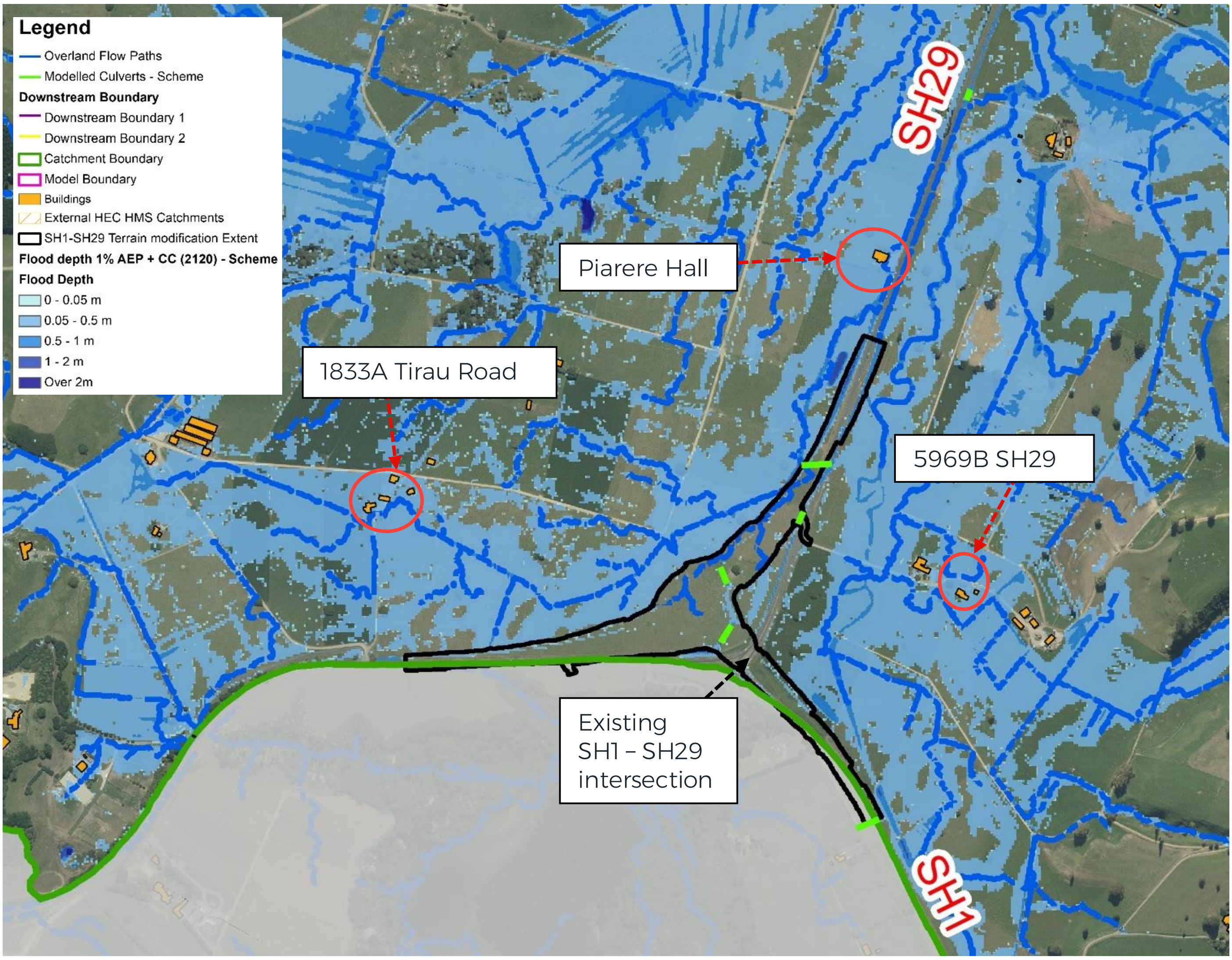

Figure 4-3: Flood depth map – scheme scenario 1 in 100yr ARI CC (2120 RCP 6.0)

Table 4-3 shows the predicted flood elevation for the properties that remain within the floodplain in the Project scenario and baseline scenario (without the Project). This represents the predicted level of water within a property for the 100-year ARI + CC rainfall event.

Table 4-3: Properties predicted to be within floodplain (1 in 100-year ARI + CC)

Address	Existing predicted flood elevation without Project (1 in 100-year ARI)	Scheme predicted flood elevation (with Project) (1 in 100-year ARI)	Increase / decrease in flood depth
Piarere Hall (5920 State Highway 29)	100.79 mRL	100.80 mRL	+ 10 mm in flood depth
5969B State Highway 29 – building 1	101.93 mRL	101.93 mRL	0 mm difference
5969B State Highway 29 – building 2	101.92 mRL	101.92 mRL	0 mm difference
1833A State Highway 1, – building 1	102.82 mRL	102.82 mRL	0 mm difference
1833A State Highway 1 – building 2	102.70 mRL	102.70 mRL	0 mm difference
1833A State Highway 1 – building 3	102.68 mRL	102.68 mRL	0 mm difference
1833A State Highway 1 – building 4	102.40 mRL	102.40 mRL	0 mm difference

The hydraulic modelling shows that the Project has no effect on flood depth at four of these properties for the 1 in 100-year+ CC ARI event. Piarere Hall is the only property that has an increase in flood depth, and this is below 10 mm. The modelling also demonstrates that any loss of flood plain storage at the Project site is quickly compensated for by a slight increase in flood depth/extent across the wider flood plain.

Figure 4-4 compares the predicted flood depth difference between the Project scenario and baseline scenario (without Project) for the 1 in 100-year ARI + CC event. Given the generous amount of flood plain storage available, and the small changes generated by the Project (no more than 50 mm flood level change outside the proposed designation boundary, except in one very localised area where the increase is still less than 100 mm[5]), we consider that the provision of additional peak flow attenuation within the stormwater devices is not warranted.

The WRC TR2020/07 guidelines stipulate that in the absence of a catchment study that evaluates a potential project in a given location, a cautious approach should be chosen – especially where human safety or structure damage is concerned. In catchments where flood problems do exist and there is no catchment management plan or catchment wide analysis, the post-development peak discharge for the 100-year ARI event for a new development should be limited to 80% of the pre-development peak discharge. This approach is based on studies cited in WRC's TR2020/07 relating to developing urban catchments where it is recognized that simple flood neutrality measures may not be sufficient because the extended outflows from multiple devices may still coincide. This is not the case at Piarere; it is not an urban catchment and cumulative effects are not a concern as the roundabout is the only significant imperviousness likely to occur.

Moreover, TR2020/07 recommends a precautionary approach in the absence of a catchment study. However, a comprehensive stormwater model of the upper catchment has been created for the Project, which effectively serves as a catchment study. The model demonstrates the flood effects of the roundabout in considerable detail and shows that these are zero or minor for the events modelled (which are considered a representative range).

[5] This small area of pasture could be filled locally by agreement with the landowner.

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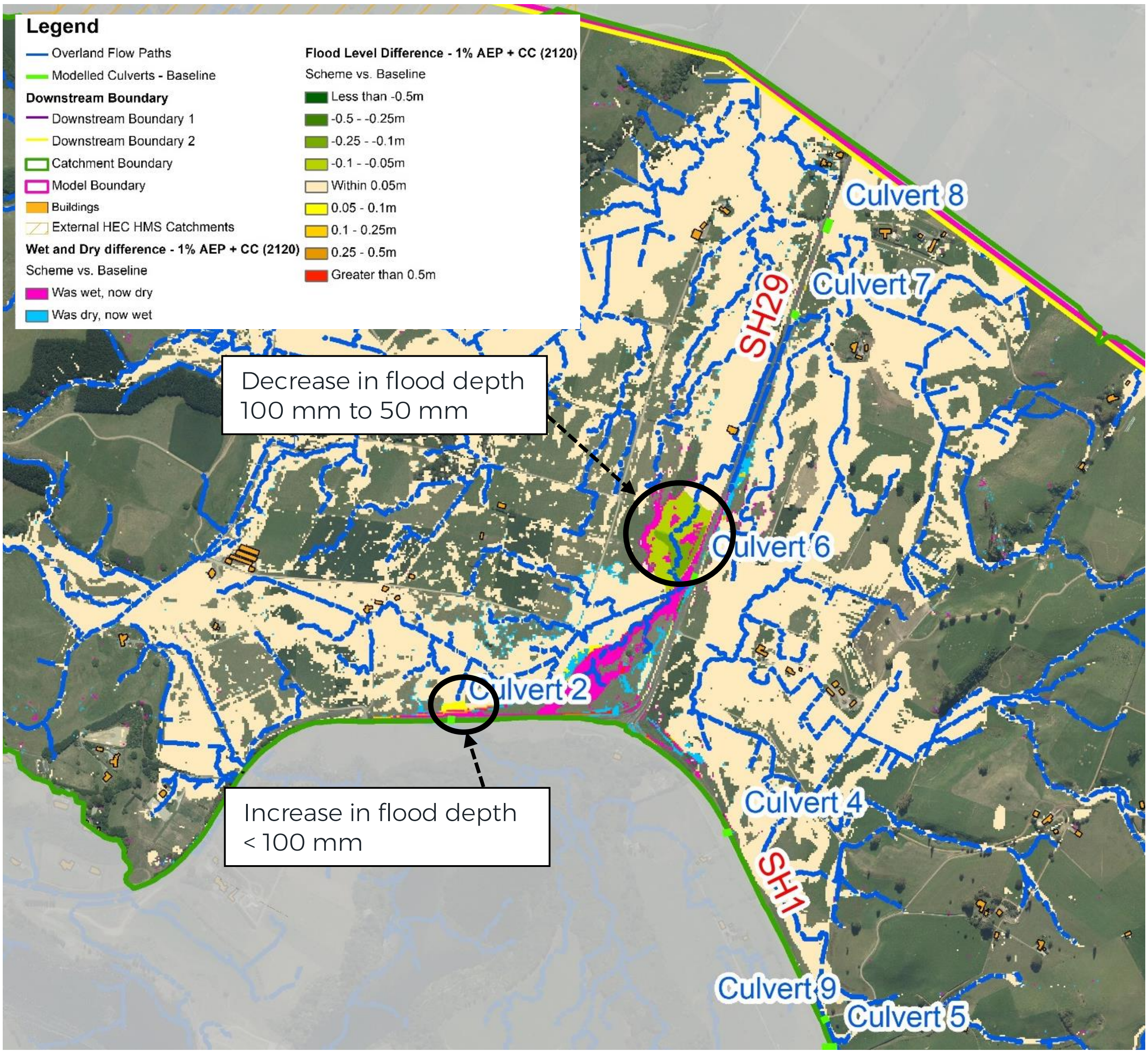

Figure 4-4: Change in flood elevation, scheme vs baseline (1 in 100yr + CC)

The increase in flood depth is due to the removal of Culvert 2. This culvert primarily functions to convey stormwater runoff from the roadside drain across the existing SH1 roadway to discharge to the western gully (part of the Waikato River catchment). This system is proposed to be superseded as part of the Project Works, as detailed in the sections below. The hydraulic model shows that this culvert also receives some stormwater flow from the adjacent farmland, however most of the flood flows tend to travel northward following SH29. Given the minor, localised increase in flood depth, it is proposed that this area of pasture be filled by agreement with the landowner to keep the flooding extent within the designation boundary. Should private property filling be unacceptable for any reason, there are other piping options that can be considered for this very minor flow.

Based on the hydraulic modelling results, a range of stormwater management devices have been designed to ensure that the potential flood effects are mitigated. The stormwater management for the proposed road reserve catchment areas includes capture and conveyance via constructed planted wetlands/swales and piped networks, which discharge to the Waitoa Stream or the Waikato River.

Constructed wetlands and wetland swales are the preferred stormwater treatment devices to achieve water quality requirements, when discharging to the Waikato River and Waitoa Stream. Up to three constructed wetland swales and one wetland are proposed within the site. Table 4-4 shows the capabilities of each stormwater management device.

Table 4-4: Stormwater device capabilities

	Treatment	Conveyance	Extended detention
Pipes network		✓	
Planted Swale (PS)	✓	✓	
Wetland Swale (WS)	✓	✓	✓
Wetland (W)	✓		✓

The constructed wetlands will be designed in accordance with the *Waikato stormwater management guideline, TR2020/07* (Waikato Regional Council, 2020) to achieve the target contaminant removal for the Water Quality rainfall equivalent to the 90th percentile rainfall event.[6]

The creation of a new pavement could also result in traffic-generated contaminants, such as heavy metals and hydrocarbons being discharged into the receiving environment. Where practicable, swales will be used to convey runoff to the treatment wetlands, thus providing pre-treatment, and soakage opportunities. Soakage is achievable due to the nature of the existing soil being highly porous. Runoff from pavement areas near the Project extent that cannot be drained to a constructed wetland will be treated in swales alone so that ultimately all trafficked areas will receive BPO treatment in accordance with the *Waikato stormwater management guidelines, TR2020/07* (Waikato Regional Council, 2020).

This is an environmental benefit, as the existing intersection has no formal stormwater treatment, so traffic will shift from an untreated to a treated road. Shallow planted swales are proposed as dual-purpose devices to provide pre-treatment and conveyance of stormwater flows. Wetland swales can provide extended detention as well. Swales are used to minimise the number of underground assets and reduce long term maintenance requirements in underground systems and improve the reliability and resilience of the stormwater conveyance systems.

Due to the porous nature of the soil around the site, liners/impermeable layer will be considered for the wetland and wetland swales to prolong standing water. Given the relatively small sub-catchment areas for each device, it is acknowledged that the wetland and wetland swale will be subject to periods of drying out. Vegetation species will be carefully selected with advice from the Project Landscape Architect to suit these conditions.

Alternatively, soakage may be utilised to a larger degree to dispose of stormwater runoff. For example, infiltration swales will also be considered as an alternative to wetland swales during the development of the design. Soakage devices will be designed to provide the same function as the wetland swales to treat, convey and dispose of stormwater runoff.

A small soakage device has provisionally been included in the Project Drawings to manage flows associated with the proposed cycleway underpass. Stormwater flows will be minimal, with the underpass entrance/exits and surrounding earthworks designed to limit the sub-catchment area.

Runoff will be captured and conveyed via piped systems in locations where planted swales are not practical due to site constraints or the safety requirements of using a kerb and channel around the roundabout. Cycle friendly grates will be provided on all left-side catchpits to ensure safety of the road users.

[6] In accordance with TR2020/07 this will be approximated by using 1/3 of the 2-year, 24-hour rainfall, derived from HIRDS v4.

Constructability and maintenance access requirements were considered while determining the proposed location of each wetland /wetland swale.

Landscaping, aesthetics and geometry of the constructed wetland and wetland swales will be considered further at the detailed design stage. The design will aim to provide a high flow bypass around the constructed wetland to minimise washout of sediment. Where this is not possible, overflow structures will be strategically used to discharge the high flows without compromising the long-term performance of the system and reduce maintenance requirements.

The stormwater management of each leg is summarised below. Please refer to the *Project Drawings in Volume 3: Drawing Set* for more detail on the proposed stormwater concept design.

Piarere Leg (SH29)

Figure 4-5 shows the proposed stormwater management design for the Piarere leg. Runoff from the Piarere leg is collected through catchpits and discharged into the planted swale (PS04). Water from the planted swale discharges into the wetland swale (WS03) and connects into a proposed new outlet discharging water to the existing roadside drain along SH29. The water is eventually conveyed to an ephemeral tributary which flows North to the Waitoa river. The devices on this leg are sized to provide suitable conveyance and treatment.

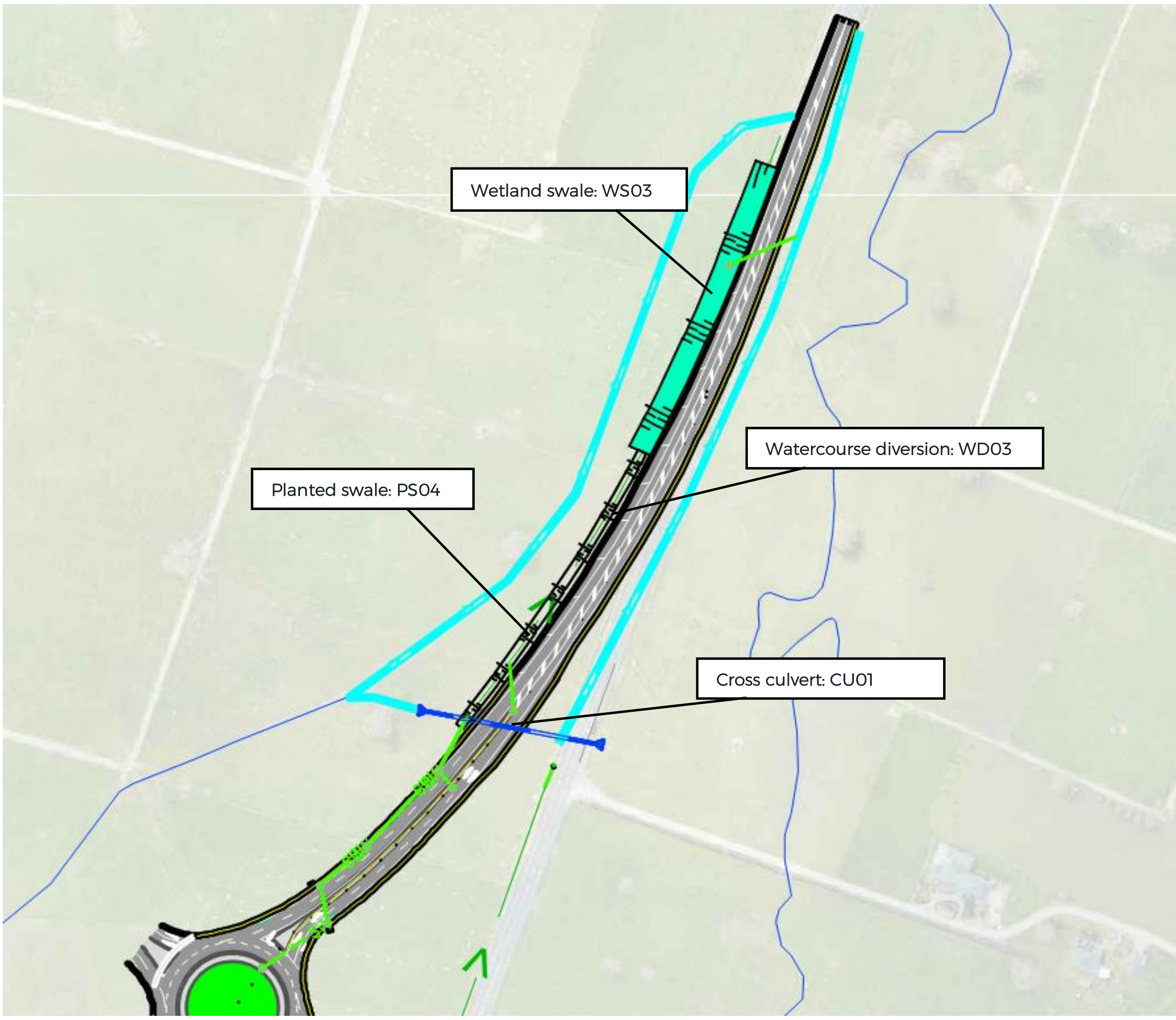

Figure 4-5: Piarere Leg - proposed stormwater design

Karapiro Leg (SH1 North)

Figure 4-5 shows the proposed stormwater management design for the Karapiro leg. Runoff for the Karapiro leg is collected through catchpits and discharged through a series of pipes to a planted swale (PS01). All runoff is collected in a wetland (WP 01) and discharges water to an unnamed river that discharged to the Waikato River through a new outlet. The wetland will be lined to address slope stability concerns near gully banks and this will have a positive effect in prolonging standing water in the wetland base. Please refer to the *Project Drawings in Volume 3: Drawing Set* for more detail on the proposed discharge outlet. The devices on this leg are sized to provide suitable conveyance and treatment.

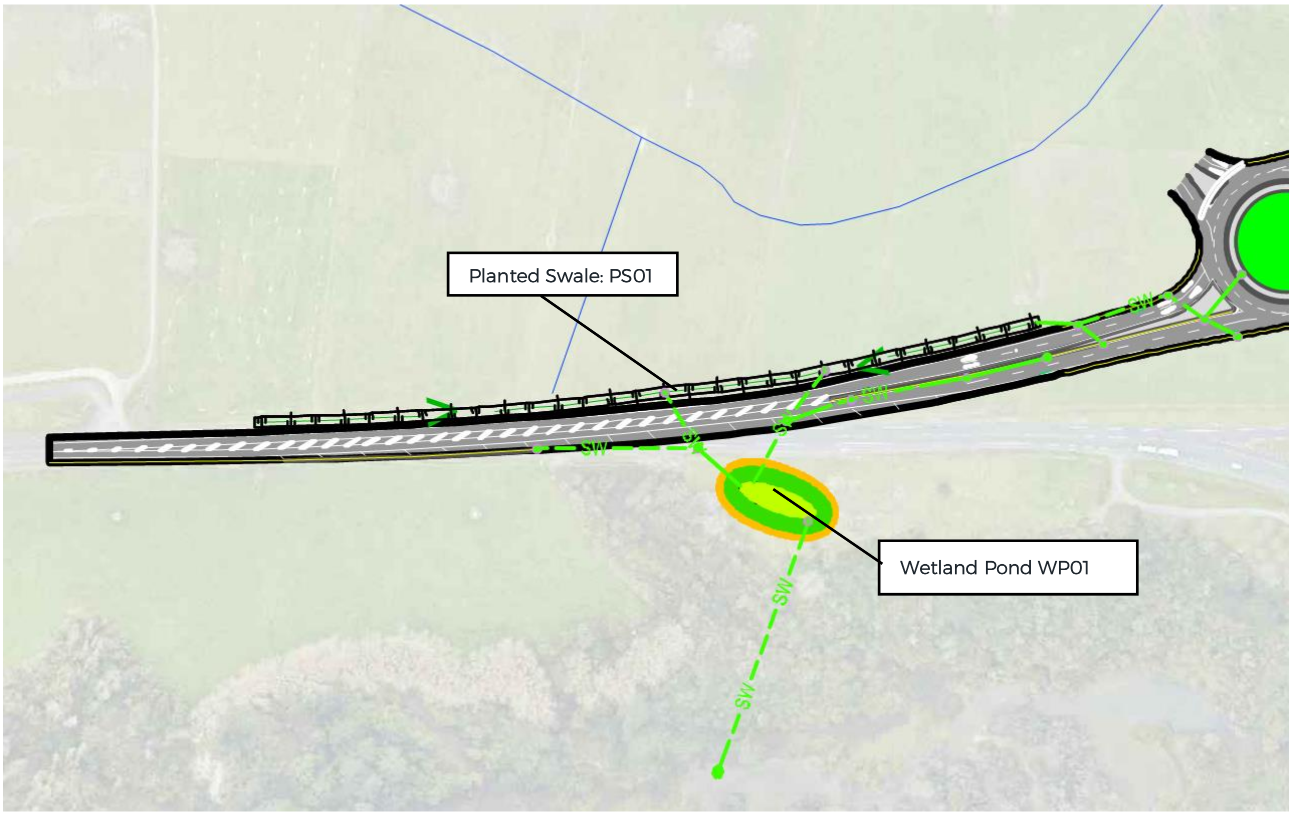

Figure 4-5: Karapiro Leg - proposed stormwater design

Tirau Leg (SH1 South)

Figure 4-6 shows the proposed stormwater management design for the Tirau leg. Runoff from this leg is collected from catchpits and discharged to the planted swales (PS02 and PS03). Runoff from the south east side of the leg is collected in the wetland swale (WS02). All swales discharge to the wetland swale (WS01) which flows north to the Waitoa River. The devices on this leg are sized to provide suitable conveyance and treatment.

Figure 4-6: Tirau Leg - proposed stormwater design

Table 4-5 describes the location, catchment area, proposed device size and treatment details of constructed wetland and wetland swales.

Table 4-5: Proposed stormwater devices

Location	ID	Type	Treatment	Extended Detention	Attenuation	Catchment Area	Indicative Volume	Discharge Location
Karapiro Leg (SH1 North)	WP 01	Wetland	Yes	No	No	15,000 m^2	1,200 m^3	Waikato River
Tirau Leg (SH1 South)	WS 01	Wetland Swale	Yes	No	No	12,300 m^2	1,350 m^3	Waitoa Stream
Tirau Leg (SH1 South)	WS 02	Wetland Swale	Yes	No	No	7,000 m^2	450 m^3	Waitoa Stream
Piarere Leg (SH29)	WS 03	Wetland Swale	Yes	No	No	16,000 m^2	950 m^3	Roadside drain to Waitoa Stream

Often treatment device sizes are optimised by isolating the area generating high contamination (i.e. the carriageway) from other “clean” areas. However, this would mean having separate drainage systems for the paved carriageway and fill batters. This may be possible where kerb and channel is used, but elsewhere, for practical reasons, both paved area and fill batter runoff will be collected together in swales and conveyed to the constructed wetlands. Having slightly larger constructed treatment device sizes is preferable to providing two separate drainage systems for this Project.

4.3.2 Watercourse Diversions

The two watercourses in the Project area located on the west and east side of SH29 are ephemeral, located in grazed pasture, and their ecological values are consequently relatively low, see the Ecology Assessment for further details.

As the drains and watercourses are dry most of the year, they are not a suitable source of water for stock watering; instead stock troughs are provided.

Constructing a culvert in the bed of a stream can affect the conveyance, or cause scour at the entry and exit, and potentially also create a barrier to fish passage.

Some existing farm and roadside channels will need to be diverted around the works, particularly along the Piarere SH29 leg. These watercourses will be replaced with equivalent channels in a more suitable location. The Project Ecologist has provided an initial assessment of the watercourse within the western land block: *While access to this land was not available, based on observations from the roadside and neighbouring properties, and review of drone imagery and google streetview, the watercourse is considered to be an ephemeral overland flowpath and does not meet the definition of an ephemeral stream in the Waikato Regional Plan. As the overland flow path is only expected to flow for short periods after heavy rain in winter months, it is expected that the watercourse will only periodically support macroinvertebrate taxa that are tolerant of degraded conditions and high disturbance. Due to the ephemeral modified nature, it is unlikely that this watercourse will support native fish.*

The western watercourse will be surveyed to confirm this initial assessment once the access is granted to the property. Should fish become anticipated by the Project Ecologist, suitable fencing and stream-side planting will be established as part of the watercourse diversion.

There are three watercourse diversions proposed as a result of the works. The length of each of these diversions is outlined in Table 4-6. The width of each watercourse diversion will match the existing profile, and this will be confirmed in the detailed design phase.

Where recommended by the Project Ecologist, fish passage will be designed in accordance with the *New Zealand Fish Passage Guidelines* (NIWA, 2018) and the *National Policy Statement for Freshwater Management 2020* (New Zealand Government, 2020).

Due to the flat terrain, new culverts (except those discharging to the Waikato River) will be laid at low gradient. As required by the Fish Passage Guidelines, and where applicable, their diameter will be equivalent to 1.3 times the width of the bed, and they will be embedded 25%-50% of their diameter. Consequently, pipe sizes may be larger than those required by hydraulic considerations alone. Flood effects have been considered together with those of the earth fills using the flood model, and reported in Section 4.3.1. No waterway bridges are anticipated. Table 4-6 provides details of the proposed culverts and watercourse diversions.

Table 4-6: Provisional culvert and watercourse diversion details

Location	ID	Type	Location	Catchment Area	Indicative Size	Discharge Location
Piarere Leg	CU 01	Cross Culvert	Piarere Leg	6 ha	DN450 - 750	WD03
Piarere Leg	WD 01	Watercourse Diversion	Piarere Leg	33 ha	350 m	Overland flowpath towards Waitoa River
Piarere Leg	WD 02	Watercourse Diversion	Piarere Leg	6 ha	38 m	CU 01
Piarere Leg	WD 03	Watercourse Diversion	Piarere Leg	6 ha	160 m	Roadside drain to Waitoa River

Cross-culvert CU 01 was modelled as a DN450 in the stormwater model to replace the existing DN375 culvert. No increase in upstream water levels would occur up to the 1% AEP event with a DN450 replacement. The location of CU 01 was moved approximately 115 m south to resolve clashes with the proposed longitudinal drainage and achieve minimum cover requirements under the new SH29 carriageway.

Should fish passage be recommended in future by the Project Ecologist (outcome pending the completion of the watercourse survey in the western property once access is obtained), CU 01 will need to be DN650 to DN750 diameter and embedded at least 25% to meet the best practice criteria under the Fish Passage Guidelines. The Project Drawings provide a typical detail of an embedded fish passage culvert on sheet C162. The stormwater model will be run to reflect the upsized culvert; however, it is anticipated that this will have little impact on the flood effects compared to the modelled scenario as the DN450 culvert causes little to no restriction of stormwater flows.

There is an existing DN750 culvert near the WS 03 outlet location that currently discharges stormwater flows from the eastern watercourse into the SH29 roadside drain. Based on site observations, the culvert was probably installed by the landowner to drain the eastern farmland more effectively. The culvert will clash with the proposed works, and it is proposed that it be abandoned/removed. This action will free up capacity in the existing SH29 roadside drain and restore the existing flow regime of the eastern watercourse.

In terms of watercourse erosion, Figure 4-7 shows the flow velocities for the scheme scenario (with Project) with the 1 in 2-year ARI rainfall applied. Flow velocities will tend to remain below the erosive threshold (e.g. Scobey, 1926, as reported in Table 6-5 of the NZTA Stormwater Treatment Standard), indicating that extended detention to control channel erosion is not warranted.

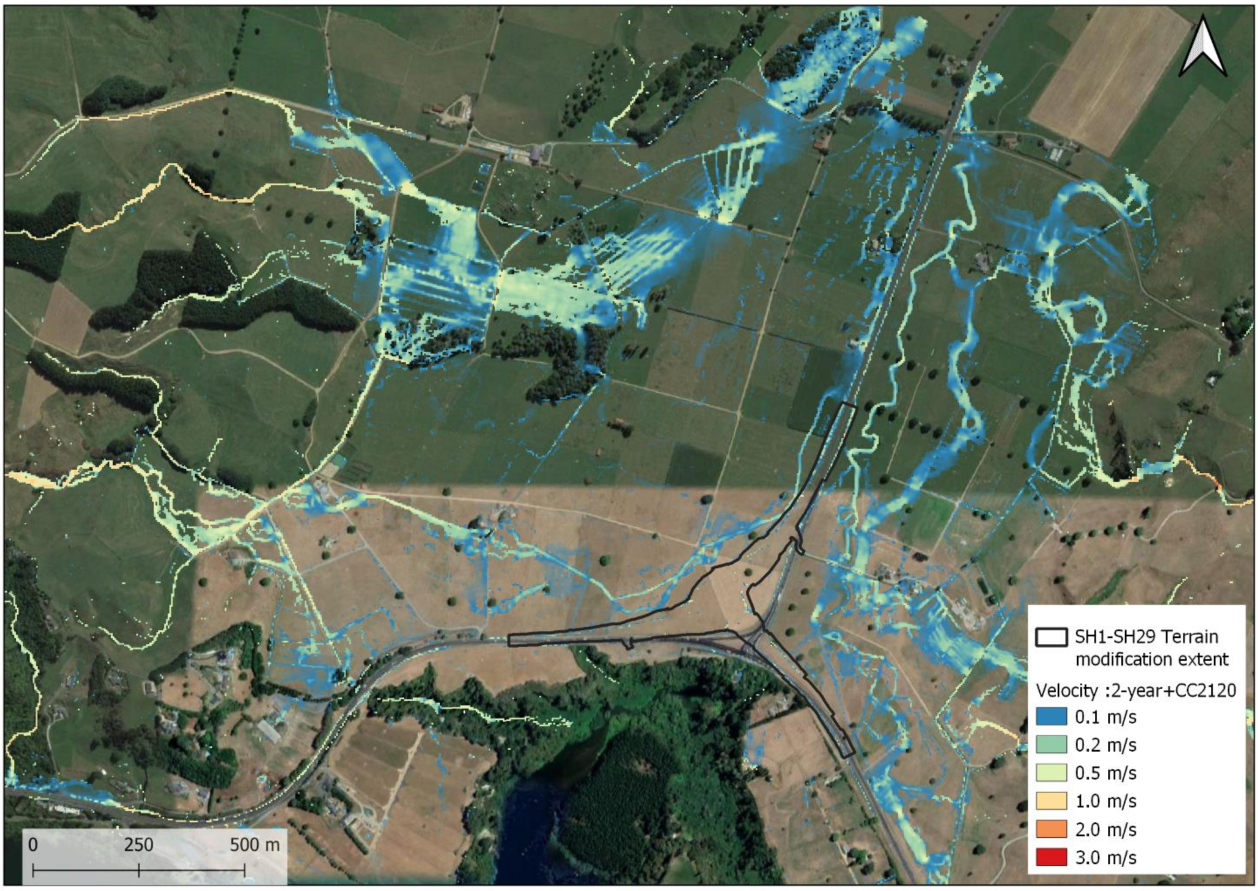

Figure 4-7: Velocity for scheme scenario (1 in 2 – year ARI + CC)

The deeply incised gullies leading to Lake Karapiro are likely to be highly erosion-prone, and therefore sensitive to increases in flow. The Project will reduce flow to the gully-head by piping flow to the lower gully and discharging it close to the lake. While the reduction in water supply to the gully is a minor negative effect, this will be more than offset by the reduction in erosive potential.

5 Assessment of Residual Effects Following Mitigation

This section assesses the likely residual effects (i.e. after mitigation) associated with stormwater and flooding, which are summarised in the table below.

Table 5-1: Residual effects

Stormwater Related Residual Effects		
Potential Effect	Mitigation through design	Residual Effects
Effect of sediment runoff during earthworks / construction activities on stream beds	Best practice erosion and sediment control measures will be applied in accordance with TR2010/02 (Waikato Regional Council, 2009).	Minor. A potential sediment yield of no more than 617 tonnes over the construction period with BPO employed.

Stormwater Related Residual Effects		
Potential Effect	**Mitigation through design**	**Residual Effects**
Sediment runoff during earthworks / construction activities to Waikato River	Construction-phase discharges to the Waikato River will be limited as far as possible, and all discharges will first be treated by BPO practices in accordance with TR2010/02 (Waikato Regional Council, 2009).	Less than minor. Site-generated pumice material discharging to the Waikato River will not measurably increase baseline volumes.
Sediment runoff during operational phase to Waikato River	New discharges to the Waikato River will be restricted to runoff from carriageway and batters that has first passed through a treatment device. Gully discharge will be controlled to ensure channel erosion does not take place.	Less than minor. Site-generated pumice material discharging to the Waikato River will not measurably increase baseline volumes.
Increased runoff from new impervious surfaces leading to flooding	This has been modelled together with other stormwater changes and the effects have been shown to be negligible. No mitigation required.	Negligible.
Displacement of floodwater due to filling of flood plain	This has been modelled together with other stormwater changes and the effects have been shown to be negligible. No mitigation required.	Negligible.
Blockage of overland flow paths causing a damming effect	This has been modelled together with other stormwater changes and the effects have been shown to be negligible. Watercourse diversions will have capacity equal to or greater than the watercourses they replace.	Negligible.
Increased runoff leading to scour at outfall locations, and in receiving watercourses	Most culverts and outfall locations will be located in low-gradient, low-energy situations. Where necessary, such as culverts draining to the Waikato River, localised energy dissipation and scour protection will be provided at outfalls. This is likely to take the form of riprap aprons at low-gradient culverts and circular stilling wells at steep culverts.	Less than minor.
Discharge of contaminants from road surface.	Swales and treatment wetlands will be provided adjacent to the new road. All new pavement areas will be treated in accordance with WRC's TR2020/07.	The proposed treatment represents a BPO, and there will be a net positive effect because a considerable area of presently untreated road will receive treatment as part of the Project.

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Provided the proposed mitigation measures are implemented, the Project will have less than minor effects on contaminant levels entering the Waitoa and Waikato Rivers’ receiving environments, on flood levels, and on scour and erosion.

6 Conclusion and Recommendations

The goal of the stormwater component of the Project has been to avoid creating heavily engineered solutions in an already-sensitive environment. This will be achieved by application of appropriate Best Practicable Option stormwater measures, including capture and conveyance via planted constructed wetlands/swales and a limited pipe network which discharges to the Waitoa or Waikato Rivers.

The proposed scheme will introduce more impervious surface area leading to more surface runoff. Therefore, post-developed surface flow volumes are expected to experience a minor increase for both the Waikato and Waitoa catchment. The minor modification to catchment delineation at the Karapiro leg and Tirau Leg is considered to have a negligible effect to water catchment volumes for the Waikato or Firth of Thames water allocation.

Flow velocities will tend to remain below the erosive threshold (e.g. Scobey, 1926, as reported in Table 6-5 of the NZTA Stormwater Treatment Standard), indicating that extended detention to control channel erosion is not warranted.

The Project has potential to create stormwater-related effects on the receiving environment, both in the short-term and long-term, as explained in section 5 of this report. Provided the proposed mitigation measures are implemented, the stormwater aspects of the Project will have a neutral or net positive environmental effect (this positive effect arising from traffic shifting from predominantly untreated to treated roads).

7 References

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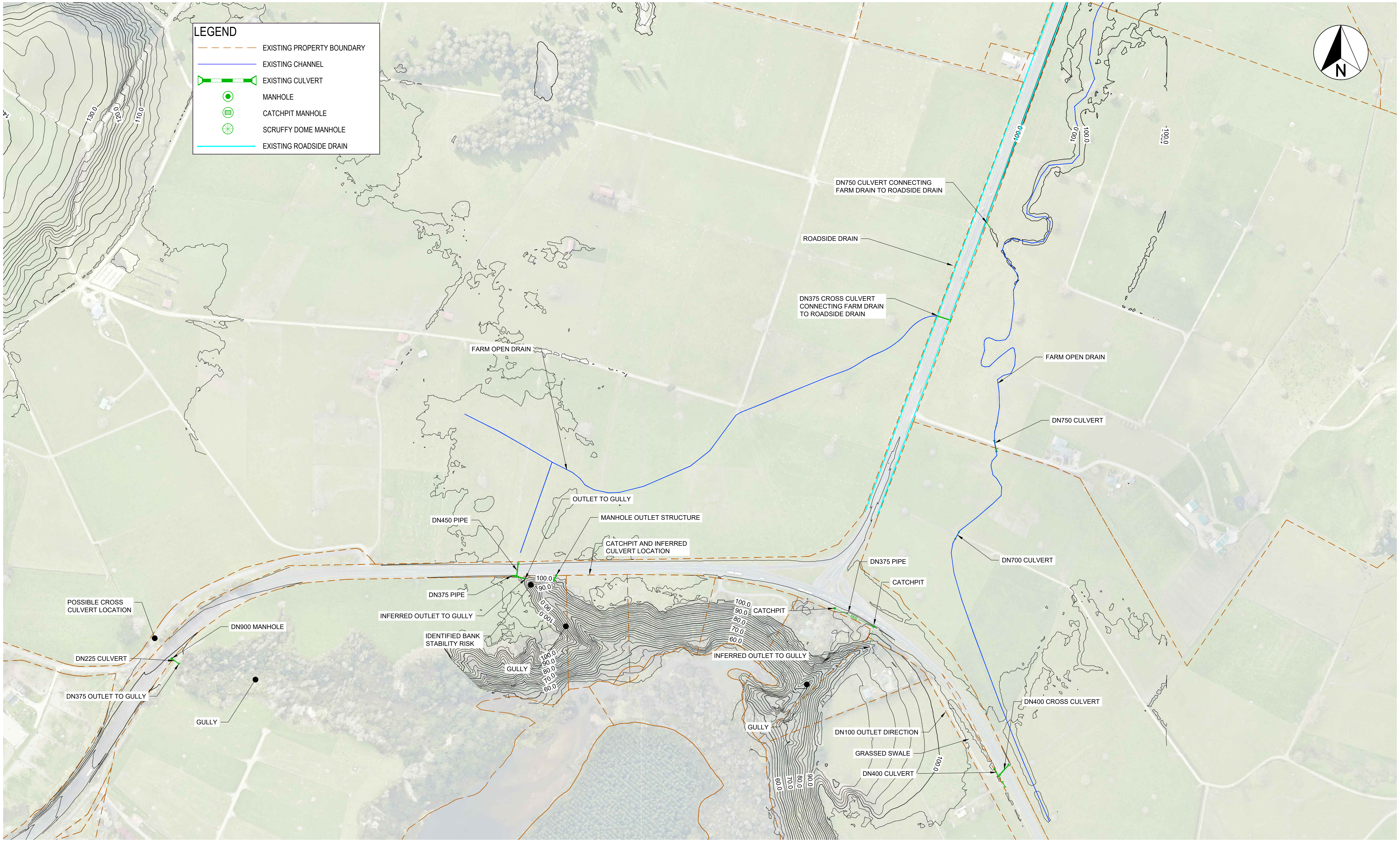
Appendix A

Existing Drainage Features Plan



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WAKA KOTAHI
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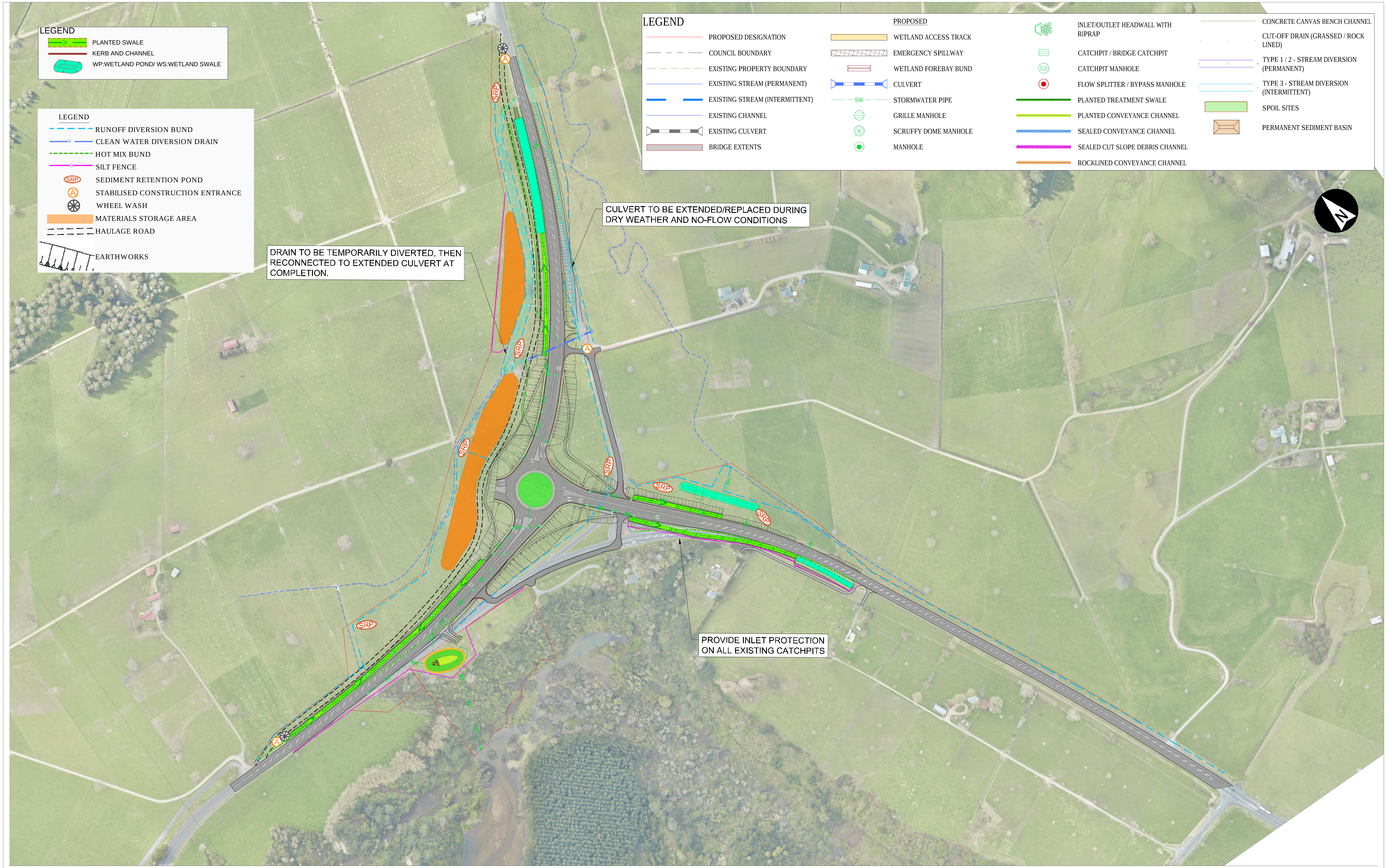
STATE HIGHWAY 1/29 INTERSECTION UPGRADE
EXISTING DRAINAGE FEATURES

Appendix B

Erosion and Sediment Control Plan



REVISION	AMENDMENT	APPROVED	DATE

NZ TRANSPORT AGENCY WAKA KOTAHI

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TRANSPORT

SCALES
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ORIGINAL SIZE
A1

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M B ARMSTRONG	KRISTINE LIM	APPROVER
DRAWING VERIFIED	DESIGN VERIFIED	APPROVED DATE
VERIFIER	VERIFIER	YYYY-MM-DD

PRELIMINARY

PROJECT
WAKA KOTAHI NZ TRANSPORT AGENCY
SH1 REGION 3 RP01N-0591-B/660 TO RP01N-0594-B/360
STATE HIGHWAY 1/29 INTERSECTION UPGRADE

TITLE
INDICATIVE SEDIMENT AND EROSION CONTROL
LAYOUT PLAN

WSP PROJECT NO.	PROJ-ORIG-VOL-LOC-TYPE	SHEET NO.	REVISION
2-A0011.05		C06	A

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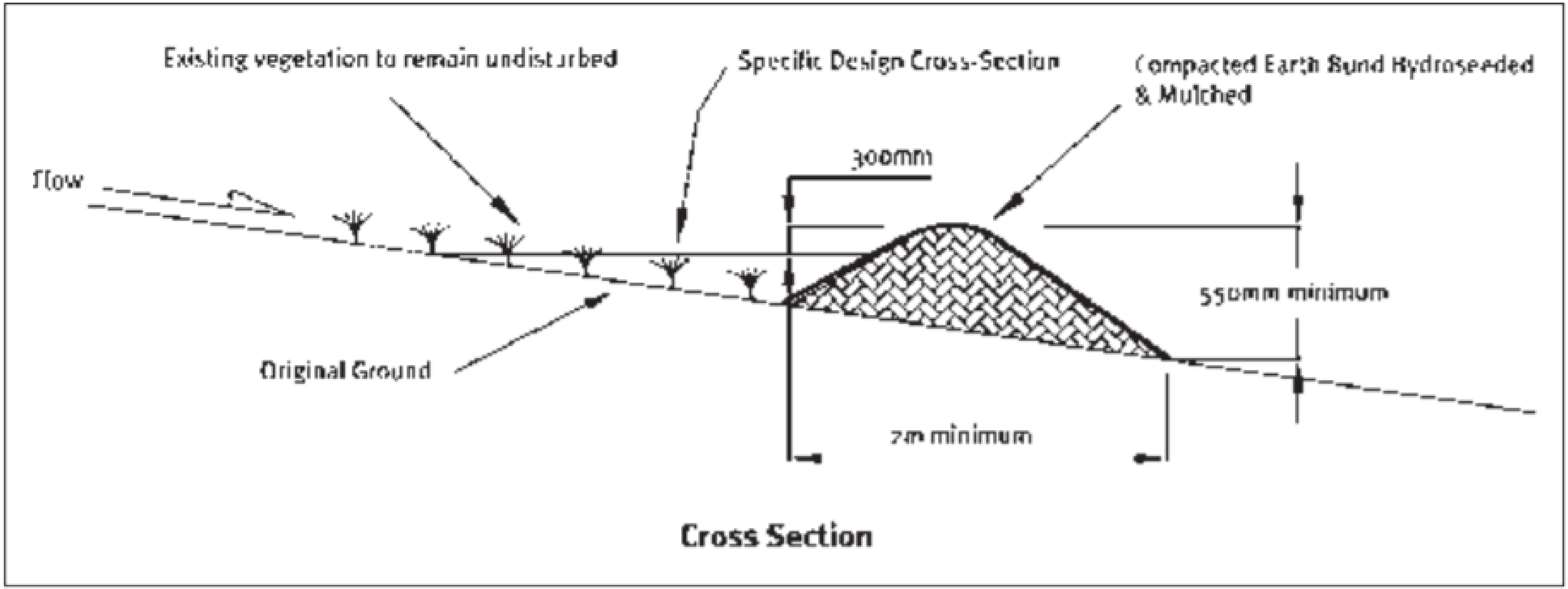

Figure 2: Clean Water Diversion Channel

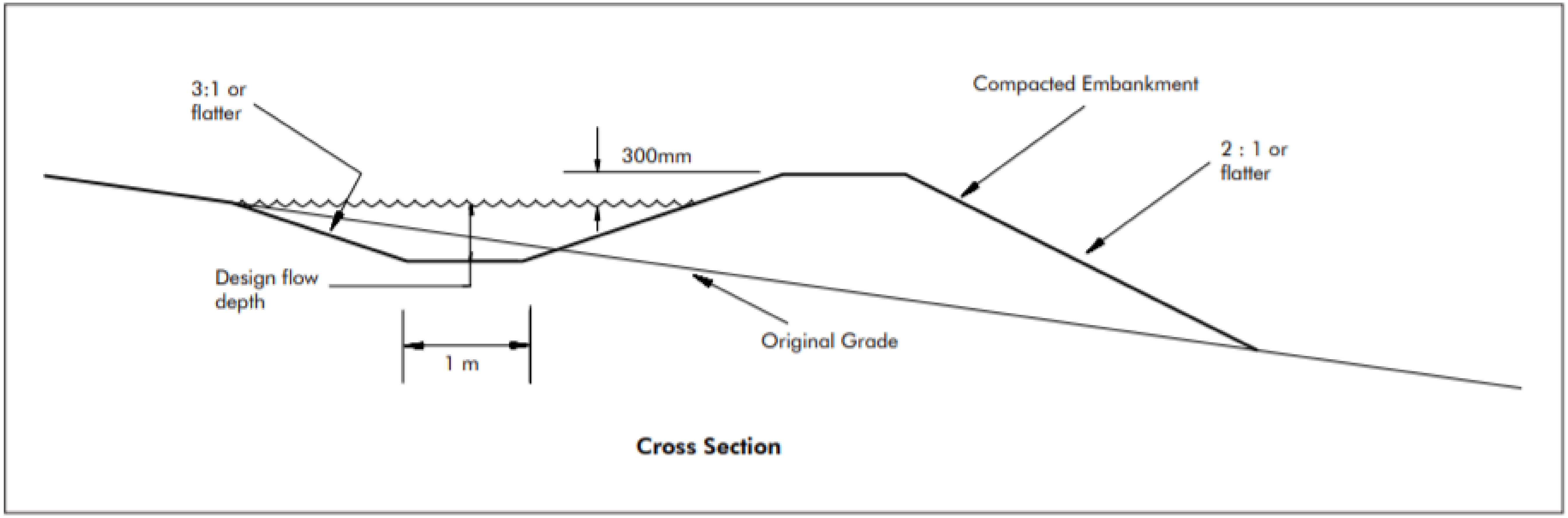

Figure 3: Runoff Diversion Channel

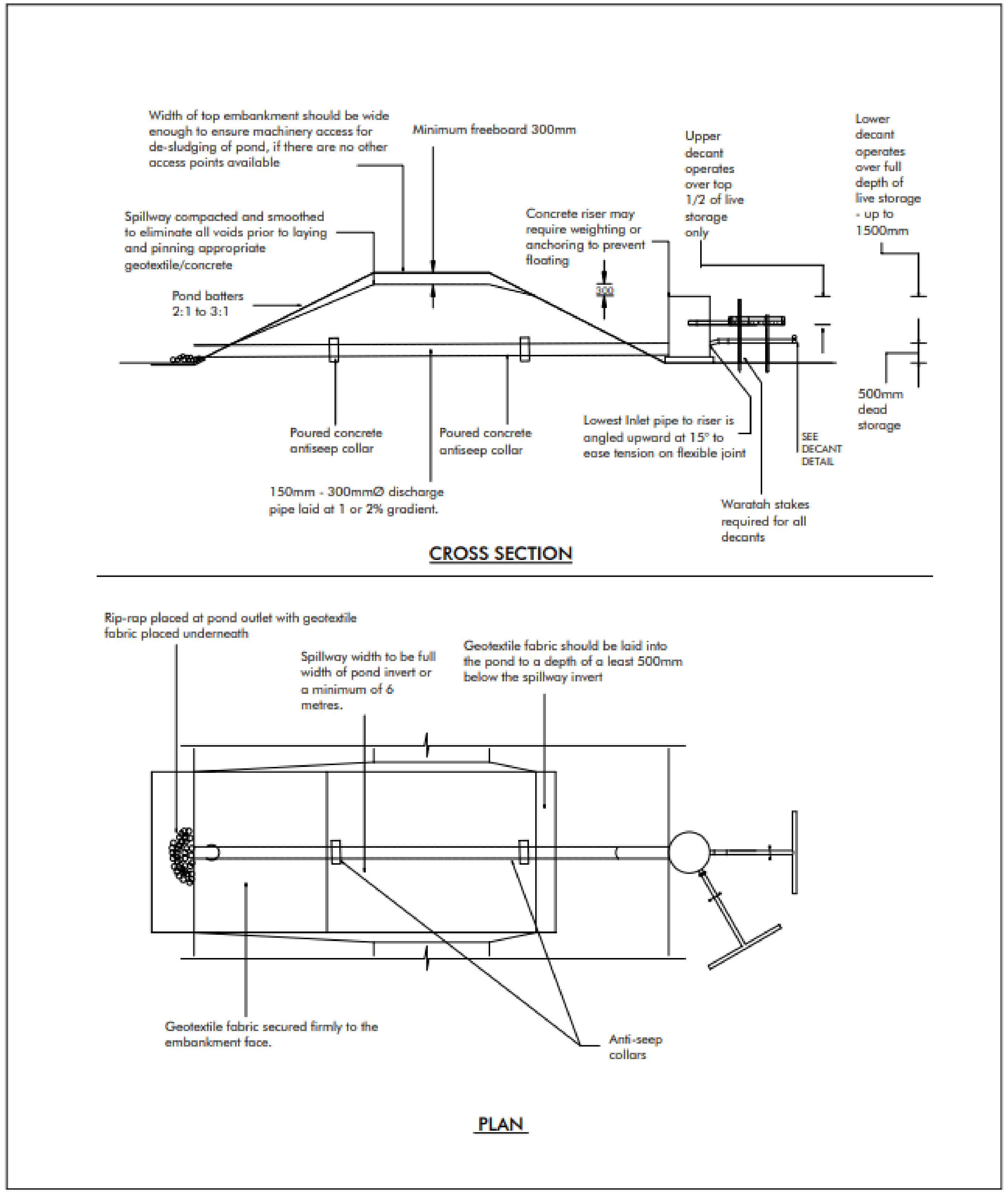

Figure 20: Sediment retention pond for catchments between 1.5 And 3 ha

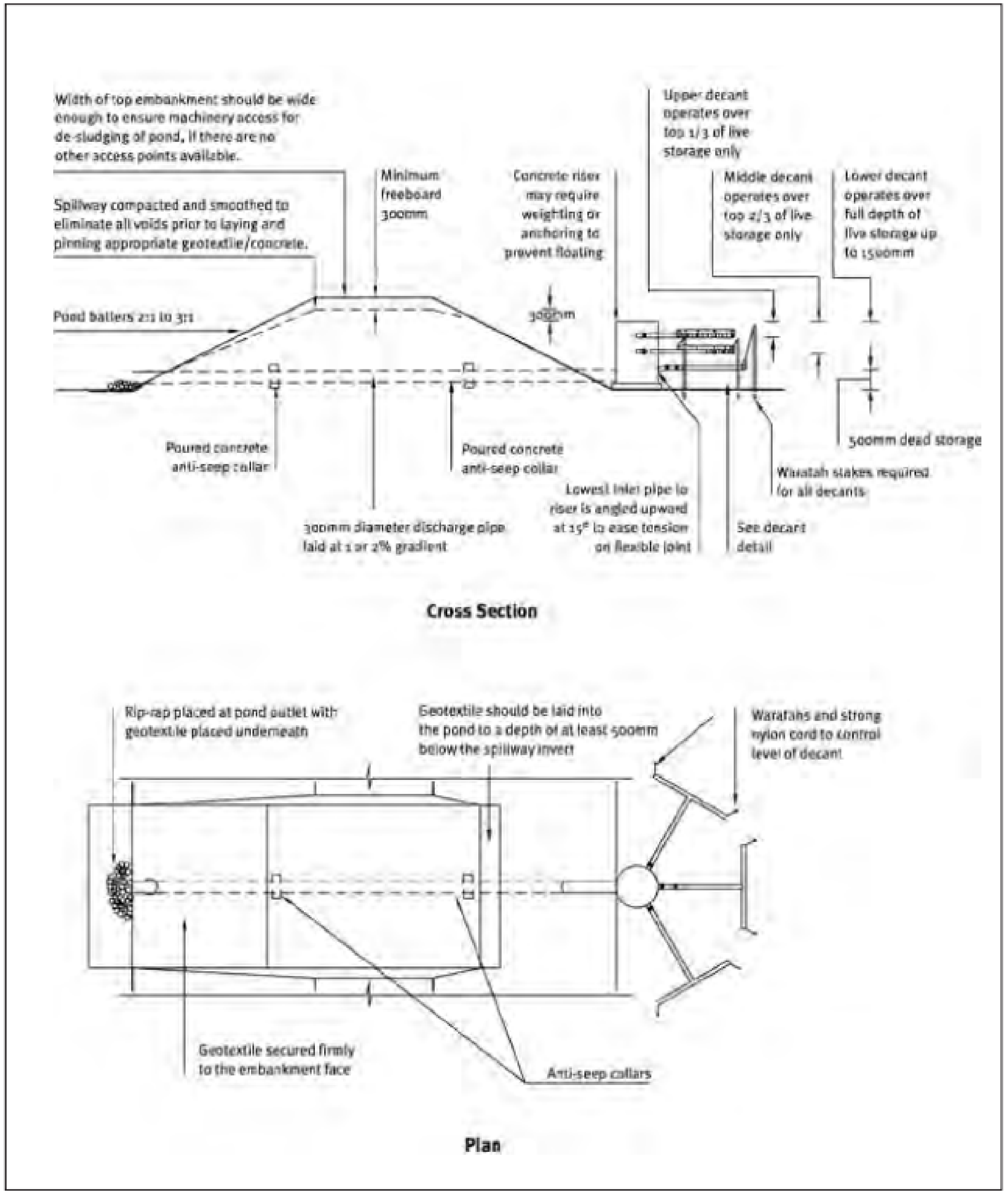

Figure 21: Sediment retention pond for catchments between 3 and 5 ha

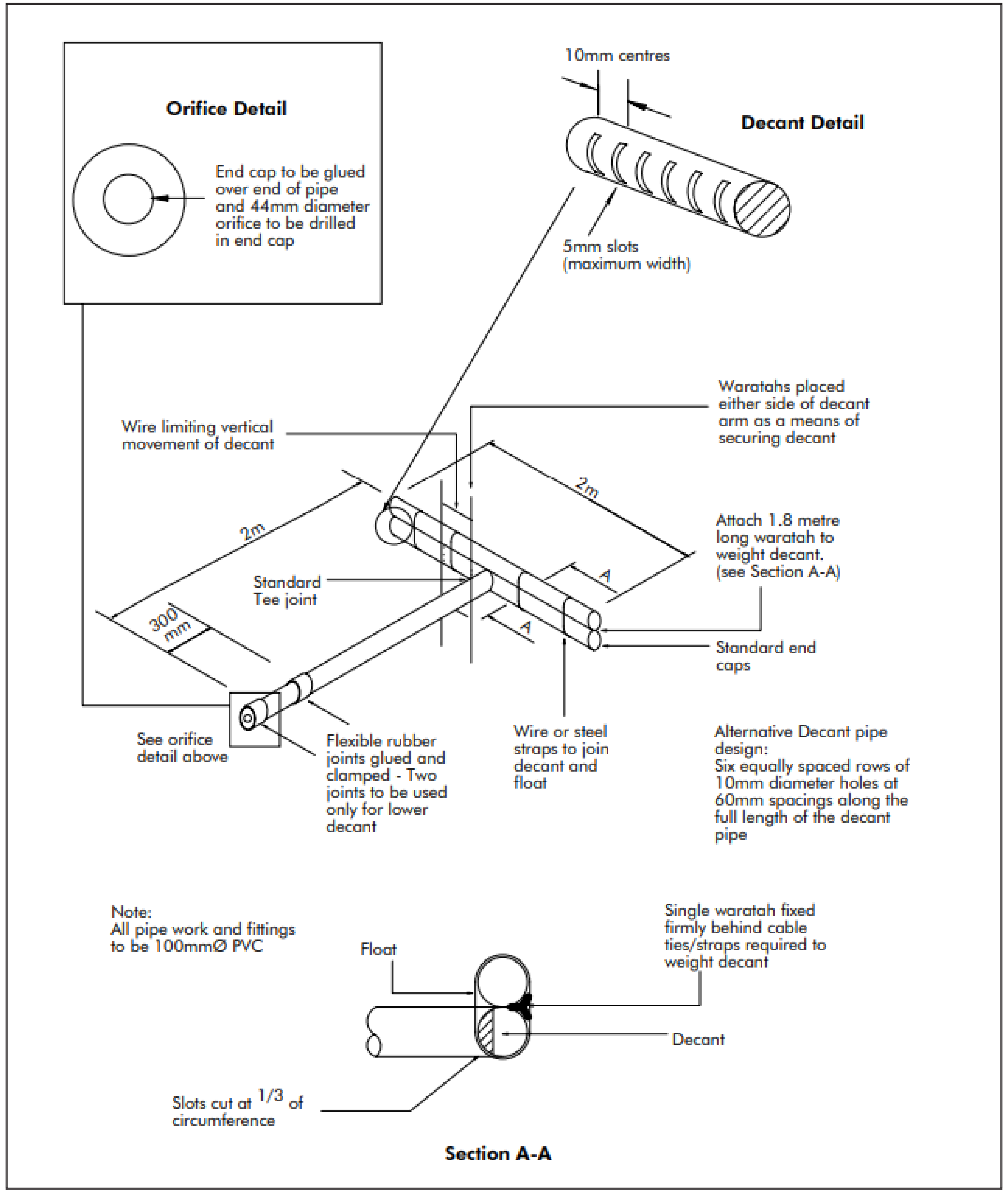

Figure 22: Sediment retention pond - decant detail

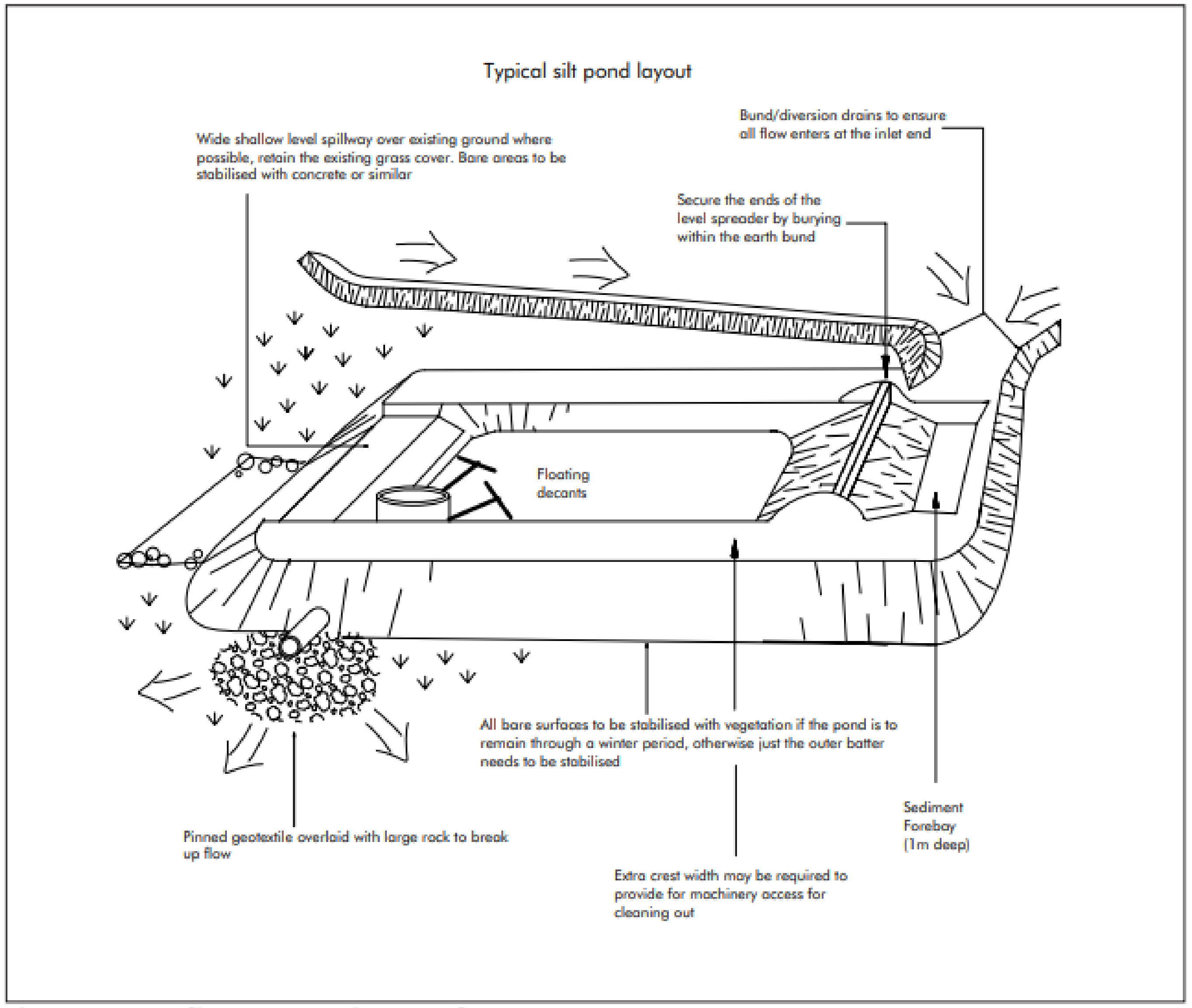

Figure 23: Sediment retention pond

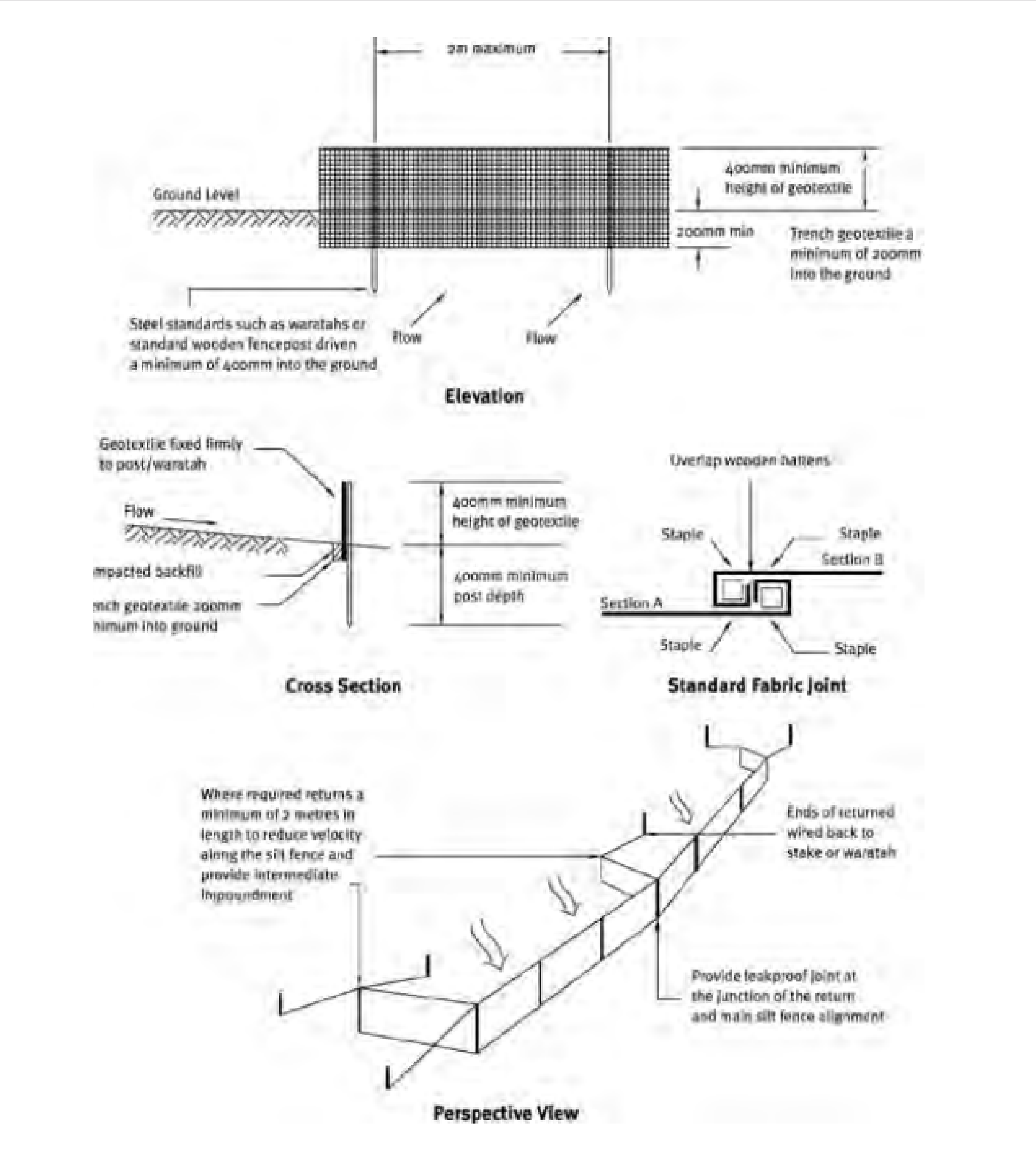

Figure 24: Silt fence

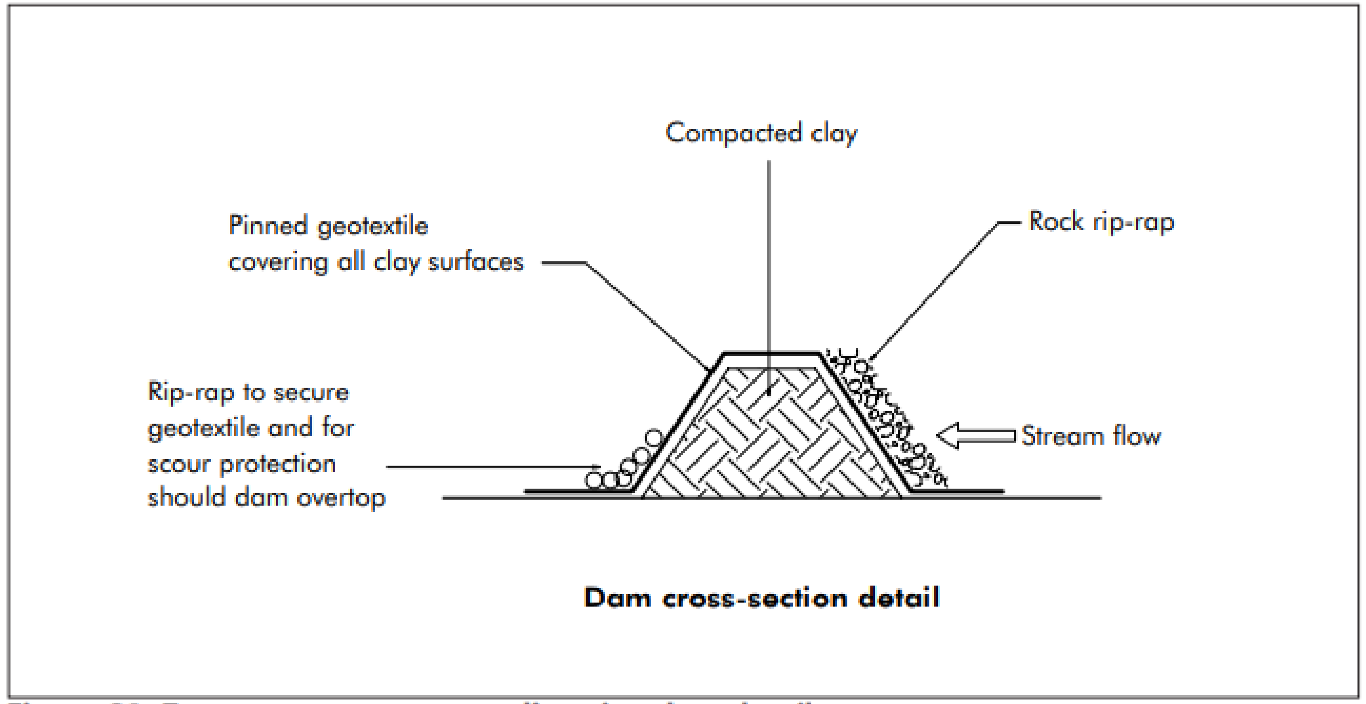

Figure 31: Temporary watercourse diversion dam detail

Appendix C

Universal Soil Loss Equation Calculations

Application of Universal Soil Loss Eqaution(USLE) for Estimation of Soil Loss from Earthworks

Site Name: **SH29-SH1 intersection**

Revised Kristine Lim 12/04/2021

Amendments Sediment removal efficiency: 75% for sediement pond and 70% for super silt fence
Incorporates best estimate of duration of exposed areas

The general form of Universal Soil Loss Equation is:

A= RKLSCP

A= Soil Loss (t/ha/yr)
R = Rainfall erosion index (J/ha)
K = Soil Erodibility Factor (tonnes/Unit of R)
LS = Slope length and steepness factor (dimensionless)
C = Vegetation cover factor (dimensionless)
P = Erosion control practice factor (dimensionless)

After sediment control measures (during construction)

	Sub-catchment	Area (ha)	USLE Parameters					Time (yrs)	Sediment Generation (t)	Sediment Delivery Ratio	Sediment Control Efficiency	Net Sediment Yield (t)
			R	K	LS	C	P					
	1	8.91432	68.1	0.55	3.91	1	1.3	1.50	2567.69	0.5	0.75	320.96
	2	7.09364	68.1	0.55	3.91	1	1.3	1.50	2043.92	0.5	0.75	255.49
	3	1.50141	68.1	0.55	1.74	1	1.3	1.50	192.60	0.5	0.75	24.08
	4	1.01374	68.1	0.55	1.74	1	1.3	1.50	130.04	0.5	0.75	16.26
Total sediment generation									**4934.25**			
Total net sediment yield												**616.78**

After sediment control measures (re-establishement)

	Sub-catchment	Area (ha)	USLE Parameters					Time (yrs)	Sediment Generation (t)	Sediment Delivery Ratio	Sediment Control Efficiency	Net Sediment Yield (t)
			R	K	LS	C	P					
	1	8.91432	68.1	0.29	3.91	0.1	1.0	0.16667	11.50	0.5	0.75	1.44
	2	7.09364	68.1	0.29	3.91	0.1	1.0	0.16667	9.15	0.5	0.75	1.14
	3	1.50141	68.1	0.29	1.74	0.1	1.0	0.16667	0.86	0.5	0.75	0.11
	4	1.01374	68.1	0.29	1.74	0.1	1.0	0.16667	0.58	0.5	0.75	0.07
Total sediment generation									**22.09**			
Total net sediment yield												**2.76**

1 An alternative rainfall coefficienct has been derived using TP108, multiplying the 2yr daily rainfall depth (fig A.1) by 0.628
Thus, R = 1.7*0.00828*(80mm x 0.628)^2.2 = 77.8
2 Slope length coefficient assumes contour drains at 40m max centres in most cases
3 Chemical treatment is recommended where sediment leaving site is greater than 20 t/ha/season
4 USLE areas considered represent areas with similar characteristics rather than individual pond catchments
5 Sediement delivery value of 0.5 for earthworks area. Steep slopes or those next to water courses may need higher sdr. For example, 0.7 for slopes above 10%.

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