SH2 Waikare Gorge

Stormwater Preliminary Design

PREPARED FOR WAKA KOTAHI NEW ZEALAND TRANSPORT AGENCY

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Executive Summary

This report presents the preliminary stormwater design to support the proposed 4.3 km Waikare Gorge Road construction project. The objective of the report is to outline the overall drainage and stormwater management constraints, opportunities and assumptions to support resource consent applications.

Stormwater Design

The proposed road surface will change approximately 75,000 m^2 (7.5ha) of land from paddock and bush into impermeable surface. Road runoff is proposed to be captured in swales and conveyed to treatment swales and constructed wetlands before release into the receiving environment.

Sizing of conveyance, treatment elements and overflow systems have been designed to the NZTA P46 Stormwater Specification to meet the water quality storm, 10-year ARI amenity, 20-year ARI erosion standards and 100-year ARI flood protection performance standards using the rational method.

The stormwater design adopts a treatment train approach where practicable. Treatment trains take advantage of the strengths of different treatment processes (filtration, sedimentation, biological uptake, infiltration, etc) to treat a wide range of contaminant characteristics (litter, oils, soluble metals, suspended solids, etc).

Swales and stormwater treatment facilities (STF) have been used in tandem to improve the treated water quality, with six stormwater treatment facilities proposed as part of the design, and approximately 2,900 m of treatment swales.

At the preliminary design phase, road runoff from over 90% of the new road surface can be treated before being discharged to the receiving environment, with 35% of road surface area being treated by both swales and wetlands.

Eight cross-drainage culverts will be required to divert existing watercourses and overland flow paths under the proposed road. At this stage it is expected that five culverts will require fish passage for climbing fish species. These cross-drainage culverts have been designed for fish passage using the stream simulation approach, to ultimately enhance, restore, and preserve existing watercourses which will be impacted by the construction of the new road.

Drainage of four stock underpasses and adjacent farm tracks have been considered following coordination with the structures and geometric teams. The drainage of stock underpasses aims to minimise runoff catchment areas from draining through the stock underpasses themselves, with either farm tracks graded in the opposite direction or culverts alongside the underpasses to convey flow where this is not possible.

Next Steps

Further details of the proposed stormwater infrastructure will be prepared at the next design phase. In particular, the following items will be addressed:

- Finalise fish passage and erosion protection requirements at cross culverts with further fish survey site investigations.
- Completion of the stormwater management strategy and coordinate with the overall design team, and include feedback from project stakeholders.
- Complete design to meet ecological requirements regarding mitigating impacts of changing flows on water courses.
- Complete stormwater designs for landscape designers for plant selections in swales and stormwater treatment facilities.
- Complete the 3D design of pond shapes and outlet structures and throttles from flood storage attenuation basins and constructed wetlands to mitigate the effects of increased impervious areas along the proposed road corridor.
- Design accessibility for maintenance, land availability, and fencing for stormwater treatment facilities.
- Confirm Kings Creek bridge drainage, design levels, scour protection and stormwater drainage with bridge designer.
- Confirm Waikare Gorge Bridge stormwater collection with the Bridge Designer and abutment design in order to confirm conveyance connections and finalise locations of the stormwater treatment facilities located on either side of Waikare Gorge.

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Abbreviations

Enter Abbreviation	Enter Full Name
ARI	Average Recurrence Interval
HBRC	Hawke’s Bay Regional Council
HRT	Hydraulic Retention Time
STF	Stormwater Treatment Facility
SH	State Highway
NZTA	Waka Kotahi New Zealand Transport Agency
WQ	Water Quality

1 Introduction

The following report details the proposed stormwater preliminary design for the Waikare Gorge project. The objective of the report is to outline the overall drainage and stormwater management constraints, opportunities and assumptions to support resource consent applications.

Stormwater management can be divided into the following general areas:

- Stormwater quantity – from the road corridor and from natural topographical catchments which are crossed by the road corridor
- Stormwater quality – containment and treatment from the road corridor, and erosion protection
- Wider catchment impacts such as erosion, fish passage, ecological and landscape design considerations.

The project transitions at each end into the existing State Highway 2 (SH2) and is adjacent to the KiwiRail rail corridor stormwater infrastructure and farmland.

Key risks and areas for further study have been identified for further consideration and refinement of details at the next design stage.

Plans of the proposed stormwater preliminary design are included in Appendix A.

1.1 Existing Stormwater Infrastructure

The project site is located west of the township of Putorino, between Napier and Wairoa on SH2.

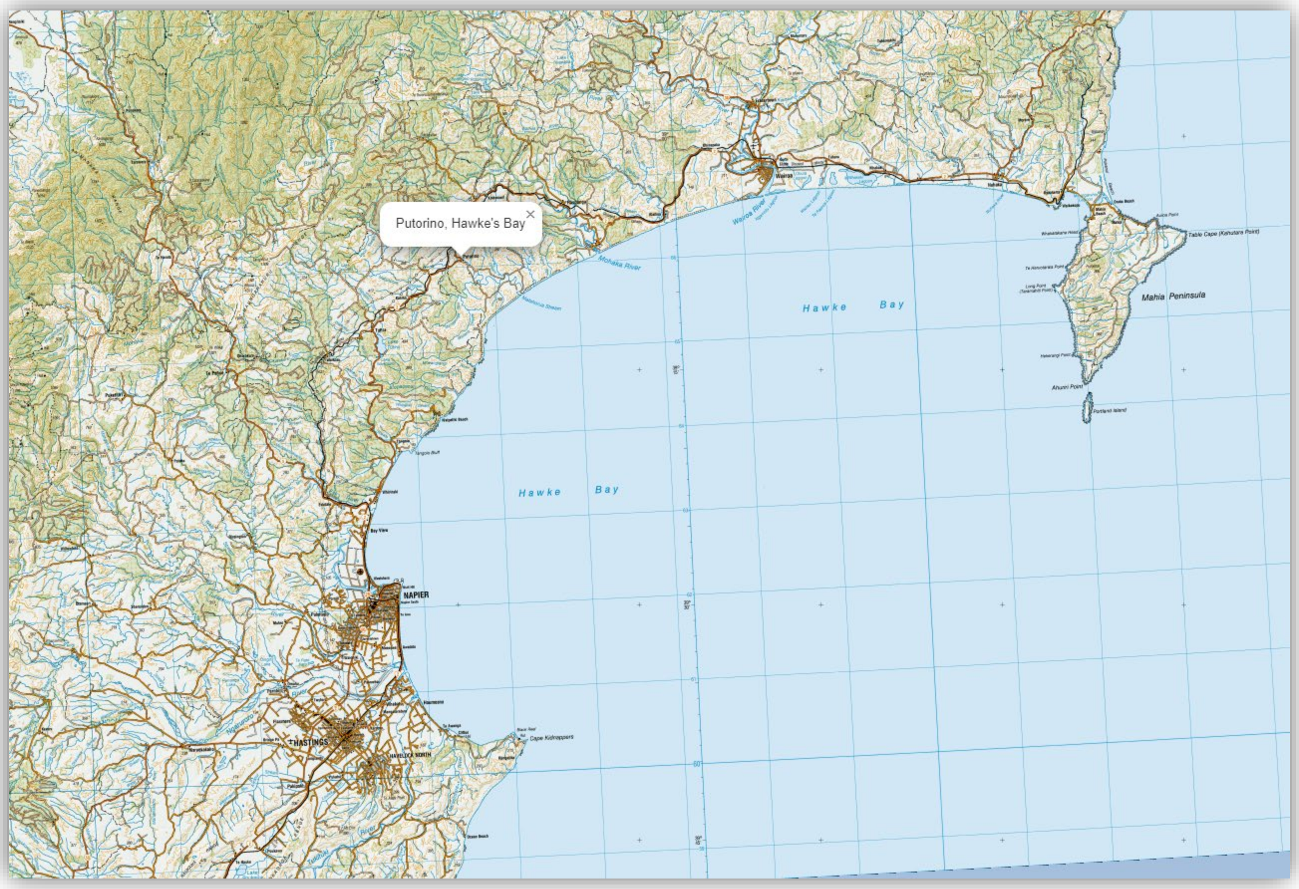


Figure 1-1: Location Plan – Hawkes Bay

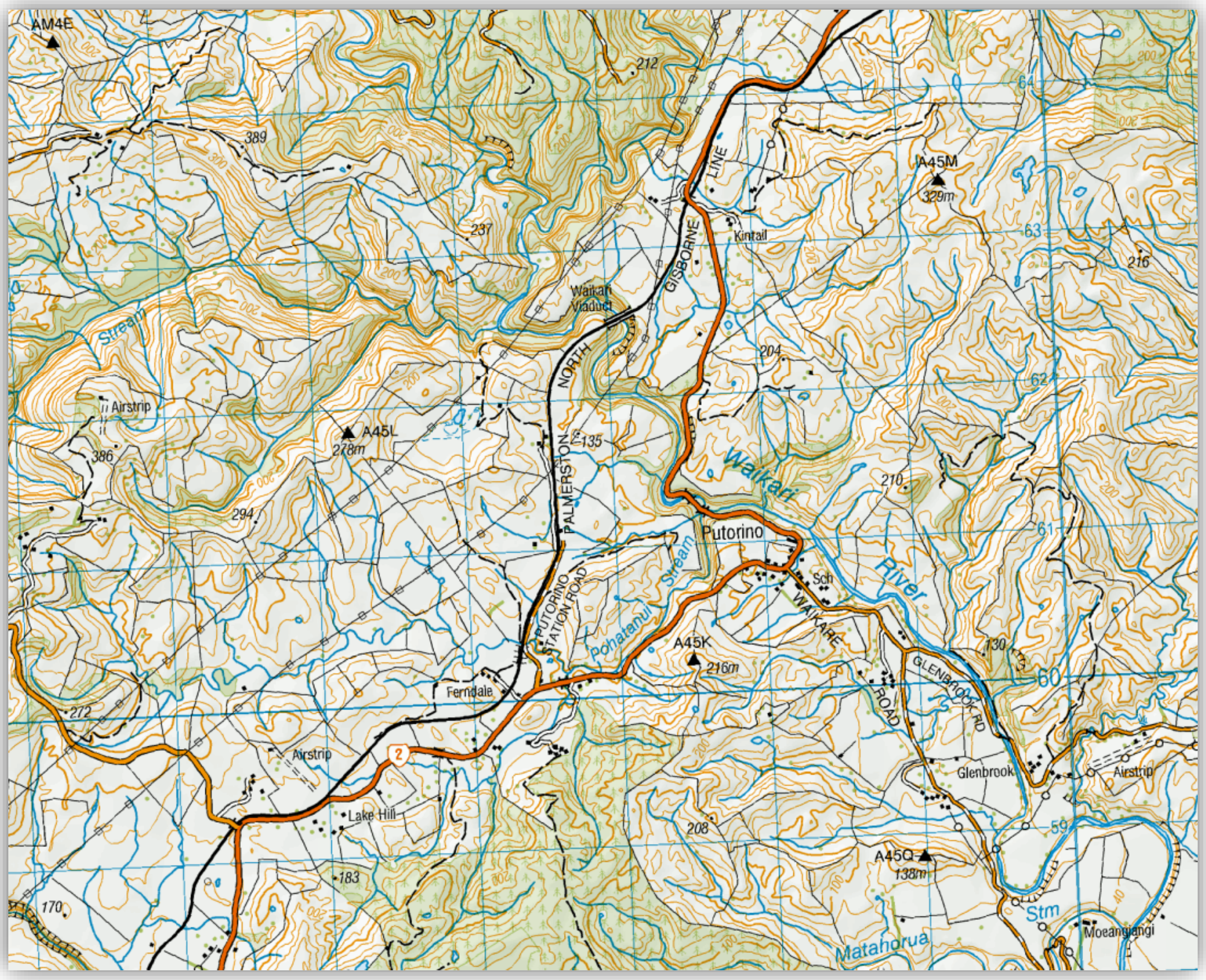


Figure 1-2: Site Plan – showing the Waikari River and the Palmerston North Gisborne Railway Line

The proposed two-lane highway re-alignment will measure approximately 4.4 km over existing farmland and include a significant bridge and passing lane for 1050 m. The two ends of the project extend onto the existing SH2 and the existing road will be retired or used for local access.

There are ten existing watercourses or overland flow paths within the area which the proposed alignment will cross. Most notably of these is the Waikari River and Pohatanui Stream/Kings Creek. There are several existing culverts under farm access tracks in the vicinity of these existing watercourses.

During a site visit in May 2022, an existing fenced off wet area which has been utilised for drainage was observed just south of the Waikare Gorge. Another fenced off existing planted wetland area was also observed at approximately chainage 14300.

The KiwiRail alignment is upgradient at the northern end of the proposed highway alignment for approximately 950 m before crossing over the proposed highway to be down gradient for part of the length.

Within the KiwiRail corridor adjacent to the proposed highway alignment there are several existing cross-drainage culverts. A DN450 culvert under KiwiRail land is located at approximately chainage 12800.

Where the proposed alignment ties into existing SH2 at the northern approach there is an existing roadside drain on the western side of the road. There is also a culvert which conveys flow from an existing watercourse to the western side of the road at chainage 12184 of the proposed alignment.

Where the proposed alignment ties into existing SH2 at the southern approach there are existing roadside drains on both sides of the road. There is an existing side culvert at approximately chainage 15900 and a culvert just past the extents of the design outside #5224 SH2.

1.2 Design Standards and References

The stormwater design is based on the following references:

- P46 Stormwater Specification, 2016, NZTA.
- Stormwater Treatment Standard for State Highway Infrastructure, 2010, NZTA.
- GD01, Stormwater Management Devices in the Auckland Region, 2017, Auckland Council.
- New Zealand Building Code Clause E1 – Surface Water, 2020, Ministry of Business, Innovation & Employment.
- New Zealand River Flood Statistics, https://niwa.maps.arcgis.com/apps/webappviewer/index.html?id=933e8f24fe9140f99dfb57173087f27d, 2018, NIWA.
- Design rainfall from NIWA HIRDS version 4
- Hawke's Bay Waterway Guidelines, 2009, Hawke's Bay Regional Council.
- National Policy Statement for Freshwater Management 2020, New Zealand Government, including Permitted Activity Regulation 70 which relates specifically to fish passage
- New Zealand Fish Passage Guidelines for structures up to 4 metres high 2018, NIWA/DOC
- KiwiRail – Civil Engineering Standard – Culverts, 1 July 2017 C-ST-CU-4103
- KiwiRail – Civil Engineering Standard – Corridor Drainage, 30 June 2016 C-ST-CU-4102
- State Highway 2 Waikare Gorge Realignment Ecological Assessment, July 2022, Stantec.

2 Design Considerations

2.1 Design Approach

The process set out below was followed for the preliminary stage of the SH2 Waikare Gorge stormwater management design:

- Team coordination with ecology, landscaping, consenting, geotechnical, structural, pavements and geometric design to integrate design aspects and outcomes.
- Rationalising stormwater treatment devices/methods identified in the concept design, to further develop infrastructure that fits within the project site constraints and the overall requirements and guidance documents
- Refining stormwater layouts and flow paths and assessing the impacts of changing these on the ecology of the area, such as fish passage and conveyance of runoff away from its original flow path.
- Refinement of sizing of conveyance elements, treatment elements and overflow systems to meet the water quality storm, 10-year ARI amenity, 20-year ARI erosion standards and 100-year ARI flood protection performance standards.

2.2 Key Assumptions

The following key assumptions were adopted for the Preliminary Design:

- Footprint areas of stormwater treatment facilities (STFs) are assumed at 10% of the catchment area serviced. This 10% figure has been derived from experience gained during past projects. This allows for the approximate footprint of a separate forebay, wetland and attenuation storage to mitigate additional runoff and potential erosion issues downstream, as well as maintenance access tracks. When the locations and general footprints have been incorporated into the overall highway design, individual shaping and sizing will be confirmed during the next design stage taking into consideration topography and calculations for detention volumes.
- Where there are earthworks cuts for the proposed road alignment, concrete-lined or standard roadside conveyance swales will be used to minimise width and cut volumes, or there will be kerb and channel with sumps and pipework to convey flow to a stormwater treatment facility.
- Where there are earthworks fills, swales will be positioned at the bottom of the fill to reduce fill volumes.
- Road drainage collection pipework materials and sizing to be confirmed during the detailed design stage
- Road drainage collection catchpit spacings, manholes and locations to be confirmed in the detailed design stage
- Minimising erosion has been the focus of preliminary design
- Upstream and downstream flooding issues have not been specifically addressed here. The mitigating effects of attenuation basin volumes and throttled outlet discharge will be assessed at a later design stage.

2.3 Key Risks, Considerations and Constraints

Key stormwater risks and constraints over the duration of the Project include:

- Erosion control measures at discharge points and culverts
- Erosion and sediment control during construction phases of the project to be managed by an Erosion Sediment Control Plan (ESCP) (expected as a condition of consent)
- Temporary diversion of stream flows and aquatic ecology to allow construction of culverts and highway earthworks
- Establishment of planting in swales and constructed wetlands, and minimisation of invasive weeds
- Consideration of local bird life by avoiding stormwater treatment facilities located on either side of the proposed road to minimise bird crossings.
- Where possible diverting, and not treating, clean paddock runoff has been assumed when sizing wetlands.
- Access to proposed stormwater treatment facilities for maintenance will need to be considered at the next design stage.
- Maintaining an appropriate stream gradient through proposed culverts or channel diversions to match the bed material and minimise increased bed movement

- Potential for geometric design to change as the design process evolves. Changes to the alignment may impact slopes and high points and create new constraints regarding topography and property boundaries.

2.4 Design Criteria

The following design criteria have been selected from Waka Kotahi New Zealand Transport Agency's P46 State Highway Stormwater Specification. Relevant key clauses have been selected from the documents.

Note: Aquaplaning is to be checked during detailed roading design. Initial checks indicate that central drainage is not required, even for the wider sections of road with passing bay and central barrier that has superelevation creating a long flow path for surface flow.

2.4.1 Hydrologic and Hydraulic Criteria

- Rainfall intensities have been derived from HIRDS V4 RCP 8.5 scenario for the period 2081 – 2100.
- For assessment of cross-drainage culverts, NIWA NZ River Flood Statistics were used where available with adjustment to allow for future climate change, calculated considering the increase based on HIRDS V4 RCP 8.5 scenario for the period 2081 – 2100 compared to existing.
- Road surface drainage flow rates have been determined using the Rational method based on a 10-minute time of concentration.

2.4.2 Surface Drainage

- Surface runoff from unpaved areas is designed to be captured and not to flow onto or across a trafficable lane surface.
- Shoulder flow does not encroach on traffic lanes in a 10-year ARI, 10-minute rainfall event.

2.4.3 Stormwater Collection and Conveyance

- All stormwater systems are gravity drainage systems, and do not rely on pumping for operation.
- Open swale drains are preferred for collection and conveyance. At this stage planted swales are preferred over grassed swales, particularly those located at the bottom fills. Liaison with landscape and ecology specialists will be required for plant selection, which must account for longer dry and wet periods with climate change. Grass swales may be considered where mowing is achievable, such as where they are located adjacent to roads.
- Stormwater assets are generally located outside of traffic lanes and if practical, outside of shoulders.
- Primary carriageway drainage systems are designed for at least the 10-year ARI rainfall event with secondary or overflow systems designed for the 100-year ARI rainfall event.
- The minimum pipe diameter is 225mm for sump leads, 300mm for sump leads crossing lanes, and 375mm or larger for main pipes crossing the live lanes.
- All new pipelines crossing the state highway are at an angle greater than 45° to the state highway alignment.
- Manholes are provided at all changes of direction, gradient and pipe size, and junctions.

2.4.4 Stormwater Treatment

- "Clean" stormwater runoff from permeable surfaces (e.g., batters etc.) is diverted away from impervious surfaces where practicable.
- Swales designed as per the swale design elements outlined in NZTA Stormwater Treatment Standard for State Highway Infrastructure Table 8-2.
- Wetlands designed with minimum area of 2% of catchment area, with a length three times the width, based on the HBRC waterway guidelines.
- A treatment train approach has been applied where practicable to treat contaminated road runoff. Treatment trains take advantage of the strengths of different treatment processes (filtration, sedimentation, biological uptake, infiltration, etc) to treat a wide range of contaminant characteristics (litter, oils, soluble metals, suspended solids, etc). In the case of this design, swales and wetlands have been used in tandem where possible.
- Diversion channels for "clean" stormwater runoff from surrounding paddocks have been included to reduce the required area for stormwater treatment facilities.

- It should be noted that the swale design can be modified to account for road safety components such as wire rope barriers. If the swale is constrained by a wire rope barrier, the swale can be designed to be narrower and steeper. However, in general swales should be wide and flat.

The following parameters were assumed for the swale size and water quality calculations:

- Swales were assumed to have a side slope of 6:1.
- Roadside swales, which are constrained by the allowable width of the road corridor, were assumed to have a base width of 0.5 m, as per the design standard cross-section.
- For swale calculations, a Manning's roughness value of 0.25 was used for WQ Storm calculations, and a roughness value of 0.03 was used for the 20-year ARI and 100-year ARI calculations.
- Where the minimum requirement for hydraulic residence time (HRT) for stormwater quality treatment is not met check dams have been used.

2.4.5 Fish Passage

- The requirements for fish passage shall be in accordance with, but not limited to, resource consent requirements, local council guidelines, Freshwater Fisheries Regulation (1983) and the National Policy Statement for Freshwater Management (2020).
- Successful migration of fish species is not disrupted by construction of the new highway through the appropriate design of new culverts and the retrofit of existing culverts to allow for fish passage.
- Reference is made to the Preliminary Ecological Assessment Report, July 2022, that characterize the terrestrial and aquatic environments in the vicinity of the project to determine the likely ecological impact of construction and operation. The report also identifies the likelihood for fish passage requirements at five culvert crossings namely, C12200, C13190, C14200, C14700 and C15290.

2.4.6 Erosion Protection

- To mitigate scour at the interface between culvert and stormwater discharge to natural or man-made waterways, appropriate energy dissipation and erosion control measures shall be incorporated including gradient design.
- 10-year ARI storm velocities will not exceed 1.5 m/s. Where this is exceeded check dams will be required.
- Erosion and scour control measures shall be sized for at least the 20-year ARI storm event. However, if there is a risk that erosion or scour could cause a serious failure with environmental, social or economic consequences, or where access for future maintenance is difficult, a 100-year ARI design standard for erosion protection is to be adopted.

2.4.7 Discharge Attenuation

- To mitigate increased peak discharge and increased runoff volume from the hard surface of the new road, the flow path from the road to the receiving environment will be lengthened through the use of vegetated slopes, vegetated swales, and treatment ponds. Where necessary check dams will be used.
- Ponds will have throttled discharge pipes to reduce the peak discharge from the new road surface to pre-development discharges to protect downstream receiving environment channels from bank and bed erosion.
- Opportunities will be developed where practicable for natural ground soakage along the lengthened flow pathways and in the pond systems to partly mimic pre-development ground infiltration conditions.

3 Proposed Design

3.1 Stormwater Management

3.1.1 Catchments

In total, 54 catchments have been identified along the length of the proposed alignment. These catchments can be separated into two categories;

- Road or corridor catchments where treatment of runoff is required and;
- Cross-drainage or paddock catchments where runoff is considered 'clean'.

There are 34 corridor catchments and 20 paddock catchments in total. Where practicable, paddock or cross-culvert catchments (which do not require treatment) have been separated from the proposed road catchments so that treatment devices do not need to be sized to take the additional flow from non-road catchments.

A summary of the catchment areas, land use and surface types are summarised for the corridor and cross-culvert catchments in Table 3-1 and Table 3-2 respectively. A plan of the stormwater management device catchments is provided in Appendix A, drawing sheet no.010.

Table 3-1 Summary of road or corridor catchments

Catchment No.	Road Area (ha)	Cut Area (ha)	Fill Area (ha)	Total Area (ha)	Catchment No.	Road Area (ha)	Cut Area (ha)	Fill Area (ha)	Total Area (ha)
1	0.166	-	0.095	**0.261**	**13A**	0.191	0.138	-	**0.329**
2A	0.074	-	0.055	**0.129**	**13B**	0.271	0.139	-	**0.410**
2B	0.074	-	0.169	**0.243**	**14A**	0.126	0.185	-	**0.311**
3	0.238	-	0.093	**0.330**	**14B**	0.223	0.021	-	**0.244**
4	0.149	-	-	**0.149**	**15**	0.499	0.271	-	**0.770**
5	0.374	-	-	**0.374**	**16**	0.236	0.266	-	**0.502**
6	0.082	-	-	**0.082**	**17**	0.130	-	0.036	**0.167**
7A	0.289	-	-	**0.289**	**18**	0.285	-	-	**0.285**
7B	0.289	0.096	-	**0.384**	**19**	0.245	-	-	**0.245**
8	0.250	0.204	-	**0.454**	**20**	0.080	-	0.035	**0.115**
9	0.195	0.161	-	**0.356**	**21**	0.272	-	-	**0.272**
10A	0.400	0.260	-	**0.660**	**22A**	0.128	-	-	**0.128**
10B		0.403	-	**0.403**	**22B**	0.128	-	-	**0.128**
11A	0.068	0.060	-	**0.127**	**23**	0.278	-	-	**0.278**
11B	0.053	0.119	-	**0.172**	**24**	0.320	-	-	**0.320**
12A	0.307	-	-	**0.307**	**25**	0.284	-	-	**0.284**
12B	0.246	-	-	**0.246**	**26**	0.423	-	-	**0.423**

Table 3-2 Summary of cross drainage or paddock catchments

Catchment No.	Paddock, Reserve Area (ha)	Cut Area (ha)	Total Area (ha)	Catchment No.	Paddock, Reserve Area (ha)	Cut Area (ha)	Total Area (ha)
P1	2.844	-	**2.844**	**P10**	2.666	-	**2.666**
P2	4.647	-	**4.647**	**P11**	1.883	-	**1.883**
P2.1	-	0.976	**0.976**	**P12**	1.415	-	**1.415**
P3	1.258	-	**1.258**	**P13**	3.761	-	**3.761**
P4	2.075	-	**2.075**	**P14**	0.117	-	**0.117**
P5	1.246	-	**1.246**	**P15**	0.281	-	**0.281**
P6	-	0.757	**0.757**	**P16**	1.757	-	**1.757**
P7	-	0.395	**0.395**	**P17**	1.779	-	**1.779**
P8	0.747	-	**0.747**	**P18**	1.149	-	**1.149**
P9	2.131	-	**2.131**	**P19**	0.216	-	**0.216**

3.1.2 Treatment Swales

Treatment swales will be used to collect and convey road runoff and provide stormwater treatment. Plans of the proposed swales are included in Appendix A sheet no. 0001 - 0006.

Planted swales are preferred over grassed swales, as, when fully established, they provide better water quality treatment and require less maintenance. In particular, planted swales are preferred for swales located at the bottom of areas of fill, as it may be difficult to access these swales for frequent mowing maintenance. Grassed swales may be considered for swales easily accessible for mowing, such as roadside swales. Plants species used for swales need to be chosen considering a range of climate conditions, including extended wet and dry periods. This should be considered at the detailed design phase with input from Ecology specialists.

The hydraulic residence time (HRT) of stormwater in swales needs to be at least nine minutes in order to claim water quality benefits. This calculation is based on conveyance of the water quality storm flow (10mm/hr rainfall intensity) along a 0.5-2.0 m wide trapezoidal channel cross section, with assumed surface roughness of Manning's n = 0.25 over a well-vegetated base, with a flow depth of under 150mm. Some swales require check dams in order to meet the minimum required HRT. Further details on check dams are included in Section 3.1.2.1 below. These swales are marked by an asterisk (*) in Table 3-3 below.

Details of each swale are summarised in Table 3-3 below. Note, STF 2 and STF 3 are not noted as outlet devices for any of the below swales because pipes or concrete lined channels will be used to convey flow to these stormwater treatment facilities.

With the addition of check dams, the majority of these swales will be able to meet the minimum HRT requirements. However, two swales, #8 and #9, are unsuitable due to their steep, longitudinal grades of 13.3% and 11.2% respectively. These swales are located at the bottom of a fill batter slope, and so combined in a treatment train approach will provide some treatment, although not enough to meet requirements. Therefore, the catchments for swales #8 and #9 have been labelled as 'no treatment' provided. A channel lining to minimise erosion will be required, such as Enkamat or another reinforcement or geosynthetic lining.

Table 3-3 Summary of Treatment Swales

Swale #	Chainage (m)	Catchment Area (ha)	Length (m)	Longitudinal Gradient (%)	HRT (minutes)	Outlet Device
1	11946-12070	0.261	124	3.4	10.81	STF 1
2A*	12070-12180	0.129	110	3.8	8.15	STF1
2B	12070-12180	0.243	110	5.2	13.03	STF1
P1	-	2.844	350	2.4	N/A	Existing Watercourse ch. 12170
3*	12180-12324	0.330	144	6.8	5.98	Existing Watercourse ch. 12170
4	12324-12414	0.149	90	2.6	9.92	Proposed culvert ch. 12350

Swale #	Chainage (m)	Catchment Area (ha)	Length (m)	Longitudinal Gradient (%)	HRT (minutes)	Outlet Device
P2 + P2.1**	-	4.647	406	3.0	N/A	Existing DN450 KiwiRail culvert
8*	13060-13188	0.454	128	13.3	5.90	Existing Watercourse ch. 13200
9*	13188-13288	0.356	100	11.2	4.62	Existing Watercourse ch. 13200
P4**	-	2.075	216	6.0	N/A	Existing Watercourse ch. 13200
P5	-	1.246	222	1.9	N/A	To paddock
14A	14050-14244	0.311	194	2.1	20.98	STF4
14B	14050-14244	0.244	194	2.1	13.15	STF 4
P6	-	0.757	186	3.5	N/A	To paddock
P7	-	0.395	166	6.0	N/A	Existing Watercourse ch. 14200
15	14244-14500	0.770	256	2.0	34.38	STF 4
P8	-	0.747	53	3.8	N/A	Existing Watercourse ch. 14200
16	14500-14643	0.502	143	1.4	12.20	STF 4
17*	14643-14722	0.167	79	1.3	8.35	Existing Watercourse ch. 14700
P9	-	2.131	570	0.5	N/A	Existing Watercourse ch. 14700
18	14722-14900	0.285	178	0.6	20.18	STF 5
19	14900-15040	0.245	140	0.7	17.44	STF 5
20*	15040-15090	0.115	50	2.0	6.50	Existing Watercourse ch. 15045
P10	-	2.666	202	0.5	N/A	Existing Watercourse ch. 15045
21+P12	15090-15260	1.687	170	1.8	14.58	Existing Watercourse ch. 15290
P11	-	1.883	227	0.5	N/A	Existing Watercourse ch. 15290
22A	15260-15420	0.128	160	0.6	24.07	Existing Watercourse ch. 15290
22B	15260-15420	0.128	160	0.6	24.07	Existing Watercourse ch. 15290
P13	-	3.761	327	0.4	N/A	Kings Creek
24+P15	15594-15840	0.601	246	1.2	15.51	STF 6
P14	-	0.117	80	1.6	N/A	Kings Creek
25+P16	15990-15840	2.041	181	0.6	24.16	STF 6
P17	-	1.779	175	1.3	N/A	Overland Flow Path
26+P18	15840-16165	0.638	325	0.1	16.76	Existing roadside drain at southern tie in
P19	-	1.149	192	0.1	N/A	Existing roadside drain at southern tie in

***=check dams to lengthen HRT; **=check dams for erosion control.**

Currently proposed swale 4b captures a small catchment in a low spot between the proposed road and the railway corridor. This flow could either be directed to the western side of the road via a culvert or allowed to soak away on the eastern side of the road.

3.1.2.1 Check Dams

Check dams are proposed to lengthen the HRT for swales where the minimum HRT is not met due to the length of the swale being too short or the grade too steep. Check dams are also required for swales which have a velocity greater than 1.5 m/s in a 100-year event. As per Table 3-3, six swales will require check dams. These are treatment swales 2A, 3, 17 and 20 to increase HRT and paddock diversion drains P2 + P2.1 and P4 to reduce velocity in a 100-year event. A summary of the number of check dams required for the proposed swales is summarised in Table 3-4 below.

It has been assumed that the check dams will have a height of 0.45 m and a downstream side slope of 2:1 (H:V). Typical details on the check dams are included in the drawings in Appendix A, sheet no. 0012. Design of the check dams will be finalised at the next design phase.

Table 3-4 Summary of required check dams.

Swale #	No. of check dams required	Check dam spacing (m)	Revised HRT (minutes)	Comments
2A	9	12	38.71	HRT without check dams 8.15 mins
3	11	8	38.73	HRT without check dams 5.98 mins
P2 + P2.1	30	12	N/A	Reduce velocity in 100-year event
P4	17	8	N/A	Reduce velocity in 100-year event
17	3	24	97.10	HRT without check dams 8.35 mins
20	4	12	94.42	HRT without check dams 6.50 mins

3.1.3 Concrete Channels in Cut Slopes

Coordination discussions with the wider team has raised the issue of runoff from cut slopes flowing across the road carriageway in areas of superelevation. The proposed solution is to have concrete channels at the bottom of the cut faces to intercept runoff before it reaches the carriageway. In these sections of cut the concept stormwater infrastructure was kerb and channel with a pipe system to convey flow to the receiving stormwater treatment facility. The concrete channel would be able to replace this infrastructure.

Concrete channels have been proposed for the two large sections of cut on either side of the Waikare Gorge (ch. 13300-13550 and ch. 13850-14050). Assuming a 3 m width between the edge of the road and the cut surface, a 0.3 m deep channel is required to allow capacity for a 100-year event. A standard detail of the channel is included in the drawings in Appendix A, sheet no. 0011.

3.1.4 Vegetated Fill Batter Slopes

Where feasible, vegetated fill batter slopes with sheet flow conditions will be used as a method of treatment in conjunction with swales and stormwater treatment facilities. In areas where the road alignment requires fill, runoff from the adjacent road area can be directed down the batter slopes to a swale. This will require slope controls and established vegetation to be in place to ensure that flows do not become too concentrated but remain as sheet flow down the slope as far as possible. It should be noted that treatment guidelines require nine minutes of travel time down the slope surface for treatment benefit and this is unlikely in this project. However, if concentrated flows can be avoided, vegetated fill slopes can be used in conjunction with swales and stormwater treatment facilities in a treatment train approach. This means that some treatment will be provided, even with a travel time of less than nine minutes down a slope and will be a positive contribution when combined with the other treatment methods.

Travel times for sheet flow runoff directed down fill slopes have not been calculated at this stage of the design, due to potential design changes which will impact on the proposed fill batter slopes required, and the treatment train approach proposed. However, this will be considered at a later design phase.

3.1.5 Proposed Stormwater Treatment Facilities

The concept stormwater design proposed thirteen stormwater treatment facilities (STFs) for the project. This number has been rationalised to six STFs at the preliminary design phase. STFs incorporate a forebay area, attenuation basin and constructed wetland, along with area for landscape planting and maintenance access. The schematic presented in Figure 3-1 below shows a diagram of where flow is directed in the stormwater treatment facility, and an example STF plan is provided in Appendix A. A forebay is provided to allow for settlement of the majority of solids and will require more frequent maintenance to remove this material. Higher frequency rainfall will be directed from the forebay to the wetland for treatment and then to the storage pond for attenuation of peak flows. In storms with lower frequency, larger rainfall, flows will bypass the wetland through to the pond.

The footprint areas of the STFs are based on 10% of the catchment draining to the STF. This includes the forebay, pond and wetland areas, as well as maintenance access tracks. A depth of 1.6 m has been assumed from invert level to top of the embankment.

Plants species used for the stormwater treatment facility wetlands need to be chosen considering a range of climate conditions, including extended wet and dry periods. This should be considered at the detailed design phase with input from ecology and landscaping.

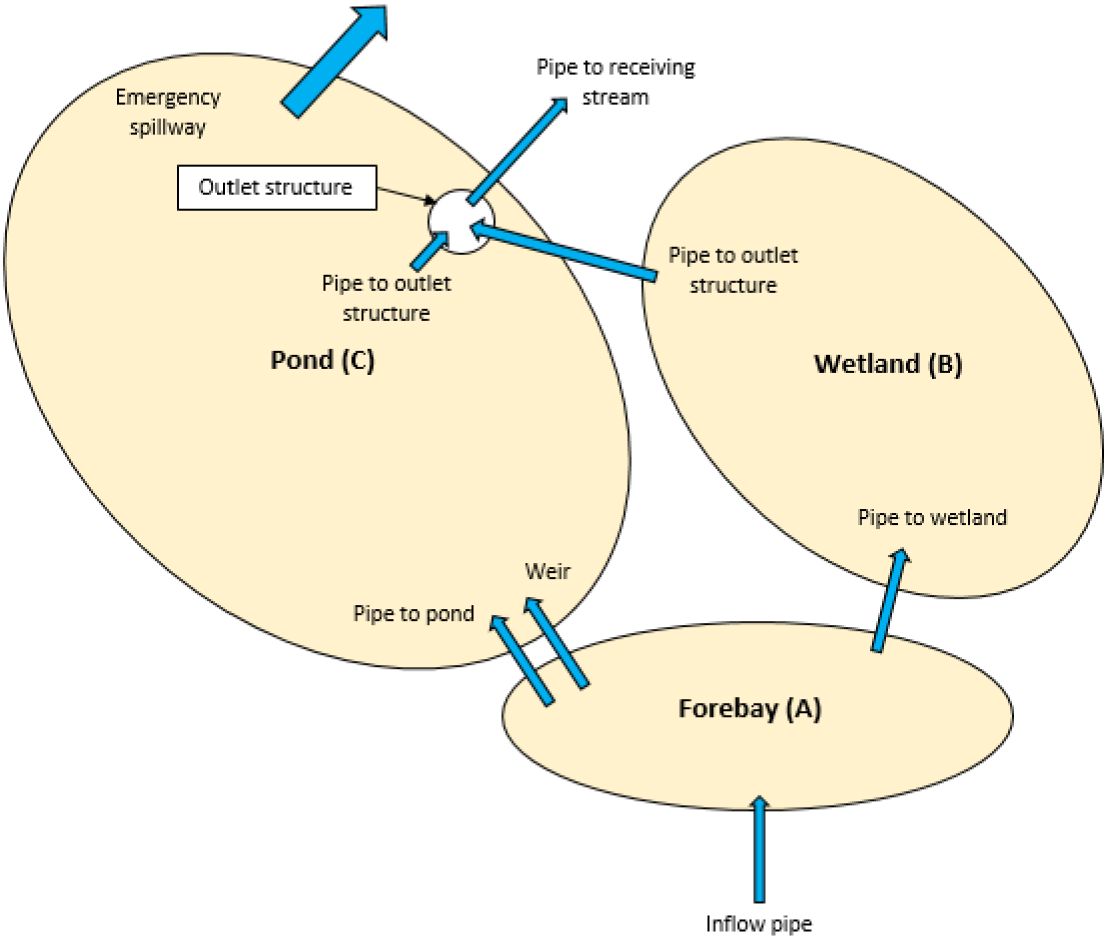


Figure 3-1 Conceptual STF with flow directions between forebay, wetland and pond areas

A summary of each of the treatment facilities is given in Table 3-5. All the treatment facilities are located along the proposed alignment and are shown as polygons in the photographs and drawings to provide an indicative location of the STF’s. Accessibility for maintenance, land availability, and fencing of these areas will need to be considered in future design stages.

Table 3-5 Summary of Stormwater Treatment Facilities

Stormwater Treatment Facility Number	Approximate Chainage Location (m)	Highway Catchment Area (ha)	Paddock/Cut/Fill Catchment Area (ha)	Approximate Footprint Area (ha)**
1	12150	0.314	0.319	0.063
2	13100	1.034	1.353	0.239
3	13600	0.520	0.842	0.136
4	13800	2.099	1.020	0.312
5	14700	0.530	0.000	0.053
6	15600	0.882	2.038	0.292

** STF area is based on 10% of the catchment area draining into the STF. This area incorporates maintenance access tracks.

3.1.5.1 Stormwater Treatment Facility 1

Proposed STF1 is located at chainage 12150 on the western side of the proposed alignment, indicated in Figure 3-2 below. STF 1 discharges into the existing water course at chainage 12150. The STF will be located at the top of a bank, and a lined outlet channel will be required to direct the treated runoff to the watercourse. Further details of this channel are given in Section 3.1.6. STF 1 is located within an area currently accessible by livestock and will need to be fenced off to ensure treated water quality.

Currently, proposed swale 2B located on the eastern side of the proposed road alignment, near the northern tie in, is directed via a culvert to STF 1 located on the western side of the proposed road alignment at approximate chainage 12150. A proposed overflow drain on the eastern side of the road allows flow from 2B to be directed straight to the existing watercourse in a high flow event. Alternatively, if a culvert is not desirable swale 2B could be directed straight to the existing watercourse in the direction of the overflow drain.

To reduce the footprint of the proposed wetland, a “clean” water diversion drain (P1) will be put in place to collect runoff from the surrounding paddocks and convey direct to the existing watercourse.

An existing culvert located at approximately chainage 12000 conveys flow to the west of the existing road. Currently, the design does not utilise this culvert, and instead conveys road runoff from approximately chainage 11750 to STF 1, to provide the best level of treatment. Potentially this culvert could be used to direct flow from chainage 11750 – 12000 to the western side of the road as per the existing arrangement. This would decrease the catchment of STF 1 to the point that it would be redundant and can be deleted.

The remaining catchment would be collected via treatment swale and discharged directly to existing watercourse. This would also mean the proposed paddock diversion drain P1 would not be necessary. This option should be considered at the next design phase, following feedback from project stakeholders if a lesser standard of treatment is acceptable at the northern tie-in section of the project.

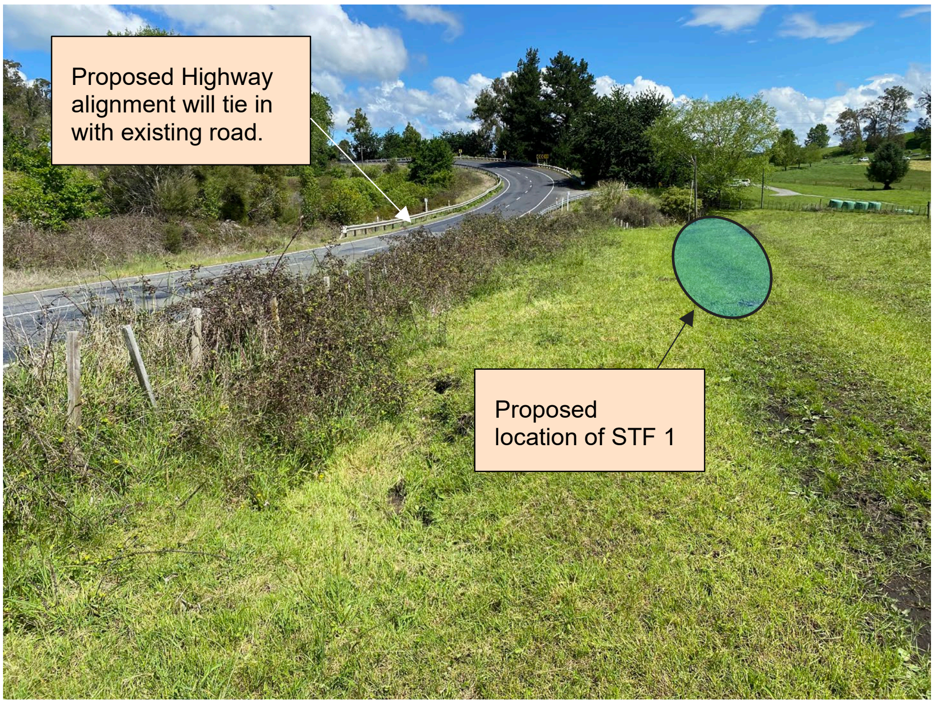


Figure 3-2 Proposed location of STF 1 (not to scale)

3.1.5.2 Stormwater Treatment Facility 2

Proposed Stormwater Treatment Facility Two (STF 2) is located approximately at chainage 13100 on the western side of the proposed alignment. Flow from highway catchments 5, 6 and 7 will be collected and piped to STF2 in order to convey flow over the proposed KiwiRail overpass.

STF 2 discharges into the existing water course which crosses the alignment at approximately chainage 12800. STF 2 is located within an area currently accessible by livestock. The area will need to be fenced off to ensure treated water quality. See approximate location of STF2 in Figure 3-3 below.

The location of STF 2 means that treated runoff will needed to be directed down a relatively steep embankment to the receiving watercourse, requiring a lined outlet channel. Further details of this channel are given in Section 3.1.6

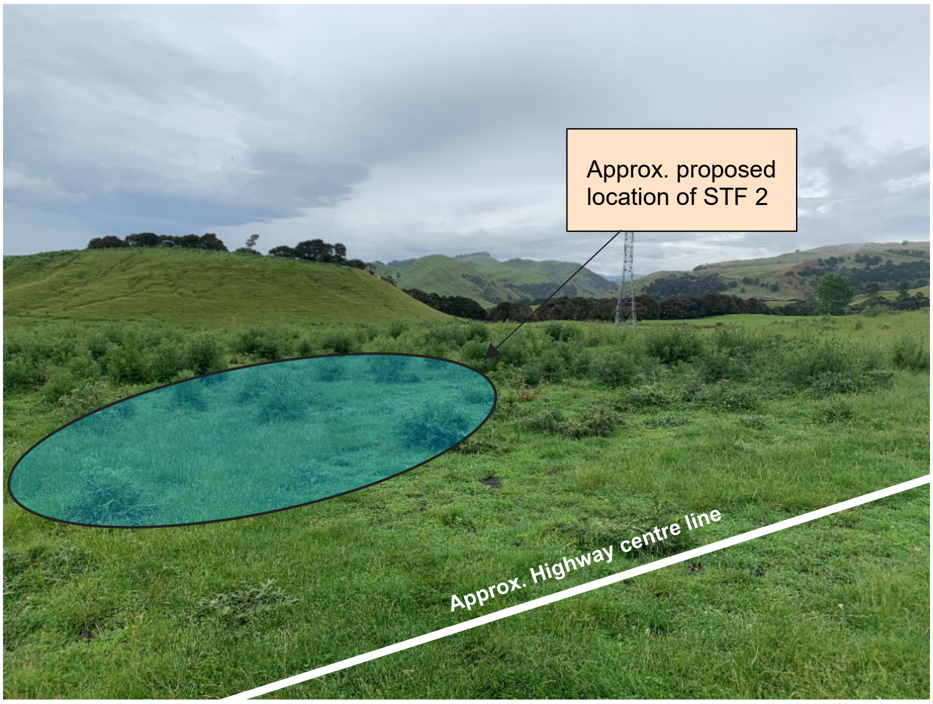


Figure 3-3 Proposed location of STF 2 (not to scale).

3.1.5.3 Stormwater Treatment Facility 3

Proposed STF 3 is located approximately at chainage 13600 on the western side of the proposed alignment, on the northern side of the proposed Waikare Gorge bridge. Runoff from catchments 10 and 11 will be collected by kerb and channel and conveyed via pipe system, or by concrete channel (refer to Section 3.1.3) to STF 3. STF 3 will discharge into the existing watercourse which crosses the proposed alignment via the culvert at chainage 13190. The exact location of STF 3 will be confirmed with the bridge abutment design, to ensure these do not clash.

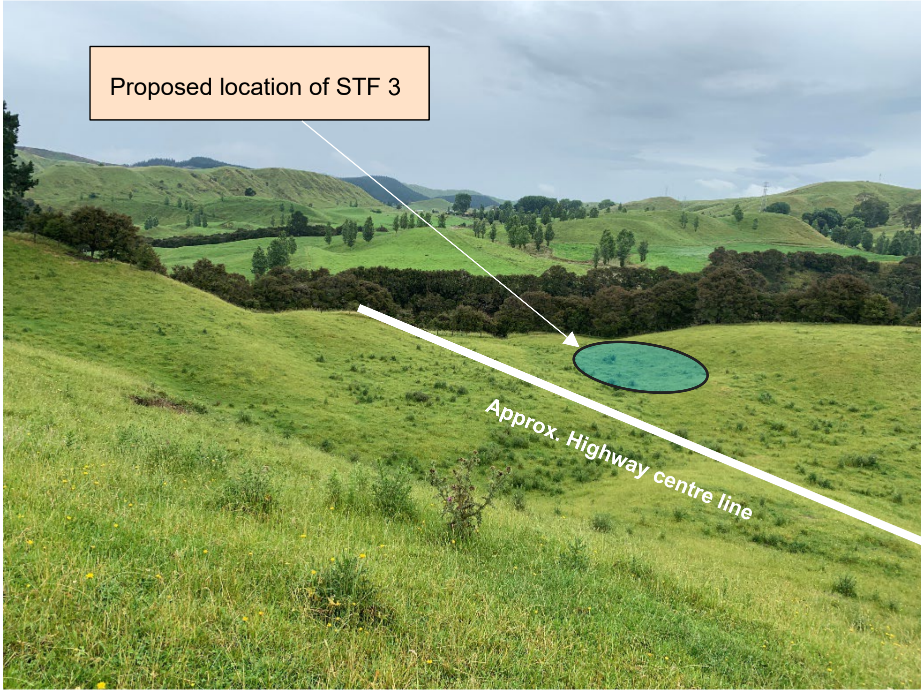


Figure 3-4 Proposed location of STF 3 (not to scale)

3.1.5.4 Stormwater Treatment Facility 4

Proposed Stormwater Treatment Facility Four (STF 4) is located at approximately chainage 13800 on the south-western side of the proposed Waikare Gorge bridge. STF 4 will utilise an existing 6000 m^2 wet area (Figure 3-5) which has been fenced off by the property owners. This was discussed with the property owners as an alternative to a STF proposed at concept design which was located on otherwise useable land.

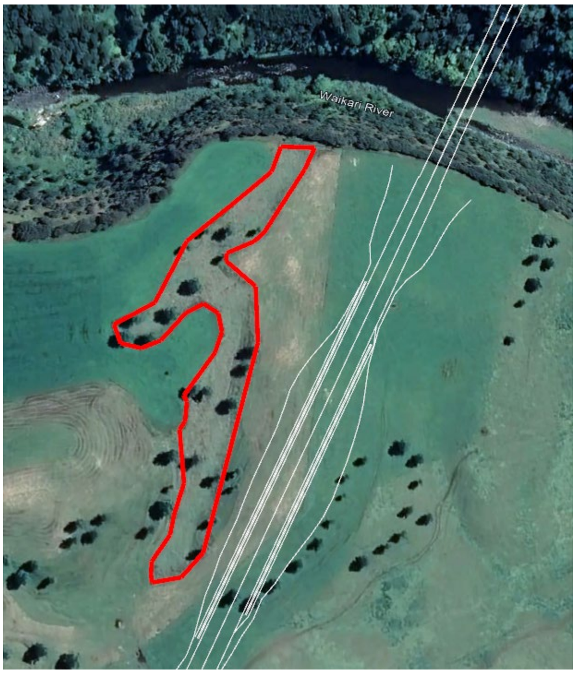


Figure 3-5 Approximate location of existing wetland.

As part of the design this wet area has been expanded to provide adequate treatment and detention facilities. A concept layout was developed, considering a forebay area, treatment area of about 0.5 m deep and a detention area about 1 m on top of that. A low point in the vertical alignment at chainage 13850 influences the inlet structure and wetland levels. The wetland's outer boundary has minimal flexibility to expand as the hilly surrounds will result in major earthworks.

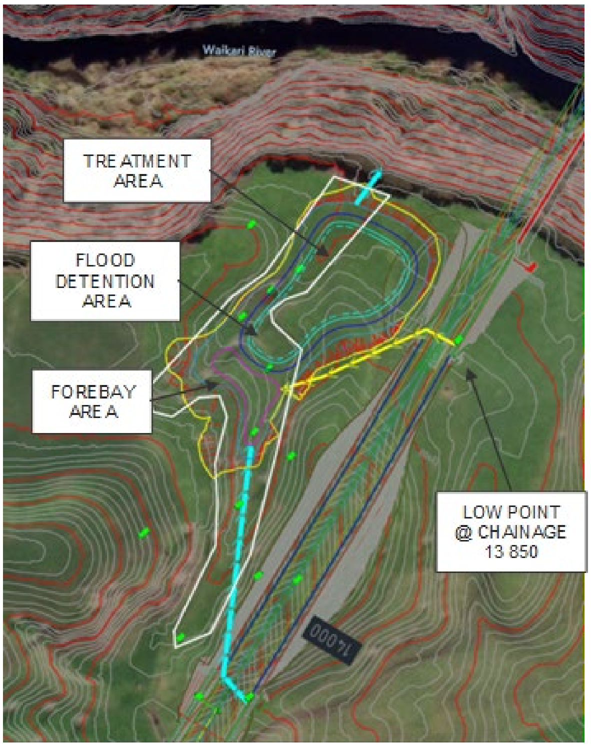


Figure 3-6 Proposed concept design of STF 4.

The outlet for this STF is directly to Waikare Gorge and will result in additional flow to the Waikare River from a concentrated point. This concentration in flow may cause erosion issues with flow being directed down the banks of the gorge. Rip rap at the STF outlet to disperse flow over a wider area will be utilised to mitigate erosion. Standard details showing the STF outlet structure with erosion protection is shown in in Appendix A, sheet no. 0015.

Figure 3-7 Existing fenced wet area to be utilised as part of STF 4.

STF 4 will service road catchment areas. Runoff from catchment 13 to be collected and conveyed via pipe (or concrete lined channel, see Section 3.1.3) to STF 4, and catchments 14, 15 and 16 collected via treatment swale. Runoff from the Waikare Gorge bridge (catchment 12) will also be conveyed to STF 4 for treatment. Details on how drainage will be conveyed from the bridge to STF 4 will be coordinated with the Bridge Designer.

3.1.5.5 Stormwater Treatment Facility 5

Proposed Stormwater Treatment Facility Five (STF 5) is located approximately at chainage 14700 on the western side of the proposed alignment. Flow from catchment 18 and 19 will be conveyed via treatment swale to STF 5, which will have an outlet to the existing watercourse which crosses the road alignment via the proposed culvert at chainage 14700. STF 5 is located within an area currently accessible by livestock. The area will need to be fenced off to ensure treated water quality.

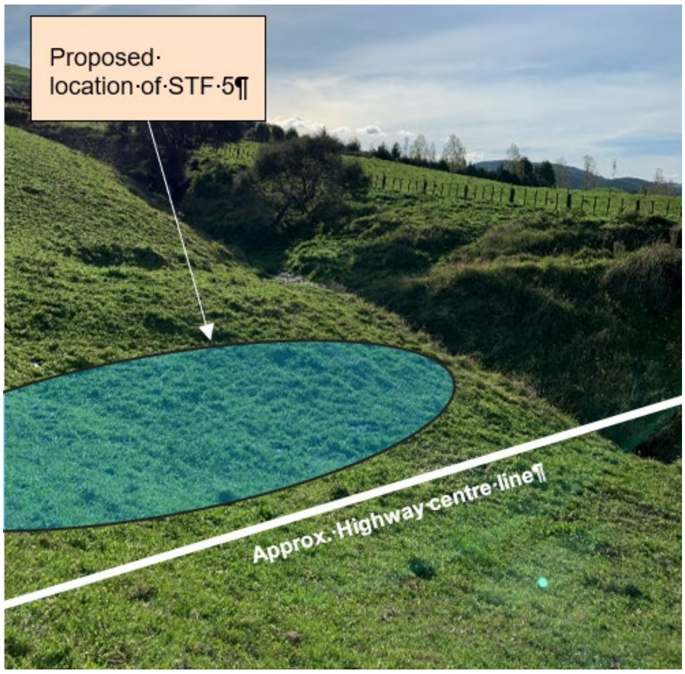


Figure 3-8 Proposed location of STF 5 (not to scale)

3.1.5.6 Stormwater Treatment Facility 6

Proposed Stormwater Treatment Facility Six (STF 6) is located approximately at chainage 15600 on the eastern side of the proposed alignment, and will have an outlet to Pohatanui Stream/Kings Creek, which the proposed alignment will cross via bridge at approximately chainage 15550. Runoff from catchments either side of Pohatanui Stream/Kings Creek will be conveyed to STF 6. From the north, runoff from catchment 23, which includes the Pohatanui Stream/Kings Creek Bridge will be conveyed to the STF. Coordination with bridge designers will be required to finalise how flow will be conveyed across the bridge, and further details are provided in Section 3.5. From the south, road catchment 24, 25, 26 and paddock catchments P15 and P16 will be conveyed to STF 6 via treatment swale. STF 6 is located within an area currently accessible by livestock. The area will need to be fenced off to ensure treated water quality.

The location of STF 6 at the top of an embankment means that a lined outlet channel will be required to direct treated runoff down to the receiving watercourse. Details of this lined outlet channel are further detailed in Section 3.1.6. Standard details showing the STF outlet structure with erosion protection is shown in in Appendix A, sheet no. 0015.

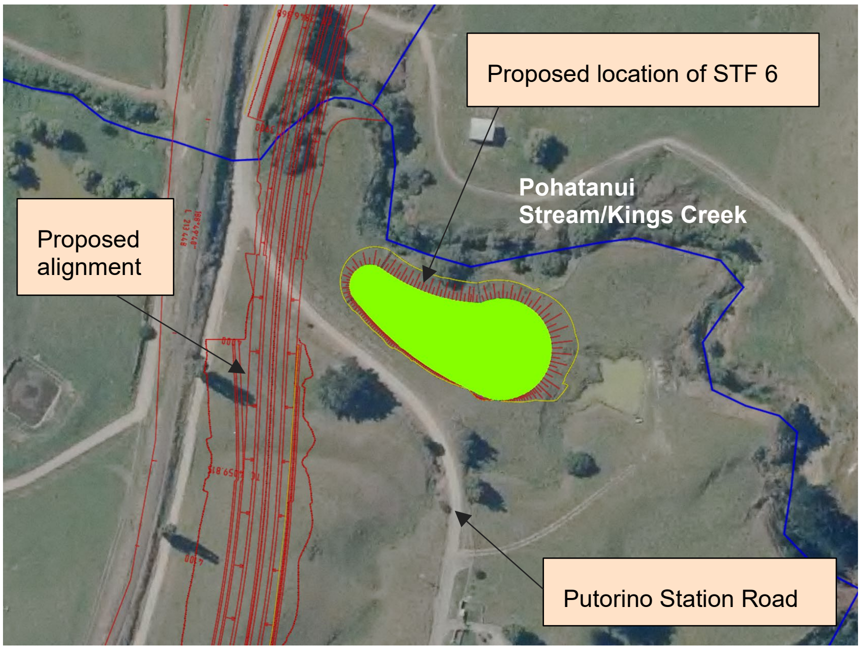


Figure 3-9 Proposed location of STF 6

3.1.6 Lined Outlet Channels

The stormwater treatment facilities will require lined outlet channels to convey treated runoff to the receiving watercourses. Materials such as Enkamat or another reinforcement or geosynthetic lining should be used to ensure erosion is minimised. Details of these lined channels are summarised in Table 3-6 below. The channels were designed considering peak flows and assuming a base width of 2 m and side slopes of 1:6 (H:V). These in conjunction with appropriate erosion protection at the outlet point will mitigate erosion. Standard details showing the STF outlet structure with erosion protection is shown in in Appendix A, sheet no. 0015.

Table 3-6 Summary of lined outlet channels for each of the STFs.

STF	Receiving watercourse	Length (m)	Longitudinal Grade (%)	Velocity (m/s) (20-year AEP)	Velocity (m/s) (100-year AEP)
1	Existing watercourse C12150	22	31.8	1.856	2.106
2	Existing watercourse C12815	31	35.5	2.996	3.365
3	Existing watercourse C13190	21	17.0	1.916	2.157
4	Waikare Gorge	15	16.7	2.686	2.995
5	Existing watercourse C14700	16	11.9	1.433	1.617
6	Pohatanui Stream/Kings Creek	35	26.9	2.754	3.089

3.1.7 Road Runoff Treatment

Where practicable, a treatment train approach has been used, which involves bringing diverse contaminant capture strategies together in series to treat a wide range of contaminant types. Where possible, swales, battered fill slopes and stormwater treatment facilities have been used together to improve water quality.

At this preliminary stage of design, we anticipate stormwater runoff from 94% of the new road surface area can be treated to some extent before discharge into the receiving environment. The breakdown of treatment at this stage is:

- 36% by treatment swale and treatment facility
- 18% by treatment swale only
- 40% by treatment facility only
- 6% no treatment.

Where possible road runoff has been directed to a treatment facility before being discharged to a receiving watercourse, which is achieved for 76% of runoff area from the project.

As noted above, 18% will be collected and conveyed by a treatment swale directly to a watercourse. These swales will look to be enhanced at the next design phase, by increasing the level of treatment provided and/or increasing attenuation of flows. This could be achieved using wetland swales.

3.1.8 Change of Catchment for Existing Watercourses

The proposed stormwater design will create changes to the volume of run-off directed towards existing watercourses along the length of the proposed alignment. The two main reasons for this are changes in land usage and conveyance of run-off.

Changing predominately farmland to impermeable road surface will increase run-off volumes to existing watercourses by reducing natural ground soakage volumes.

The collection and conveyance of road runoff to stormwater treatment facilities will impact on the catchments of existing watercourses by either a reduction in catchment area due to the road corridor footprint or an accumulation of catchment areas at pond locations. Runoff which falls to a particular watercourse pre-construction may be conveyed to another post-construction, potentially impacting on the ecology of both watercourses depending on the scale of the catchments that are affected.

Changes to the catchment areas pre- and post-construction, and changes to both 10-year and 100-year flows are summarised in Table 3-7, Table 3-8 and Table 3-9 below respectively. It should be noted that the values presented do not consider attenuation of flow as will be provided by the stormwater treatment facilities. This means that the values presented are more of a worst-case scenario, if there were no provisions for attenuation.

It should be noted that the watercourses that cross the alignment at chainages C12815, C15045 and C15830 have not been included in the below tables because these are overland flow paths where runoff from surrounding paddock areas falls to during wet periods and do not have significant upstream catchments. Surrounding paddock catchments will still fall towards these overland flow paths, however any road catchments will be conveyed away to stormwater treatment facilities.

Waikare River has not been included as it is assumed that any changes to catchments or flows will be insignificant when compared to its large catchment area.

Table 3-7 Changes to catchment size pre- and post-construction

Road chainage	Watercourse name	Catchment area pre-construction (ha)	Catchment area post-construction (ha)	Change in catchment area (ha)	Percentage change in area (%)
C12220	Anaura Stream Tributary	70.9	70.9	0.0	0.0
C13190	Waikare River Tributary	140.7	140.5	-0.2	-0.2
C14200	Waikare River Tributary	20.2	18.4	-1.8	-9.1
C14700	Waikare River Tributary	35.8	36.1	0.3	0.7
C15290	Pohatanui Stream Tributary	10.8	10.9	0.1	1.2
C15550	Pohatanui Stream/Kings Creek	493.3	495.9	2.6	0.5

Table 3-8 Changes to 10-year flows pre- and post-construction

Road chainage	Watercourse name	10-year flow pre-construction (m^3/s)	10-year flow post-construction (m^3/s)*	Change in 10-year flow (m^3/s)*	Percentage change in 10-year flow (%)*
C12220	Anaura Stream Tributary	4.11	4.13	0.02	0.4
C13190	Waikare River Tributary	8.19	8.45	0.26	3.2
C14200	Waikare River Tributary	3.79	3.65	-0.14	-3.7
C14700	Waikare River Tributary	2.07	2.21	0.14	7.0
C15290	Pohatanui Stream Tributary	1.49	1.60	0.11	7.4
C15550	Pohatanui Stream/Kings Creek	18.56	18.98	0.42	2.3

*** Note that these values do not consider attenuation**

Table 3-9 Changes to 100-year flows pre and post construction *not considering attenuation

Road chainage	Watercourse name	100-year flow pre-construction (m^3/s)	100-year flow post-construction (m^3/s)**	Change in 100-year flow (m^3/s)**	Percentage change in 100-year flow (%)**
C12220	Anaura Stream Tributary	6.90	6.93	0.03	0.4
C13190	Waikare River Tributary	13.51	13.95	0.44	3.3
C14200	Waikare River Tributary	6.29	6.055	-0.24	-3.7
C14700	Waikare River Tributary	3.48	3.72	0.24	7.0
C15290	Pohatanui Stream Tributary	2.46	2.65	0.19	7.6
C15550	Pohatanui Stream/Kings Creek	30.78	31.49	0.71	2.3

**** Note that these values do not consider attenuation**

It should be noted that the flows presented in the tables above indicate the total change in flow being directly discharged to the receiving watercourse. In the case of Pohatanui Stream/Kings Creek, previously some of this flow would have been discharged to a tributary watercourse and so would have entered the river/stream indirectly at some point pre-construction, although this volume will have increased due to surface changes.

From Table 3-7 changes to water course catchments range from -9.1% to 1.2%. The watercourse at chainage 14200 has the largest decrease in catchment at -9.1%, with road catchments being directed away from the watercourse to STF 4. However, 10-year and 100-year flows only decrease by 3.1% and 3.2% respectively due to a cut face increasing the gradient of the catchment and therefore decreasing the volume of runoff able to soak away. Pohatanui Stream/Kings Creek sees the greatest increase in catchment by hectare, however due to the large overall size of the catchment the percentage change is only 0.5%.

From Table 3-8 changes to 10-year flows ranges from -3.7% to 7.4%. The greatest increase of 7.4% was seen at the watercourse at chainage 15290, a tributary of Pohatanui Stream/Kings Creek. The catchment for this tributary did not see a significant increase, at just 1.2%. It is therefore assumed that the increase in flow is mainly attributed to the increase in impervious surface due to the construction of the road. This is similar to the watercourse at chainage 14700 which saw an increase in flow of 7.0% due to an increase in impervious surface as the catchment size only increased by 0.7%. Pohatanui Stream/Kings Creek increased by the largest amount per m^3/s, however again due to its larger catchment this only resulted in a percentage increase of 2.3%.

From Table 3-9 it can be seen that changes to 100-year flows are similar to what is seen for the 10-year flows, with changes ranging from -3.7% to 7.6%. The watercourses at chainages 15290 again had the highest percentage increase in flow (7.6%), and Pohatanui Stream/Kings Creek the highest increase per m^3/s (0.7 m^3/s).

Overall, the runoff volumes directed to watercourses will increase post-construction. In addition to this, the conveyance of runoff to STFs means that flow which in pre-construction conditions entered the watercourse over a dispersed area will be concentrated to the STF outlets. As described in Section 3.1.5 above, STFs incorporate ponds which provide attenuation of peak flows. The attenuation ponds will be sized to minimise the impacts of changes to catchments and runoff volumes. The STF outlets will also be throttled to further control flow directed to the watercourses. These measures will reduce post-development flows being directed to watercourses back down to pre-development flows.

Design of the stormwater treatment facilities, including attenuation ponds and outlet structures, will be carried out at the detailed design phase. Overall, the environmental effects from catchment run-off is considered to be minor. The minor effects, amongst other things, will be addressed through various sized attenuation ponds to minimise the impacts of changes to catchments and runoff volumes. Through careful design run-off flows to watercourses will be at pre-development flows. To allow for a reasonable and flexible approach to respective STF design, the detailed design phase will be addressed through the codification of criteria and / or parameters through consent conditions. Aside from this preliminary design considerations outlined in this report, criteria and / or parameters will be reliant on those additional matters addressed in the Ecology Report.

3.2 Cross-Drainage Culverts

The proposed alignment will cross ten existing watercourses or overland flow paths within the project extents. The two most significant watercourses are the Waikare River and Pohatanui Stream/Kings Creek which will be spanned by bridges. The other eight watercourses/flow paths will be culverted under the proposed road. The cross-drainage culvert design has considered both hydraulics and fish passage, addressing both erosion potential and fish passage requirements. The ultimate aim of the cross-drainage culvert design is to enhance, restore and preserve existing watercourses which will be impacted by the construction of the new road.

Five cross culverts have been identified as requiring fish passage based on catchment areas, existing watercourse topography, the nature of the watercourse and with reference to the Ecological Assessment Report, dated July 2022. Modelling of the culverts was undertaken using HY-8, a culvert analysis program by the U.S. Department of Transportation Federal Highway Administration (FIWA). This tool was used to calculate velocities and water levels at the headwaters, tailwaters and through the culverts.

In addition to the cross-drainage culverts, other culverts include existing and proposed farm access and stock underpass culverts, road drainage culverts, and proposed culverts as part of road stormwater design. These are covered in separate sections of this report.

Plans of the cross-culvert catchments are provided in sheet 10 of the stormwater plans, which are included in Appendix A.

3.2.1 Upstream Catchments

The existing upstream catchment information for each of the watercourses which are intended to be culverted under the proposed alignment is summarised in Table 3-10 below. This includes the catchment area, stream name, design flows and whether fish passage is required. This information was used to inform the design of the eight cross-drainage culverts. Flood level considerations for the proposed bridge of the Pohatanui Stream (Kings Creek) are covered in a separate memo in Appendix B.

The watercourse which intercepts the proposed alignment at chainage 12200 is already culverted under the existing SH2, near the northern tie in-for this project. This culvert has been considered in the design process as there is potential to upgrade it to allow for improved fish passage.

Table 3-10 Summary of existing watercourses which are to be culverted under the proposed alignment.

Catchment No. / Roading Chainage	Catchment Area (ha)	NIWA Reach#	Stream Name	Tc Rounded (min)	Design Flow – 2-year (m^3/s)	Design Flow – 100 year (m^3/s)	Live/wet waterway	Fish Passage Requirement
1/C12200 (Existing cross-drainage culvert)	70.9	8015828	Anaura Stream Tributary	30	2.46	6.90	Yes	Climbers
2/C12815	4.2	nil	Waikare River Tributary	10	0.242	0.694	No	No fish passage required
3/C13190	140.7	8015978	Waikare River Tributary	60	4.83	13.51	Yes	Climbers
4/C14200	20.2	8016262	Waikare River Tributary	20	2.25	6.29	Yes	Climbers
5/C14700	35.8	8016262	Waikare River Tributary	30	1.24	3.48	Yes	Climbers
6/C15045	1.0	nil	Overland flow path	10	0.06	0.17	No	No fish passage required

Catchment No. / Roading Chainage	Catchment Area (ha)	NIWA Reach#	Stream Name	Tc Rounded (min)	Design Flow – 2-year (m^3/s)	Design Flow – 100 year (m^3/s)	Live/wet waterway	Fish Passage Requirement
7/C15290	10.8	8016507	Pohatanui Stream Tributary	20	0.88	2.46	No	Climbers
8/C15550 **(Proposed Pohatanui Stream Bridge)**	493.3	8016581	Pohatanui Stream	90	10.99	30.78	Yes	N/A
9/C15830	2.6	nil	Overland flow path	10	0.15	0.42	No	No fish passage required

3.2.2 Summary of Proposed Cross-Drainage Culvert Locations

3.2.2.1 Cross-Drainage Culvert 1/C12200

Cross-drainage culvert 1/C12200 is an existing DN1500 pipe culvert, conveying flow for a tributary of the Anaura Stream which crosses the proposed alignment at approximately chainage 12200. The culvert is located near the proposed northern tie in with the existing state highway, and the outlet is located within the northern most property within the project extents. The cross culvert has a capacity of 12.3 m^3/s, which is adequately sized for an expected 100-year flow of 6.90 m^3/s.

The existing culvert presents a barrier for fish passage, with a large drop at the outlet, as shown in Figure 3-8. Options to enhance the fish friendliness of the culvert is discussed in Section 3.2.4 below.

Figure 3-10 Outlet at cross-culvert C12200 with a large drop.

3.2.2.2 Cross-Drainage Culvert 2/C12815

Cross-drainage culvert 2/C12815 is proposed to direct flow from eastern paddock catchments to an existing flow path/watercourse, a tributary of the Waikare River, just south of the proposed KiwiRail Overpass (refer to Section 3.3) and within the property to the north of Waikare Gorge (Figure 3-9:). The upstream end of the existing flow path will be filled in by the proposed road alignment, and the culvert will be located under this large fill area. The culvert will have an outlet to a proposed channel which will direct flow to the existing flow path. An existing DN450 KiwiRail culvert will also discharge to this proposed channel. No fish passage will be required for this culvert. Further details on this arrangement including the U1-CH14540-Stock Underpass are included in Section 3.4.1.

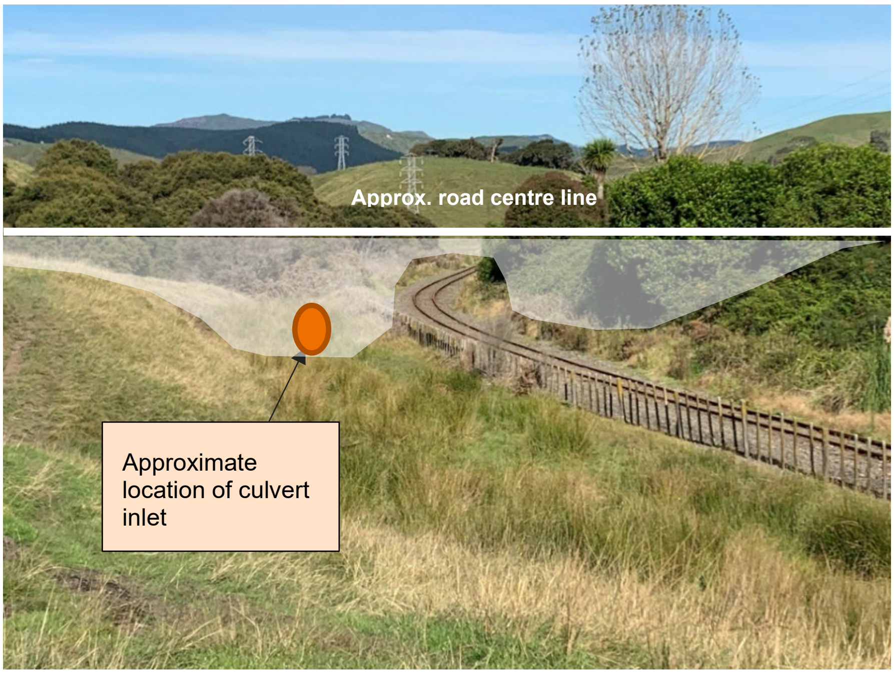


Figure 3-11: Culvert 2/C12815: Existing overland flow path to be culverted through proposed fill embankment (looking south-west).

3.2.2.3 Cross-Drainage Culvert 3/C13190

Cross-drainage culvert 3/C13190 is a proposed cross-drainage culvert to direct flow from an existing tributary of the Waikare River within the property north of Waikare Gorge (Figure 3-10). From the ecology report fish passage will be required for climbing species, based on the large catchment area for this watercourse and the natural existing topography.

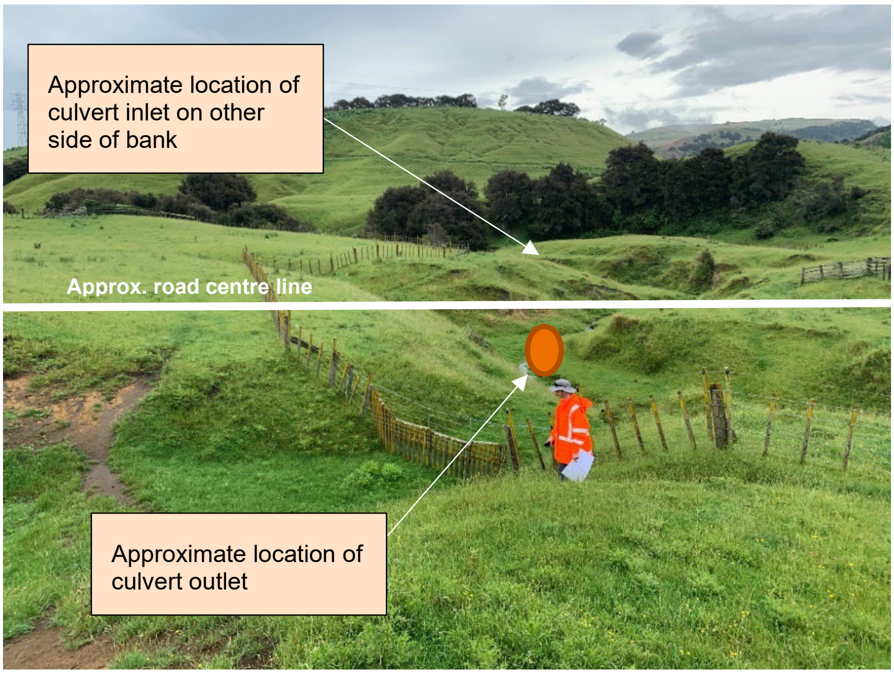


Figure 3-12 Existing watercourse at chainage 13190

3.2.2.4 Cross-Drainage Culvert 4/C14200

Cross-drainage culvert 4/C14200 is a proposed cross-drainage culvert to direct flow from an existing tributary of the Waikare River within the property just south of Waikare Gorge. Observations on site show that the existing watercourse includes a pond/dam which only has a piped outlet at a high level, refer to Figure 3-12 and Figure 3-13. A plan of the existing watercourse C14200 is detailed in Figure 3-11 below. This pond/dam is located at approximately chainage 14200, and the proposed road alignment goes over it, therefore the existing pond will be filled.

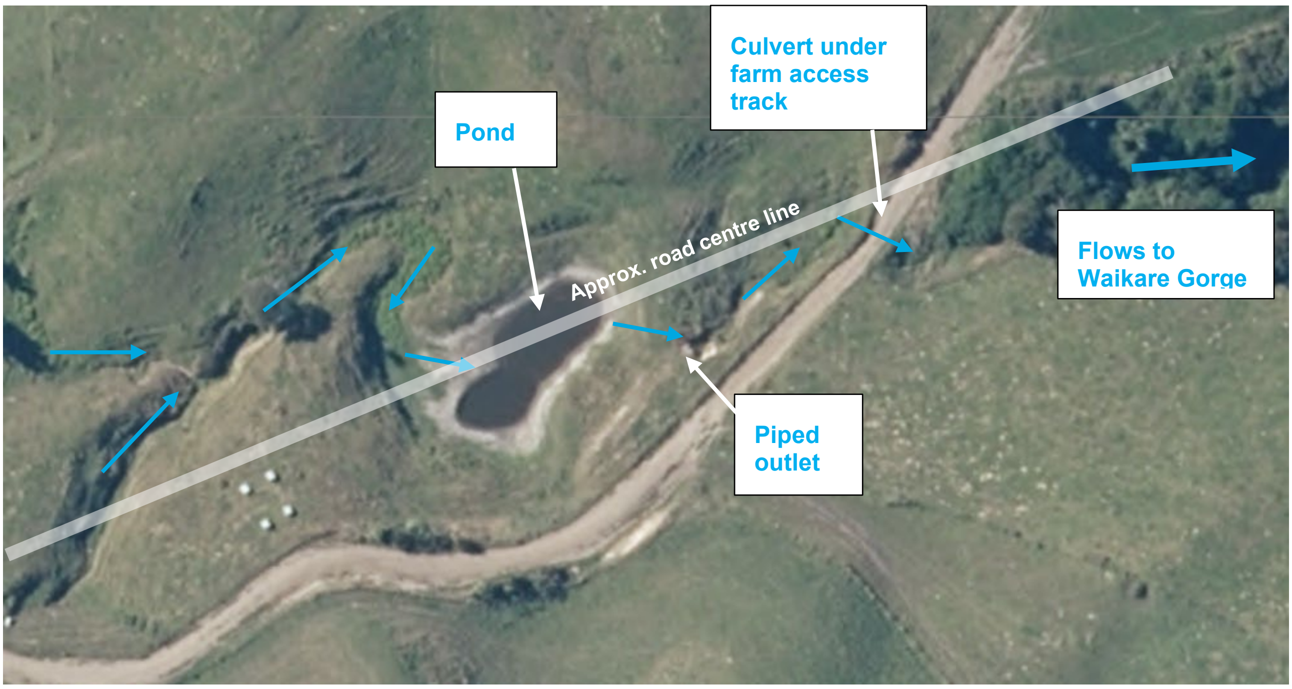


Figure 3-13 Direction of flow through the existing watercourse 14200

Figure 3-14 Pond at chainage 14200

Figure 3-15 Piped drainage outlet for the existing pond. The pond can be seen in the background

The Ecologist advised fish passage design for climbers at this crossing and that further site investigation is required during spring season to survey for fish. Considering the observations made on site of the pond/dam it may not currently be possible for fish to move through the existing waterway. If appropriate, based on the catchment and topography of the existing watercourse, this could be an opportunity to restore or create a means for fish passage and enhance the ecological value of the watercourse.

3.2.2.5 Cross-Drainage Culvert 5/C14700

Cross-drainage culvert 5/C14700 is proposed to direct flow from a tributary of the Waikare River located in the southernmost property within the project extents. Initial discussions with Ecologists indicate the proposed culvert will need to provide passage for climbing fish species, based on the catchment and topography of the existing watercourse.

Figure 3-14Figure 3-15 below indicates that the channel bed material has scoured, leaving the firm ground (silt stone material) exposed.

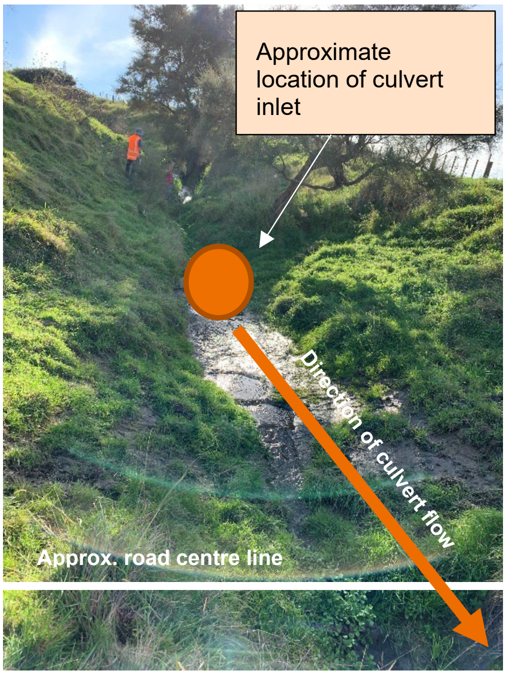


Figure 3-16 Existing watercourse at chainage 14700 looking upstream (north-west) from the approximate location of cross-culvert C14700

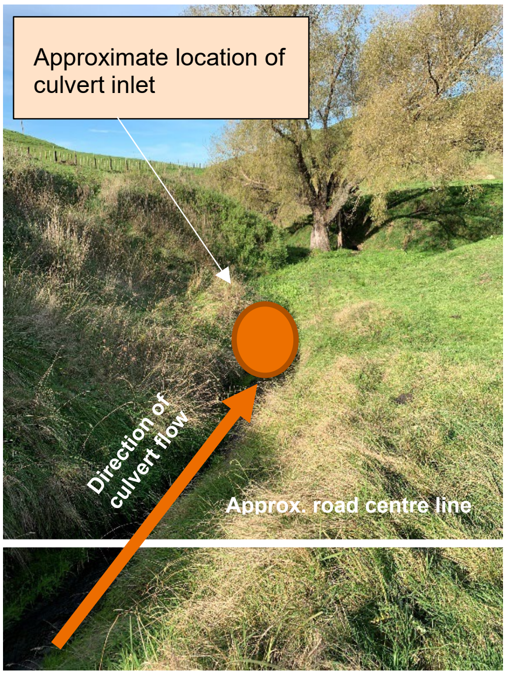


Figure 3-17 Existing watercourse at chainage 14700 looking downstream (south-east) from the approximate location of cross-culvert C14700

3.2.2.6 Cross-Drainage Culvert 6/C15045

Cross-drainage culvert 6/C15045 would service an existing drainage channel located on the southern most property within the project extents, which is planned to be diverted from its original course so that the culvert can link in with an existing KiwiRail culvert in the adjacent rail corridor. Fish passage is not required at this crossing as the watercourse is an overland flow path which only has flow during larger rain events.

There is potential for the channel to be diverted to existing watercourses at chainage 14700 or chainage 15290, to link in with other proposed cross-drainage culverts. This would negate the need for cross-drainage culvert C15045.

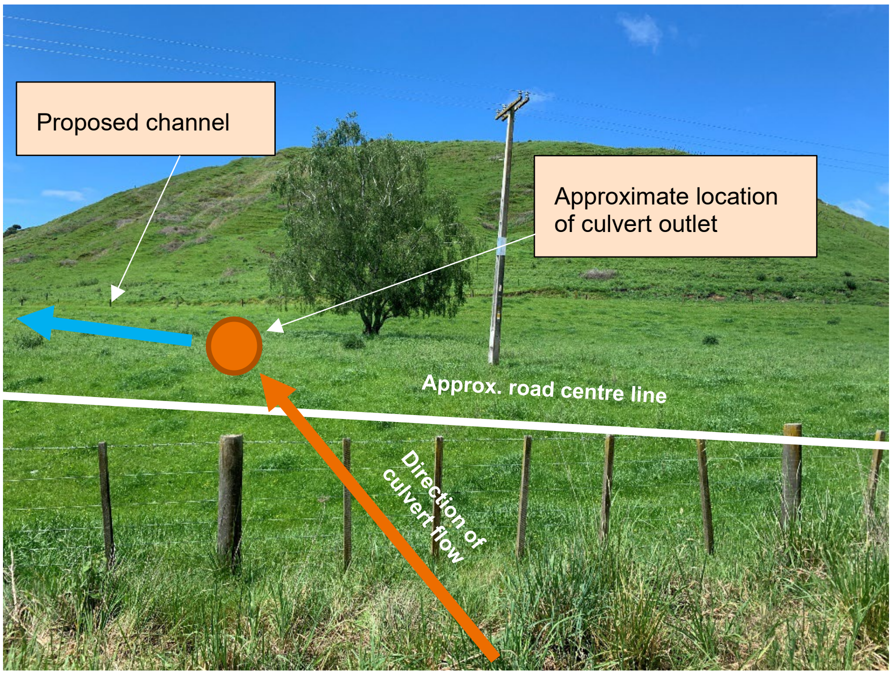


Figure 3-18 Proposed location of cross-drainage culvert C15045

3.2.2.7 Cross-Drainage Culvert 7/C15290

Cross-drainage culvert C15290 is a proposed cross-drainage culvert which will service a tributary of Pohatanui Stream/Kings Creek. The culvert will expand both the proposed alignment and the adjacent farm track. The Ecologist advised fish passage design for climbers is required for this crossing and that further site investigation is required during spring season to survey for fish.

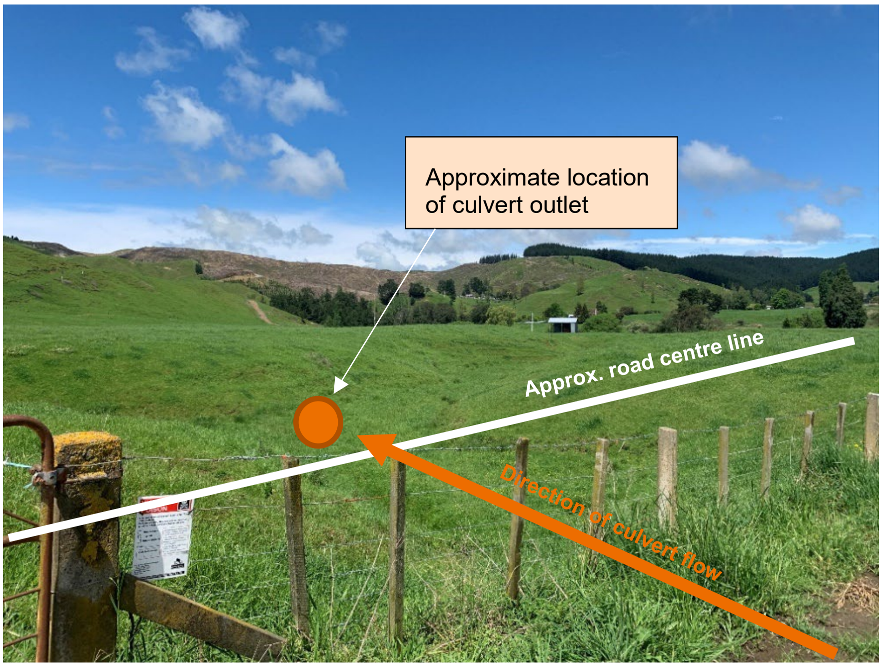


Figure 3-19 Proposed location of cross-drainage culvert C15290.

3.2.2.8 Cross-Drainage Culvert 9/C15830

Cross-drainage culvert 9/C15830 will direct runoff from a small paddock catchment to the east of the proposed alignment, just north of the stock underpass U4-CH15820, where the proposed alignment will fill an existing overland flow path. The proposed culvert will convey flow to a proposed channel at the bottom of the fill on the western side of the alignment, which will convey flow to the remaining existing overland flow path. This culvert will be adjacent to other stormwater infrastructure related to stock underpass U4-CH15820, which is detailed in Section 3.4.4. No fish passage is required for this culvert.

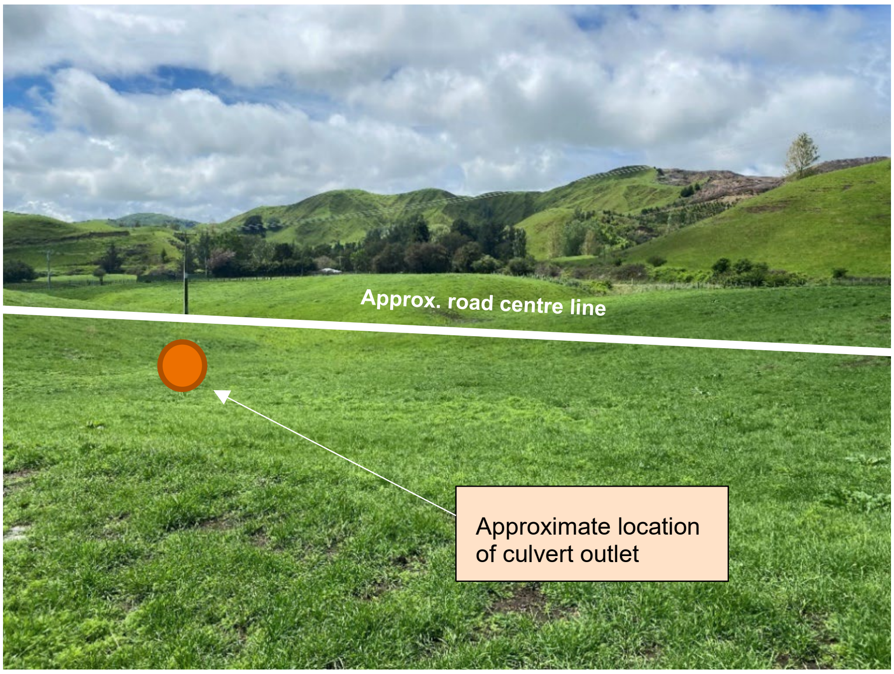


Figure 3-20 Existing overland flow path at chainage 15830.

3.2.3 Hydraulic Design

The hydraulic design was carried out considering the existing watercourse catchment information presented in Table 3-10. At the concept design phase, the cross-drainage culverts were sized to have capacity for a 100-year rain event. Culverts 2/C12815 and 9/C15830 were identified at the preliminary design phase and have also been sized for a 100-year storm event. Details on the sizing, length and grade of the cross-drainage culverts are summarised in Table 3-11 below.

Table 3-11 Summary of hydraulic design

Catchment No.	Max Flow - 2 year	Max Flow - 100 year	Initial Culvert Size	Length (m)	Grade	Comments
1/C12200 (Existing cross-drainage culvert)	2.46	6.90	1.8m wide by 1.5m Box	64	3.4%	Existing Culvert - Size TBC
2/C12815	0.242	0.694	DN450	127.5	5.49	-
3/C13190	4.83	13.51	2.5m by 1m Box	118	3.2%	Could be pipe culvert
4/C14200	2.25	6.29	1.5m by 1m Box	92	13.0%	Could be pipe culvert; Steep grade
5/C14700	1.24	3.48	DN900	51	6.3%	
6/C15045	0.06	0.17	DN450	TBC	TBC	Potentially divert to ch.15290 or ch.14700
7/C15290	0.88	2.46	DN1500	37	1.80%	
8/C15550 **(Proposed Bridge)**	10.99	30.78	N/A	N/A	N/A	Proposed Bridge
9/C15830	0.15	0.42	DN375	43.9	5.92	-

3.2.4 Fish Passage Design

Five cross culverts have been identified as requiring fish passage based on catchment areas, existing watercourse topography, the nature of the watercourse and with reference to the Ecological Assessment Report, dated July 2022. These culverts were 1/C12200, 3/C13190, 4/C14200, 5/C14700 and 7/C15290. The ecologist identified the need for Best Practice Design to account for climbers at these five culvert crossings with the recommendation that further site investigation is required during spring to survey for fish.

3.2.4.1 Design Approach

A stream simulation design approach was followed to create a channel inside the culvert as similar as possible to the adjacent stream channel in both structure and function.

The existing stream slopes taken upstream (column 2), downstream (column 4) and between the proposed culvert locations (column 5) are summarized in Table 3-12. A 10% tolerance of the slopes obtained in column 5 have been used to adjust the design slope of the culvert structure therefore mimicking the existing stream slope or natural ground level (NGL). To achieve a 10% tolerance at culvert C12200 and C13190, the downstream outlet level was lifted, and this resulted in a drop between 0.6 m and 0.7 m to exiting ground level. This drop can be constructed with a rock ramp to provide for the climbers' fish passage and erosion protection. Culvert C15290 is kept at a flat slope as this is more preferred design for fish passage.

Table 3-12 Summary of the stream and proposed cross-drainage culverts slopes

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Catchment No. / Roading Chainage	Existing US slope (%)	Existing stream slope between culvert location (%)	Existing DS slope (%)	Culvert slope as per NGL (%)	Proposed culvert slope within 10% tolerance (%)	Culvert length (m)
1 / C12200	2.81	No survey	1.26	3.84	3.0	75
3 / C13190	0.68	2.45	1.45	3.24	2.65	117
4 / C14200	4.33	Existing pond	No survey	4.75	4.75	80
5 / C14700	12.02	8.38	10.0	8.68	8.68	53
7 / C15290	3.70	1.12	3.46	0.61	0.61	33

An integrated substrate can be used within the culverts to create a variety of pathways and low velocity resting areas. Culvert baffles can also be used to create greater bed roughness and varied flow within the culvert which improves conditions for fish passage. An example of good fish passage design for box culverts are shown in Figure 3-19 which is pre-cast off-site and a more sustainable option compared to anything plastic. The baffles create resting pools and a concentrated low-flow channel which is ideally installed at a low gradient if possible.

Figure 3-21 Concrete pre-cast baffles in box culverts for fish passage

3.2.4.2 Culvert Sizing

Culvert cross drainage is sized to convey the 100-year peak flow and not to constrict the bankfull flow. According to the NZ Fish Passage Guidelines, the following rules of thumb are suggested:

For streams with bankfull width (w) ≤ 3m, the culvert span (s) should be 1.3 x bankfull width (Equation 1)

For streams with bankfull width (w) > 3m, the culvert span (s) should be 1.2 x bankfull width +0.6 m (Equation 2)

The bankfull width in the streams were taken as the 2-year ARI flow width in the stream and the above equations were used to calculate the required culvert width. Refer to Table 3-133-13 below for the upstream channel dimensions and calculated bankfull width.

Table 3-13 Upstream channel dimensions and bankfull width

Catchment No. / Roading Chainage	Upstream channel bottom width (m)	Upstream channel sides slopes (%)	Existing US slope (%)	2-year ARI flow (m^3/s)	2-year ARI flow width (m)	Calculated culvert width (s) using Eq. 1 or 2 (m)
1 / C12200	2.56	1:1 both sides	2.81	2.46	3.31	4.5 (choose 5 m)
3 / C13190	2.76	1:1.5 both sides	0.68	4.83	3.98	5.3 (choose 5 m)
4 / C14200	0.44	1:4.4 and 1:1.3	4.33	2.25	2.90	3.8 (choose 4 m)
5 / C14700	0.44	1:2.2 both sides	12.02	1.30	2.90	3.8 (choose 4 m)
7 / C15290	0.89	1:2 and 1:3	3.70	0.88	2.41	3.1 (choose 3 m)

From the above results in Table 3-12 and Table 3-13 the required culvert height is calculated using the manning equation. The manning roughness used for the culvert bed is 0.04 and 25% of the culvert is proposed to be embedded into the stream channels. The proposed culvert sizes to accommodate fish passage are summarized in Table 3-14.

Table 3-14 Proposed cross drainage culvert sizes for fish passage

Catchment No. / Roading Chainage	Culvert width for fish passage (m)	100-year ARI flow depth (m)	Culvert height (m)	25% embedded depth (m)	100-year flow velocity (m^2/s)
1 / C12200	(x2) 2.5 m	0.55	1.0	0.25	2.54
3 / C13190	(x2) 2.5 m	0.88	1.0	0.25	3.06
4 / C14200	4 m or two 2.0 m barrels	0.52	1.0	0.25	3.02
5 / C14700	4 m or two 2.0 m barrels	0.30	1.0	0.25	3.01
7 / C15290	3.0 m	0.70	1.0	0.25	1.18

Erosion and sediment control plans (refer to Section 4) should be incorporated during construction phase while permanent erosion control measures can include vegetation of exposed soils, riprap at inlet and outlets and by eliminating abrupt bends in relation to the existing stream path.

3.2.5 Debris Capture for Cross-Drainage Culverts

Debris capture upstream of culverts will be required to minimise the risk of blockages. Screens or grid cages can be used to prevent debris from entering culverts. These require regular maintenance to clear, particularly after large rain events. For culverts which require fish passage, screens or cages will be designed to avoid obstructing fish movement through the culvert.

Cross-drainage culverts which are likely require a screen or guard for debris capture include:

- 2/C12815
- 3/C13190
- 4/C14200
- 5/C14700

These culverts do not have any other upstream barriers which will prevent debris from reaching the culvert inlet.

3.2.6 Summary of Cross-Drainage Culvert Design

The proposed cross-drainage culverts have been designed considering both hydraulics and fish passage requirements. All of the cross-drainage culverts have been designed to have capacity for 100-year design flows. Five of the culverts (1/C12200, 3/C13190, 4/C14200, 5/C14700 and 7/C15290) have been designed to meet fish passage requirements. The cross-drainage culverts have been modelled in HY-8, which provide information on velocity and flow depths. The following tables (Table 3-15 and Table 3-16) summarise the design details, including culvert design, fish passage requirements and design velocities and depths for each of the cross-drainage culverts.

Further site investigations in order to conduct fish surveys are planned to be carried out in future. This information will be able to inform the fish passage design. Currently the design is conservative, and with the results of site investigations and using engineering judgment the size of some of the culverts may be able to be reduced at the detailed design phase. In addition to this, different fish species require specific flow velocities and streambed materials in order for the culvert to be considered an appropriate habitat. With further fish species information, these details can be finalised.

Erosion controls for culverts which do not require fish passage have been detailed, including rip-rap diameter and apron extents. Erosion controls for fish-passage designed culverts will be finalised at the detailed design phase when sizing is confirmed.

Debris capture upstream of culverts to minimise blockage risks will be considered at the next design phase.

Standard details for culverts are included in Appendix A, sheet no. 0010 and 0012.

Table 3-15 Summary of cross-drainage culvert design

Culvert No./Chainage	Size	Shape	Length (m)	Gradient (%)	US IL (m)	DS IL (m)	Fish passage required?	Embedment depth (m)	Varied flow design	Stream changes	Outlet Protection (Culverts without fish passage)		
											Rip-rap diameter (mm)	Length (m)	Width (m)
1/C12200 (New culvert with fish passage)	(x2) 2.5 x 1.0 m	Box	74.8	3.03	121.6	123.9	Yes - Climbers	0.25	Baffles or similar	Lift outlet to 121.6 by 0.6 m, create rock ramp at the outlet			
2/C12815	DN450	Round	127.5	5.49	120.8	113.8	No	-	-	-	200	5.5	1.4
3/C13190	(x2) 2.5 x 1.0 m	Box	117.2	2.65	97.6	94.5	Yes - Climbers	0.25	Baffles or similar	Lift outlet to 94.5 by 0.7 m, create rock ramp at outlet	-		
4/C14200	4.0 m x 1.0 m or two 2.0 m barrels	Box/ Round	80.0	4.75	93.8	90.0	Yes - Climbers	0.25	Baffles or similar	-	-		
5/C14700	4.0 m x 1.0 m or two 2.0 m barrels	Box/ Round	53.0	8.68	105.8	101.2	Yes - Climbers	0.25	Baffles or similar	-	-		
6/C15045	DN450	Round	45.0	0.45	112.0	112.2	No	-	-	-	200	5.0	1.4
7/C15290	3.0 x 1.0 m	Box	32.70	0.61	109.2	109.0	Yes - Climbers	0.25	Baffles or similar	-	-		
9/C15830	DN375	Round	43.9	5.92	109.0	106.4	No	-	-	-	100	3.0	1.2

Table 3-16 Summary of hydraulic details of cross-drainage culverts.

Culvert No./Chainage	Size	Design Flow - 2 year (m^3/s)	Design Flow - 100 year (m^3/s)	Outlet velocity (100-year event) (m/s)	Headwater elevation (100-year event) (m)	Proposed road centreline elevation (100-year event) (m)
1/C12200 (New culvert with fish passage)	(x2) 2.5 x 1.0 m	2.46	6.90	2.09	124.6	131.8
2/C12815	DN450	0.242	0.694	5.19	123.7	128.0
3/C13190	(x2) 2.5 x 1.0 m	4.83	13.51	1.99	98.8	112.1
4/C14200	4.0 m x 1.0 m or two 2.0 m barrels	2.25	6.29	3.08	95.2	99.5
5/C14700	4.0 m x 1.0 m or two 2.0 m barrels	1.24	3.48	2.06	106.8	109.4
6/C15045	DN450	0.06	0.17	1.57	112.7	115.8
7/C15290	3.0 x 1.0 m	0.88	2.46	0.90	110.09	113.3
9/C15830	DN375	0.15	0.42	2.90	109.25	111.4

3.3 KiwiRail Interfaces and Rail Overpass

An overpass has been proposed where the new road will intercept KiwiRail railway tracks at approximately chainage 12750. This will involve the road passing over the railway tracks. An updated assessment of the flows and catchments for the drains within the proposed KiwiRail overpass has been carried out and is included in Appendix C. Through discussion with the structures team, it has been confirmed that there will be drains on either side of the tracks through the overpass to capture run off from the tracks. Cross drainage culvert C12815 has been proposed to convey the paddock catchments to the east of the tracks under the proposed road, to link in with an existing overland flow path. Further details on this culvert are included in Section 3.2.2.2.

There are several existing KiwiRail culverts which pass under the tracks within the vicinity of the proposed road. These KiwiRail culverts are upstream of the proposed road and so any ponding upstream of the culverts should not impact upon the road. An existing DN450 KiwiRail culvert located south of the proposed overpass was picked up in survey. This culvert conveys flow from the western side of the railway to the overland flow path to the east. This includes paddock catchments P2 and P2.1, along with other paddock catchments. This culvert was found to be undersized for a 100-year event. The inlet of the culvert is located within a paddock, which if the culvert were to backup would not impact on the proposed road. However, it is likely that headwaters will overtop the railway tracks in a 10-year event. It is expected that a DN600 culvert would provide sufficient capacity if it was considered that this culvert needs to be replaced.

3.4 Stock Underpasses and Farm Access Tracks

There are four proposed stock underpasses to allow movement between paddocks located on either side of the proposed road alignment. These stock underpasses are U1-CH12840, U2-CH13275, U3-CH14540 and U4-CH15820. Drainage details for these stock underpasses and related farm access tracks are summarised in the sections below. Plans of the proposed drainage for each underpass are included with the drawings in Appendix A sheet no.0020, 0021, 0030 & 0031.

3.4.1 U1-C12840 Stock Underpass

Stock underpass U1-C12840 is located to the south of the proposed KiwiRail underpass and the proposed cross-culvert C12815. The farm track passing through the stock underpass will be graded so that runoff falls away from the underpass, so through drainage will not be required. The farm track to the east of the proposed road will be shaped so that runoff will be directed to a drain which will run along the bottom of the proposed road fill batter slope. This drain will direct flow to C12815, which will be conveyed to the western side of the road. Similarly, the farm track to the west of the proposed road will be shaped so runoff will be directed down the fill to a proposed channel which will convey flow to the existing watercourse. Refer to Appendix A Sheet no. 0030 for a plan of the underpass and stormwater infrastructure.

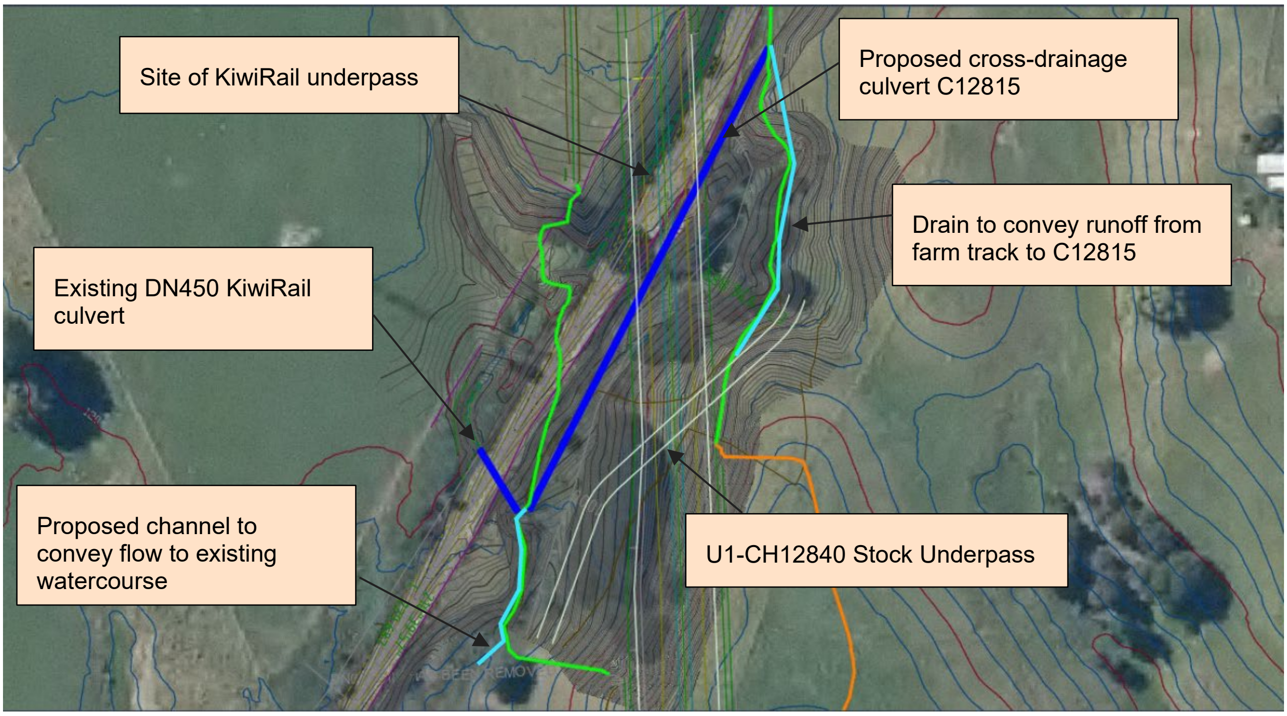


Figure 3-22 Stock Underpass U1-CH12840 drainage

3.4.2 U2-CH13275 Stock Underpass

The U2-CH13275 stock underpass is located just south of the existing watercourse at chainage C13190. A scruffy dome will be located near the eastern entrance of the stock underpass to collect flow from the incoming farm track, which is graded towards the underpass, and a paddock catchment which is also falling towards the underpass. This runoff will be conveyed via culvert under the farm track to paddock diversion drain P4. To the west, a drain on the eastern side of the farm track will convey runoff to a scruffy dome and culvert which will direct flow towards the adjacent watercourse. Refer to Appendix A Sheet no. 0020 for a plan of the underpass and stormwater infrastructure.

3.4.3 U3-CH14540 Stock Underpass

The stock underpass U3-CH1450 will require drainage for runoff from the farm track on the western side of the proposed alignment, which is graded towards the underpass entrance. A drain on either side of the farm track will convey flow to one of two DN375 culverts, which will run parallel to the underpass and have an outlet into a drain on the eastern side farm track. This will discharge into an existing overland flow path. Refer to Appendix A Sheet no. 0021 for a plan of the underpass and stormwater infrastructure.

3.4.4 U4-CH15820 Stock Underpass

Stock underpass U4-CH15820 is located just north of the new intersection between the proposed new road alignment and existing state highway. The stock underpass also coincides with the existing overland flow path at chainage C15830 which will be partially filled in by the proposed road.

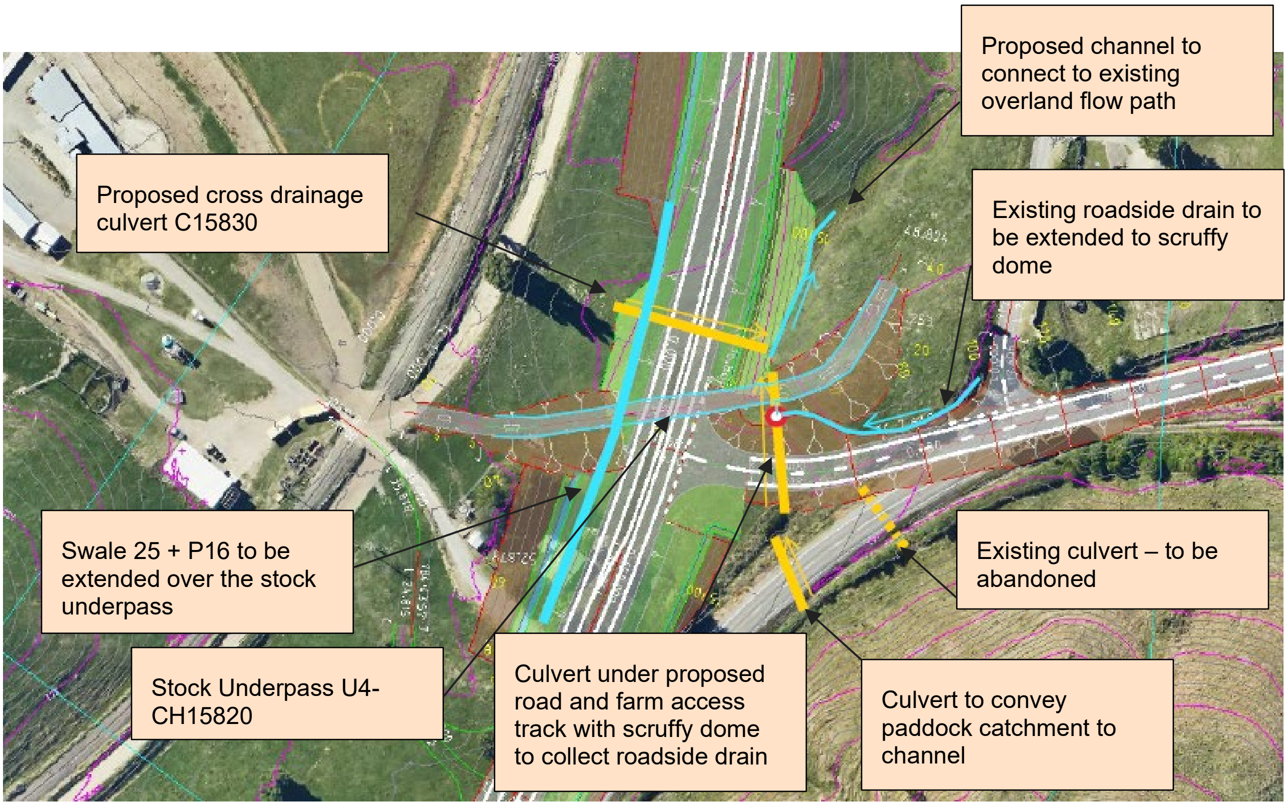


Figure 3-23 Stock Underpass U4-CH15820 drainage.

As shown in Figure 3-21 above, the paddock catchment to the west of the proposed alignment will be collected by cross-drainage culvert C15830 as detailed in Section 3.2.2.8 above. This culvert will have an outlet to a proposed channel along the bottom of the fill slope, which will connect to the existing overland flow path. The paddock catchment P17 will be conveyed to the proposed channel via a culvert which will cross under the proposed road connection and farm access track. A scruffy dome will collect stormwater from the farm track at a low point just outside the stock underpass entrance into this culvert, and also stormwater from an existing roadside drain. An existing road culvert which will clash with the proposed road connection will be abandoned.

3.5 Pohatanui Stream/Kings Creek Bridge

The Pohatanui Stream/Kings Creek Bridge will be located at approximately chainage 15500 along the proposed road alignment. At this stage, the design of the bridge has not been confirmed, however there have been initial discussions regarding drainage of this area. Runoff from catchments north of the bridge will be collected via swale and discharged to the existing overland flow path which crosses the alignment at approximately chainage 15290.

The bridge will fall longitudinally towards the south and will have a superelevation which will direct runoff to the east of the bridge deck. It is proposed that precipitation that falls onto the bridge deck will be collected by a dish drain on the eastern side of the alignment. This runoff will then be conveyed to the south of the bridge where it will be collected in a catchpit and conveyed to STF 6. The details of the drainage design should be coordinated with the structures and geometrics team when the bridge design is confirmed.

It should be noted that bridge abutments and piers will require scour protection to limit erosion, however this may disturb the creek bed and/or banks. How disturbance of the creek can be minimised or mitigated should be assessed at a later stage, with confirmation of the abutment details. A memo regarding flood levels in the creek has been prepared and is included in Appendix B.

3.6 Pohatanui Stream/Kings Creek Stock Bridge

The proposed Pohatanui Stream/Kings Creek Stock Bridge will be located downstream of the Pohatanui Stream/Kings Creek Road bridge. A farm track will provide access to the bridge and will link in with Putorino Station Road to the south of Pohatanui Stream/Kings Creek. In terms of drainage, precipitation which falls on the bridge deck will run off the sides of the bridge directly into the Pohatanui Stream.

Drainage will be required for the farm tracks leading up to the bridge, to convey runoff away from the bridge deck. The alignment of the farm track has not been finalised, but from initial long sections and contour information available it is likely the farm track will grade towards the bridge on the northern side of the stream, and away from the bridge on the southern side. Runoff from the northern approach should be collected and discharged down the stream bank, considering appropriate erosion protection such as riprap and lined channels. The details for drainage of the farm tracks should be confirmed at the detailed design stage.

Coordination with the structures and geometrics team is required to finalise the location of the farm track to the south of Pohatanui Stream/Kings Creek Stock Bridge as this may clash with proposed STF 6. This should be discussed and confirmed at the detailed design stage.

The current bridge design proposes abutments located in the stream embankment, which may cause scouring issues. An assessment in coordination with the structures and geotechnical teams should be carried out to assess this risk. Any scour protection utilised may affect the creek bed or banks. How this can be minimised and mitigated should be assessed and discussed with the Ecology team.

A memo regarding flood levels in the creek has been prepared and is included in Appendix B.

3.7 Waikare Gorge Bridge

The Waikare Gorge Bridge will be located from approximately chainage 13950 to chainage 13600 along the proposed alignment. As per the Waikare Gorge Bridge Structures Options Report prepared by WSP in May 2022, the bridge will have a 1% gradient which will direct runoff from the bridge towards the southern abutment. Precipitation on the bridge is proposed to be collected by catchpits and conveyed via pipe system to STF 4. STF 4 has been sized considering this flow. Runoff from the northern land span of the bridge will be conveyed along the shoulders to catchpits and ultimately to STF 3.

The Waikare Gorge Bridge Structures Options Report indicates that at the detailed design phase it will be investigated if runoff can be conveyed along the shoulder for the length of the bridge to avoid the need for pipes and associated maintenance. This should be coordinated with the bridge designers at the detailed design stage.

4 Environmental Management and Sediment Control

Environmental management shall be based on practices described in the site-specific erosion and sediment control plan (ESCP) to be prepared by the Contractor and approved by the Hawke's Bay Regional Council prior to commencement of works. The ESCP shall be a condition of consent and will be based on the detailed design. Proposed erosion and sediment control practices for this stage of the project are described below and will be updated as required at the detailed design stage.

Works should be staged appropriately to ensure that exposed soil is kept to manageable areas. Clean water diversion bunds will be used at the top of cut faces to prevent runoff from surrounding paddock areas entering the exposed site. Dirty water diversion channels at the bottom of cut/fill slopes should be utilised to convey runoff to either decanting earth bunds or sediment retention ponds. Where diversion drains are used on steep gradients check dams should be considered to prevent erosion. Where diversion channels are not possible, silt fences or super silt fences should be used at the bottom of exposed banks. Silt fences can also be used in conjunction with diversion channels in a treatment train type approach. As work progresses fill batter slopes and cut slopes should be grassed as completed to ensure the soil is stabilised.

Decanting earth bunds or sediment retention ponds should be utilised depending on the size of the catchment. These temporary ponds could potentially be located at the sites of the proposed stormwater treatment facilities. Many of the watercourses within the project extent have steep embankments. Where discharging to a watercourse, lined channels are required to protect these banks.

Any works being carried out near waterways are required to be isolated from the flow and base flows maintained. This will be particularly important when constructing the proposed cross-drainage culverts, Kings Creek Bridge and batter fill slopes near waterways. Silt fences at the bottom of constructed embankments or a temporary surface protective layer should be used to prevent sediment runoff entering the watercourse.

Figure 4-1 Steep embankments and watercourses, such as the above at chainage 13190 will require protection as works proceed.

5 Conclusions

5.1 Design Summary

The stormwater for SH2 Waikare Gorge has been prepared to a preliminary level of design to meet the current design stage of the Highway.

The stormwater design adopts a treatment train approach, with vegetated fill batter slopes, swales and stormwater treatment facilities used in series to treat a wide range of contaminant types and improve the treated water quality. At the preliminary design phase, over 90% of the new road surface area can be treated to some extent before being discharged to the receiving environment, with 35% of runoff being treated by both swale and wetland.

Changes to existing watercourse catchments due to increased impervious surfaces and conveyance of runoff to stormwater treatment facilities will see an overall increase in runoff volumes directed to watercourses post-construction. Attenuation ponds with throttled outlets will be utilised to generally limit flow rates discharged into watercourses to pre-development levels.

Cross-drainage culverts sized to the 100-year return period event plus climate change will be used to divert existing watercourses and overland flow paths under the proposed road. Cross-drainage culverts have been designed to incorporate fish passage requirements using a stream simulation approach, with the aim to ultimately enhance, restore, and preserve existing watercourses which will be impacted by the construction of the new road. Each culvert will have erosion control measures including precast headworks and rock riprap placements at each intake and outlet.

Drainage of the four proposed stock underpass and adjacent farm access tracks has been considered and designed to limit runoff through the underpasses. Drainage has also been considered for the KiwiRail overpass and the Pohatanui Stream/Kings Creek and Waikare Bridges. Drainage infrastructure for both bridges are to be confirmed at the detailed design phase with confirmation of the bridge designs.

Environmental management and sediment control will be based on the site-specific ESCP which will be developed considering the detailed design. Proposed erosion and sediment control practices at this stage include erosion protection measures such as staging to ensure minimum soil exposure, lined channels and stabilisation, and sediment control devices such as silt fences, diversion bunds and sedimentation retention ponds.

5.2 Considerations for Next Stage of Design.

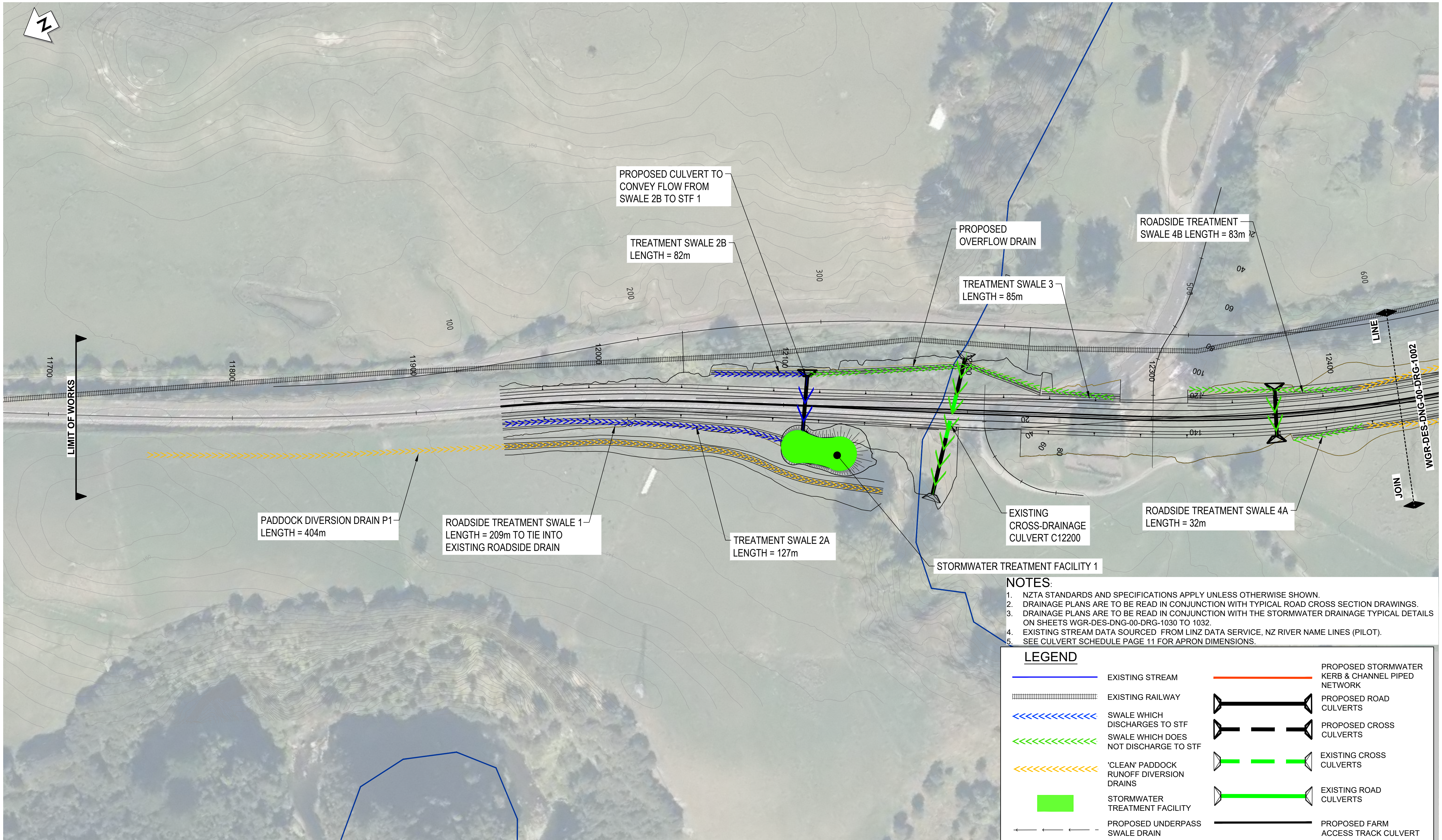
A more detailed assessment of the proposed stormwater infrastructure will be carried out at the detailed design phase. In particular, the following items should be addressed:

- Completion of the stormwater management strategy coordination with the overall design team, and feedback from project stakeholders.
- Detailed attenuation design for the STFs. At this stage a footprint area of 10% of the contributing runoff catchment has been assumed. It is expected that focus will be on erosion control in downstream systems. Peak flow for flooding (1% AEP) has not been considered in all locations where there are only farm paddocks/watercourses downstream to the Waikare Gorge.
- Confirm potential option to delete STF 1, by directing flow through the existing culvert at chainage 12000.
- Liaise with Ecology and Landscaping to choose appropriate plant species for swales and stormwater treatment facilities considering a range of climate conditions.
- Design accessibility for maintenance, land availability, and fencing for stormwater treatment facilities.
- Design of swales which do not convey to an STF and therefore are the only means of treatment runoff.
- Further investigations of whether the existing cross-drainage culvert C12200 needs to be ungraded for capacity/fish passage issues.
- Confirm fish passage design requirements with further fish survey investigations on site.
- Finalise cross-drainage culvert design, including erosion protection and debris capture.
- Assessment of the drainage for the stock bridge at Kings Creek.
- Assess and discuss Kings Creek bridge design levels, scour protection and stormwater drainage with Bridge Designer once design confirmed.
- Discuss Waikare Gorge Bridge stormwater collection with the Bridge Designer and abutment details to confirm location of STF 3 and STF 4.

Appendices

We design with community in mind

Appendix A Preliminary Design Plans



NOTES:
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4. EXISTING STREAM DATA SOURCED FROM LINZ DATA SERVICE, NZ RIVER NAME LINES (PILOT).
5. SEE CULVERT SCHEDULE PAGE 11 FOR APRON DIMENSIONS.

LEGEND

EXISTING STREAM	PROPOSED STORMWATER KERB & CHANNEL PIPED NETWORK
EXISTING RAILWAY	PROPOSED ROAD CULVERTS
SWALE WHICH DISCHARGES TO STF	PROPOSED CROSS CULVERTS
SWALE WHICH DOES NOT DISCHARGE TO STF	EXISTING CROSS CULVERTS
'CLEAN' PADDOCK RUNOFF DIVERSION DRAINS	EXISTING ROAD CULVERTS
STORMWATER TREATMENT FACILITY	PROPOSED FARM ACCESS TRACK CULVERT
PROPOSED UNDERPASS SWALE DRAIN	STF OUTLET PIPE
SCRUFFY DOME	CONCRETE LINE CHANNEL

PLAN
SCALE 1 : 1000

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B	CONCEPT DESIGN	PAC	NK	LY	02.2022
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D	PRELIMINARY	SL	WAH	LY	09.2022

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SCALES: AS SHOWN @ A1
ORIGINAL SIZE: A1
DRAWN: Jess Morgan
DESIGNED: Jess Morgan
APPROVED:
DRAWING VERIFIED:
DESIGN VERIFIED:
APPROVED DATE:

WORKING PLOT

PROJECT
WAKA KOTAHI
TAIRAWHITI ROAD PACKAGE PANEL
SH2 RP 577/11.600-592/2.500 WAIKARE GORGE REALIGNMENT

TITLE
STORMWATER LAYOUT PLAN
SHEET 1 OF 6

DOCUMENT NO.: WGR - DES - DNG - - DRG
SHEET NO.: 0001
REVISION: D

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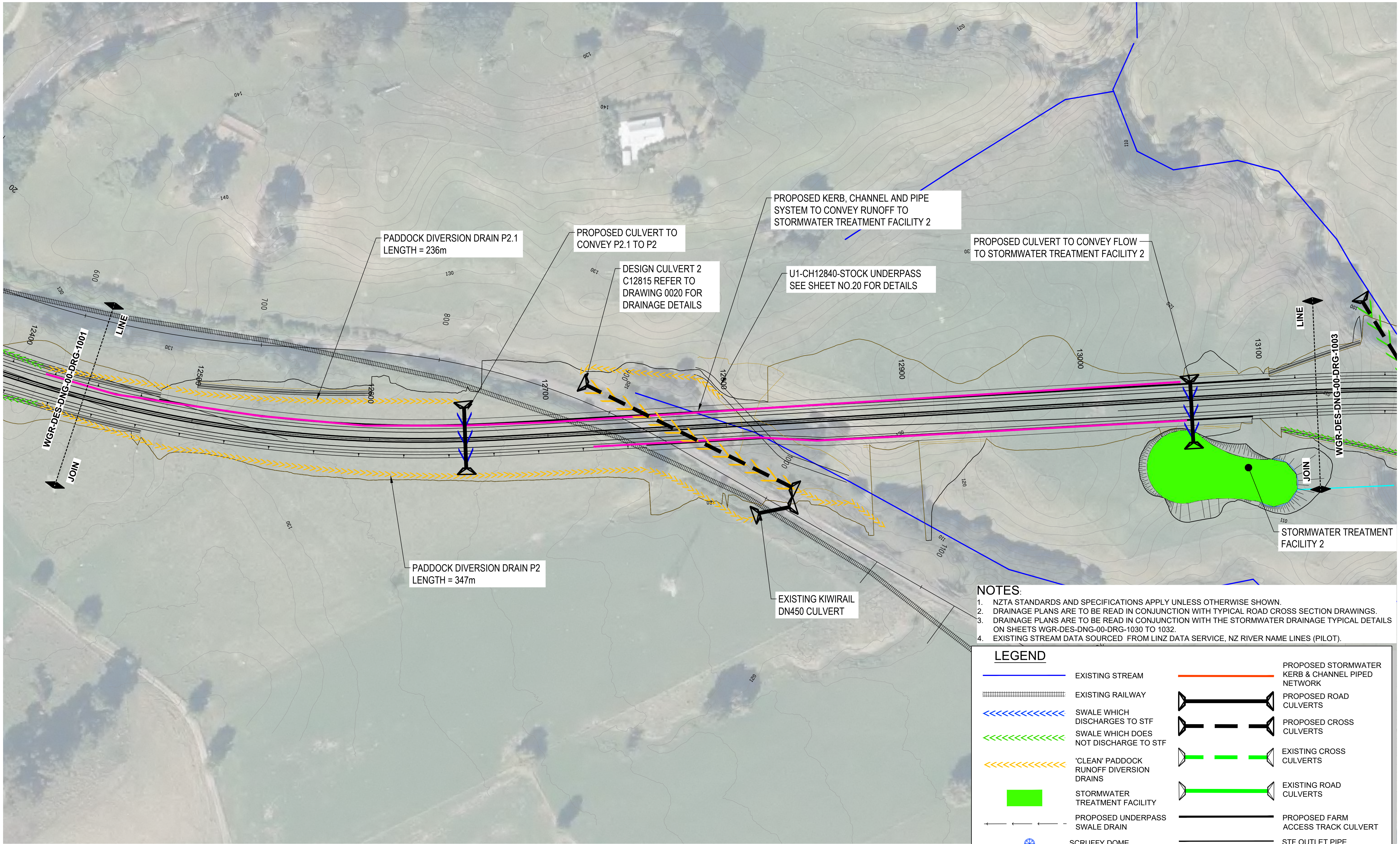
ORIGINATING ORGANISATION: WSP



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Jess Morgan	Jess Morgan	Jamie Povall
DRAWING VERIFIED	**DESIGN VERIFIED**	**APPROVED DATE**
Paul Chilton	Nick Keenan	09.11.22

PRELIMINARY

PROJECT
WAKA KOTAHI
TAIRAWHITI ROAD PACKAGE PANEL
SH2 RP 577/11.600-592/2.500 WAIKARE GORGE REALIGNMENT

TITLE
STORMWATER LAYOUT PLAN
SHEET 2 OF 6

DOCUMENT NO.: WGR - DES - DNG - 00 - DRG
SHEET NO.: 0002
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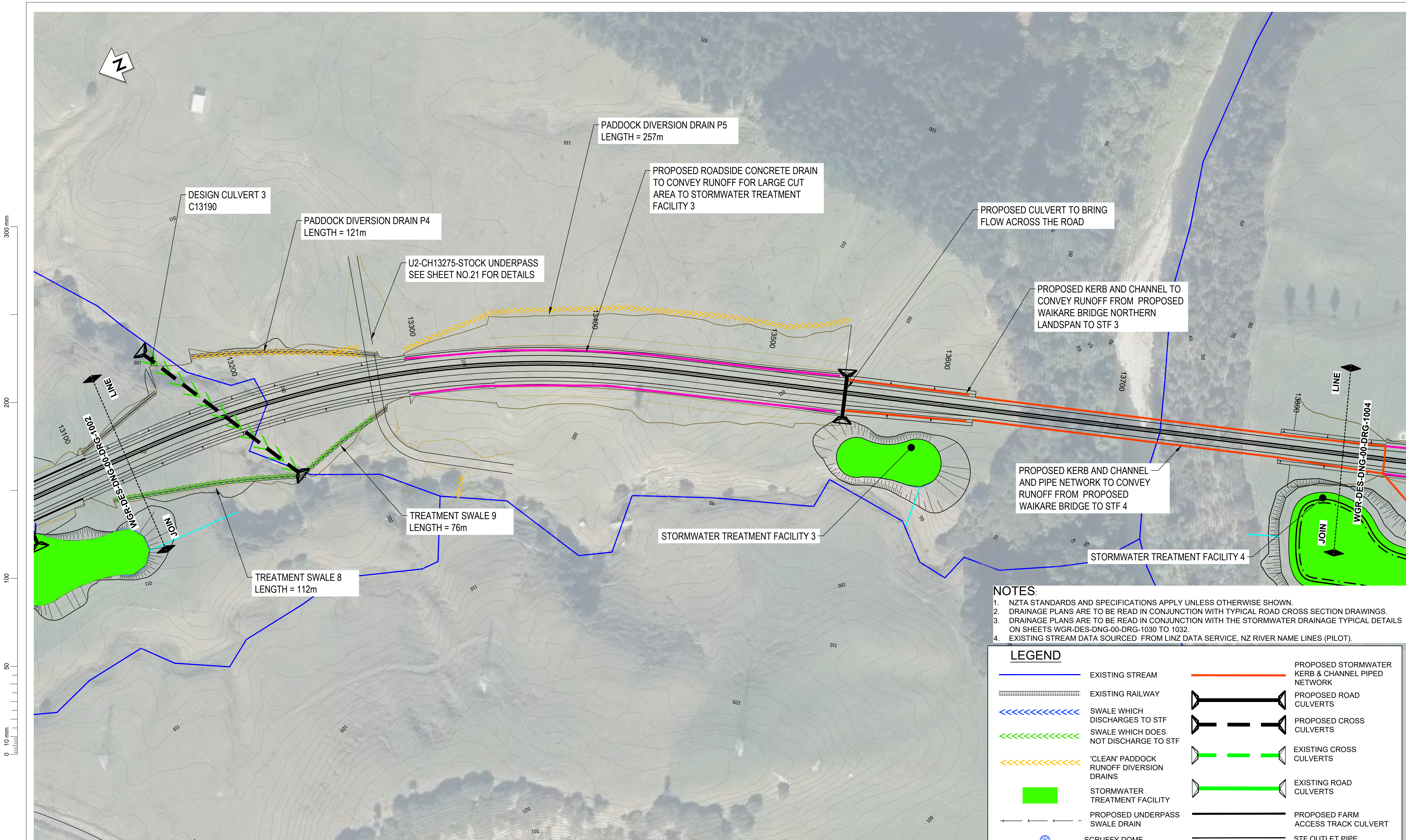

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TITLE
STORMWATER LAYOUT PLAN
SHEET 3 OF 6

DOCUMENT NO.: WGR - DES - DNG - 00 - DRG
SHEET NO.: 0003
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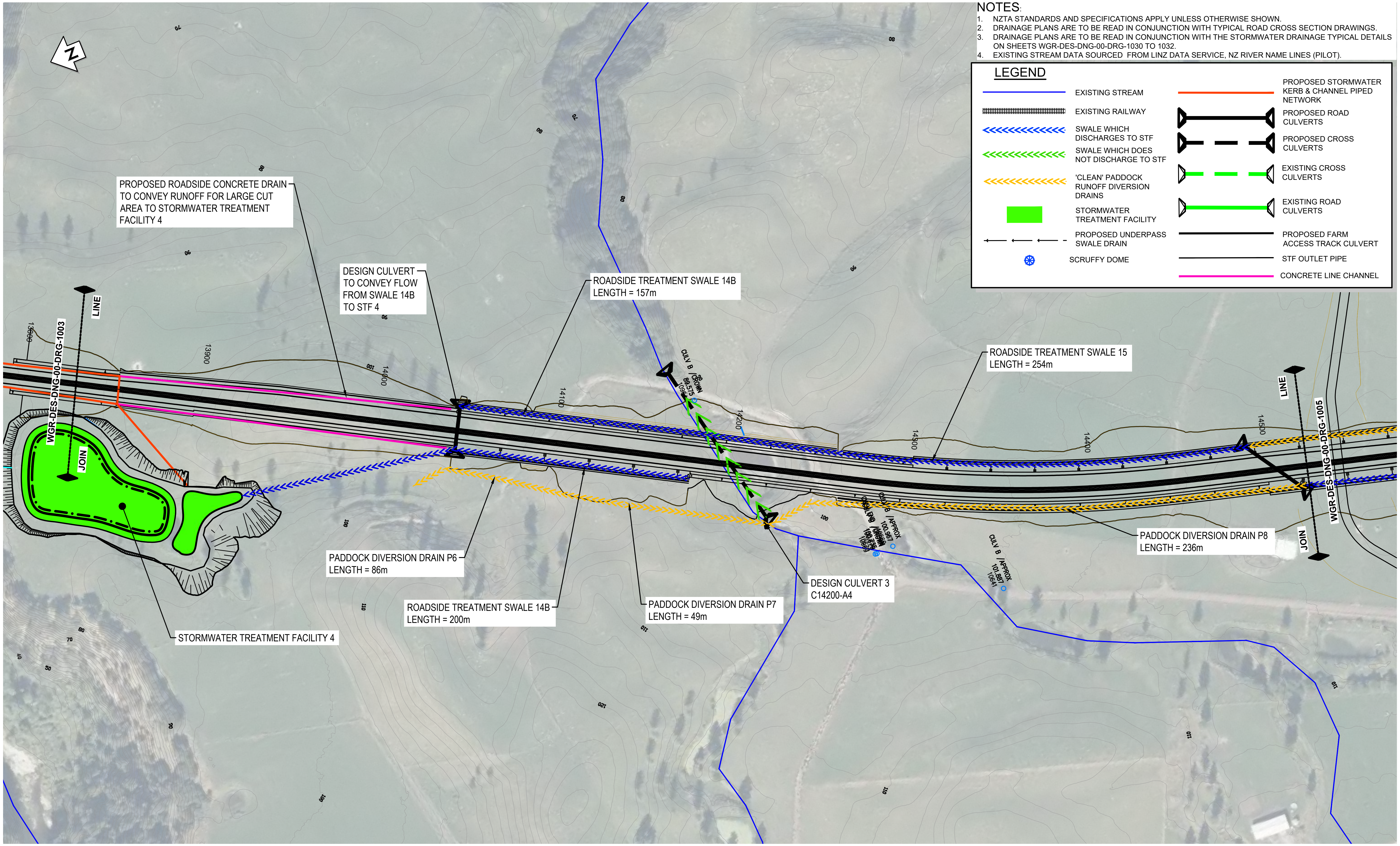

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STORMWATER LAYOUT PLAN
SHEET 4 OF 6

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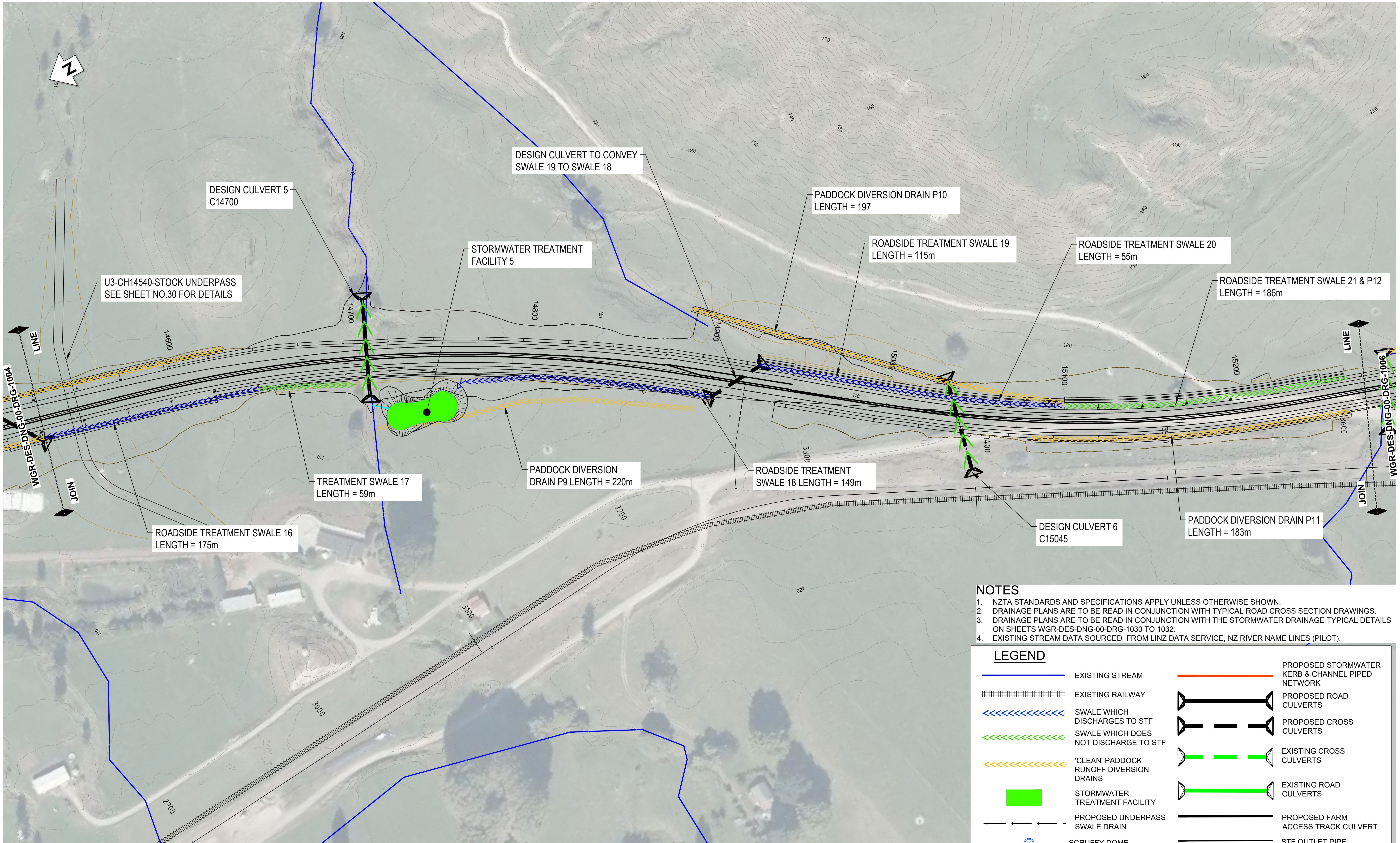

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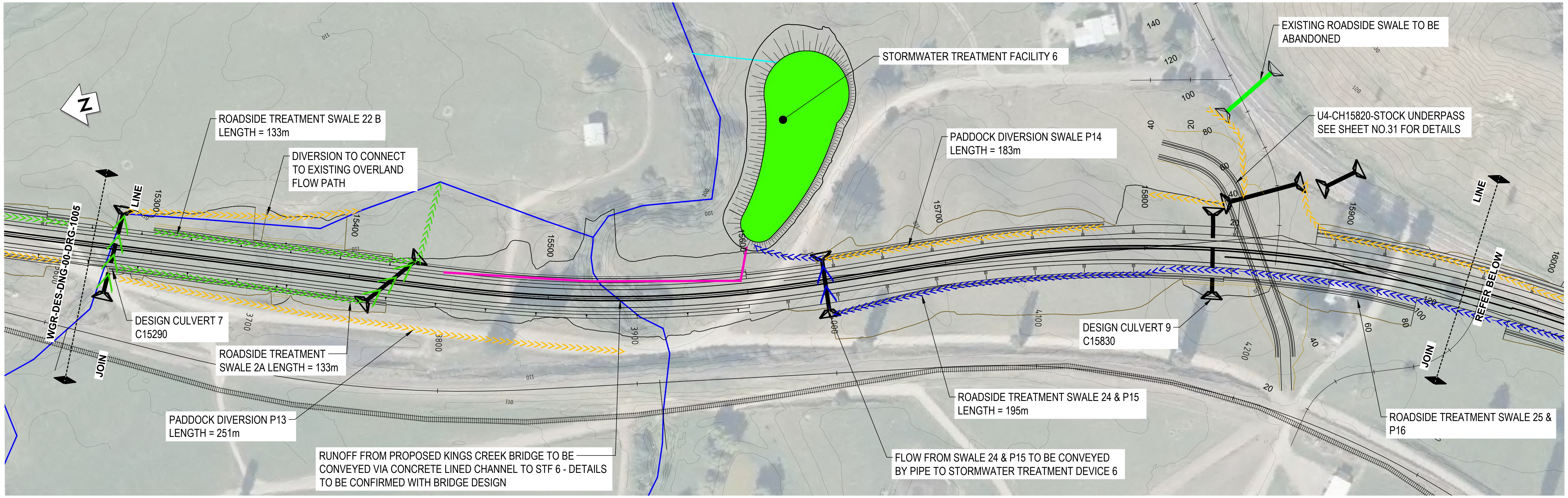

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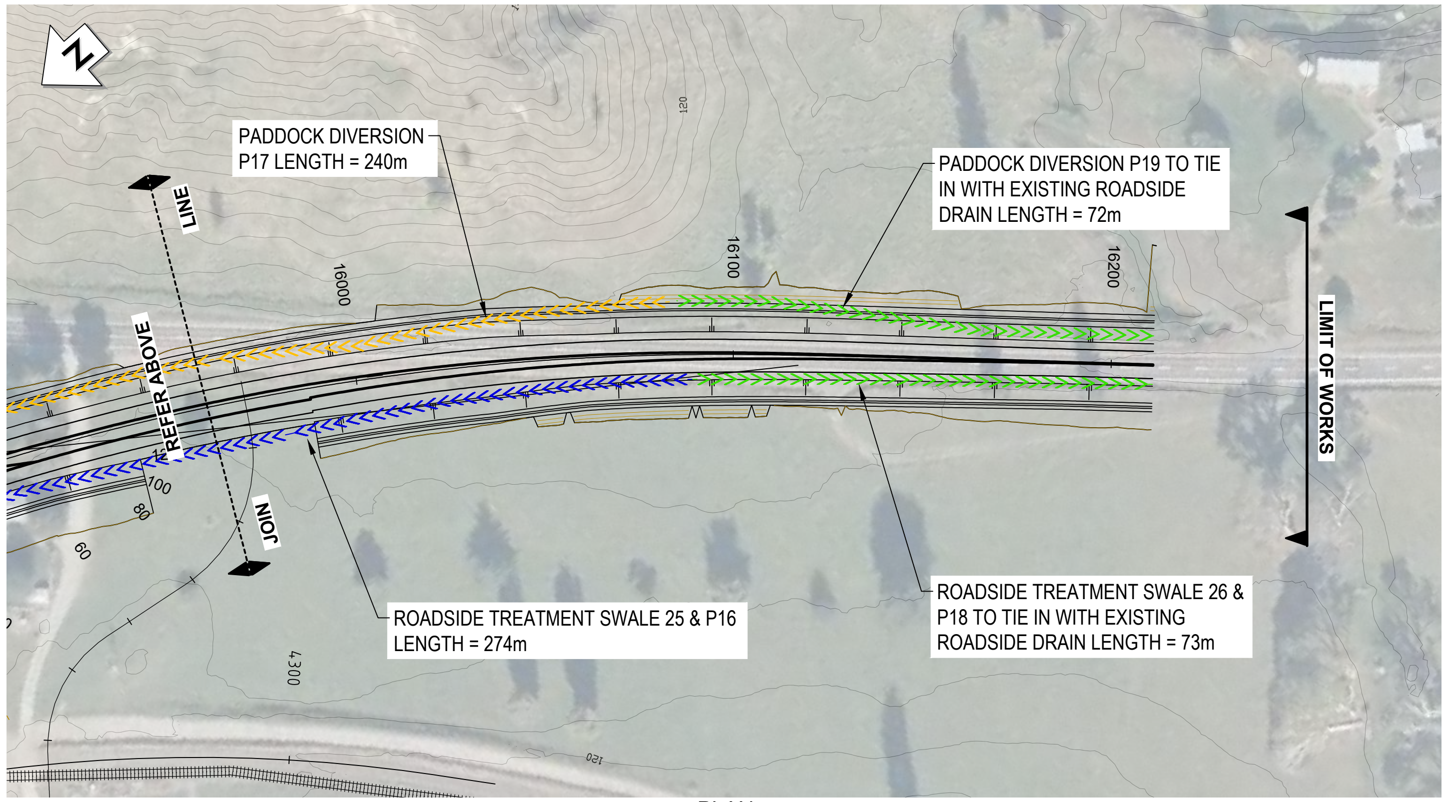

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LEGEND

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PRELIMINARY

PROJECT
WAKA KOTAHI
TAIRAWHITI ROAD PACKAGE PANEL
SH2 RP 577/11.600-592/2.500 WAIKARE GORGE REALIGNMENT

TITLE
STORMWATER LAYOUT PLAN
SHEET 6 OF 6

DOCUMENT NO.: WGR - DES - DNG - 00 - DRG
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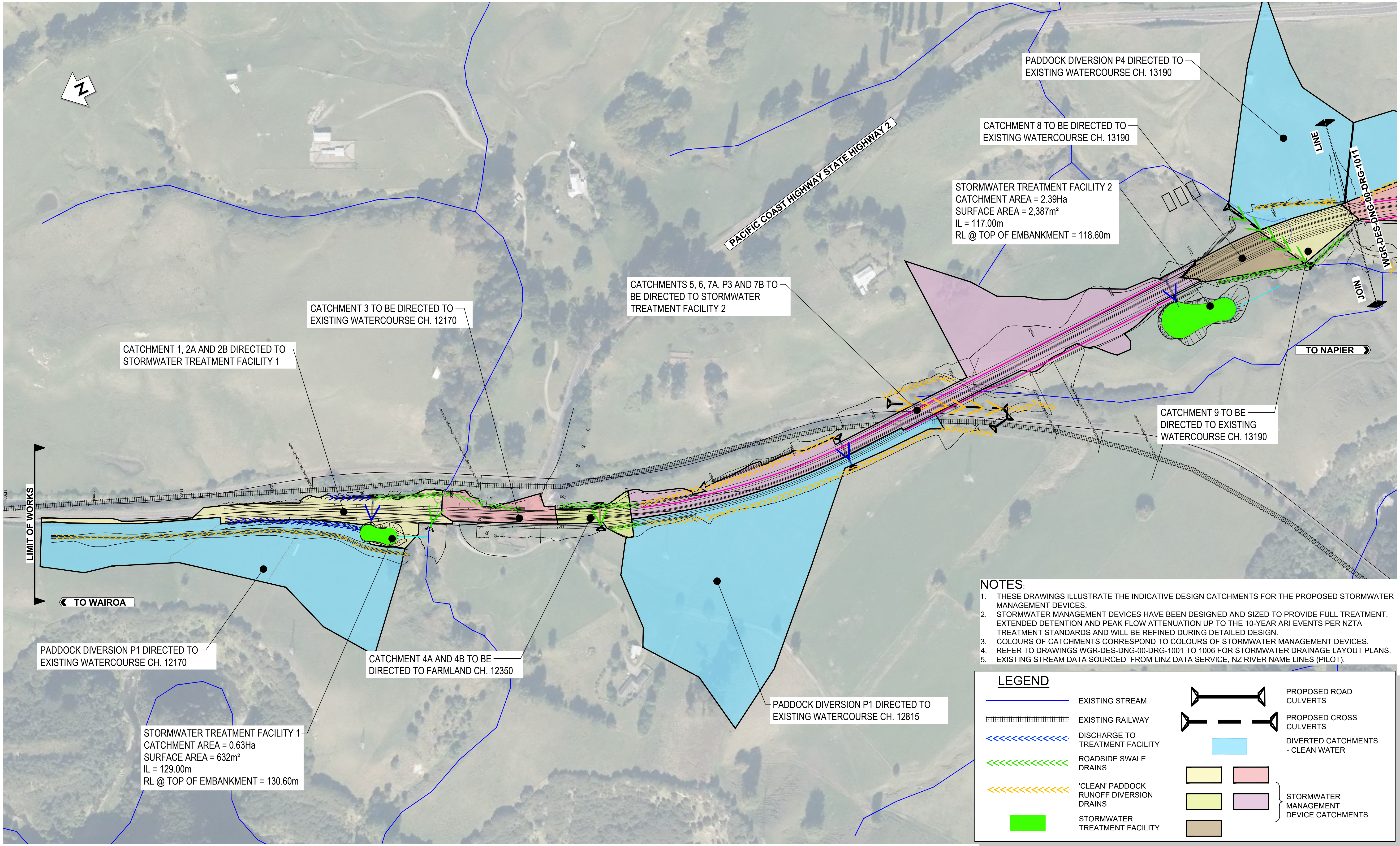

NOTES:

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3. COLOURS OF CATCHMENTS CORRESPOND TO COLOURS OF STORMWATER MANAGEMENT DEVICES.
4. REFER TO DRAWINGS WGR-DES-DNG-00-DRG-1001 TO 1006 FOR STORMWATER DRAINAGE LAYOUT PLANS.
5. EXISTING STREAM DATA SOURCED FROM LINZ DATA SERVICE, NZ RIVER NAME LINES (PILOT).

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TITLE
STORMWATER MANAGEMENT DEVICES
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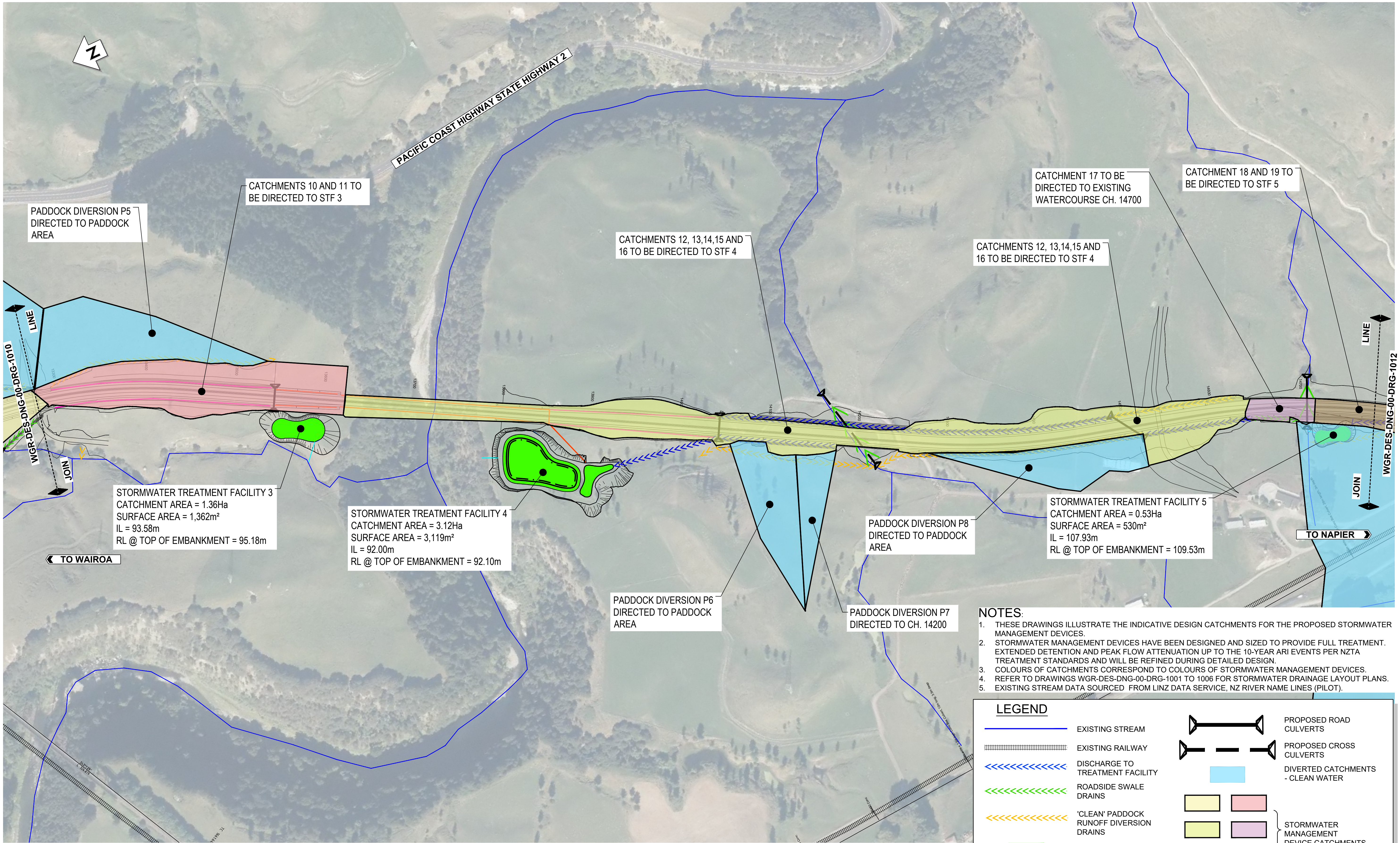

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- PROPOSED CROSS CULVERTS
- DIVERTED CATCHMENTS - CLEAN WATER
- STORMWATER MANAGEMENT DEVICE CATCHMENTS

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B	CONCEPT DESIGN	JM	NK	LY	02/2022
C	PRELIMINARY	PAC	NK	LY	08.2022
D	PRELIMINARY	SL	WAH	LY	09.2022

WAKA KOTAHI NZ TRANSPORT AGENCY

wsp

Stantec

GHD

SCALES: AS SHOWN @ A1
ORIGINAL SIZE: A1

DRAWN	DESIGNED	APPROVED
Jess Morgan	Jess Morgan	Jamie Povall
DRAWING VERIFIED	**DESIGN VERIFIED**	**APPROVED DATE**
Paul Chilton	Nick Keenan	09.11.22

PRELIMINARY

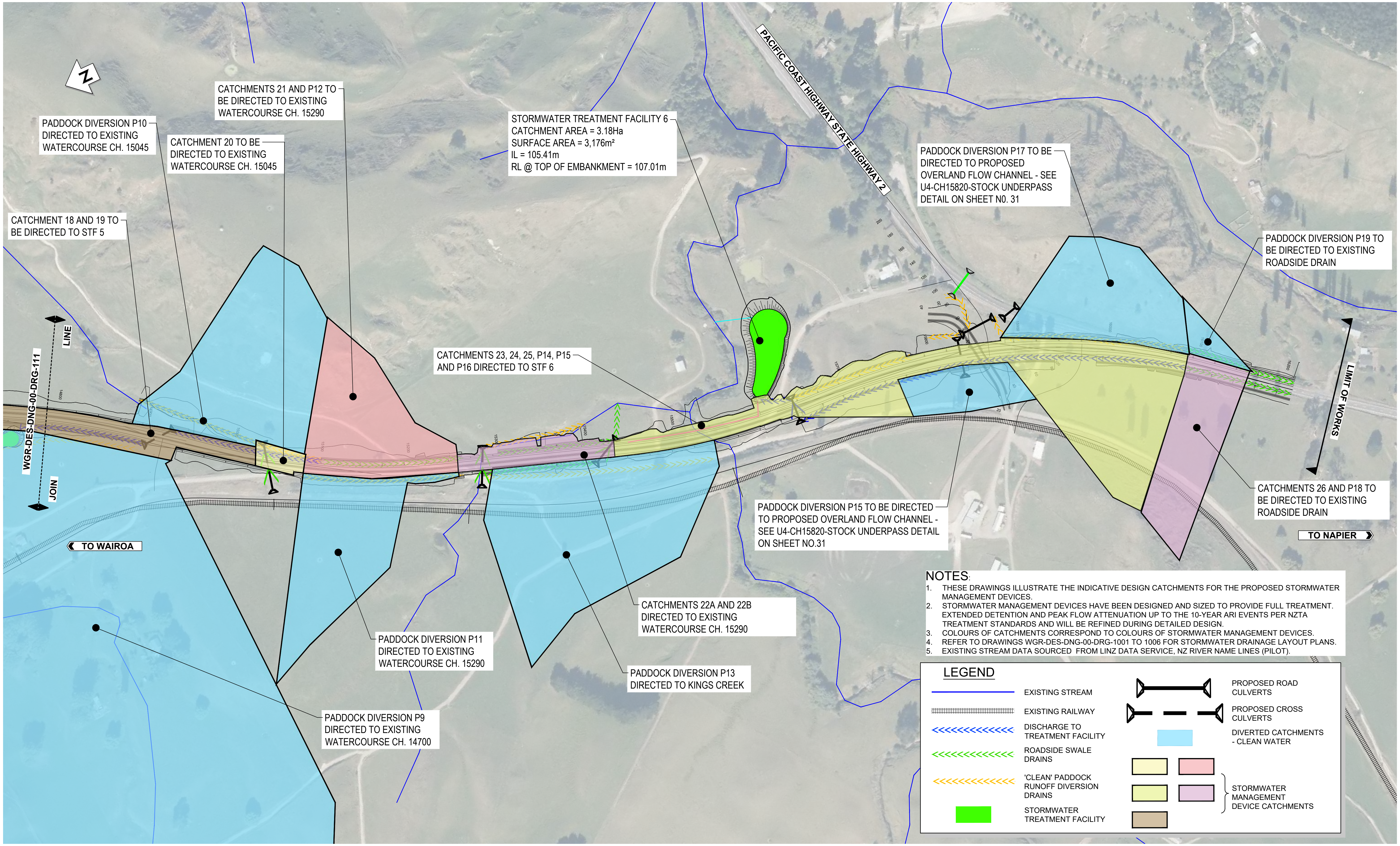
PROJECT
WAKA KOTAHI
TAIRAWHITI ROAD PACKAGE PANEL
SH2 RP 577/11.600-592/2.500 WAIKARE GORGE REALIGNMENT

TITLE
STORMWATER MANAGEMENT DEVICES
SHEET 2 OF 3

DOCUMENT NO. WGR - DES - DNG - 00 - DRG
SHEET NO. 0008
REVISION D

Original sheet size A1 (841x594) C:\pwworkdir\Exports\Waikare Gorge\WGR-DES-DNG-00-DRG-0008.dwg Layout1

ORGANISATION JOB CODE: 2-S5416.01 ORIGINATING ORGANISATION: WSP



NOTES:

1. THESE DRAWINGS ILLUSTRATE THE INDICATIVE DESIGN CATCHMENTS FOR THE PROPOSED STORMWATER MANAGEMENT DEVICES.
2. STORMWATER MANAGEMENT DEVICES HAVE BEEN DESIGNED AND SIZED TO PROVIDE FULL TREATMENT. EXTENDED DETENTION AND PEAK FLOW ATTENUATION UP TO THE 10-YEAR ARI EVENTS PER NZTA TREATMENT STANDARDS AND WILL BE REFINED DURING DETAILED DESIGN.
3. COLOURS OF CATCHMENTS CORRESPOND TO COLOURS OF STORMWATER MANAGEMENT DEVICES.
4. REFER TO DRAWINGS WGR-DES-DNG-00-DRG-1001 TO 1006 FOR STORMWATER DRAINAGE LAYOUT PLANS.
5. EXISTING STREAM DATA SOURCED FROM LINZ DATA SERVICE, NZ RIVER NAME LINES (PILOT).

PLAN
SCALE 1 : 2000

REVISION	AMENDMENT	DRAWN	CHECKED	APPROVED	DATE
A	WORKING PLOT	PAC			11.2021
B	CONCEPT DESIGN	JM	NK	LY	02/2022
C	PRELIMINARY	PAC	NK	LY	08.2022
D	PRELIMINARY	SL	WAH	LY	09.2022

WAKA KOTAHI NZ TRANSPORT AGENCY
wsp
Stantec
GHD

SCALES: AS SHOWN @ A1
ORIGINAL SIZE: A1

DRAWN	DESIGNED	APPROVED
Jess Morgan	Jess Morgan	Jamie Povall
DRAWING VERIFIED	**DESIGN VERIFIED**	**APPROVED DATE**
Paul Chilton	Nick Keenan	09.11.22

PRELIMINARY

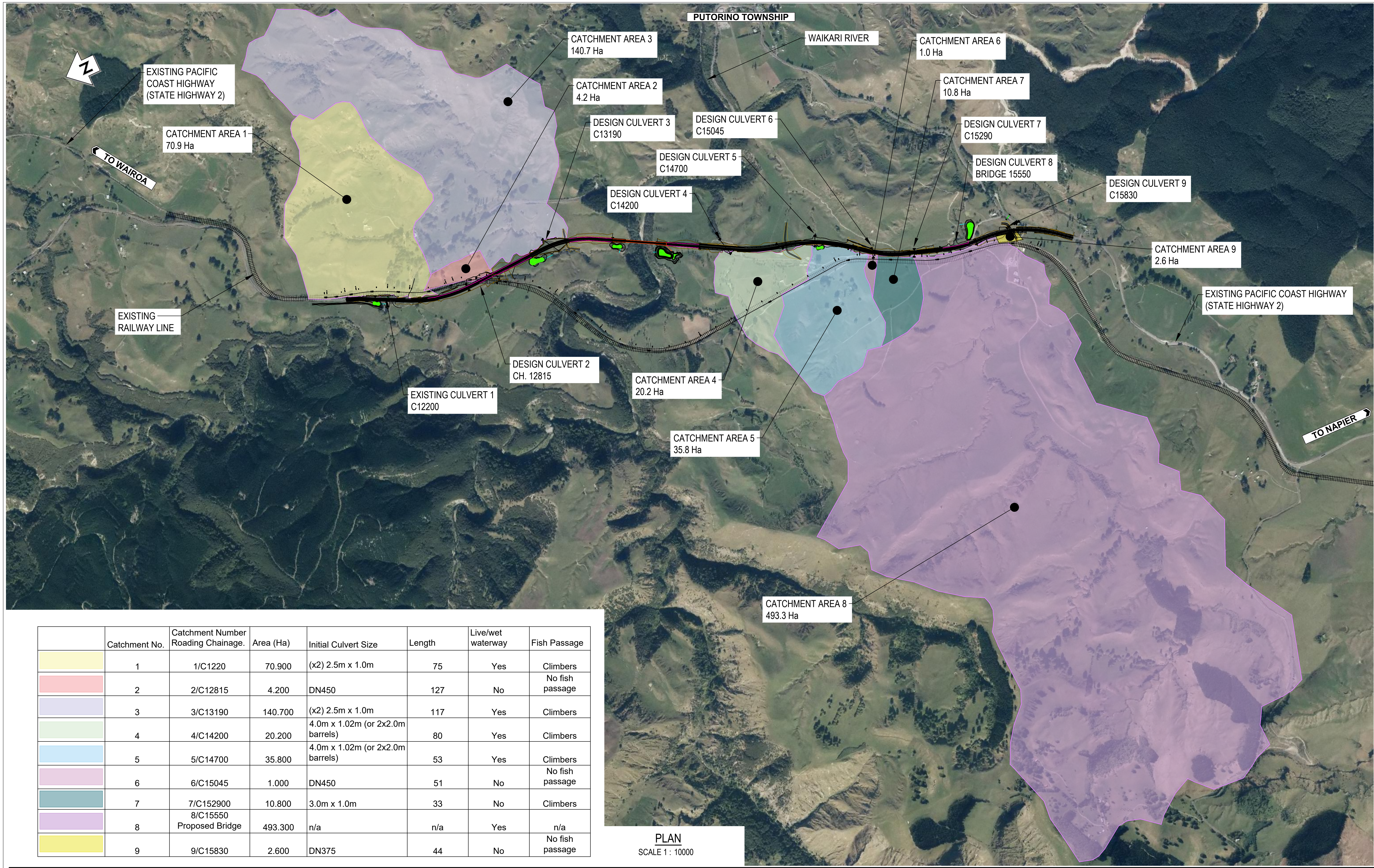
PROJECT
WAKA KOTAHI
TAIRAWHITI ROAD PACKAGE PANEL
SH2 RP 577/11.600-592/2.500 WAIKARE GORGE REALIGNMENT

TITLE
STORMWATER MANAGEMENT DEVICES
SHEET 3 OF 3

DOCUMENT NO.: WGR - DES - DNG - 00 - DRG
SHEET NO.: 0009
REVISION: D

Original sheet size A1 (841x594) C:\pwworkdir\ap_projects01\d0145797\WGR-DES-DNG-00-DRG-0009.dwg Layout1

ORGANISATION JOB CODE: 2-S5416.01 ORIGINATING ORGANISATION: WSP



	Catchment No.	Catchment Number Roading Chainage.	Area (Ha)	Initial Culvert Size	Length	Live/wet waterway	Fish Passage
	1	1/C1220	70.900	(x2) 2.5m x 1.0m	75	Yes	Climbers
	2	2/C12815	4.200	DN450	127	No	No fish passage
	3	3/C13190	140.700	(x2) 2.5m x 1.0m	117	Yes	Climbers
	4	4/C14200	20.200	4.0m x 1.02m (or 2x2.0m barrels)	80	Yes	Climbers
	5	5/C14700	35.800	4.0m x 1.02m (or 2x2.0m barrels)	53	Yes	Climbers
	6	6/C15045	1.000	DN450	51	No	No fish passage
	7	7/C152900	10.800	3.0m x 1.0m	33	No	Climbers
	8	8/C15550 Proposed Bridge	493.300	n/a	n/a	Yes	n/a
	9	9/C15830	2.600	DN375	44	No	No fish passage

PLAN
SCALE 1 : 10000

REVISION	AMENDMENT	DRAWN	CHECKED	APPROVED	DATE
A	WORKING PLOT	PAC			11.2021
B	CONCEPT DESIGN	JM	NK	LY	02/2022
C	PRELIMINARY	PAC	NK	LY	08.2022
D	PRELIMINARY	SL	WAH	LY	09.2022

SCALES: AS SHOWN @ A1
ORIGINAL SIZE: A1

DRAWN: Jess Morgan
DESIGNED: Jess Morgan
APPROVED: Jamie Povall
DRAWING VERIFIED: Paul Chilton
DESIGN VERIFIED: Nick Keenan
APPROVED DATE: 09.11.22

PRELIMINARY

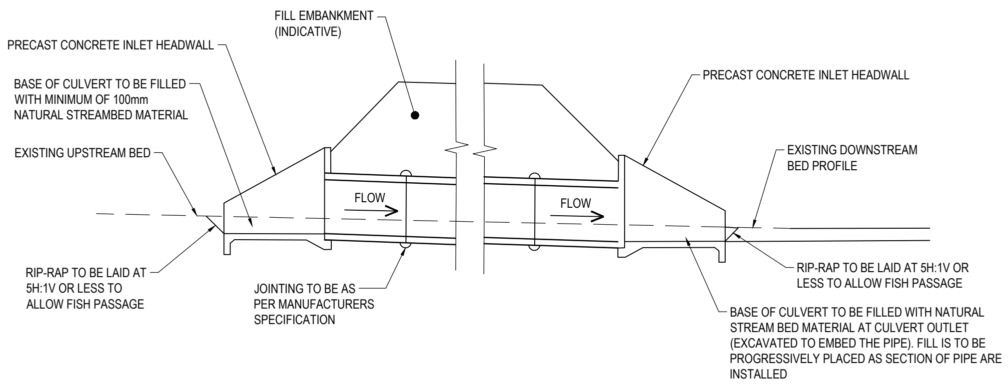
PROJECT
WAKA KOTAHI
TAIRAWHITI ROAD PACKAGE PANEL
SH2 RP 577/11.600-592/2.500 WAIKARE GORGE REALIGNMENT

TITLE
STORMWATER CROSS CULVERTS
CATCHMENT OVERVIEW PLAN

DOCUMENT NO.: WGR - DES - DNG - 00 - DRG
SHEET NO.: 0010
REVISION: D

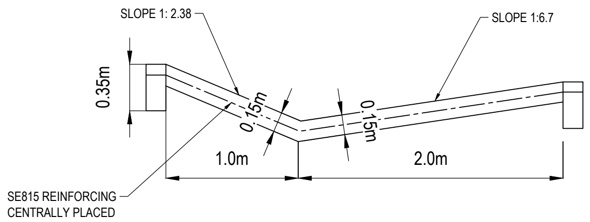
Original sheet size A1 (841x594) C:\pwworkdir\Exports\Waikare Gorge\WGR-DES-DNG-00-DRG-0010.dwg Layout1

ORGANISATION JOB CODE: 2-S5416.01 ORIGINATING ORGANISATION: WSP



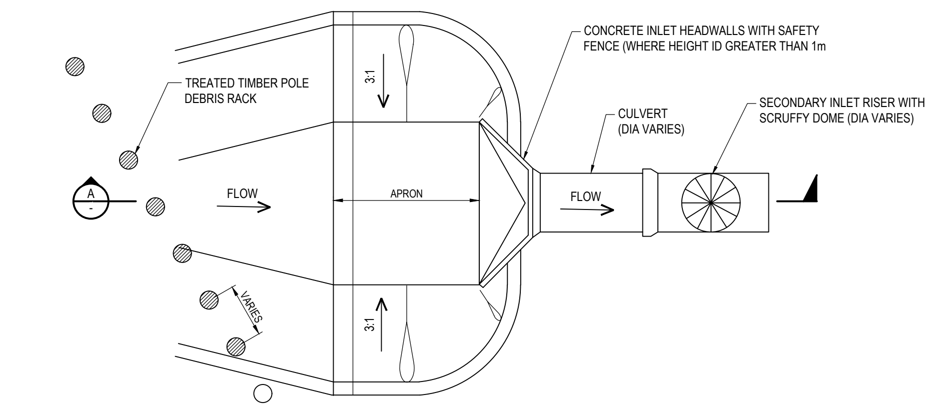
EMBEDED FISH PASSAGE CULVERT - TYPICAL DETAIL

NTS



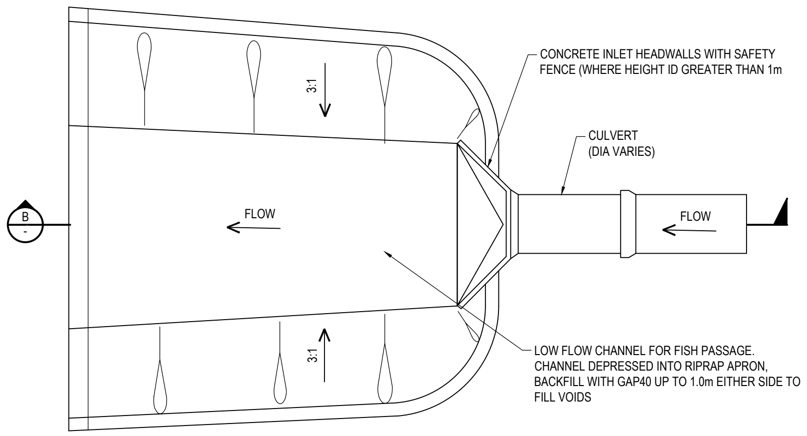
CONCRETE LINED DRAIN - TYPICAL DETAIL

NTS



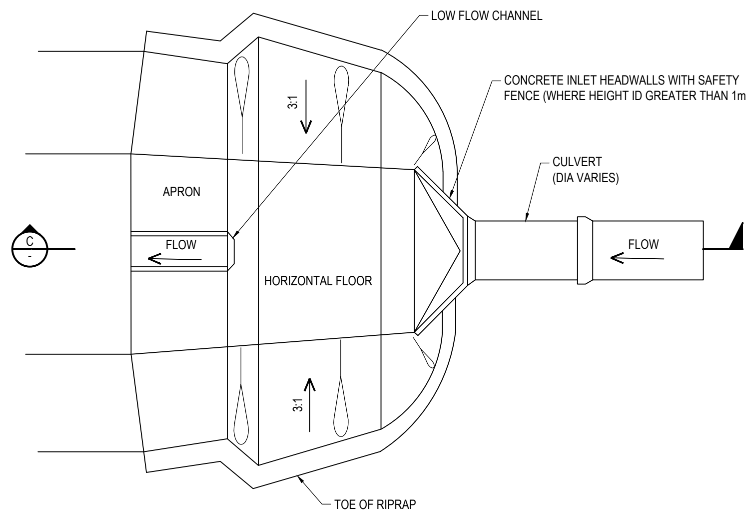
TYPICAL CULVERT INLET
(WITH RELEIF INLET AND DEBRIS RACK - PLAN VIEW

NTS



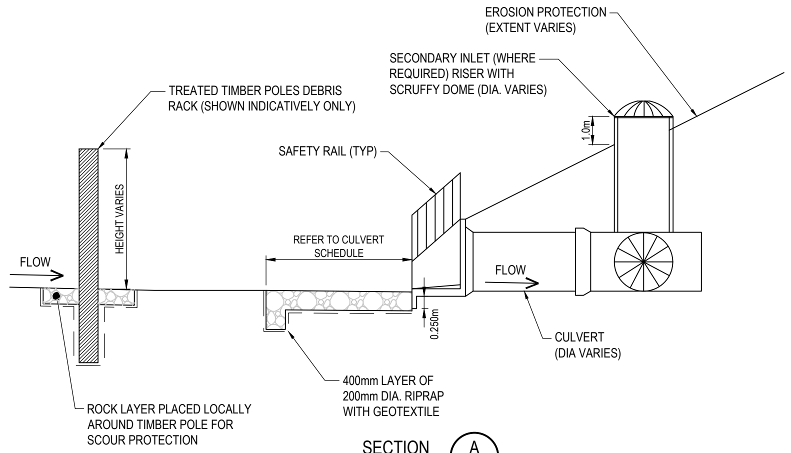
TYPICAL CULVERT OUTLET (RIPRAP APRON) - PLAN VIEW

NTS



TYPICAL CULVERT OUTLET (RIPRAP BASIN) - PLAN VIEW

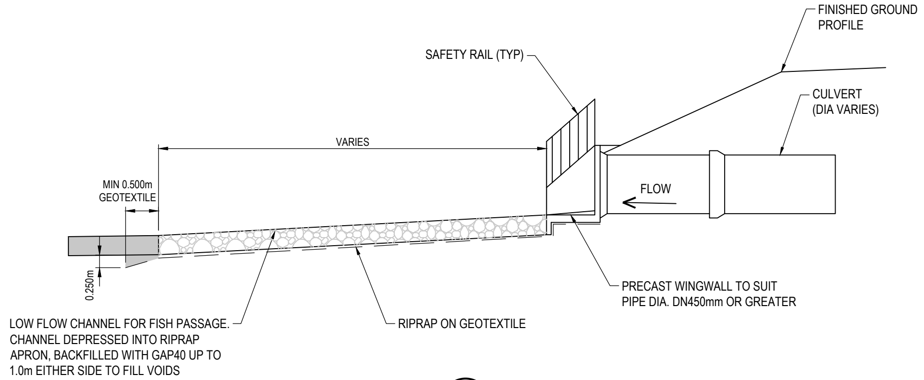
NTS



SECTION A

TYPICAL CULVERT INLET
WITH FLOOD PROTECTION AND MITIGATION - DEBRIS RACK AND SECONDARY INLET

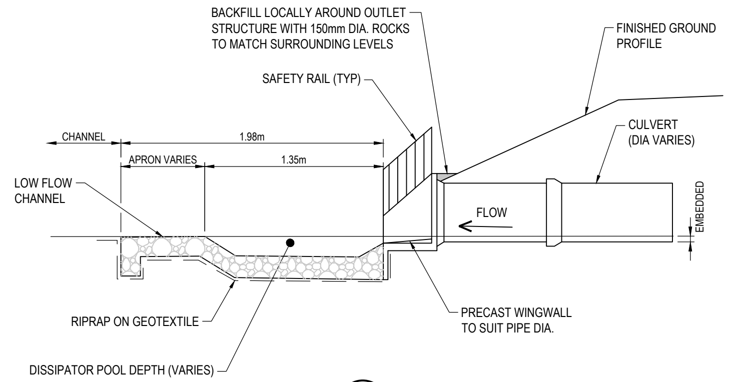
NTS



SECTION B

TYPICAL CULVERT OUTLET (RIPRAP APRON)

NTS



SECTION C

TYPICAL CULVERT OUTLET (RIPRAP BASIN)

NTS

REVISION	AMENDMENT	DRAWN	CHECKED	APPROVED	DATE
A	WORKING PLOT	PAC			11.2021
B	CONCEPT DESIGN	JM	NK	LY	02/2022
C	PRELIMINARY	PAC	NK	LY	08.2022
D	PRELIMINARY	SL	WAH	LY	09.2022

WAKA KOTAHI NZ TRANSPORT AGENCY

wsp

GHD

Stantec

SCALES: AS SHOWN @ A1
ORIGINAL SIZE: A1

DRAWN	DESIGNED	APPROVED
Jess Morgan	Jess Morgan	Jamie Povall
DRAWING VERIFIED	DESIGN VERIFIED	APPROVED DATE
Paul Chilton	Nick Keenan	09.11.22

PRELIMINARY

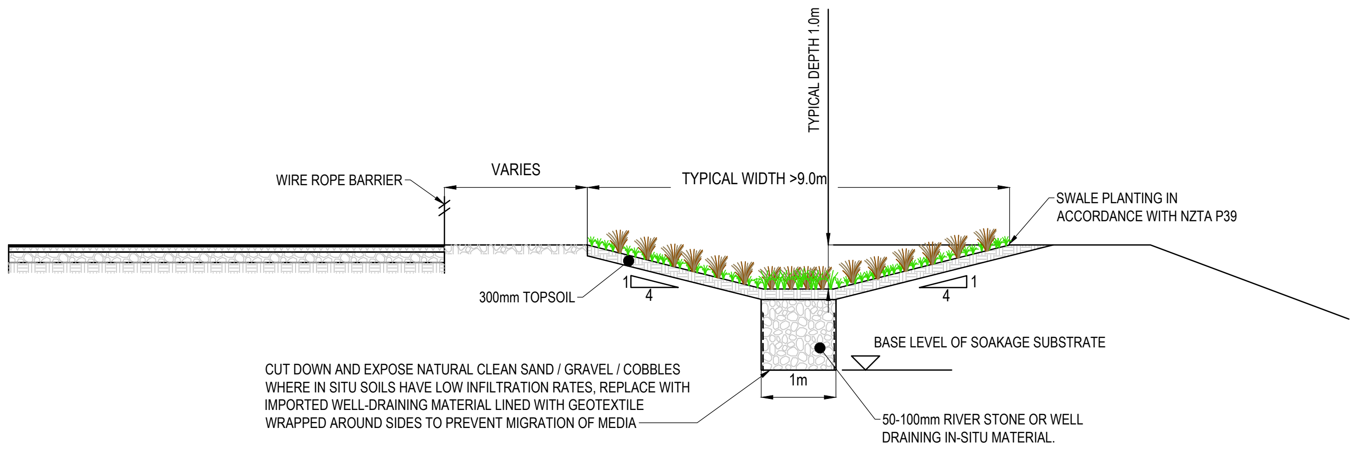
PROJECT
WAKA KOTAHI
TAIRAWHITI ROAD PACKAGE PANEL
SH2 RP 577/11.600-592/2.500 WAIKARE GORGE REALIGNMENT

TITLE
TYPICAL STORMWATER DETAILS SHEET 1 of 4
CULVERT INLET AND OUTLET DETAILS

DOCUMENT NO. WGR - DES - DNG - 00 - DRG
SHEET NO. 0011
REVISION D

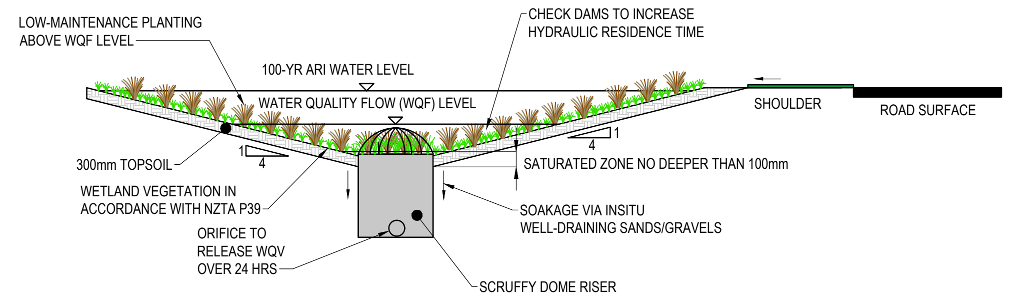
Original sheet size A1 (841x594) C:\pwworkdir\Exports\Waikare Gorge\WGR-DES-DNG-00-DRG-0011.dwg Layout1

ORGANISATION JOB CODE: 2-S5416.01 ORIGINATING ORGANISATION: WSP



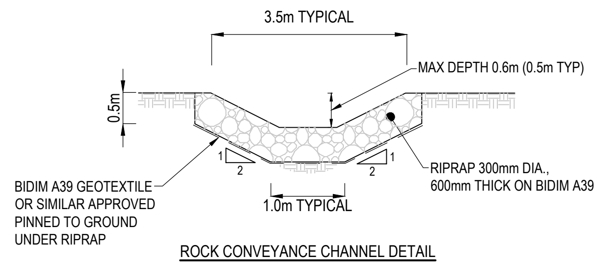
TYPICAL VEGETATED SWALE DETAIL WITH INFILTRTION

NTS



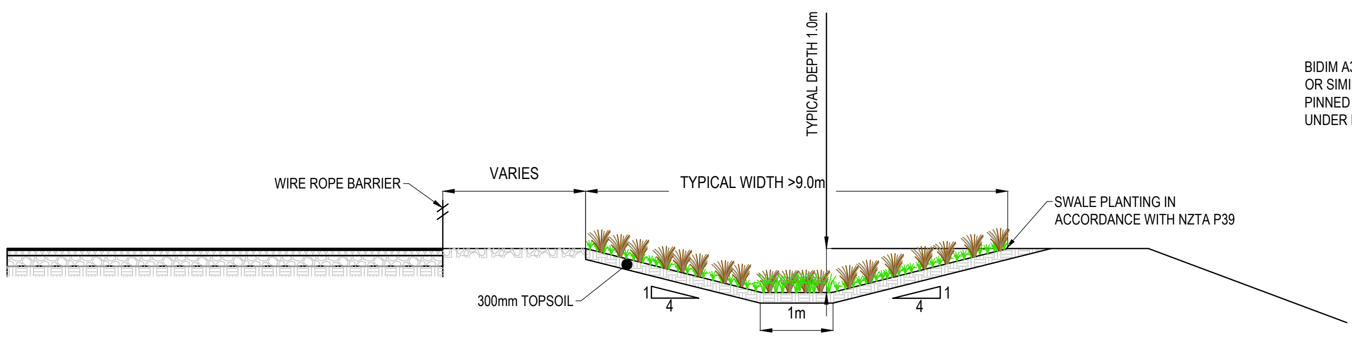
WETLAND SWALE DETAIL

NTS



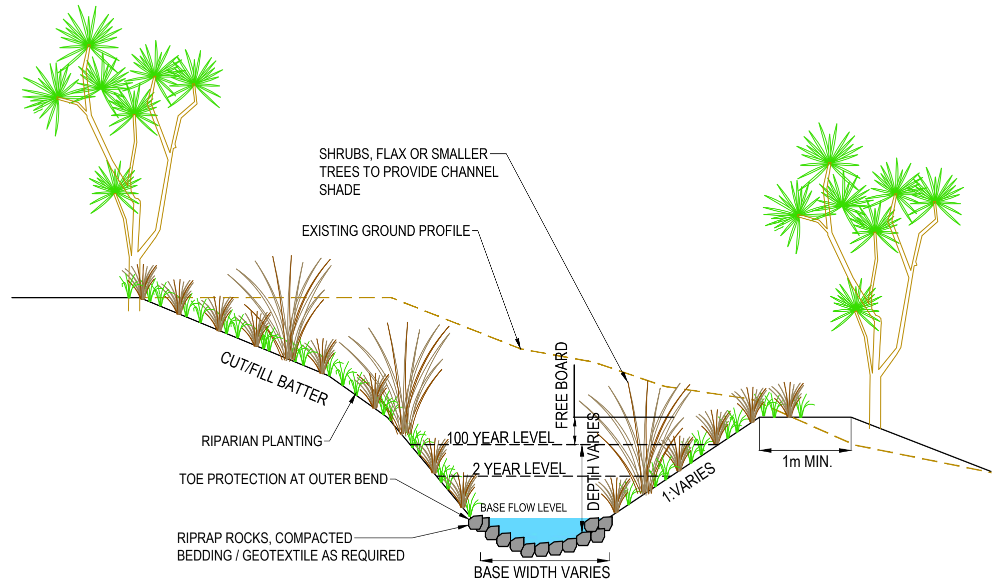
ROCK CONVEYANCE CHANNEL DETAIL

NTS



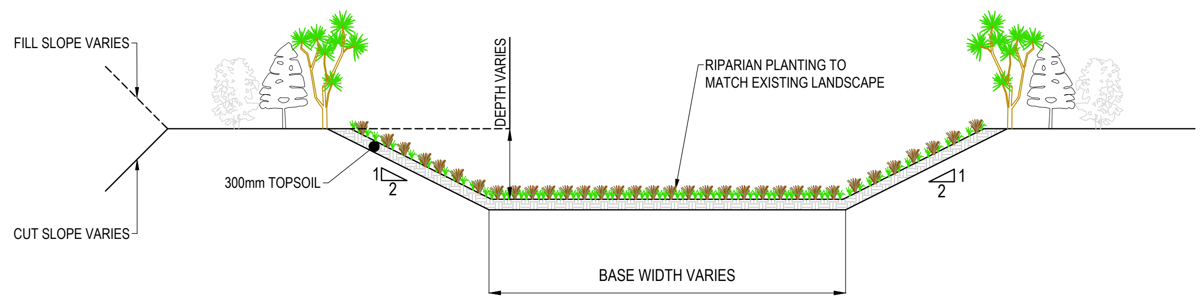
TYPICAL VEGETATED SWALE DETAIL

NTS



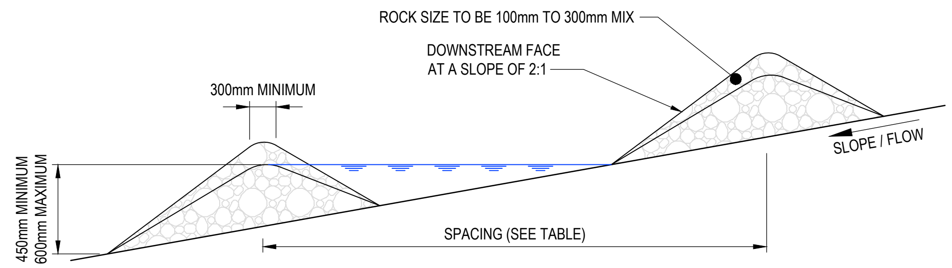
OPEN CHANNEL / STREAM DIVERSION TYPICAL CROSS SECTION FOR EXTENSION/DIVERSION OF NATURAL STREAMS

NTS



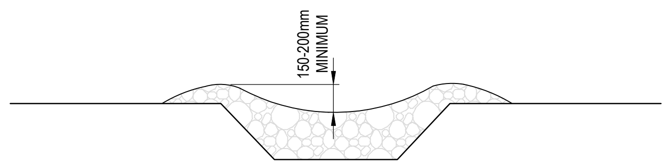
OPEN CHANNEL / TYPICAL CUT-OFF DRAIN - AT BASE OF CUT/FILLS

NTS



TYPICAL ELEVATION OF CHECK DAM

NTS



TYPICAL SECTION OF CHECK DAM

NTS

POSITIONING OF CHECK DAMS

SLOPE OF SITE (LESS THAN)	SPACING (m) BETWEEN DAMS WITH A 450mm CENTRE HEIGHT	SPACING (m) BETWEEN DAMS WITH A 600mm CENTRE HEIGHT
2%	24	30
2-4%	12	15
4-7%	8	11
7-10%	5	6
10%	UNSUITABLE - USE STABILISED CHANNEL OR SPECIFIC ENGINEERED DESIGN	UNSUITABLE - USE STABILISED CHANNEL OR SPECIFIC ENGINEERED DESIGN

REVISION	AMENDMENT	DRAWN	CHECKED	APPROVED	DATE
A	WORKING PLOT	PAC			11.2021
B	CONCEPT DESIGN	JM	NK	LY	02/2022
C	PRELIMINARY	PAC	NK	LY	08.2022
D	PRELIMINARY	SL	WAH	LY	09.2022

WAKA KOTAHI NZ TRANSPORT AGENCY

wsp

Stantec

GHD

SCALES: AS SHOWN @ A1
ORIGINAL SIZE: A1

DRAWN	DESIGNED	APPROVED
Jess Morgan	Jess Morgan	Jamie Povall
DRAWING VERIFIED	DESIGN VERIFIED	APPROVED DATE
Paul Chilton	Nick Keenan	09.11.22

PRELIMINARY

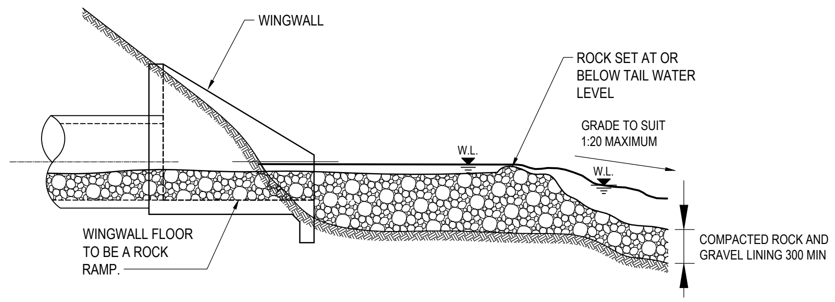
PROJECT
WAKA KOTAHI
TAIRAWHITI ROAD PACKAGE PANEL
SH2 RP 577/11.600-592/2.500 WAIKARE GORGE REALIGNMENT

TITLE
TYPICAL STORMWATER DETAILS SHEET 2 of 4
TYPICAL SWALE AND CHANNEL DETAILS

DOCUMENT NO. WGR - DES - DNG - 00 - DRG
SHEET NO. 0012
REVISION D

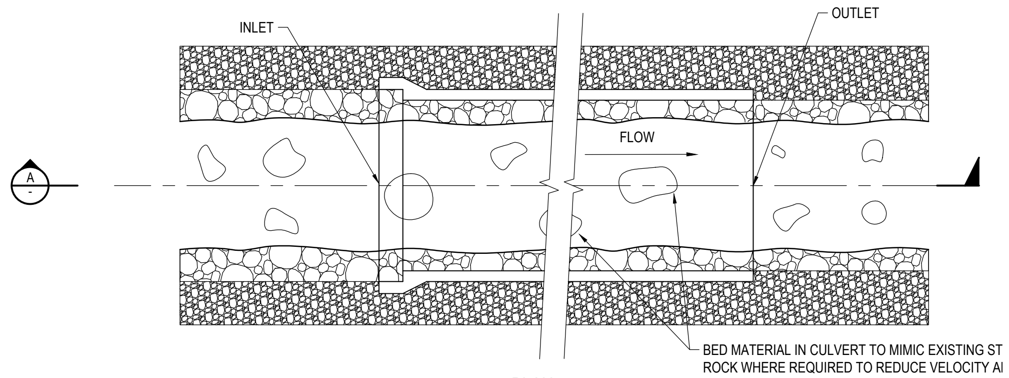
Original sheet size A1 (841x594) C:\pwworkdir\Exports\Waikare Gorge\WGR-DES-DNG-00-DRG-0012.dwg Layout1

ORGANISATION JOB CODE: 2-S5416.01 ORIGINATING ORGANISATION: WSP

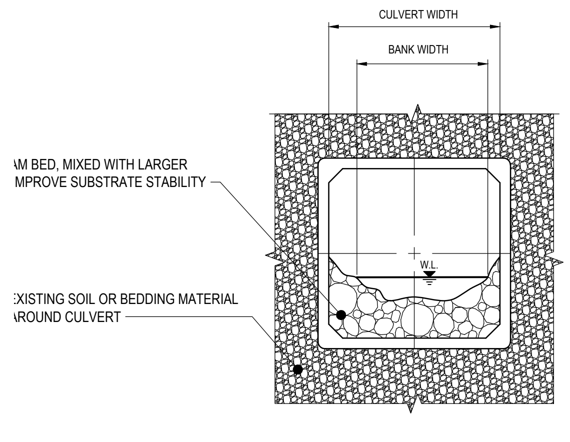


CULVERT OUTLET WITH WINGWALL

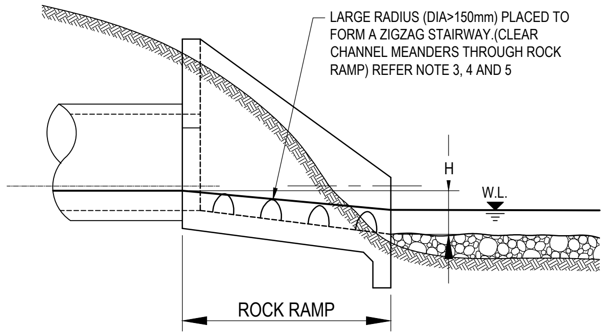
FISH PASSAGE IMPROVEMENT ROCKRAMP AND POOL
NTS



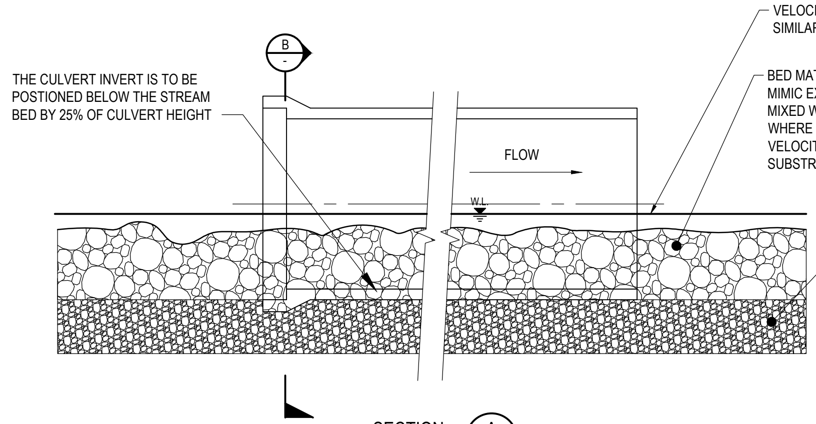
PLAN
N.T.S



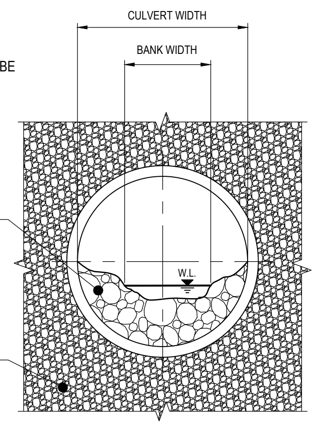
SECTION B
N.T.S



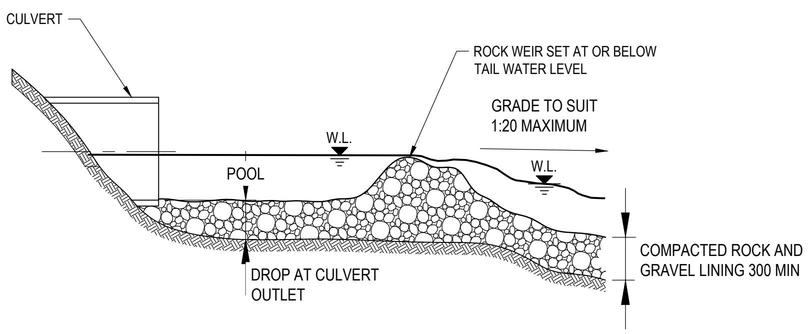
FISH PASSAGE ROCKRAMP ONLY
NTS



SECTION A
NTS



SECTION B
N.T.S



ROCKRAMP AND POOL FOR CULVERT WITHOUT WINGWALL

PRECAST BOX CULVERT WITH FISH PASSAGE
NTS

REVISION	AMENDMENT	DRAWN	CHECKED	APPROVED	DATE
A	WORKING PLOT	PAC			11.2021
B	CONCEPT DESIGN	JM	NK	LY	02/2022
C	PRELIMINARY	PAC	NK	LY	08.2022
D	PRELIMINARY	SL	WAH	LY	09.2022

WAKA KOTAHI NZ TRANSPORT AGENCY

wsp

GHD

Stantec

SCALES		ORIGINAL SIZE
AS SHOWN @ A1		A1
DRAWN	DESIGNED	APPROVED
Jess Morgan	Jess Morgan	Jamie Povall
DRAWING VERIFIED	DESIGN VERIFIED	APPROVED DATE
Paul Chilton	Nick Keenan	09.11.22

PRELIMINARY

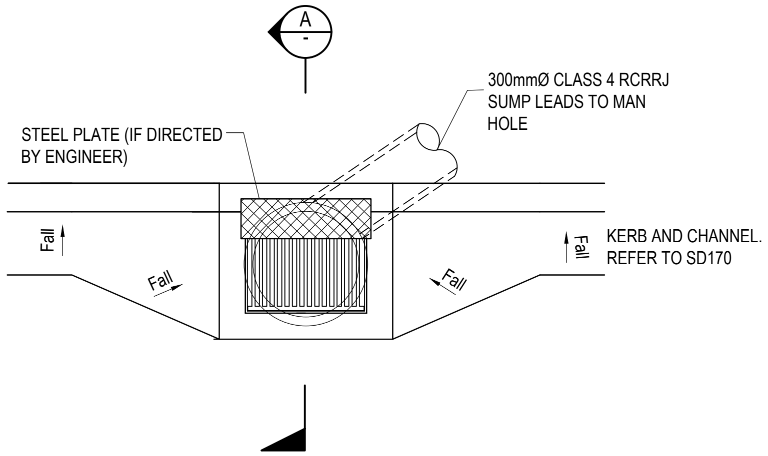
PROJECT
WAKA KOTAHI
TAIRAWHITI ROAD PACKAGE PANEL
SH2 RP 577/11.600-592/2.500 WAIKARE GORGE REALIGNMENT

TITLE
TYPICAL STORMWATER DETAILS SHEET 3 of 4
FISH PASSAGE DETAILS

DOCUMENT NO.	SHEET NO.	REVISION
WGR - DES - DNG - 00 - DRG	0013	D

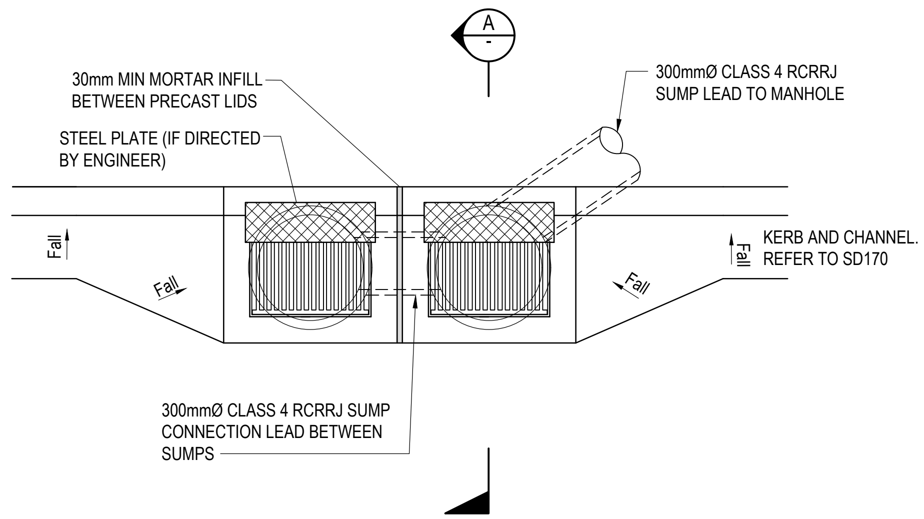
Original sheet size A1 (841x594) C:\pwworkdir\Exports\Waikare Gorge\WGR-DES-DNG-00-DRG-0013.dwg Layout1

ORGANISATION JOB CODE: 2-S5416.01 ORIGINATING ORGANISATION: WSP



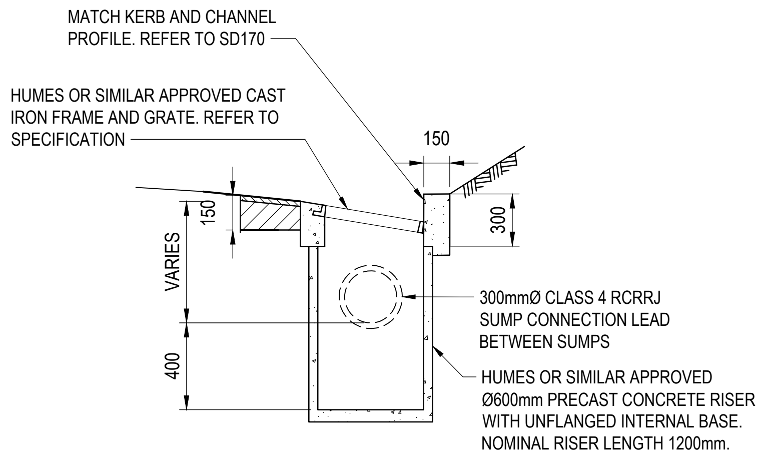
TYPICAL SINGLE BACK ENTRY SUMP/GRATE

NTS



TYPICAL DOUBLE BACK ENTRY SUMP/GRATE

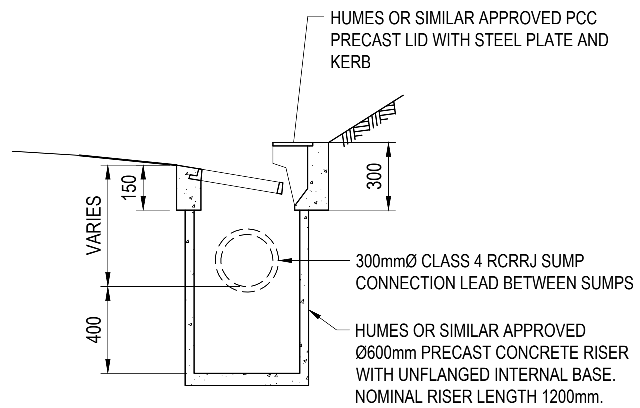
NTS



SECTION WITHOUT BACK ENTRY

SECTION A -

NTS



SECTION WITH BACK ENTRY

SECTION A -

NTS

TYPICAL ENTRY SUMPS

REVISION	AMENDMENT	DRAWN	CHECKED	APPROVED	DATE
A	WORKING PLOT	PAC			
B	CONCEPT DESIGN	JM	NK	LY	02/2022
C	PRELIMINARY	PAC	NK	LY	08.2022
D	PRELIMINARY	SL	WAH	LY	09.2022

WAKA KOTAHI NZ TRANSPORT AGENCY

wsp

Stantec

GHD

SCALES		ORIGINAL SIZE
AS SHOWN @ A1		A1
DRAWN	DESIGNED	APPROVED
Jess Morgan	Jess Morgan	Jamie Povall
DRAWING VERIFIED	DESIGN VERIFIED	APPROVED DATE
Paul Chilton	Nick Keenan	09.11.22

PRELIMINARY

PROJECT
WAKA KOTAHI
TAIRAWHITI ROAD PACKAGE PANEL
SH2 RP 577/11.600-592/2.500 WAIKARE GORGE REALIGNMENT

TITLE
TYPICAL STORMWATER DETAILS SHEET 4 of 4
SUMP DETAILS

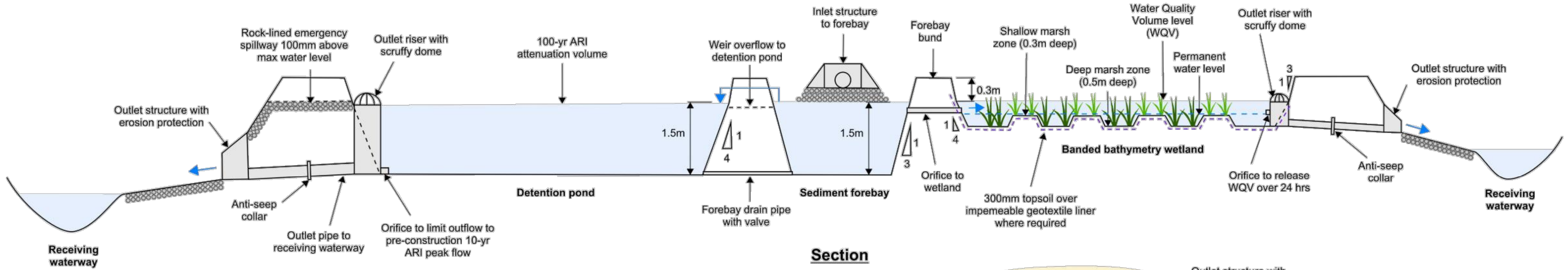
DOCUMENT NO.	SHEET NO.	REVISION
WGR - DES - DNG - 00 - DRG	0014	D

Original sheet size A1 (841x594) C:\pwworkdir\Exports\Waikare Gorge\WGR-DES-DNG-00-DRG-0014.dwg Layout1

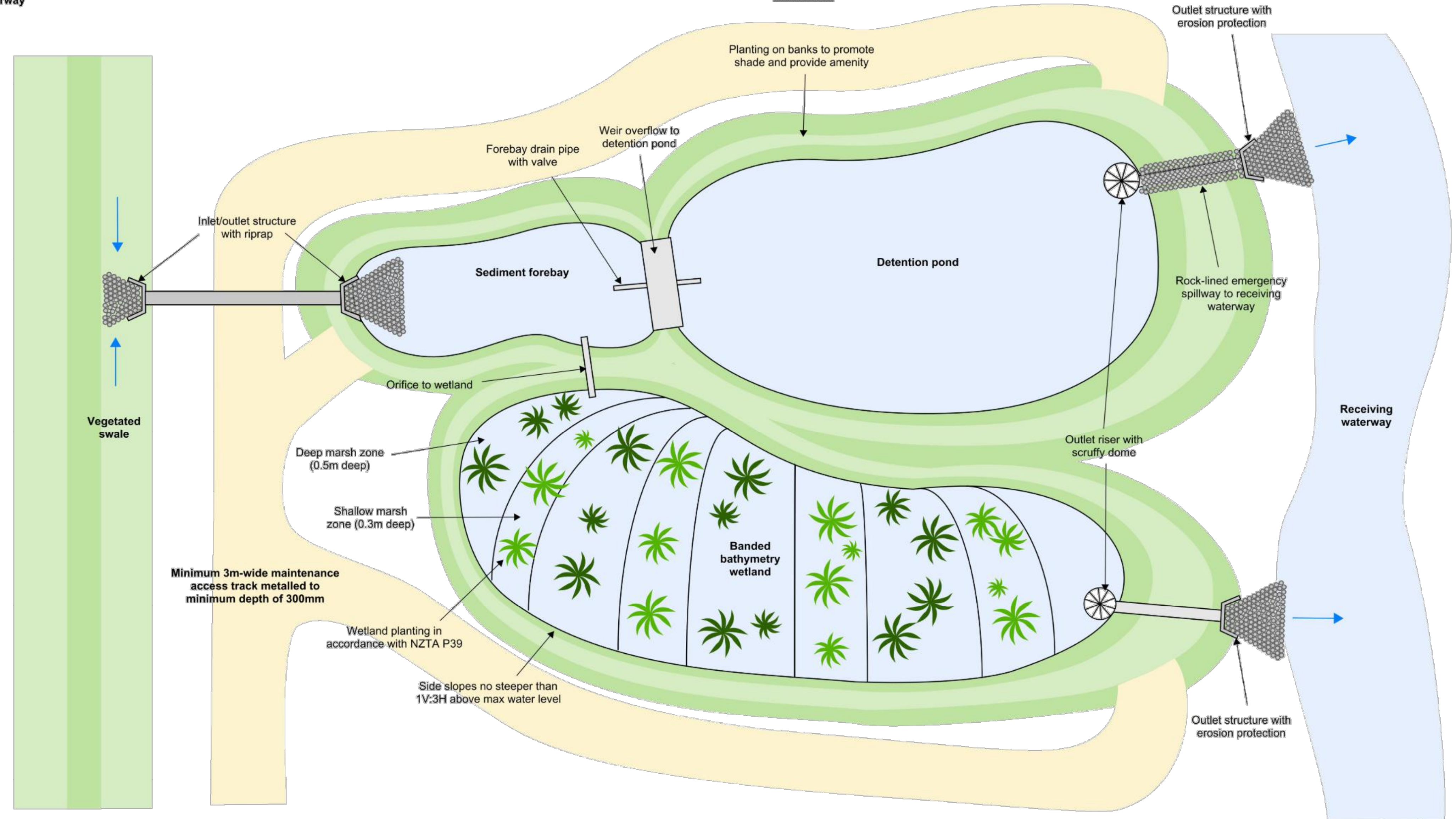
ORGANISATION JOB CODE: 2-S5416.01 ORIGINATING ORGANISATION: WSP

0 10 mm 50 100 200 300 mm

Section



Plan



Typical forebay-wetland-pond arrangement to receiving waterway arrangement

(NOT TO SCALE)

REVISION	AMENDMENT	DRAWN	CHECKED	APPROVED	DATE
A	WORKING PLOT	PAC			11.2021
B	CONCEPT DESIGN	JM	NK	LY	02/2022
C	PRELIMINARY	PAC	NK	LY	08.2022
D	PRELIMINARY	SL	WAH	LY	09.2022

WAKA KOTAHI NZ TRANSPORT AGENCY

wsp

Stantec

GHD

SCALES: AS SHOWN @ A1
ORIGINAL SIZE: A1

DRAWN	DESIGNED	APPROVED
Jess Morgan	Jess Morgan	Jamie Povall
DRAWING VERIFIED	DESIGN VERIFIED	APPROVED DATE
Paul Chilton	Nick Keenan	09.11.22

PRELIMINARY

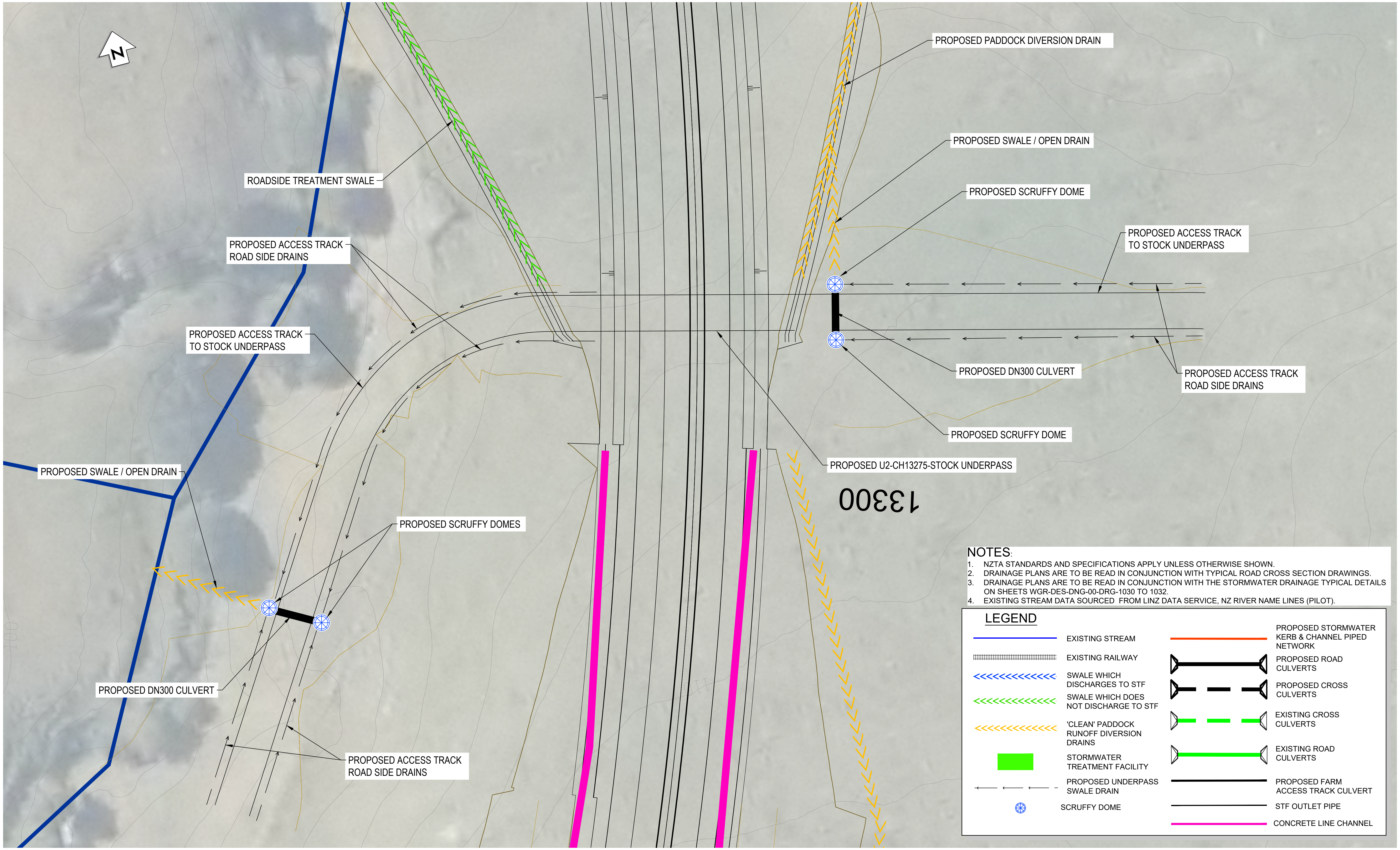
PROJECT
WAKA KOTAHI
TAIRAWHITI ROAD PACKAGE PANEL
SH2 RP 577/11.600-592/2.500 WAIKARE GORGE REALIGNMENT

TITLE
TYPICAL STORMWATER DRAINAGE DETAILS
TYPICAL WETLAND GENERAL ARRANGEMENT

DOCUMENT NO.: WGR - DES - DNG - 00 - DRG
SHEET NO.: 0015
REVISION: D

Original sheet size A1 (841x594) C:\pwworkdir\Exports\Waikare Gorge\WGR-DES-DNG-00-DRG-0015.dwg Layout1

ORGANISATION JOB CODE: 2-S5416.01
ORIGINATING ORGANISATION: WSP



NOTES:

1. NZTA STANDARDS AND SPECIFICATIONS APPLY UNLESS OTHERWISE SHOWN.
2. DRAINAGE PLANS ARE TO BE READ IN CONJUNCTION WITH TYPICAL ROAD CROSS SECTION DRAWINGS.
3. DRAINAGE PLANS ARE TO BE READ IN CONJUNCTION WITH THE STORMWATER DRAINAGE TYPICAL DETAILS ON SHEETS WGR-DES-DNG-00-DRG-1030 TO 1032.
4. EXISTING STREAM DATA SOURCED FROM LINZ DATA SERVICE, NZ RIVER NAME LINES (PILOT).

LEGEND

EXISTING STREAM	PROPOSED STORMWATER KERB & CHANNEL PIPED NETWORK
EXISTING RAILWAY	PROPOSED ROAD CULVERTS
SWALE WHICH DISCHARGES TO STF	PROPOSED CROSS CULVERTS
SWALE WHICH DOES NOT DISCHARGE TO STF	EXISTING CROSS CULVERTS
'CLEAN' PADDOCK RUNOFF DIVERSION DRAINS	EXISTING ROAD CULVERTS
STORMWATER TREATMENT FACILITY	
PROPOSED UNDERPASS SWALE DRAIN	PROPOSED FARM ACCESS TRACK CULVERT
SCRUFFY DOME	STF OUTLET PIPE
	CONCRETE LINE CHANNEL

PLAN

SCALE 1 : 250

REVISION	AMENDMENT	DRAWN	CHECKED	APPROVED	DATE
C	PRELIMINARY	PAC			08.2022
D	PRELIMINARY	SL	WAH	LY	09.2022

WAKA KOTAHI NZ TRANSPORT AGENCY

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Stantec

GHD

SCALES

ORIGINAL SIZE A1

DRAWN	DESIGNED	APPROVED
Jess Morgan	Jess Morgan	Jamie Povall
DRAWING VERIFIED	DESIGN VERIFIED	APPROVED DATE
Paul Chilton	Nick Keenan	09.11.22

PRELIMINARY

PROJECT
WAKA KOTAHI
TAIRAWHITI ROAD PACKAGE PANEL
SH2 RP 577/11.600-592/2.500 WAIKARE GORGE REALIGNMENT

TITLE
U2 - CH13275 - STOCK UNDERPASS

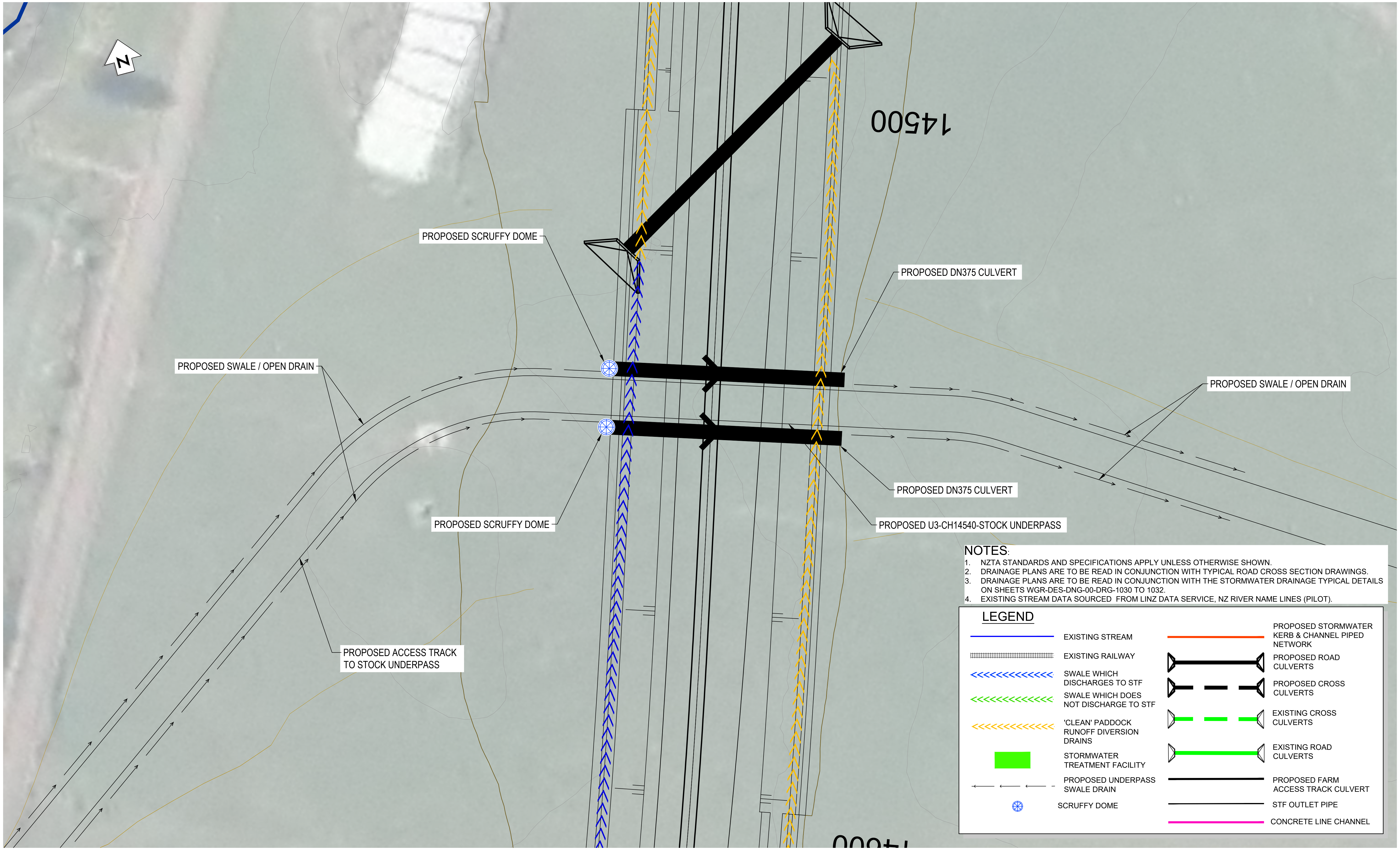
DOCUMENT NO. WGR - DES - DNG - - DRG

SHEET NO. 0020

REVISION D

Original sheet size A1 (841x594) C:\pwworkdir\Exports\Waikare Gorge\WGR-DES-DNG-00-DRG-0020.dwg Layout1

ORGANISATION JOB CODE: 2-S5416.01 ORIGINATING ORGANISATION: WSP



NOTES:
1. NZTA STANDARDS AND SPECIFICATIONS APPLY UNLESS OTHERWISE SHOWN.
2. DRAINAGE PLANS ARE TO BE READ IN CONJUNCTION WITH TYPICAL ROAD CROSS SECTION DRAWINGS.
3. DRAINAGE PLANS ARE TO BE READ IN CONJUNCTION WITH THE STORMWATER DRAINAGE TYPICAL DETAILS ON SHEETS WGR-DES-DNG-00-DRG-1030 TO 1032.
4. EXISTING STREAM DATA SOURCED FROM LINZ DATA SERVICE, NZ RIVER NAME LINES (PILOT).

LEGEND

EXISTING STREAM
EXISTING RAILWAY
SWALE WHICH DISCHARGES TO STF
SWALE WHICH DOES NOT DISCHARGE TO STF
'CLEAN' PADDOCK RUNOFF DIVERSION DRAINS
STORMWATER TREATMENT FACILITY
PROPOSED UNDERPASS SWALE DRAIN
SCRUFFY DOME
PROPOSED STORMWATER KERB & CHANNEL PIPED NETWORK
PROPOSED ROAD CULVERTS
PROPOSED CROSS CULVERTS
EXISTING CROSS CULVERTS
EXISTING ROAD CULVERTS
PROPOSED FARM ACCESS TRACK CULVERT
STF OUTLET PIPE
CONCRETE LINE CHANNEL

PLAN
SCALE 1 : 1000

REVISION	AMENDMENT	DRAWN	CHECKED	APPROVED	DATE
C	PRELIMINARY	PAC			08.2022
D	PRELIMINARY	SL	WAH	LY	09.2022

WAKA KOTAHI NZ TRANSPORT AGENCY
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SCALES
ORIGINAL SIZE A1

DRAWN	DESIGNED	APPROVED
Jess Morgan	Jess Morgan	Jamie Povall
DRAWING VERIFIED	DESIGN VERIFIED	APPROVED DATE
Paul Chilton	Nick Keenan	09.11.22

PRELIMINARY

PROJECT
WAKA KOTAHI
TAIRAWHITI ROAD PACKAGE PANEL
SH2 RP 577/11.600-592/2.500 WAIKARE GORGE REALIGNMENT

TITLE
U3 - CH14540 - STOCK UNDERPASS

DOCUMENT NO. WGR - DES - DNG - - DRG
SHEET NO. 0021
REVISION D

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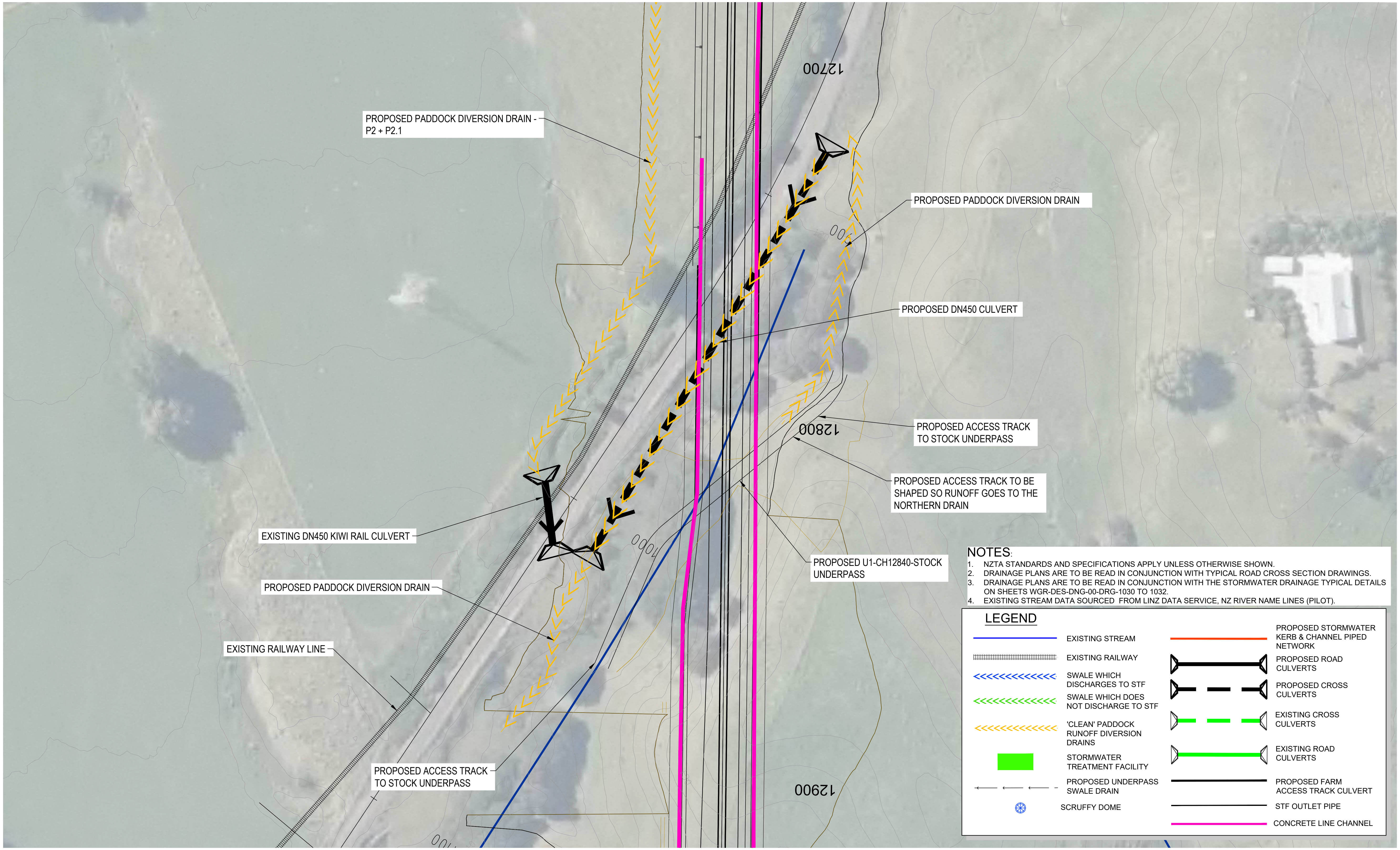
ORIGINATING ORGANISATION: WSP



NOTES:
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4. EXISTING STREAM DATA SOURCED FROM LINZ DATA SERVICE, NZ RIVER NAME LINES (PILOT).

LEGEND
- EXISTING STREAM
- EXISTING RAILWAY
- SWALE WHICH DISCHARGES TO STF
- SWALE WHICH DOES NOT DISCHARGE TO STF
- 'CLEAN' PADDOCK RUNOFF DIVERSION DRAINS
- STORMWATER TREATMENT FACILITY
- PROPOSED UNDERPASS SWALE DRAIN
- SCRUFFY DOME
- PROPOSED STORMWATER KERB & CHANNEL PIPED NETWORK
- PROPOSED ROAD CULVERTS
- PROPOSED CROSS CULVERTS
- EXISTING CROSS CULVERTS
- EXISTING ROAD CULVERTS
- PROPOSED FARM ACCESS TRACK CULVERT
- STF OUTLET PIPE
- CONCRETE LINE CHANNEL

PLAN
SCALE 1 : 500

REVISION	AMENDMENT	DRAWN	CHECKED	APPROVED	DATE
C	PAC			08.2022	PRELIMINARY
D	PRELIMINARY	SL	WAH	LY	09.2022

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SCALES
ORIGINAL SIZE A1

DRAWN	DESIGNED	APPROVED
Jess Morgan	Jess Morgan	Jamie Povall
DRAWING VERIFIED	DESIGN VERIFIED	APPROVED DATE
Paul Chilton	Nick Keenan	09.11.22

PRELIMINARY

PROJECT
WAKA KOTAHI
TAIRAWHITI ROAD PACKAGE PANEL
SH2 RP 577/11.600-592/2.500 WAIKARE GORGE REALIGNMENT

TITLE
U1 - CH12840 - STOCK UNDERPASS

DOCUMENT NO. WGR - DES - DNG - - DRG
SHEET NO. 0030
REVISION F

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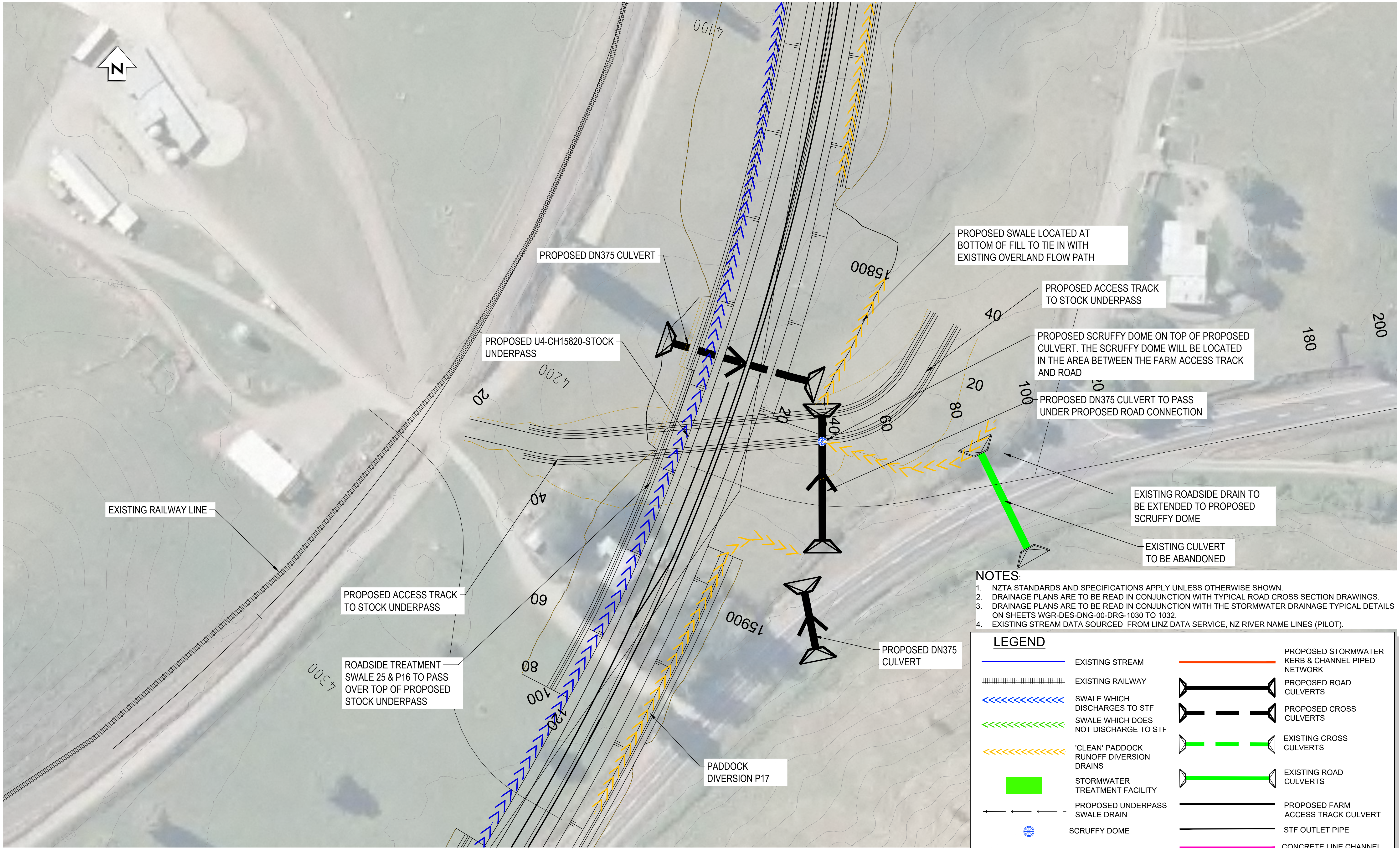

PLAN

SCALE 1 : 500

NOTES:

1. NZTA STANDARDS AND SPECIFICATIONS APPLY UNLESS OTHERWISE SHOWN.
2. DRAINAGE PLANS ARE TO BE READ IN CONJUNCTION WITH TYPICAL ROAD CROSS SECTION DRAWINGS.
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4. EXISTING STREAM DATA SOURCED FROM LINZ DATA SERVICE, NZ RIVER NAME LINES (PILOT).

LEGEND

EXISTING STREAM
EXISTING RAILWAY
SWALE WHICH DISCHARGES TO STF
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PROPOSED FARM ACCESS TRACK CULVERT
STF OUTLET PIPE
CONCRETE LINE CHANNEL

REVISION	AMENDMENT	DRAWN	CHECKED	APPROVED	DATE
C	PAC			08.2022	PRELIMINARY
D	PRELIMINARY	SL	WAH	LY	09.2022

WAKA KOTAHI NZ TRANSPORT AGENCY

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Stantec

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SCALES

ORIGINAL SIZE A1

DRAWN	DESIGNED	APPROVED
Jess Morgan	Jess Morgan	Jamie Povall
DRAWING VERIFIED	DESIGN VERIFIED	APPROVED DATE
Paul Chilton	Nick Keenan	09.11.22

PRELIMINARY

PROJECT
WAKA KOTAHI
TAIRAWHITI ROAD PACKAGE PANEL
SH2 RP 577/11.600-592/2.500 WAIKARE GORGE REALIGNMENT

TITLE
U4 - CH15820 - STOCK UNDERPASS

DOCUMENT NO. WGR - DES - DNG - - DRG

SHEET NO. 0031

REVISION D

Original sheet size A1 (841x594) C:\pwworkdir\Exports\Waikare Gorge\WGR-DES-DNG-00-DRG-0031.dwg Layout1

ORGANISATION JOB CODE: 2-S5416.01 ORIGINATING ORGANISATION: WSP

Appendix B Kings Creek Flooding Memo

Stantec **Memo**

To:	Nghia Dinh Wellington	From:	Wayne Hodson Hastings
Project/File:	310203918	Date:	11 January 2022

Reference: Waikare Gorge - Kings Creek Flood Levels

1 INTRODUCTION

A high-level consideration of the hydrology and hydraulics for the Kings Creek has been carried out to understand indicative flood levels to assist with the preliminary design of bridge structures. A simplified approach has been used with limited site information and assumptions made as noted.

2 HYDROLOGY

Flow rates have been taken from Niwa data (New Zealand River Flood Statistics. (arcgis.com)). Refer to extract below in Figure 1.

Flood Statistics 2018 REC1: Pohatanui Stream

Shape	
NZREACH	8016581
Shape_Length	827.61
Rivername	Pohatanui Stream
Areakm2	4.86
q100_reach	3.05
H_C18_MAF	7.47
H_C18_5_yr	10.99
H_C18_10y	13.85
H_C18_20y	16.59
H_C18_50y	20.14
H_C18_100y	22.80
H_C18_1000	31.58

Figure 1 - Location and Flood Statistics

To allow for climate change the flow rates have been increased by adding an additional 35%. This is based on the increase in rainfall intensity expected and has been calculated from comparing HIRDS V4 data for the site for existing rainfall against the climate change RCP8.5 2081-2100 scenario. Calculated design flows are in Table 1. Note flows for the 1/25, 1/250 and 1/500 events have been interpolated.

Reference: Waikare Gorge - Kings Creek Flood Levels

Annual Probability of Exceedance	Existing (from Niwa River Flood Statistics) – m^3/s	With Climate Change Allowance (35% increase) - m^3/s
1/25	17.4	23.5
1/50	20.1	27.2
1/100	22.8	30.8
1/250	26.3	35.5
1/500	29.0	39.1
1/1000	31.6	42.6

Table 1 - Kings Creek - Design Flows

3 HYDRAULICS

There is an existing culvert under the rail line and Putorino Station Road. Information from KiwiRail on the culverts in this area has been used, however the culvert shape and levels would need to be confirmed by survey. Refer to Figure 3 below of photos from a site visit in October 2021 of the Kings Creek culvert outlet and stream channel downstream.

Aerial LiDAR survey information has been used for the assessments referencing to 200mm contours produced from the survey. The existing rail formation and culvert levels at the site are shown in Figure 2 below.

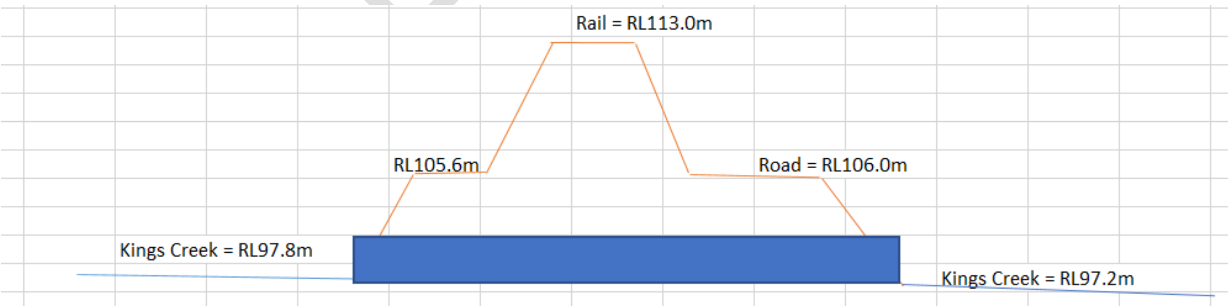


Figure 2 – Levels at Rail embankment and culvert

Reference: Waikare Gorge - Kings Creek Flood Levels

 Existing Culvert Outlet	 Kings Creek Downstream

Kings Creek downstream of culvert (Looking upstream)

Figure 3 - Site Photos - October 2021

Reference: Waikare Gorge - Kings Creek Flood Levels

Existing culvert capacity has been assessed based on the information from KiwiRail of a 2.7m by 2.7m culvert. However, the downstream end, under Putorino Station Road, as shown in the photos above is circular and although not measured during the site visit appeared smaller in size than 2.7m diameter. Culvert depth information from KiwiRail of 13.7m is consistent with aerial survey levels.

Calculations on the capacity of the existing culvert, based on a box 2.7m by 2.7m indicate that it has adequate capacity for the 100-year event. Although velocity and heading up on the upstream end would be significant in the 1000-year event. If the culvert is actually circular and only around 2m in diameter (estimated from site visit), there is likely to be a significant restriction from the culvert for flows in excess of the 25-year event. This would cause attenuation of flows passed downstream with rail embankment providing a dam with associated flooding occurring upstream of the rail line.

At this stage we have assumed that the culvert and rail embankment does not significantly attenuate peak flows.

Downstream of the culvert the Kings Creek is within a steep sided gully that is approximately 8-9m in depth below the surrounding farmland. Aerial survey extends to more than 500m downstream of the existing culvert.

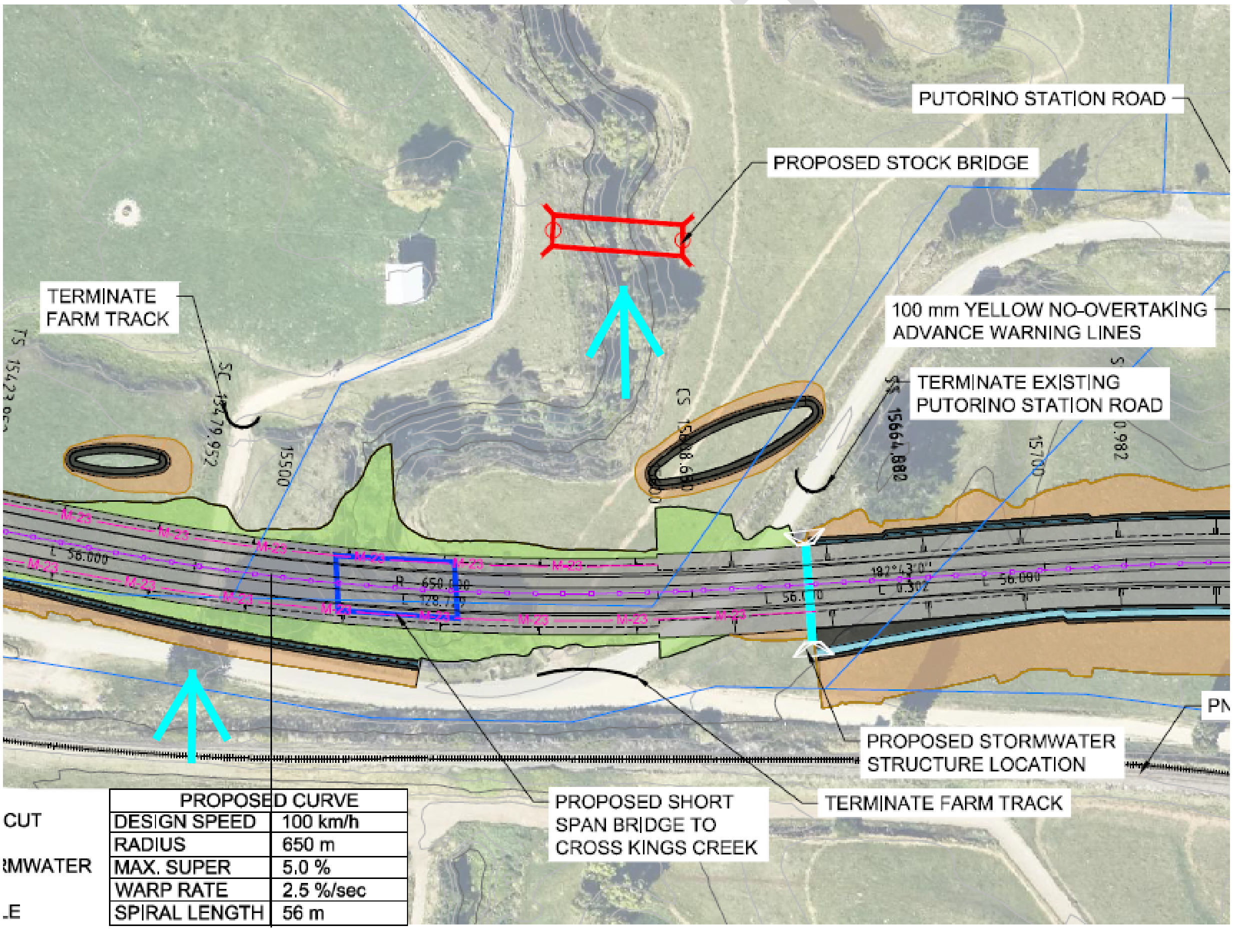


Figure 4 – Site Plan – Proposed bridge locations – Extract from Preliminary Geometric Design Drawings – December 2021

Reference: Waikare Gorge - Kings Creek Flood Levels

4 FLOOD LEVELS

A range of flood levels have been estimated to support the preliminary design of proposed bridge structures. These should be reviewed when more detailed survey information is available of the site and if proposed bridge structures are within 1m freeboard allowance consideration should be given to more detailed modelling and assessment to inform the bridge structure designs.

Levels at the proposed bridge locations shown in Figure 4 are summarised in Table 2 below.

Annual Probability of Exceedance	Assumed Flow Rate (m^3/s)	Estimated Water Depth (m)	Estimated Flood Level at proposed Stock Bridge (m RL)	Estimated Flood Level at proposed SH Road Bridge (m RL)
1/25	23.5	2.9	97.9	100.1
1/50	27.2	3.1	98.1	100.3
1/100	30.8	3.3	98.3	100.5
1/250	35.5	3.5	98.5	100.7
1/500	39.1	3.7	98.7	100.9
1/1000	42.6	3.8	98.8	101.0

Table 2 Estimated Flood Levels at Proposed Bridges

These levels are not expected to impact the proposed state highway road bridge structure design due to the road surface elevation proposed of RL108m being 7m above the predicted 1/1000 flood level. However this will need to be confirmed by the Structural designer once the bridge structure has been determined. Refer to extract from the preliminary geometric design at the proposed bridge in Figure 5.

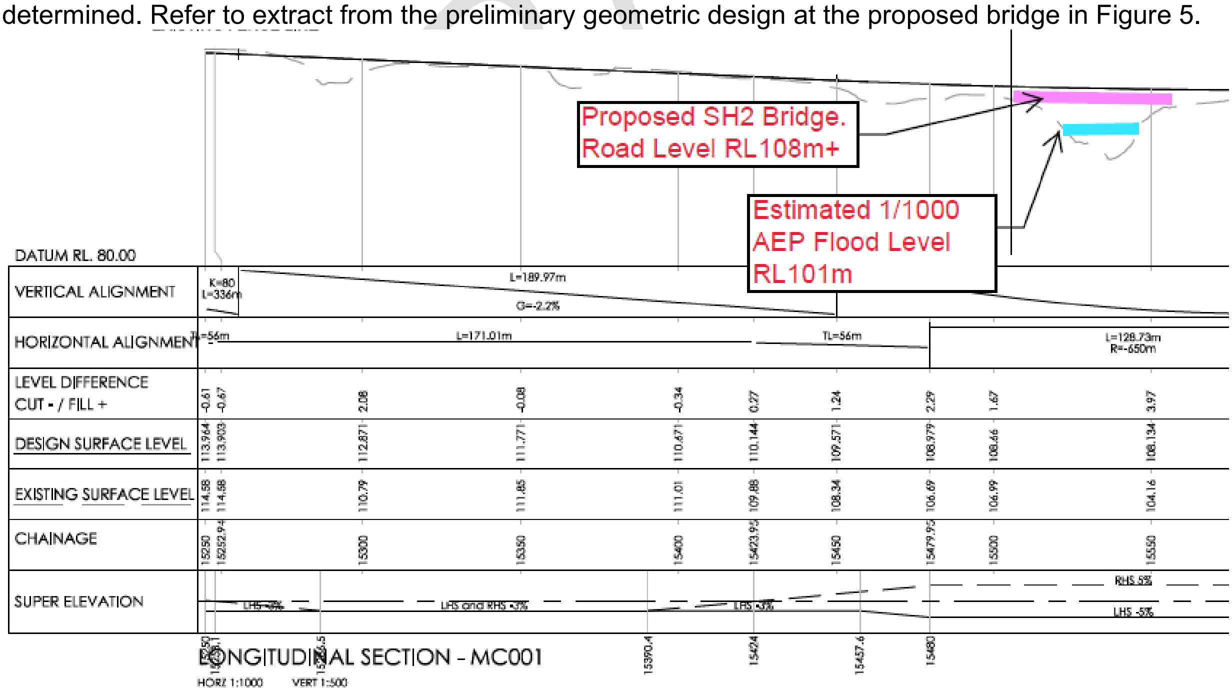


Figure 5 - Extract from Preliminary Geometric Design Drawings – December 2021, Long Section

5 KEY ASSUMPTIONS

a) Limited site inspection carried out that was limited to the existing culvert outlet and location of the proposed state highway bridge. Further downstream was not inspected, including the location of the proposed stock bridge. It is assumed that stream conditions are similar to the area inspected.

b) A simplified trapezoidal cross section has been assumed for Kings Creek assuming conservative average base width and steeper side slopes than average based on aerial survey contours at the site. This is expected to overestimate flood levels.

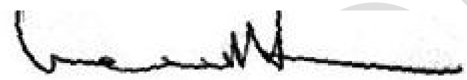
c) Mannings formula has been used for determining water depths and flood levels, with a manning's n of 0.06 assumed based on an allowance for 0.05 for light to heavy shrubbery on banks and an additional allowance 0.01 for irregular sections and channel meander.

d) Flood level hydraulic gradient assumed to match stream bed gradients. Bed levels and grades are based on average gradients from contours in the vicinity of the proposed bridges. A grade of 1.1% used in flood level calculations. Gradient over a 500m length downstream of the existing culvert averages to 1.2% based on contours. Gradients further downstream are unknown.

e) Assumed that there is no backwater influence or capacity restriction in Kings Creek further downstream that impacts flood levels at the site.

Regards,

Stantec New Zealand



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Senior Principal Civil Engineer
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Attachment: [Attachment]

Checked
Nolan Naidoo (Senior Civil Engineer)
Nolan.naidoo@stantec.com

Reviewed
Nick Keenan
nick.keenan@stantec.com

Appendix C Waikare Gorge KiwiRail Overpass Drainage Memo

Stantec Memo

To:	Nghia Dinh Wellington NZ	From:	Jess Morgan Hastings NZ
File:	Rail Overpass Memo	Date:	July 29, 2022

Reference: Waikare Gorge KiwiRail Overpass Drainage – Updated July 2022

The below is an update to the original KiwiRail Overpass Drainage memo issued November 2021. Since that memo, changes to the stormwater design have reduced the amount of run-off directed to KiwiRail land post-construction. These changes include:

- Deletion of Stormwater Treatment Facility Two (STF 2) – Original calculations assumed the outlet to STF 7 would discharge directly to KiwiRail land. At the preliminary design phase this STF was deleted, and flow directed elsewhere.

- Inclusion of cross-drainage culvert C12815 – A cross-drainage culvert has been proposed just south of the KiwiRail overpass and has been sized to take flow from the paddock catchments to the east of the tracks.

The catchments and design flows for a 20- and 100-year event were calculated for the rail side drains through the proposed KiwiRail overpass as part of the Waikare Gorge realignment project.

Assumptions

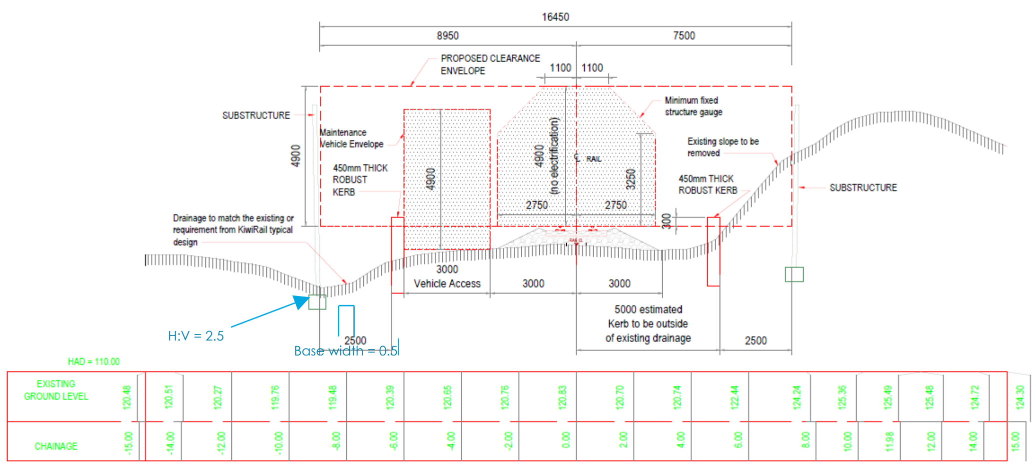
The following assumptions about the rail side drains were made based on the cross-section supplied via email:

Base width = 0.5 m

Side slope H:V = 2.5

Length = 100 m (assumed 50 m upstream/downstream from the proposed road centerline)

Longitudinal grade = 1/42 (based on aerial contours)



RAILWAY OVERPASS AT PNGL 242.742
TYPICAL CLEARANCE ENVELOPE
(Looking South to Napier - Not for Scale)

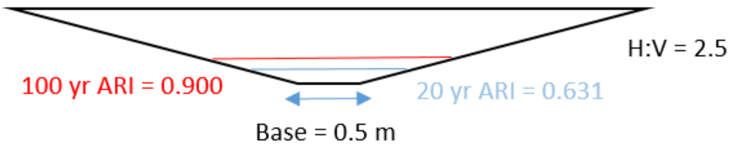
Scenarios

Different scenarios assessing pre and post development were considered for both the east and west side of the tracks, assuming that flow cannot pass over the tracks. Two scenarios were considered for a drain on the east side of the tracks, including flow being directed through proposed cross-drainage culvert C12815, and all flow being directed to the east-side track drain.

Results

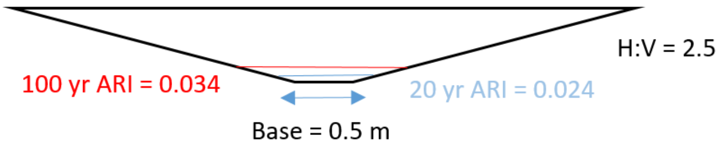
Pre-development, west side of the tracks

Event	Depth (m)
20-year	0.281
100-year	0.330



Post-development, west side of the tracks

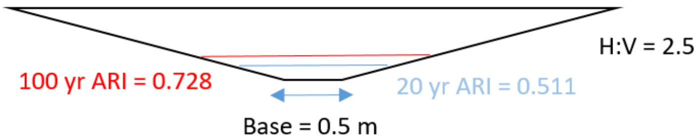
Event	Depth (m)
20-year	0.051
100-year	0.062



Pre-development/Post-development assuming all run-off is directed to drain, east side of the tracks

No works are proposed for the east side of the track upstream of the proposed overpass, therefore pre- and post-development design flows are the same. This scenario assumes that flow from paddocks east of the track will be directed through the proposed KiwiRail overpass drain, and not through cross-drainage culvert C12815.

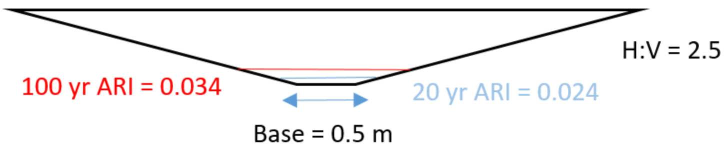
Event	Depth (m)
20-year	0.254
100-year	0.300



Post-development assuming runoff directed through C12815, east side of tracks

This scenario assumes that flow from paddocks east of the track will be directed through cross-drainage culvert C12815, and only run-off from KiwiRail land directed through the proposed KiwiRail overpass drain.

Event	Depth (m)
20-year	0.051
100-year	0.062



Recommendations/Options

West side of the tracks

As part of the stormwater design, a large section of paddock area which would have otherwise drained into KiwiRail land upstream of the proposed overpass will be redirected, hence why there is a decrease in flow between pre and post development.

Drains are proposed for both sides of the track through the KiwiRail overpass. A drain designed as per the dimensions above would be an adequate size for the west side of the tracks. The drain size could be decreased due to only minimal flow from KiwiRail land being directed to the drain. Acceptable vertical clearance would need to be confirmed with KiwiRail.

An existing DN450 culvert was picked up in survey which crosses under the railway tracks downstream of the proposed KiwiRail overpass. This culvert conveys flow from paddock catchments north of the tracks to the existing overland flow path proposed that cross-drainage culvert C12815 will outlet to. This culvert was found to be undersized for a 100-year storm event and would need to be upsized to a DN600 culvert to provide adequate capacity. The inlet of the culvert is located within a paddock, which if the culvert were to backup would not impact on the proposed road. However, headwater depth at the culvert is such that flow could overtop the railway tracks. Consideration as to whether this KiwiRail culvert should be upgraded as part of the project should be discussed at the next design phase with KiwiRail as part of consultation with them.

East side of the tracks

From contours and imagery of the existing topography, it appears that the drain on the east side of the tracks currently drains away into an existing low point at approximately chainage 12800, upstream of the proposed overpass. This will be the location of proposed cross-drainage culvert C12815.

A drain is proposed for the eastern side of the track, and a drain designed as per the dimensions above would be an adequate size when including flow from surrounding catchment paddocks. Potentially, this KiwiRail overpass drain could be downsized or even deleted if all flow is directed to the C12815 culvert.

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