SH1 Rolleston Access Improvements

Stormwater Management Report (Package 1)

Prepared for Waka Kotahi NZ Transport Agency
Prepared by Beca Limited

21 October 2024

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Revision History

Revision Nº	Prepared By	Description	Date
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Document Acceptance

Action	Name	Signed	Date
Prepared by	Steve Harvey	S. Harvey	21/10/2024
Reviewed by	Kate Purton	K Purton	21/10/2024
Approved by	David Aldridge	D Aldridge	21/10/2024
on behalf of	Beca Limited		

Executive Summary

This Stormwater Management Report has been prepared by Beca Limited (Beca) to inform the Assessment of Effects on the Environment (AEE) for the Notice of Requirement (NoR 1) and the s15 resource consent being sought by New Zealand Transport Agency Waka Kotahi (NZTA) for Package 1 of the overall SH1 Rolleston Access Improvements (the Project).

The Project includes a number of safety improvements to intersections along SH1 through Rolleston to reduce deaths, serious injuries and better manage the forecast future growth in traffic volumes. The Project includes two packages:

- Package 1 - SH1 / Dunns Crossing Road Roundabout and associated works.
- Package 2 - Overpass and balance of the works.

This report sets out the stormwater management approach for Package 1 only, which is currently in the Preliminary Design phase. The stormwater management approach considers both the road corridor catchments and the cross-drainage catchments draining toward the road corridor.

Package 1 involves the construction of a roundabout and associated works at the SH1, Dunns Crossing and Walkers Roads intersection to support safe and efficient access across the highway and to and from Rolleston.

The associated works include the realignment of Dunns Crossing Road and of Walkers Road to align with the new roundabout, construction of a new cycle/pedestrian subway across the state highway and an upgraded railway level crossing for both vehicles and pedestrians.

This report considers both the potential stormwater effects and expected stormwater effects (i.e. mitigated by the proposed stormwater management) for the construction and operational phases of Package 1.

Runoff from road corridor catchments is generally treated, attenuated and discharged to ground in accordance with NZTA's guidelines and local Selwyn District Council standards. Where practicable, runoff from the road corridor catchments will be conveyed to stormwater basins which will provide first flush treatment, attenuation and discharge to ground. The first flush (water quality) treatment will be designed for the runoff from the first 25mm rainfall depth from a rainfall event. First flush treatment will be provided by first flush basins with infiltration through a designed sand media, prior to discharge to ground. Runoff in excess of the first flush volume will be conveyed to soakage basins, where stormwater up to the 1% AEP will discharge to ground. Attenuation (or buffer storage) will be provided in the soakage basins, where stormwater will be stored when the rate of runoff into the soakage area exceeds the discharge rate to ground.

Small areas at the extremities of the Package 1 footprint, which are unable to drain to new basins due to the geometry, will drain to existing soak pits or will continue to run off to the berms before discharging to the ground. However, these areas are minor, and overall, the stormwater system will manage and discharge to ground runoff from a larger impervious area than the additional impervious area created by Package 1.

Cross-drainage is proposed to convey stormwater runoff from the cross-catchments (i.e. existing overland flow paths) through the Package 1 footprint. The cross-drainage catchments (which are outside the NOR footprint) will be defined according to the geometric design of the road and how this intersects the fall of adjacent land (i.e. existing overland flow paths).

The stormwater design for Package 1 follows the stormwater management principles detailed in this report.

The Package 1 stormwater management system mitigates the stormwater effects of the proposed works by providing first flush treatment, attenuation and discharge to ground up to the 1% AEP event for at least the increase in impervious area of the project.

Cross-catchment peak flows will be conveyed safely across Package 1 by the cross-drainage network up to the 1% AEP event, without flooding the state highway and without increasing flood risk outside of the designation or to private properties.

A set of preliminary design stormwater drawings is included in Appendix A – RM Approval Drawings.

Construction-related discharge of sediment will be mitigated by the preparation and implementation of an Erosion and Sediment Control Plan.

1 Introduction

1.1 Purpose

This Stormwater Management Report has been prepared by Beca Limited (Beca) to inform the Assessment of Effects on the Environment (AEE) for the Notice of Requirement (NoR 1) and the s15 resource consent being sought by New Zealand Transport Agency Waka Kotahi (NZTA) for Package 1 of the overall SH1 Rolleston Access Improvements (the Project).

1.2 Project Description

Rolleston is one of the fastest growing towns in New Zealand and is experiencing transport pressures to keep the community connected and state highway intersections safe. In addition, there are increasing potential conflicts at road/rail crossings.

The urgent need for investment in the Rolleston transport network has been recognised as a Road of Regional (ROR) significance, with the Project part of the 'Canterbury Package'.

The project includes a number of safety and efficiency improvements (reduced deaths and serious injuries, greater travel choices and reduced travel times) on State Highway 1 and adjacent local roads in Rolleston.

The Project is being delivered in two packages:

- Package 1 - SH1 / Dunns Crossing Road Roundabout and associated works.
- Package 2 - Overpass and balance of the works.

This report discusses Package 1 only.

Package 1 involves the construction of a roundabout and associated works at the SH1, Dunns Crossing and Walkers Roads intersection to support safe and efficient access across the highway and to and from Rolleston.

The associated works include the realignment of Dunns Crossing Road and of Walkers Road to align with the new roundabout, construction of a new cycle/pedestrian subway across the state highway and an upgraded railway level crossing for both vehicles and pedestrians.

The improvements will provide for a safe crossing of the State Highway adjacent to the Walkers Road / Dunns Crossing Road roundabout and better connectivity between the Rolleston residential area the expanding industrial area.

The Package 1 footprint is shown in Figure 1-1.

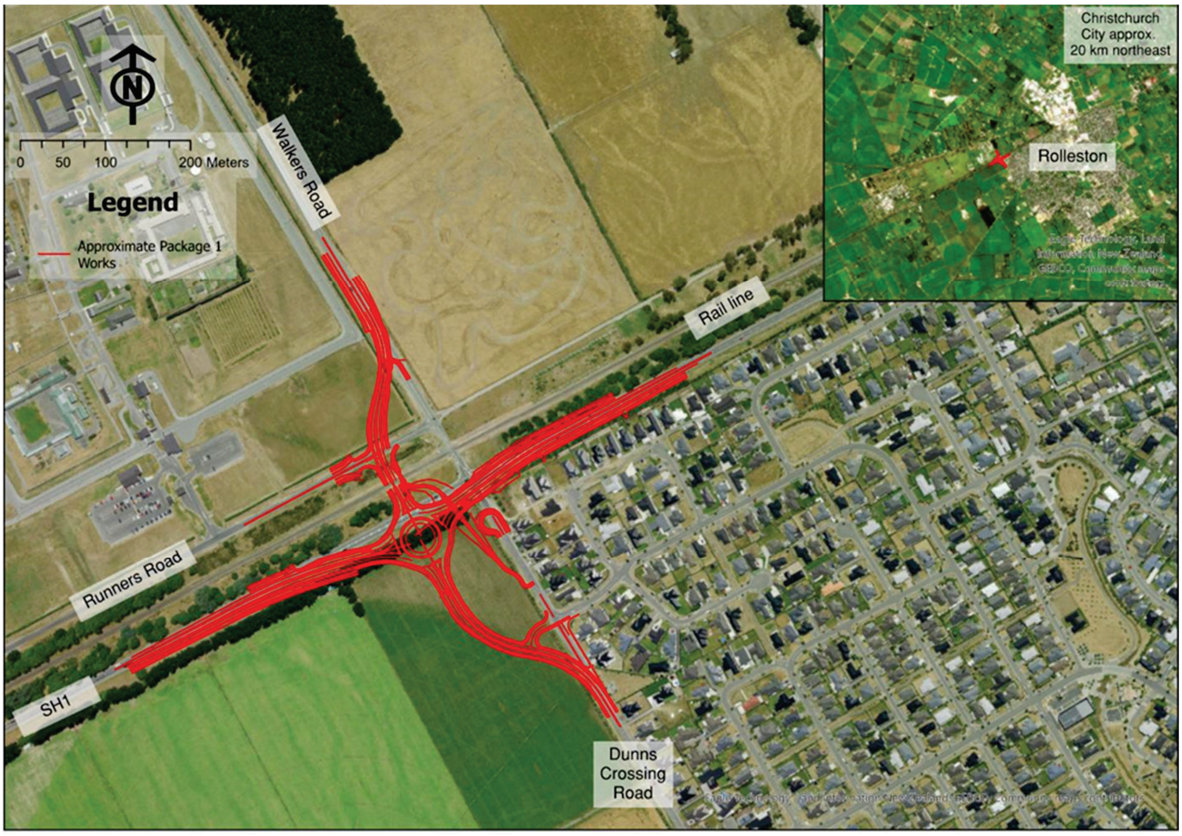

Figure 1-1: Package 1 footprint

1.3 Scope of Report

The scope of this report is to set out the stormwater management approach for Package 1, i.e. the SH1 / Dunns Crossing Road roundabout and associated works. This includes the capture, conveyance, treatment, attenuation and discharge of runoff from the state highway and local authority roads, as well as conveyance of cross-catchment flows across the state highway. It also includes the construction phase stormwater management, and the operation and maintenance of the stormwater system.

This report will form part of the NoR and resource consent application to Environment Canterbury.

This report should be read alongside the AEE, which contains further details on the history and context of the Project. The AEE also contains a detailed description of works to be authorised under the NoR and applied for under the regional consents, and the typical construction methodologies that will be used to implement this work.

2 Existing Environment

2.1 General Environment

The topography of Package 1 and the surrounding area forms part of the Canterbury Plains and is therefore generally flat, with a gentle slope from northwest to southeast.

Package 1 is located on the western edge of Rolleston, approximately 22km southwest of Christchurch. Package 1 is entirely within Selwyn District.

SH1 extends approximately 4km through Rolleston in a northeast to southwest orientation. To the north and west of Package 1 the land is largely rural, although partially developed for the Rolleston Prison facility. The rail corridor also separates SH1 from the land to the northwest. The formed corridors of SH1 and the South Island Main Trunk (SIMT) railway run parallel to each other (separated by approximately 30m). The land to the southeast comprises residential housing (generally medium density, single storey and detached), connected to the commercial and town centre land uses further east.

2.2 Ground Conditions

The ground conditions for Package 1 are generally a mixture of sands, silts and gravel. Typically, the nearer surface material contains a larger proportion of silts and organics, with underlying sandy gravels that appear to have better drainage properties. The composition of, and depth to, the sandy gravel material varies across site.

The geotechnical investigation was commenced on 17 June 2024 and was completed by 9 August 2024.

The physical works for the ground investigation were undertaken by Corde Ltd, and the full description of the investigations is reported in the Geotechnical Interpretive Report (Beca, 2024) which has been included in Appendix B.

2.3 Groundwater

As part of the geotechnical investigations, several piezometers were also installed to investigate groundwater levels.

The depth to groundwater was measured in the piezometers on 12 July and 12 August 2024 with the unconfined water table observed on site as greater than 10m below ground level. Based on the observed groundwater depths, a groundwater mounding assessment is not required for the proposed stormwater discharge to ground.

There are 124 bores within 2km of the site. The use types are:

- 46x Domestic & stockwater
- 33x Domestic
- 22x irrigation
- 8x groundwater level and quality observation
- 1x stock supply
- 3x public water supply
- 11x other or not stated.

The majority of bores are screened within 20-60m depth, with just three deeper bores, and seven shallower bores.

The Package 1 project footprint and associated stormwater infrastructure does not fall within any Community Drinking Water Protection zones (CDWPZ), nor are there any bores within the Package 1 project footprint.

There is a small community supply bore at Rolleston Prison (M36/4459) located north of the site. M36/4459 is 55m deep (with no screen information given). The location of bore M36/4459 and its associated Community Drinking Water Protection Zone (CDWPZ) are shown in Figure 2-1.

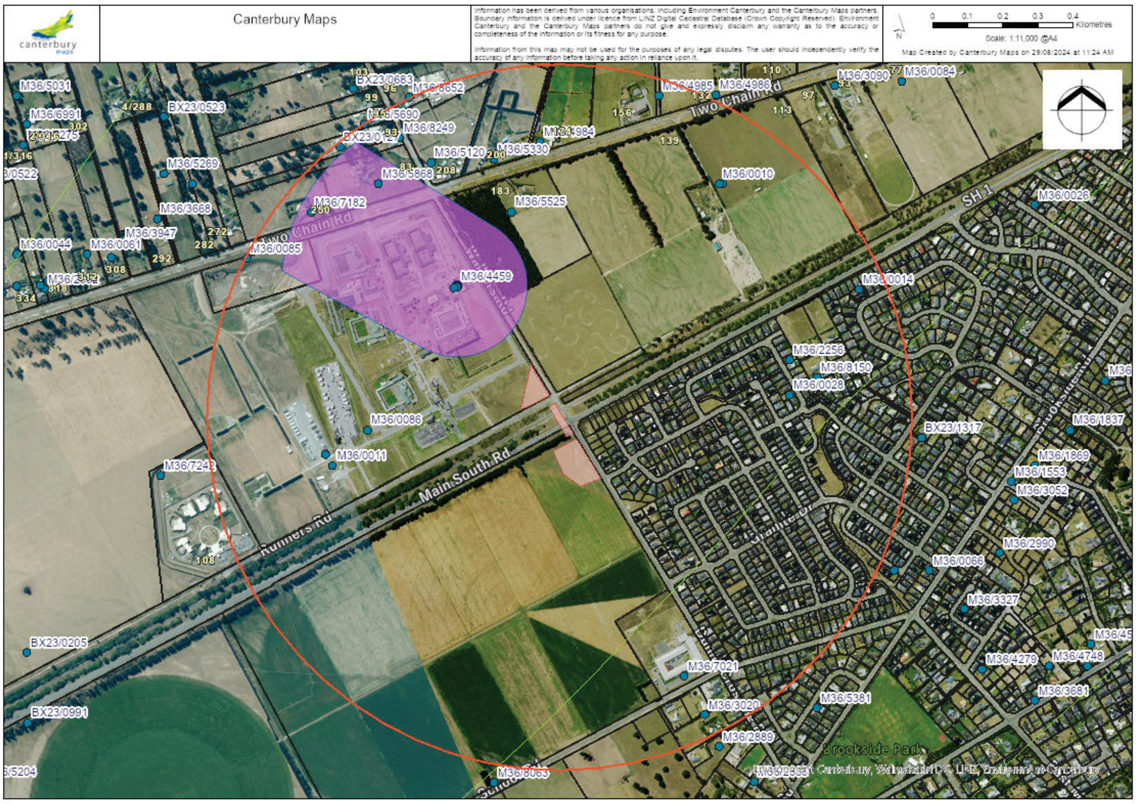

Figure 2-1: Approximate Package 1 soakage locations (pale red polygons), 1km radius from soakage locations (red circle), nearby bores, community water supplies and protection zones (purple) and regional piezometric contours showing groundwater flow direction (in green).

The ECan Wells database indicates that bore M36/4459 is only used for emergency supply, and that the prison is connected to the Rolleston public water supply.

2.4 Existing Secondary Flow Paths

Based on the Selwyn District Council’s 200 year ARI flood modelling maps (refer excerpt shown in Figure 2-2), it is understood that there are secondary flow paths from the northwest of Package 1, heading southeast across SH1.

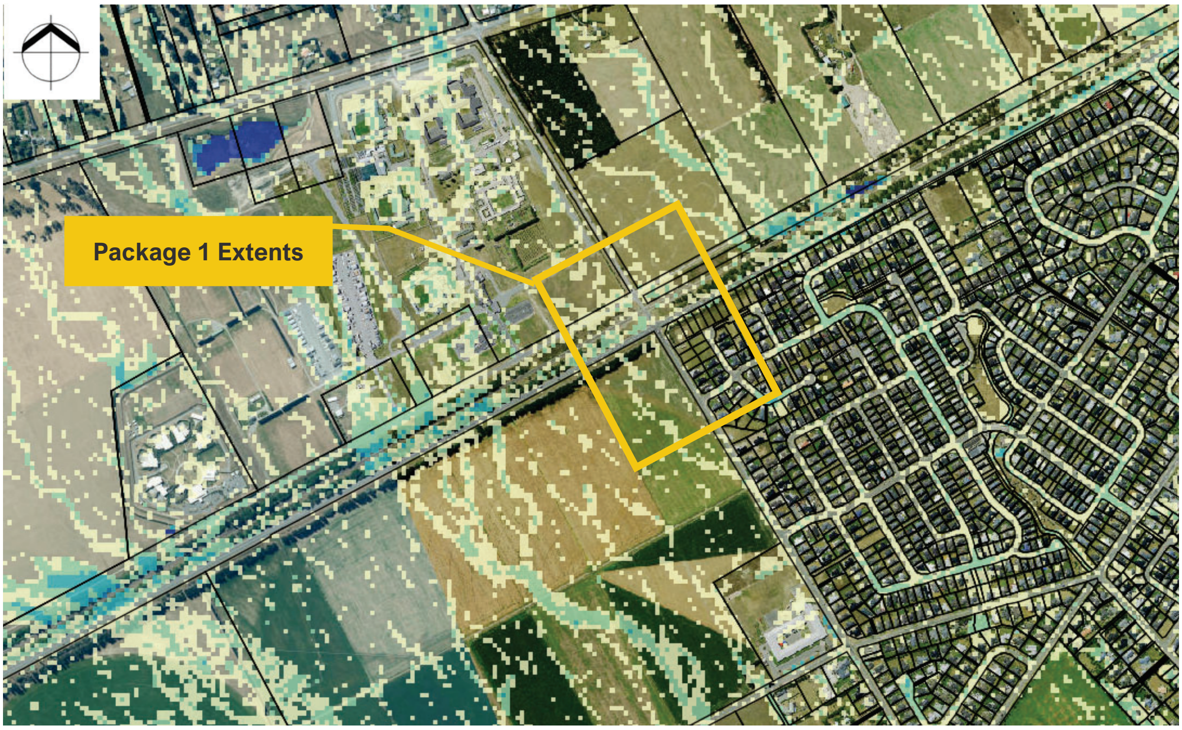

Figure 2-2: Extract from SDC 200 year ARI flood modelling map (Accessed 29/08/2024)

2.5 Existing SH1 Stormwater System

Based on the information available in Canterbury Maps Viewer, discussions with NZTA / SDC, and a site inspection, the existing stormwater infrastructure within the Package 1 area is understood to be limited, consisting of several soak pits on Dunns Crossing Road, Walkers Road and Runners Road. Refer to Figure 2-3 which shows the stormwater asset information extracted from Canterbury Maps Viewer. Stormwater nodes (sumps and/or soak pits) are identified as a green dot, with stormwater pipes identified as green lines.

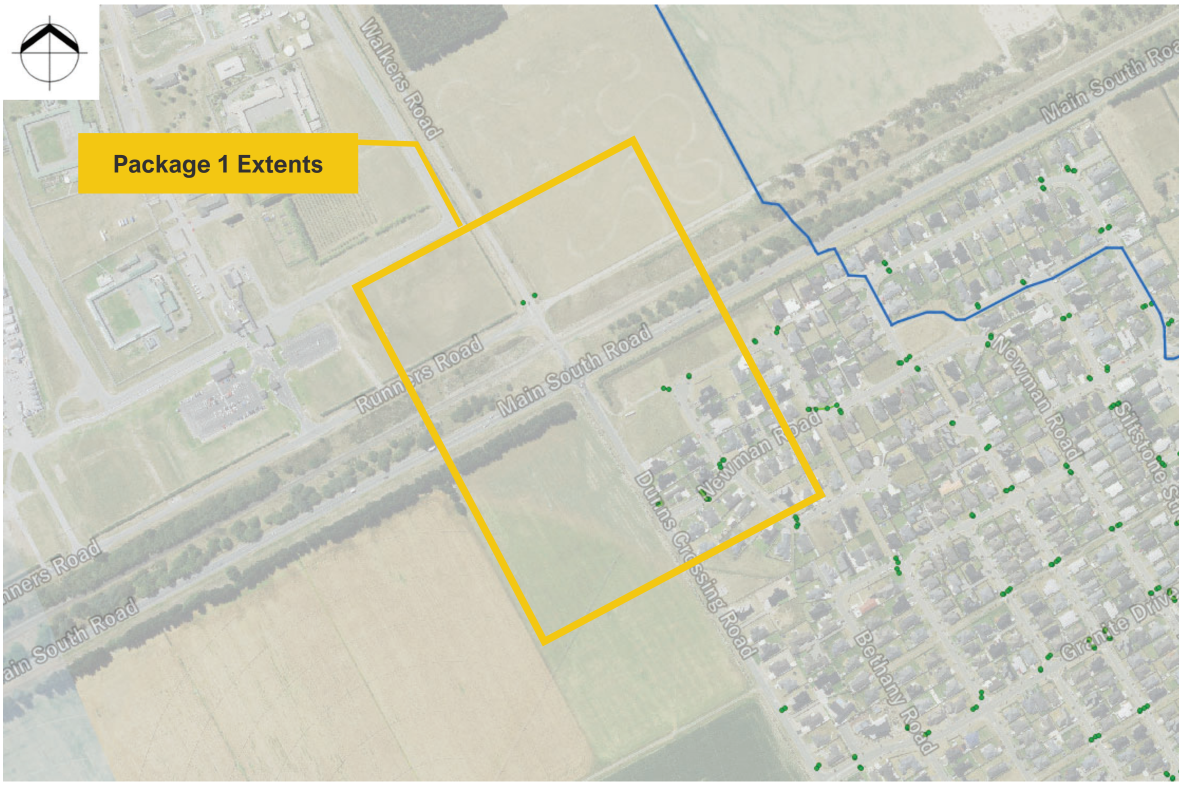

Figure 2-3: Existing stormwater infrastructure in Package 1 area (Existing SDC Stormwater Infrastructure from Canterbury Maps (accessed 03/05/2024) in green, the water race shown in blue, plus soak pits identified from site walkover in red)

A site walkover, carried out by Beca on 5 August 2024, confirmed the presence of the assets identified on Walkers Road, Dunns Crossing Road and Newman Road in Canterbury Maps Viewer and also confirmed the presence of two soak pits on Runners Road, shown as two red dots on Figure 2-3, one on either side of the road.

There is no information relating to any existing stormwater infrastructure along SH1, either within or adjacent to Package 1, other than a water race that crosses the state highway adjacent with Lignite Drive, shown as the blue line in Figure 2-3. This falls outside of the footprint for Package 1 and is not impacted by the works.

It is assumed that stormwater runoff from the highway in low intensity events discharges to land, soaking to ground in the berm areas of the state highway (i.e. informal discharge to ground). During more intense periods of rainfall it is assumed that stormwater runoff from SH1 discharges down Dunns Crossing Road, where there are a number of sporadic soakage pits along the length of the road.

Overall there is limited existing formal stormwater infrastructure within and adjacent to Package 1.

3 Design Philosophy

3.1 Design Standards and Guidelines

A number of design standards and guidelines have been used in the development of the stormwater design for Package 1. These include, but are not limited to:

- NZTA Waka Kotahi, P46 Stormwater Specification (P46), 2016
- NZTA Waka Kotahi, Stormwater Treatment Standard for State Highway Infrastructure, 2010
- NZTA Waka Kotahi, Bridge Manual, Third edition, Amendment 4, 2022
- TNZ Highway Surface Drainage, A Design Guide for Highways with a Positive Collection, 1977
- NZTA TM-2502 Preferred method for calculating road surface water run-off in New Zealand, 2021
- Selwyn District Council (SDC), Engineering Code of Practice (ECOP), 2012
- Christchurch City Council (CCC), Waterways Wetlands and Drainage Guide (WWDG), Part A, 2003
- Christchurch City Council (CCC), Waterways Wetlands and Drainage Guide (WWDG), Part B, 2012
- Ministry for the Environment (MfE), National Policy Statement for Freshwater Management 2020 (NPS-FM), Amended January 2024
- CIRIA, CIRIA C753 The SuDS Manual 2015, version 5 2016
- CRC for Water Sensitive Cities, Adoption guidelines for stormwater biofiltration systems: Cities as water supply catchments – sustainable technologies, 2015
- KiwiRail, Track Standard, Level Crossings (T-ST-AM-5360), Issue 2, 2018

3.2 Design Assumptions

The key design assumptions are:

- Treatment and attenuation of stormwater is required in general accordance with NZTA's guidelines and local Selwyn District Council standards. This includes first flush treatment for water quality, attenuation and discharge to ground of runoff from the road corridor up to the 1% AEP event, where practicable.
- As a minimum, the design will include first flush treatment, attenuation and disposal to ground up to the 1% AEP event for an impervious area equal to the additional impervious area created by the project.
- The cross-drainage is designed so that the Package 1 works do not increase flood levels in the surrounding catchments or increase flood risk to private properties up to the 1% AEP event.

3.3 Design Constraints

The following constraints have been identified for the Package 1 stormwater design:

- Existing ground levels
- Management of road corridor catchments and secondary flow paths
- Management of cross-catchment flow paths
- Geotechnical conditions

3.4 Key Design Parameters

3.4.1 Rainfall

The design rainfall event intensities for the Package 1 shall be in accordance with Table 3-1. These rainfall intensities have been adopted from HIRDS Version 4, with climate change allowance for scenario RCP 8.5 (2081-2100).

Table 3-1: Rainfall intensities (mm/hr) from HIRDS V4 RCP8.5 for the period 2081-2100 (Accessed 04/04/2024)

ARI	AEP	10m	20m	30m	1h	2h	6h	12h	24h	48h	72h
1.58	0.633	32.1	21.4	17.1	11.9	8.26	4.53	3.02	1.96	1.21	0.887
2	0.5	36.3	24.1	19.3	13.4	9.32	5.09	3.39	2.18	1.35	0.991
5	0.2	51.6	34.1	27.2	18.8	13	7.05	4.66	2.98	1.83	1.35
10	0.1	63.9	42.1	33.5	23	15.9	8.57	5.65	3.6	2.2	1.62
20	0.05	77.4	50.8	40.3	27.6	19	10.2	6.7	4.24	2.59	1.9
30	0.033	85.9	56.3	44.6	30.5	20.9	11.2	7.35	4.64	2.83	2.07
40	0.025	92.1	60.2	47.7	32.6	22.3	12	7.82	4.94	3	2.19
50	0.02	97.3	63.5	50.3	34.3	23.5	12.5	8.19	5.16	3.14	2.29
60	0.017	101	66.2	52.4	35.7	24.4	13	8.51	5.36	3.25	2.38
80	0.013	108	70.7	55.9	38	25.9	13.8	9	5.66	3.44	2.5
100	0.01	114	74.1	58.5	39.8	27.1	14.4	9.41	5.91	3.58	2.6
250	0.004	137	89	70.1	47.4	32.2	17	11	6.9	4.16	3.02

The first flush rainfall depth is 25mm.

3.4.2 Runoff Coefficients

The runoff coefficients used for peak flow, volume and first flush are shown in Table 3-2 and Table 3-3.

First flush volumes have been determined using NZTA P46, with the remaining peak flow and volume coefficients determined using CCC WWDG.

Table 3-2: Runoff Coefficients Peak Flow

Events	C Pervious	C Impervious	C Industrial / Business	C Residential	C Rural
First Flush	0.15	0.95	-	-	-
10% AEP	0.30	0.85	0.77	0.42	0.30
1% AEP	0.35	0.99	0.82	0.47	0.35

Table 3-3: Runoff Coefficients Volume

Events	C Pervious	C Impervious	C Industrial / Business	C Residential	C Rural
First Flush	0.15	0.95	-	-	-
10% AEP	0.35	0.98	0.89	0.44	0.35
1% AEP	0.35	0.99	0.89	0.44	0.35

3.4.3 Catchments

Package 1 catchments are defined according to the geometric design of the road and the surrounding ground levels (from topographical survey and LiDAR). The catchments are split into the road corridor catchments and cross-catchments, with the road runoff generally having first flush treatment and being discharged to ground, and the runoff from the cross-catchment being conveyed across the Package 1 footprint.

Cross-catchments (catchments outside the NOR footprint) are generally assumed not to enter the Package 1 stormwater system.

3.4.4 First Flush Volumes

First flush volumes will be calculated using a first flush rainfall depth of 25mm, with a 0.95 runoff coefficient for the impervious area and 0.15 runoff coefficient for the pervious area.

3.4.5 Ground Soakage Rates

The geotechnical investigations included a number of soakage tests to investigate the existing subsurface capacity for stormwater soakage. The full details of the soakage testing are reported in the Memorandum on Infiltration (Soakage) Testing for Rolleston Access Improvement Project (Beca, 2024). This memo forms part of the Geotechnical Interpretive Report (Beca, 2024) which has been included in Appendix B.

The measured soakage test rates were factored to arrive a design soakage rate, with the factor of safety used based on the potential consequence of failure in accordance with Table 3-3, taken from Table 25.2, SuDS, CIRIA 2015.

Table 3-4: Suggested Factors of Safety for Hydraulic Design of Soakage Systems (CIRIA, 2015)

Size of Area to be Drained (m^2)	Consequence of Failure		
	No Damage or Inconvenience	Minor Damage to External Areas or Inconvenience (e.g. surface water on car park)	Damage to Buildings or Structures, or Major Inconvenience (e.g flooding of major roads)
<100	1.5	2	10
100-1000	1.5	3	10
>1000	1.5	5	10

Based on the catchment areas and the likely consequences of failure, a factor of safety of 5 has been applied to the measured soakage rates to derive the factored soakage rates, as shown in Table 3-5 below. Factored soakage rates were limited to a maximum of 300mm/hr due to the uncertainty of long-term performance.

Table 3-5: Summary of Measured and Factored Soakage Rates for Package 1

Infiltration Pit ID	Location	Measured Soakage Rate (mm/hr)	Factored Soakage Rate (mm/hr)
IP01	West of Roundabout	660	132
IP02	South of Roundabout	1,882	300*
IP03	North of Roundabout	2,100	300*

Note(s):

* Factored soakage rate limited to a maximum of 300mm/hr due to the uncertainty of long-term performance

The design soakage rate used in the design of each soakage facility is based on the nearest test location. Further soakage testing is required at construction to confirm the design soakage rates used.

3.4.6 Roughness Coefficients

Manning's roughness coefficients will be as summarised in Table 3-6.

Table 3-6: Roughness Coefficients

Description	Manning's n
Swales (flow along)	0.035 – 0.05
Concrete pipes	0.012
Concrete culverts	0.012
Kerb & channel and pavement	0.013

3.4.7 Survey Datum

All levels are in Christchurch Drainage Datum (CDD), which is the drainage datum for Christchurch. This datum is 9.043m below Lyttelton Vertical Datum 1937 (mean sea level, MSL), or in other words in Christchurch Drainage Datum (CDD), MSL=9.043m.

3.5 Proposed Design Departures

Proposed departures are outlined in Table 3-7.

Table 3-7: Proposed Design Departures

Topic	Description
Minimum Pipe Cover	Reduce pipe cover from 1.2m to 0.5m while meeting NZS 3725 to enable shallower stormwater systems (including connections to swales and basins).
Minimum Pipe Velocities	Due to the flat grade of the Canterbury Plains and to enable shallow stormwater systems (including connections to swales and basins), flatter pipe gradients may be required which may result in pipe velocities less than the minimum pipe velocities in the first sections of the pipe.
Swale Underdrainage System	Where a swale is at a grade of less than 2%, an underdrainage system (subsoil drain) is usually required as per NZTA P46. Due to the relatively flat grades of the alignment and existing ground, subsoils would likely be required under all swales. Due to the high soakage rates expected within the project extents, no subsoil drains under swales are proposed.
Road Corridor and Cross-Drainage Network Head Level	Due to the flat grade of the Canterbury Plains and currently unknown 3D geometric design levels it is not known whether the below design parameters can be met for the road corridor or cross-drainage networks. • the 10% AEP critical duration event without heading up above pipe soffit level • the 1% AEP critical duration event without heading up closer than 500mm to the road surface

4 Long-Term Stormwater Management

4.1 Introduction

Unless stated otherwise, the stormwater management approach discussed in this report relates to the long-term stormwater management for Package 1. The short term or construction stormwater management is discussed in section 6 of this report.

4.2 Operation and Maintenance

A Stormwater Operation and Maintenance Manual will be prepared as part of the overall Operation and Maintenance Manual for the Project. This will include requirements and schedules for inspection, operation and maintenance of all stormwater management system including catchpits, pipes, culverts, basins, and planting. Refer to section 7 of this report for further information.

4.3 Overview of Stormwater Design Approach

The stormwater management system for Package 1 considers the two main stormwater contributors:

- Road corridor catchments
- Cross-catchments

The design of the stormwater management system has been carried out using the design philosophy set out in section 3 of this report.

The stormwater design for the Package 1 road corridor runoff manages stormwater through various elements such as collection and conveyance, treatment, discharge to ground and attenuation. Key features include the use of kerb and channel, catchpits, manholes, swales, and pipework to effectively collect and convey stormwater. The system also uses first flush basins for treatment, mitigating contaminants coming from the road corridor during the early part of a storm event. Infiltration and soakage methods are used for discharging stormwater to ground, with the soakage basins providing storage.

As a minimum the design includes the treatment, attenuation and disposal to ground of stormwater runoff from the road corridor for the additional impervious area created by Package 1. The new impervious areas are identified in section 4.3.1.1.

Where existing network is to be removed to facilitate the new road corridor, or whereby the changes in geometric design cause road corridor drainage to operate differently to existing, the design allows for the treatment, attenuation and disposal to ground of stormwater for the existing catchment area of that asset. These catchment areas are identified in section 4.3.1.2.

Cross-drainage has been designed to manage stormwater impacts on existing cross-catchments and maintain the state highway's operational performance. The system collects stormwater from eastern and western cross-catchments using a network of scruffy domes, pipes, manholes, and swales. It is designed to mitigate the impact of Package one up to the 1% AEP critical duration event without increasing flood risk. The cross-drainage catchment areas are identified in section 4.3.2.

4.3.1 Road Corridor Catchments

4.3.1.1 Additional Impervious and Pervious Areas

Figure 4-1 below shows the changes to impervious and pervious areas as a result of the proposed works within Package 1 and Table 4-1 quantifies the areas:

- Additional impervious area (i.e. existing pervious areas that will become impervious) are shown in blue; and
- Additional pervious areas (i.e. existing impervious areas that will become pervious) are shown in green.

Table 4-1: Proposed additional impervious and pervious areas and overall increase in impervious area

Description	Area (m²)
Additional impervious area	14,400
Additional pervious area	3,600
Overall increase in impervious area	10,800

There is an overall increase in impervious area within Package 1 of approximately 10,800m².

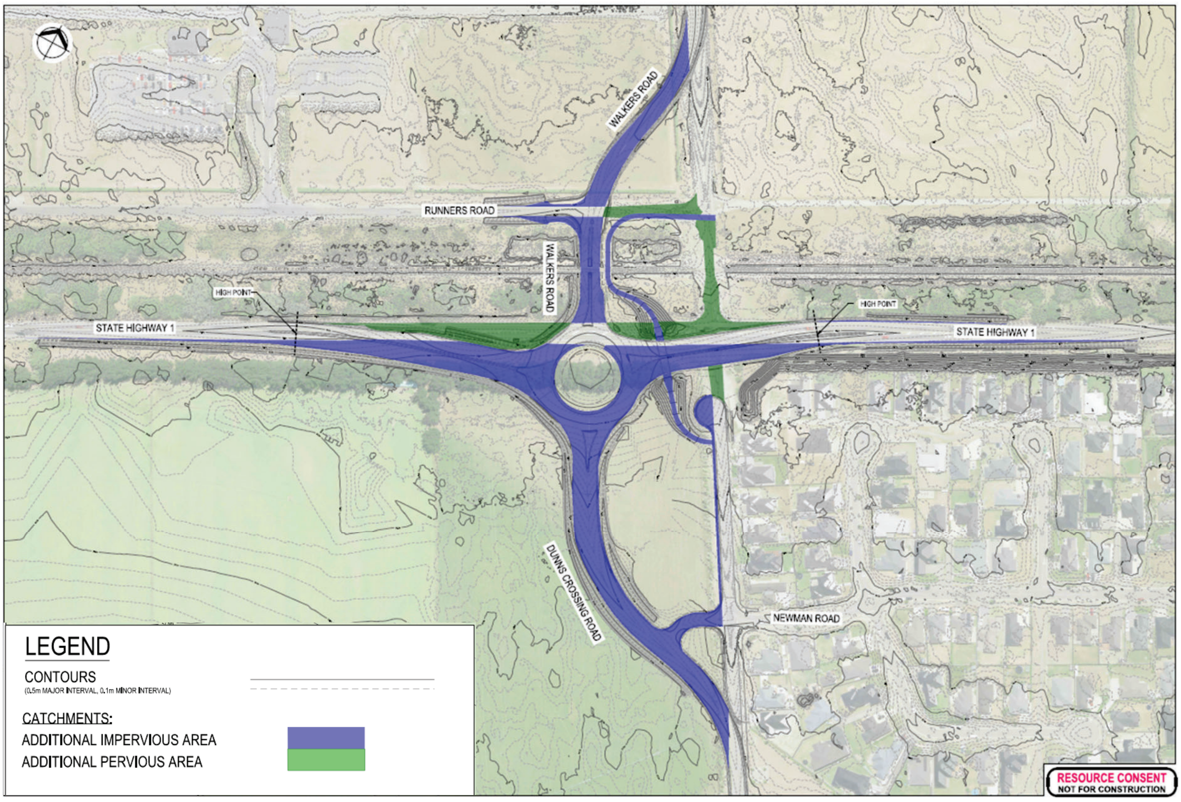

Figure 4-1: Additional Impervious and Pervious Areas Plan for Package 1

4.3.1.2 Proposed Impervious and Pervious Areas

Figure 4-2 shows the proposed impervious and pervious areas forming the Package 1 road corridor catchments. These impervious and pervious areas are defined by the geometric design of the road and the surrounding ground levels and are broken down into catchment areas in section 5.

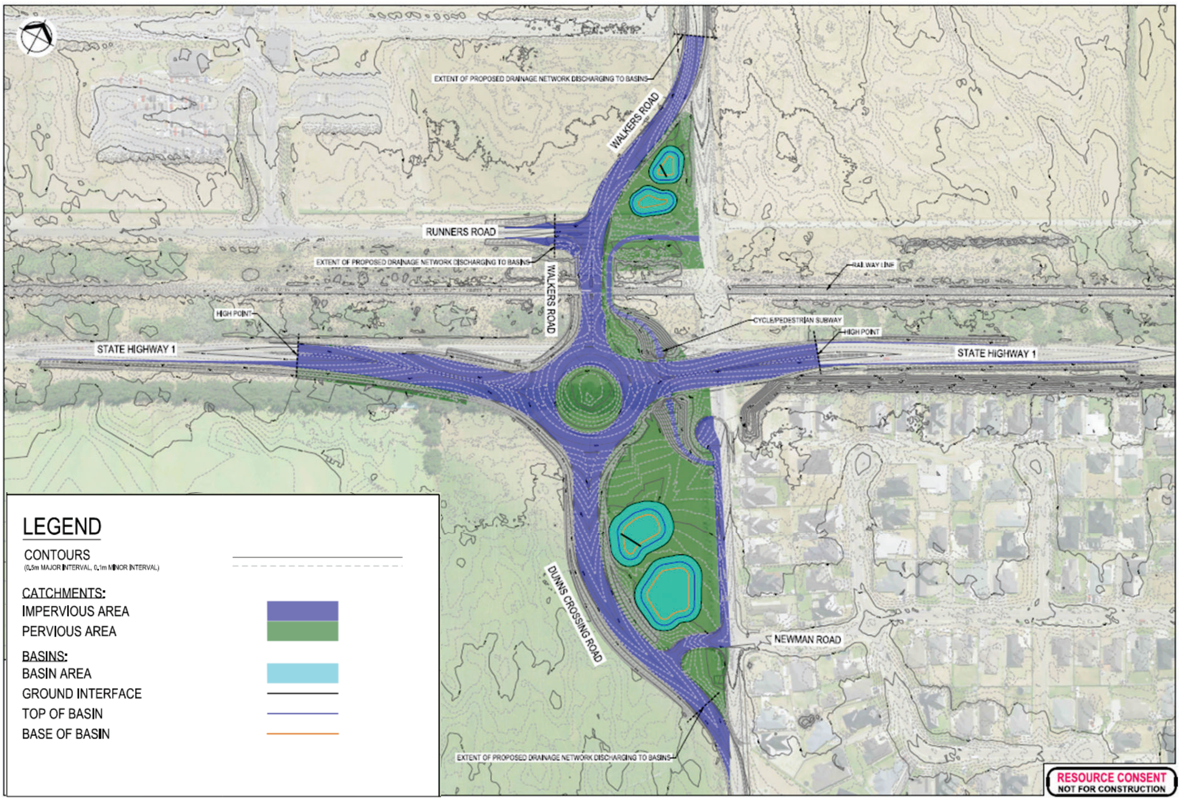

Figure 4-2: Proposed Impervious and Pervious Areas for Package 1

4.3.2 Cross-Drainage Catchments

Package 1 cross-drainage catchments are defined according to the geometric design of the road and how this impacts the existing overland secondary flow paths as identified in section 2.4. The cross-drainage catchment areas are shown in Table 4-2.

Table 4-2: Cross-Drainage Catchment Areas

Catchment	Area (ha)
Western Cross-Drainage Catchment (Catchment 1)	15.2
Eastern Cross-Drainage Catchment (Catchment 2)	4.4

For the western cross-drainage catchment (catchment 1) we have used the residential runoff coefficient from Table 3-2 to calculate the runoff volume due to the low density of the prison development. For the eastern cross-drainage catchment (catchment 2) we have used the rural runoff coefficient.

Figure 4-3 below shows the cross-drainage catchment areas identified as part of the Preliminary Design for the Package 1 footprint.

Figure 4-3: Proposed Cross-Drainage Catchment Plan for Package 1

4.4 Key Design Elements

The key elements of the long-term stormwater management design are:

- Collection and conveyance
- Treatment of first flush
- Discharge to ground
- Attenuation
- Cross-drainage

The following sections of this report break down the approach taken for each of these key design elements.

4.4.1 Collection and Conveyance

The design of the collection and conveyance network for Package 1 includes a number of different elements, including;

- Kerb and channel
- Catchpits
- Manholes
- Swales
- Pipework

Stormwater runoff from Package 1 will generally be conveyed using swales, other than where space is constrained, resulting in a piped network being required.

All collection and conveyance will be designed using the Rational Method (with the runoff coefficients and rainfalls value described in section 3.4) to calculate runoff and Manning's equation (with a roughness value as stated in section 3.4) to calculate conveyance capacity.

4.4.1.1 Kerb and Channel

Channel flow widths within the highway will be generally been designed in accordance with P46, which includes:

- During a 10% AEP 10 minute duration event
  - shoulder flows shall not encroach on the trafficable lanes (including shoulder priority lanes)
- During a 1% AEP 10 minute duration event
  - For two lane state highways, ramps and local roads, at least 3m of live traffic lane must be free of stormwater with a maximum depth of 100mm in the covered lane
  - For multi-lane section of state highway, channel flow may cover 1 lane (including priority lanes) at a maximum depth of 100mm
  - No surface runoff from unpaved areas is permitted to flow onto or across a traffic lane surface

Whilst the above design approach has been taken along the proposed alignment for Package 1, this does not mean that there will be no flooding in a 1% AEP. The capacity of the existing stormwater networks in the vicinity of the Package 1 alignment is unknown, and there may be stormwater which runs onto the Package 1 alignment from the existing roads or adjacent land which is not allowed for in the design.

4.4.1.2 Catchpits

The positioning of catchpits has been carried out in accordance with section 4.4.1.1 above.

Catchpits are in accordance with the requirements set out in NZTA P46. These catchpits have a minimum dimension of 675mm x 450mm x 1200mm deep and have a bypass (or back-entry). The following catchpit capacities have been used:

- 30 L/s for a single in-line catchpit

- 50 L/s for a single valley position catchpit
- 60 L/s for a double in-line catchpit
- 100 L/s for a double valley position catchpit

4.4.1.3 Manholes

All manholes will be designed in accordance with the requirements set out in NZTA P46.

4.4.1.4 Swales

Due to the high permeability gravel beneath the upper soil layer and low groundwater table, swales will generally be grassed as they are not required to tolerate long period of stormwater retention.

Swales do not form part of the formal treatment design but provide conveyance and some pre-treatment. The swales are designed to convey the peak flow 1% AEP event.

The design proposes that full treatment occurs in first flush basins, and therefore the water quality design criteria for swales will not apply. Where a swale is at a grade of less than 2%, an underdrainage system (subsoil drain) is usually required as per NZTA P46. Due to the relatively flat grades of the alignment and existing ground, subsoils would likely be required under all swales, however, due to the high soakage rates observed within the project extents, it is proposed that subsoil drains are not required.

4.4.1.5 Pipework

All pipework within the state highway have been designed in accordance with the requirements set out in NZTA P46 and are designed to convey the 1% AEP critical duration event where there is no secondary flow path. Where localised networks service only SDC roads, the local standard (SDC ECOP) has been adopted as not to provide significantly larger network capacity than required.

On this basis, the minimum pipe size is 300mm diameter for catchpit leads and reticulation not crossing lanes in the state highway and 225mm in SDC roads. The minimum pipe size for reticulation (other than catchpit leads) crossing lanes will be 375mm diameter for the state highway and 225mm diameter for SDC roads.

Where possible, pipework has been designed to have a minimum velocity of 0.6m/s at half the 50% AEP (2 year ARI) peak flow. However, as pipes will generally need to be graded with ground surface to prevent basins and soak pits becoming too deep, due to the relatively flat grade of the Canterbury plains it is not possible to meet the minimum velocity requirements for the majority of the network.

4.4.2 Treatment

Stormwater treatment will be provided using the industry standard method of treating the first flush (water quality volume) to significantly reduce contaminant loads. The first flush concept is based on the contaminant build-up / wash-off process, meaning that the smaller storms, or the first part of the larger storms, have the highest contaminant loads.

Treatment will be provided by capturing the first flush volume (i.e. runoff volume from first 25mm of rainfall), and treating this via infiltration through designed sand media (in basins), before discharging to the ground beneath the basin. Infiltration (biofiltration) treatment provides very good removal efficiencies of total suspended sediment (TSS), metals, and hydrocarbons, and good removal of nutrients.

For the majority of Package 1, the full width of the main alignment and the Dunns Crossing Road / Walkers Road legs of the roundabout have been allowed for in the first flush treatment design. The exceptions to this are at the western and eastern ends of the state highway, where the proposed alignment ties into the existing, and the additional pavement area is minor and therefore existing informal stormwater system is being left in place. Informal treatment is already provided in this area by runoff flowing over existing grass berms (acting as informal filter strips).

The first flush basins will include a sediment forebay, sized for 15% of the first flush volume. The first flush basins, with exception of the forebays, will be lined with at least 400mm thick constructed infiltration media. Rather than being designed to achieve a particular infiltration rate, the sand media will be designed to meet the CRC for Water Sensitive Cities, *Adoption Guidelines for Stormwater Biofiltration Systems* (2015), Appendix C Guidelines for filter media in stormwater biofiltration systems.

Although the initial infiltration rate for the infiltration media will be quite high (e.g. in the order of 300mm/hr or higher) it will clog over time and the infiltration rate will reduce. The area and depth of the first flush infiltration basins will therefore be sized to allow the first flush volume to drain down at a minimum (long-term) infiltration rate of 20mm/hr, over a maximum of 48 hours to maintain healthy grass cover.

Once the first flush basin is full, a weir immediately upstream of the first flush basin will divert inflows to the soakage basin.

4.4.3 Discharge to Ground

Infiltration, for the purpose of this report, is where stormwater from the first flush basins infiltrates through a design sand (biofiltration) media to provide treatment. This treated stormwater then discharges to ground beneath the infiltration media. A constructed soakage area may be required, subject to the quality of gravels at the subgrade level of the first flush basin.

Soakage, for the purpose of this report, is where stormwater is discharged to ground. In the case of the Package 1 basins, post-first flush stormwater with flow into the attenuation/soakage basin, be buffered or attenuated, and flow into an open manhole with a debris screen (scruffy dome). This manhole will connect to a network of below ground perforated pipes that discharge stormwater into a constructed soakage area or insitu gravels. A constructed soakage area may be required, subject to the quality of gravels at the subgrade level of the soakage basin. For the soak pits, the stormwater reticulation will connect direct to a manhole discharging to a constructed soakage area. The voids between the rocks in the soak pit provide the attenuation storage. Depending on the size of the soak pit, perforated pipes may also be included to improve distribution into the gravels.

For the Package 1 first flush basins and soakage basins, discharge to ground is expected to be able to be achieved by discharging into the native gravels beneath the basins. Where constructed soak pits are required (e.g. at the underpass), this will consist of clean rock, with geotextile over top and sides (but not the base) to prevent migration of the surrounding soil into the soakage areas (but reduce the risk of the base clogging). The clean rock for constructed soakage areas will be selected based on its grading and porosity (or percentage voids). The geotextile will be selected based on the grading of the surrounding soil.

Factored soakage rates that are used in the design have been determined based on the measured soakage rates observed in field soakage tests. These rates have been factored according to industry standard practice, as described in section 3.4.5 of this report.

Discharge to ground will occur at a level sufficiently above predicted groundwater levels, with the unconfined water table observed on site as greater than 10m below ground level at the site.

The discharge of stormwater to ground has the potential to impact on groundwater mounding and wells depending on the volume and proximity of discharge to ground. This is described in more detail in section 2.2 of this report.

4.4.4 Attenuation

Soakage basins discharging to ground have been sized to provide stormwater attenuation for buffering between the inflows from stormwater runoff and the discharge to ground.

The basin sizing calculations are relatively straightforward and have therefore been carried out using spreadsheets. The inflow rates and volumes vary with different storm durations, while the outflow rate depends on the soakage area size and its design soakage rate. For each duration, the inflow volume, outflow volume, and buffer storage (difference between inflow and outflow) are calculated. The soakage area and storage volume are optimised, considering a range of durations to find the critical duration (i.e. the duration that results in the largest storage volume).

In both the northern and southern catchment, the stormwater network will discharge into the first flush basin, with a weir diversion structure immediately upstream of the first flush basin. The weir will be designed so that once the first flush basin is full, stormwater will begin discharging over the weir and into the soakage basin (which discharges via soakage to ground).

When inflows into the soakage basin exceed the soakage capacity of the ground, water will be stored in the basin and the basin will fill. When the inflow reduces and the soakage rate is greater than the inflow, the soakage basin will start to drain down, discharging to ground via the open manhole with scruffy dome debris screen and subsoil soakage network.

The soakage basin will be sized to provide sufficient storage to balance the inflows and outflows for all durations of events up to the 1% AEP event.

4.4.5 Cross-Drainage

Cross-drainage is required to mitigate the impact of Package 1 on the existing cross-catchments (overland flow paths) that have been discussed in section 4.3.2, whilst also maintaining the operational performance of the state highway.

Cross-drainage has been designed to collect the eastern and western cross-catchments, conveying stormwater through the Package 1 footprint via a network of inlets and outlets, pipes/culverts, manholes and swales. This network has been designed in accordance with the parameters set out in section.3.4

Cross-catchment peak flows will be conveyed safely across Package 1 by the cross-drainage network up to the 1% AEP event, without flooding the state highway and without increasing flood risk outside of the designation or to private properties.

5 Stormwater Management by Catchment

5.1 Overview

The Package 1 stormwater catchments are shown in Figure 5-1.

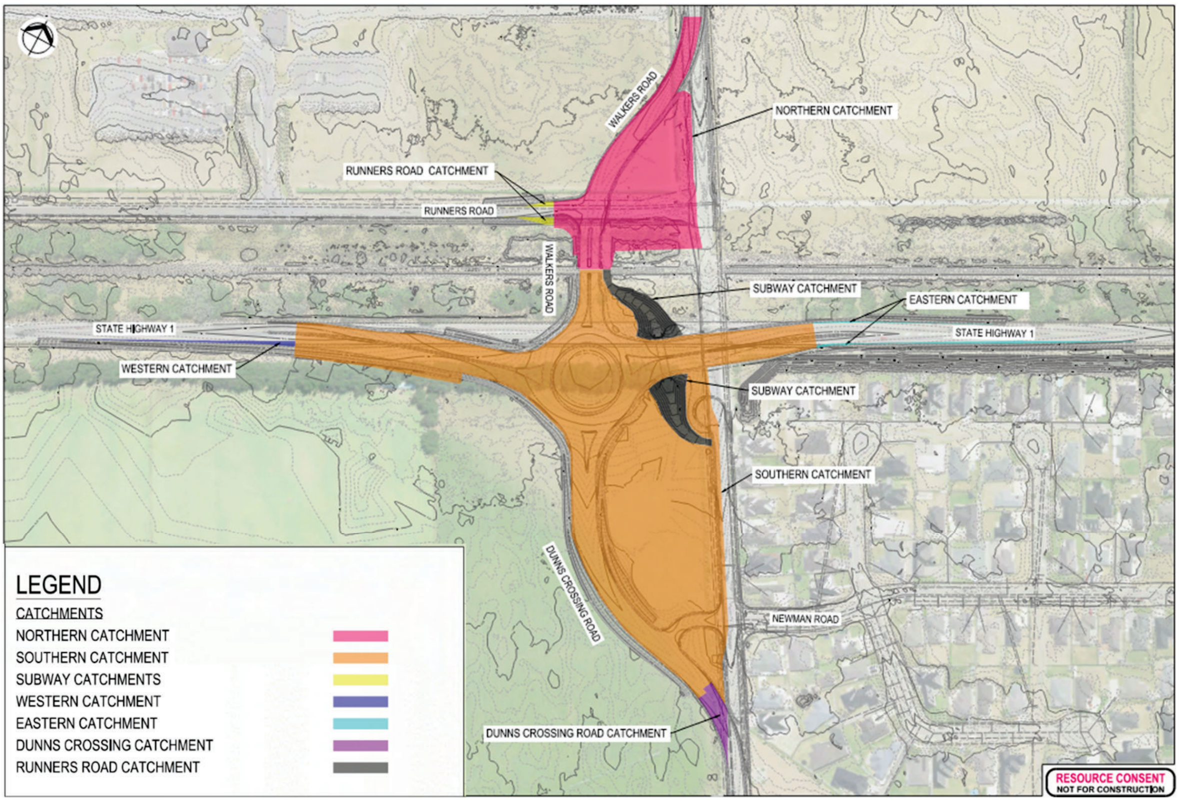

Figure 5-1: Proposed Catchment Plan for Package 1

The major catchment areas, listed in Table 5-1, are the catchments collected by the proposed new stormwater management network. These catchments are described in more detail in section 5.2.

Table 5-1: Major Catchments Areas

Catchment	Impervious Area (m²)	Pervious Area (m²)	Total
Northern Catchment	3,100	4,500	**7,600**
Southern Catchment	14,900	18,200	**33,100**
Subway Catchments	450	1,400	**1,850**
Total	**18,450**	**24,100**	**42,550**

The minor catchments are the catchments that are not able to be conveyed to the proposed new stormwater management network because of the geometric design. The additional impervious areas for these catchments are summarised in Table 5-2 and these catchments are described in more detail in Section 5.3.

Table 5-2: Minor Catchment Areas

Catchment	Additional Impervious Area (m^2)
Western Catchment	195
Eastern Catchment	230
Dunns Crossing Road	440
Runners Road	110
Total	**975**

5.2 Major Catchments

5.2.1 Northern Catchment

The northern catchment is delineated by the KiwiRail corridor to the south and the tie into the existing Walkers Road to the North. The KiwiRail corridor will be unchanged with a new level crossing being provided and stormwater falling away from the crossing in accordance with KiwiRail standards.

Stormwater from the northern catchment will have first flush treatment (via infiltration in a first flush basin) and runoff up to the 1% AEP event will be conveyed to the soakage basin, attenuated and discharged to ground.

The deviation of Walkers Road away from its existing alignment, facilitating a connection to the new roundabout, has provided a space for the first flush and soakage basins required for stormwater management. The area is sufficient to facilitate a first flush infiltration basin and soakage basin to cater for road runoff from the northern catchment.

Due to limited space along the western edge of the new Walker Roads section, stormwater is collected in sumps and conveyed through a piped network to the first flush and soakage basins.

5.2.2 Southern Catchment

The southern catchment is delineated by the KiwiRail corridor to the north and the tie into the existing Dunns Crossing Road to the South. The KiwiRail corridor will remain raised with a new level crossing being provided and stormwater falling away from the crossing in accordance with KiwiRail standards. Additionally, along SH1 there are existing high points to the east and west of the roundabout that the geometric design ties into, further constraining the catchment.

Stormwater from the southern catchment will have first flush treatment (via infiltration in a first flush basin) and runoff up to the 1% AEP event will be conveyed to the soakage basin, attenuated and discharged to ground.

At the tie-in point to Dunns Crossing Road, the road runoff catchment is limited due to the sump lid level and the basin level.

The deviation of Dunns Crossing Road away from its existing alignment, facilitating a connection to the new roundabout, has provided a space for the first flush and soakage basins required for stormwater management. The area is sufficient to facilitate a first flush infiltration basin and soakage basin to cater for runoff from the southern catchment.

Stormwater is captured by a mixture of kerb breakouts and sumps, conveyed to the basins via a combination of swale and piped network. Swales have been utilised where space allows, with pipe networks where space constraints exist.

5.2.3 Subway Catchments

The subway catchments are split into north and south, delineated by the grading required to facilitate the access path down to the subway level, approximately 2.5m below existing ground level. Where required due to surrounding levels, a bund will be provided along the top of the grading to prevent overland flow from entering the subway cutting.

Stormwater from the subway catchments does not require treatment and will discharge via a catchpit to capture suspended solids from the catchment and will be conveyed to a soakage area below the pedestrian/cycle path and discharged to ground.

Separate stormwater networks will be provided at each end of the subway, with stormwater being captured by a channel drains across each entrance and conveyed to a catchpit for sediment capture and then a soakage area for discharge to ground.

Stormwater runoff within the subway catchments is from the planted grading and access path, meaning no water quality treatment is required. Attenuation of stormwater for the subway catchments will be provided in the soak pit and sized following further discussion with NZTA on the level of serviceability required for the subway users.

5.3 Minor Catchments

5.3.1 Eastern Catchment

At the eastern end of the state highway beyond the existing high point noted on the drawings, the proposed widening of the existing state highway lanes is minor. In this area it is proposed that the existing stormwater runoff discharging to grassed berms and soak pits discharging to ground will be kept in its current form. The existing grassed berms provide some informal water quality treatment prior to discharge to ground.

5.3.2 Western Catchment

At the western end of the state highway beyond the existing high point noted on the drawings, the proposed widening of the existing state highway lanes is minor. In this area it is proposed that the existing stormwater runoff discharging to grassed berms and soak pits discharging to ground will be kept in its current form. The existing grassed berms provide some informal water quality treatment prior to discharge to ground.

5.3.3 Dunns Crossing Road Catchment

At the Dunns Crossing Road tie-in there is a minor increase in new impervious surface that isn’t being captured by the proposed network. This runoff will discharge to the existing grassed berm and soak pits on the western edge of Dunns Crossing Road. The existing grassed berms provide some informal water quality treatment prior to discharge to ground.

This minor area of new impervious surface is being offset by the capture of existing road runoff from the section of Dunns Crossing Road north of Newman Road, which is approximately double the impervious area of this section.

5.3.4 Runners Road Catchment

New soak pits will be installed at the Walkers Road intersection on both sides of Runners Road to capture runoff from the existing Runners Road catchment and the additional impervious area. These new soak pits will replace the existing soak pits on Runners Road, as the geometric design of Package 1 obstructs the existing flow paths to the current soak pits. The new soak pits will offer an equivalent level of service to the existing soak pits, but will have a smaller catchment area than the existing ones.

5.3.5 Existing Walkers Road Catchment

North of the Package 1 tie-in with Walkers Road and Northern Catchment, there is an existing catchment (not shown on Figure 5-1 or Table 5-2) which drains south to existing soak pits inside the proposed Package 1 footprint. At the proposed Package 1 tie-in with Walkers Road, new soak pits will be installed within the berm on both sides of the road to collect runoff coming from the existing catchment north of Package 1. These new soak pits will replace the existing soak pits on Runners Road, as the geometric design of Package 1 obstructs the existing flow paths to the existing soak pits. The new soak pits will offer an equivalent level of service but will have a smaller catchment area than the existing ones.

5.4 Summary

From Table 5-1 it can be seen that the proposed stormwater basins provide first flush treatment, attenuation and discharge to ground up to the 1% AEP event for 18,000m² of impervious area.

The proposed subway soak pits provide attenuation and discharge to ground for a further 450m² of impervious area.

This compares to approximately 10,150m² of additional impervious area (refer section 4.3.1.1) created by the Package 1 works.

6 Construction Stormwater Management

6.1 General

During construction, the principal short-term potential effect of Package 1 will be on water quality, arising from runoff during earthworks.

Earthworks activities will be managed such that proposed erosion and sediment control (E&SC) measures will best practicably minimise erosion, sedimentation and dust generation. The fundamental principles of good E&SC practice for the Canterbury region are;

- Control run-on water entering the site;
- Separate ‘clean’ water from ‘dirty’ water;
- Protect the land surface from erosion;
- Minimise sediment leaving the site.

6.2 Site-Specific Erosion and Sediment Control

As noted in section 2, Package 1 and surrounding area is relatively flat. Run-on to site is unlikely to be a significant issue due to the localised levels and relatively limited cross-catchment area. However, Walkers Road, Runners Road and Dunns Crossing Road all have some catchments which discharge towards Package 1. There are existing soak pits within Package 1 footprint, some of which will be removed and some which will remain.

Soils are generally free draining to the gravel layers below and the groundwater level is sufficiently deep so that natural drainage is likely to occur across most of the site. Dewatering is unlikely to be required, however, if required this would be disposed of in a manner which manages erosion and sediment.

Construction stormwater runoff should be able to be effectively managed within the site. This could include adapting some of the long-term stormwater management system (e.g. swales) for erosion and sediment control purposes (e.g. establishing bunds along the swales), but not the basins. It is important that construction runoff and erosion and sediment devices are kept clear of the proposed first flush infiltration basins, soakage basins, and soak pit sites, to protect the underlying ground from clogging.

6.3 Erosion and Sediment Control Toolbox and Erosion and Sediment Control Plan

The effects of erosion and sediment will be mitigated in accordance with the Environment Canterbury Erosion and Sediment Control Toolbox.

The Contractor will develop a Package 1 specific Erosion and Sediment Control (E&SC) plan in accordance with the ECan toolbox, whilst suiting the construction programme. That E&SC plan will form part of the Construction Environmental Management Plan (CEMP), which is described in section 6.6.

Some general principles of the E&SC framework will include:

- Earthworks and any vegetation clearance should, wherever practicable, be limited to the footprint of the works (including the contractor’s yard and stockpile areas) to minimise site disturbance. This minimises the site erosion potential.
- Construction works should be staged in manageable sections where practicable, such that progressive reinstatement works can be carried out (i.e. logical work sections should be stabilised before moving on to the next section).
- Unless being actively worked, any exposed areas should be progressively stabilised, generally with topsoil, and grassing. Biodegradable geotextile, mulching, or hydro seeding may be required at some locations, such as protecting steeper slopes.

- Any excavated material should be removed from site immediately (if not required for re-use) or stockpiled away from any swales, basins or overland flow paths. Appropriate E&SC measures should be applied to stockpiles, which could include silt fences, bunding, etc around it. Stockpiles should be located adjacent to vegetated areas, where practicable, that will act as vegetative buffers. Practical measures would be taken to divert clean runoff from working areas.
- Control of run-off and run-on through the work areas through the use of flow diversions, fluming, silt fences, temporary drains or bunding.
- Dust suppression during dry periods.
- All proposed erosion and sediment control measures are to be installed prior to carrying out physical works (as reasonably practicable) and maintained until satisfactory surface stabilisation is achieved.
- Enable the plan to evolve as the project progresses (e.g. weather, staging, altered drainage, etc. will require changes to the planned E&SC measures whilst achieving its purpose).
- Regularly inspect, monitor and maintain the erosion and sediment control measures. Any rips, tears, and the like to fabrics should be repaired immediately. Any sediment build-up should be cleared and appropriately disposed off site. Maintenance checks are to be carried out at regular intervals and after any significant rainfall event.

6.3.1 Specific Erosion, Sediment and Dust Control Measures

Specific erosion, sediment, and dust control measures which could be utilised, as appropriate as part of the E&SC Plan for the short-term management of the Package 1 works, include:

- Erosion Control Measures: runoff diversion channels and bunds, contour drains, check dams, level spreaders, surface roughening, stabilised construction entrances, and stabilisation techniques such as geosynthetic erosion control systems, and/or revegetation techniques (e.g. topsoiling, seeding, hydroseeding, mulching, and turfing);
- Sediment Control Measures: sediment retention ponds, grit traps, silt fences, super silt fences, inlet protection, decanting earth bunds, sump/sediment pits, wheel washdowns, etc;
- Dust Control Measures: watering of exposed areas, and/or stabilisation techniques such as geosynthetic stabilisation, revegetation, hydroseeding, mulching, or turf.

6.4 Monitoring and Maintenance

All temporary treatment devices are to be adequately monitored and maintained throughout the construction phase and the maintenance period until the areas are sufficiently stabilised to allow for the removal or decommissioning of E&SC devices. The Contractor will be required to prepare a maintenance programme together with a contingency plan for instances when the sediment control devices are not operating as required and for assessing sediment control devices after heavy rainfall.

6.5 Construction Environmental Management Plan

For Package 1 construction works, the contractor will be required to develop a Construction Environmental Management Plan (CEMP) prior to commencement of construction activities. The CEMP will include a detailed E&SC plan. The E&SC plan will be considered a “live” document and be regularly updated.

The CEMP will also include mitigation measures for failure of the protection works for earthworks, access and haul roads, stockpile sites and work areas, etc, as well as a programme and details for the proposed monitoring and maintenance plan and operational procedures.

The CEMP will include locations and details of E&SC devices (incl expected efficiencies), where the W&SC devices discharge to, and the construction methodology and how this methodology will minimise the amount of sediment being controlled and released. The CEMP will also outline procedures to be undertaken should heavy rain be forecast, in terms of implementing erosion control measures as well as checking that devices are working adequately and monitoring these during and after the event.

7 Operation and Maintenance (O&M)

7.1 Stormwater O&M Manual

A Stormwater Operation and Maintenance Manual will be prepared as part of the detailed design. This will help NZTA, SDC and their contractors to understand the Package 1 stormwater system and its intended operation, and assist them in planning and undertaking effective inspection, monitoring and maintenance works. It will also help the stormwater management system operate as intended, assisting NZTA to fulfil its social and environmental responsibilities.

It is noted that NZTA already maintains significant lengths of state highway and the associated stormwater systems in the Canterbury region and around New Zealand, including SH1 immediately adjacent to the project. This project is a small addition to NZTA's existing operation and maintenance programme.

7.1.1.1 General Operational Objectives

The O&M Manual will provide a tool for use by the maintenance operators, SDC and NZTA, to monitor, plan and commission works associated with maintenance of the Package 1 stormwater management system.

The O&M Manual should provide guidance on the operational objectives and methods that relate to the monitoring and maintenance actions, including regular and reactive maintenance activities and procedures, including emergency spill incidents, and includes a list of important contacts. The monitoring and maintenance activities will manage the effects of the stormwater system on the local and downstream environments will be best practicably avoided, remedied or mitigated.

7.1.1.2 Stormwater Collection and Conveyance Systems

The principal operational objectives of the stormwater collection and conveyance system are:

- Conveyance to prevent surface flooding: System needs to be cleared of blockages and debris so stormwater from the road surface is safely conveyed away.
- Provide stability and safety of conveyance systems: Maintain grass cover/vegetation and inspect for erosion and repair as required. The hydraulic action of flowing water in the system can cause erosion or structural damage to infrastructure, in particular open channels, swales, outlets and culverts.
- Provide pre-treatment of stormwater: Maintain grass cover/planting and maintain any flow control devices (e.g. weirs) designed to direct the flows to provide suitable water quality treatment.

7.1.1.3 Stormwater Treatment Devices and Attenuation and Soakage Devices

The principal operational objectives of the stormwater treatment, attenuation and disposal devices are:

- First flush basins to provide water quality treatment via sediment and rubbish removal, filtration or settlement and biological process: Maintain grass cover/planting and maintain any inlet/outlet structures (e.g. headwalls) designed to direct the flows to provide suitable water quality treatment.
- Soakage basins to provide buffer storage of stormwater: Maintain grass cover/planting and maintain any inlet/outlet structures (e.g. headwalls) designed to direct the flows to provide suitable attenuation.
- Disposal devices to facilitate stormwater discharge to ground: Maintain any inlet/outlet structures (e.g. open manhole with scruffy dome) designed to direct stormwater discharge to ground.

All the above devices are designed and maintained to protect the receiving environment from erosion, flooding and contamination.

7.1.1.4 Landscape

The general objective of landscape maintenance as it relates to the stormwater management devices is to maintain appropriate planting and grass in a sound and healthy condition in a way that does not adversely impact upon flow conveyance, treatment characteristics or aesthetic values.

The overall landscape planting strategy aims to reinstate and enhance the underlying landscape elements, patterns, and processes using endemic native species.

The proposed stormwater management devices will be grassed, which will be mown, and planting will be used around the extremities of the devices which will naturalise the form of the basins and swales adding ecological and amenity value to the devices and adjacent spaces. By introducing areas of native planting to these devices ongoing mowing maintenance efforts will be reduced.

Throughout the establishment phase weed species will be managed as part of the landscape maintenance programme to increase levels of canopy closure in turn reducing the need for ongoing maintenance.

7.1.1.5 Implementation

The O&M Manual should include figures and drawings showing the system features, a description of how the system functions, and a schedule of recommended O&M activities. Appointed operators will need to be skilled and take responsibility for undertaking scheduled activities to an acceptable industry standard.

Maintenance works at specific stormwater management devices should be covered in checklists (i.e. swales, basins, etc.) in the O&M Manual. Such forms should be completed and submitted with the regular summary report of the maintenance activities.

7.2 Design Considerations for O&M

The stormwater management Preliminary Design includes consideration of convenient operational and maintenance features as follows:

- Swales: Ease of access for inspection, mowing (grass) or weeding (plants) and maintenance. Geometric design considerate of mowing and maintenance requirements (where appropriate).
- Basins: Treatment device features such as inlets, underdrainage and outlets (eg to soakage) will be readily accessible and incorporate visible features (e.g. observation wells) meaning that the site inspection and performance monitoring can be undertaken with ease.

Maintenance access to swales and basins has not been shown on the RM approval drawings, however there is sufficient space to allow for access within the NOR footprint. The maintenance access design will need to be carried out at detailed design.

7.3 O&M Manual Review

A regular review of the O&M Manual should include:

- Updating the maintenance schedule where action and frequency refinements can be made based on the previous monitoring and maintenance report findings
- Review and update the regular and reactive monitoring and maintenance procedures for the stormwater collection and conveyance system and for the stormwater treatment devices based on the previous year's report findings
- Review and update the regular and reactive monitoring and maintenance procedures for landscape features associated with the stormwater management system, including general elements, swales, basins, riparian margins, etc.
- Review and update the emergency spill procedures, based on any 'incident' experiences.
- Review and update the monitoring and maintenance contacts list
- Review and refinement of the budget estimates, based on the cost of monitoring and maintenance works incurred in the previous year.

8 Assessment of Effects

8.1 Effects on Water Quantity

8.1.1 Cross-Drainage and Effects on Flood Risk

8.1.1.1 Potential Effects

There are existing flow paths across the State Highway 1, as demonstrated by the SDC's flood modelling. The upgraded alignment for Package 1 crosses these flow paths. This has the potential to block the existing flow paths, increasing flood levels, or diverting the flow paths, changing the flooded area.

8.1.1.2 Proposed Mitigation

To manage existing flow paths across State Highway 1, runoff from the cross-drainage catchments up to the 1% AEP event will be captured and conveyed through the footprint of the Project (Package 1), before being discharged into the existing overland flow route that it currently travels.

The proposed Package 1 cross-drainage stormwater management system will include a series of swales, inlets and culverts/pipes to capture and convey these overland or flood flows across the highway. The cross-drainage system will be designed to manage the 1% AEP critical duration event without increasing flood levels or extents of flooding outside the road designation or NTZA land.

Due to the proposed cross-drainage system described above, flood risk effects for the Package 1 will be less than minor.

8.1.2 Road Runoff and Effects on Flood Risk

8.1.2.1 Potential Effects

The additional impervious areas constructed as part of Package 1 will increase stormwater runoff. If not managed, this has the potential to:

- Increase peak discharges to surface water, potentially causing erosion and increasing flood levels.
- Increase the volume of water discharged to surface water during the critical duration event for the catchment, increasing flood levels.

8.1.2.2 Proposed Mitigation

During operation, effects on water quantity will be managed through attenuation and soakage to ground. The proposed Package 1 stormwater system includes soakage basins and soak pits with discharge to ground (via soakage), mitigating the water quantity effects. Stormwater runoff from the additional impervious area within Package 1 will be discharged to ground, up to the 1% AEP event.

Stormwater runoff will be collected and conveyed to stormwater basins or soak pits. Stormwater attenuation will be provided in the soakage basins (and in some locations, soak pits) which discharge to the ground below the basins (or soak pits). Attenuation storage in the basins (or soak pits) provides a buffer between the inflow of runoff into the basins (or soak pits) and the discharge to ground via soakage.

The basins and swales will be located and designed so that during events larger than the 1% AEP design event, stormwater will follow the existing overland flow paths.

Due to the proposed stormwater management system described above, the water quantity and flood risk effects for the Package 1 will be less than minor.

8.2 Effects on Water Quality

8.2.1.1 Potential Effects

The Package 1 improvements may result in additional contaminant loads from vehicular traffic, littering, pavement and landscape activities. The main contaminants will be gross pollutants (litter), suspended sediments, heavy metals (including zinc and copper from vehicle wear), hydrocarbons, and to a lesser extent nutrients. If not managed there is the potential for additional contaminant load to have a negative effect on the receiving environment (i.e. the local groundwater).

8.2.1.2 Proposed Mitigation

During operation, effects on water quality will be mitigated through capture of first flush runoff and treatment via infiltration (also called biofiltration) through a designed sand media. The proposed Package 1 stormwater system includes first flush basins for infiltration treatment of first flush stormwater, before soakage to ground, to mitigate these effects.

Swales have been provided where space allows. While the swales have been designed for conveyance purposes, and are not part of the formal treatment design, they will provide some pre-treatment before the first flush infiltration basin (i.e. treatment train).

There are small sections of new impervious area at the extremities of the Package 1 footprint that are not able to be conveyed to the first flush infiltration basins. This is because the proposed highway vertical alignment and the distance from the proposed basins means that stormwater from these areas is unable to drain to the basins. Stormwater from these areas will run off the road over the grass berm, as stormwater from the existing adjacent road does. This will provide some treatment (from filtration through the grass berm) prior to discharge to land, either via infiltration through the berm or an existing soak pit.

The proposed stormwater design for the Package 1 includes first flush treatment of a larger area than the increase in impervious area across the Package 1 footprint. As such, the water quality effects for the Package 1 will be less than minor.

8.2.2 Discharge to Ground and Groundwater Effects

8.2.2.1 Potential Effects on Groundwater Levels

As stormwater system for the Project discharges to stormwater to ground at basins and soak pits, this has the potential to locally increase groundwater levels and affect nearby groundwater users.

As part of the site investigations, the local water table has been identified at depths greater than 10m below ground level at the Project (Package 1) site. Soakage from basins is therefore expected to be subject to at least 8m vertical unsaturated flow through the vadose zone from the soakage basins (assuming basin depth of less than 2m). At the subway, the soakage is expected to occur at depths of approx. 4.0m below existing ground level, with at least 6.0m vertical unsaturated flow before the infiltrated water reaches the water table.

The discharge of stormwater to ground via soakage will locally raise the water table, however the mounding at the water table is likely to be delayed, and of lesser magnitude than the peak flooding event at the basin, due to the soakage through the unsaturated land. For example, an event resulting in 1m deep water in the basin would result in less than 1m mounding at the water table, with the peak level at the water table likely occurring hours to days later than the peak level in the basin.

Currently local groundwater is recharged by soakage from rainfall events. The proposed basins will not increase the total volume of water infiltrated to the water table but will redirect it to infiltrate over a smaller area (i.e. at the basins and soak pits). This will locally raise the water table directly under the basins and soak pits, and then as pressures equalise, result in a groundwater level change comparable to current groundwater level response to rainfall events, i.e. within the seasonal range.

As such, effects on groundwater levels due to the proposed soakage basins are expected to be localised, and short term, with no long-term effects on groundwater levels in the area. No effects on water availability are anticipated at any nearby bores due to the net neutral change in water soakage.

8.2.2.2 Potential Effects on Drinking Water Supplies

Potential effects on drinking water supplies have also been considered, noting the Package 1 area and associated stormwater infrastructure does not fall within any Community Drinking Water Protection zones (CDWPZ) nor are there any bores within the Project area.

The small community supply bore at Rolleston Prison (M36/4459) located north of the site is only used for emergency supply, and the prison is connected to the Rolleston water supply.

The Walkers Road soakage basin is outside the CDWPZ for M36/4459, is located down gradient of the bore, and there presumably is at least 50m vertical offset between the soakage basin and the bore intake. Therefore, no adverse effects are expected at this bore.

8.3 Construction Effects

8.3.1.1 Potential Effects

During construction, there is the potential for adverse effects to arise as a result in discharges of sediment from earthworks during road construction, and from construction of pipes, culverts, swales and stormwater basins.

8.3.1.2 Proposed Mitigation

During construction, the potential discharge of sediment during construction will be mitigated via the preparation and implementation of an Erosion and Sediment Control Plan, including maintenance of the erosion and sediment control (E&SC) measures such as:

- Construction staging to limit stripped/open areas and stabilising surfaces as soon as possible
- Diversion of run-on water
- Silt fences
- Decanting earth bunds
- Sediment ponds
- Construction soakage basins – not in locations where long-term soakage is proposed.

9 Conclusions

The proposed State Highway 1 Rolleston Access Improvements, Package 1 stormwater management, mitigates the operational stormwater effects of the proposed works by providing stormwater treatment, attenuation and discharge to ground. Where practicable, stormwater will be conveyed to basins which provide first flush treatment, attenuation and discharge to ground up to the 1% AEP event. Small areas at the extremities of Package 1 unable to drain to new basins due the geometry will drain to existing soak pits or will continue to discharge overland to the berms before discharging to the ground. However, these areas are minor, and overall, the stormwater system will manage, treat and discharge to ground runoff from a larger impervious area than the additional impervious area created by the Package 1 works.

Cross-catchment peak flows will be conveyed safely across Package 1 in the 1% AEP event, without flooding the state highway, and without increasing flood levels in the catchment or increasing flood risk to private properties.

During construction, the potential discharge of sediment will be mitigated by the preparation and implementation of an Erosion and Sediment Control Plan.

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