Sensitivity: General

# Willows Farm Stormwater Management Report

## Wharekirauponga Underground Mine

Prepared for Oceana Gold (New Zealand) Ltd
Prepared by Beca Limited

**24 February 2025**


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## Revision History

| Revision Nº | Prepared By | Description | Date |
|---|---|---|---|
| A | Kristi Whyte | DRAFT For Client Review | 27.08.2021 |
| B | Hamish Kerr | Revised DRAFT For Client Review | 06.04.2022 |
| C | Hamish Kerr | DRAFT – OGNZL comments incorporated | 27.05.2022 |
| 0 | Hamish Kerr | Update for Final OGNZL comments | 16.06.2022 |
| 1 | Reuben Seeley | DRAFT Update for Changes to Site Design – For Review | 20.12.2024 |
| 2 | Reuben Seeley | DRAFT Update following OGNZL comments – For Review | 12.02.2025 |
| 3 | Reuben Seeley | Update following OGNZL review | 24.02.2025 |

## Document Acceptance

| Action | Name | Signed | Date |
|---|---|---|---|
| Prepared by | Reuben Seeley | | 24.02.2025 |
| Reviewed by | Justin Kirkman | | |
| Approved by | Eric Galopin | | 25.02.2025 |
| on behalf of | Beca Limited | | |

# Contents



# Appendices

# List of Abbreviations

| Abbreviation | |
|---|---|
| DOC | Department of Conservation |
| OGNZL | OceanaGold New Zealand |
| SFA | Surface Facilities Area |
| WRC | Waikato Regional Council |
| WRS | Willows Rock Stack |
| WUG | Wharekirauponga Underground |

# 1 Introduction

OceanaGold New Zealand Ltd (**OGNZL**) owns and operates both open pit and underground mines in the provincial town of Waihi, New Zealand. The main area of current mining occurs within the Martha Underground Mine located mostly under the Martha open pit.

Since the 1980s, exploration work has been conducted on an area of Department of Conservation (**DOC**) land in the Coromandel Peninsula, about 10 km north west of the existing processing plant at Waihi. OGNZL is in the process of securing resource consent for further development at their Waihi Mine site. This development includes a new underground mine, Wharekirauponga Underground (**WUG**) to the north of Waihi.

OGNZL has purchased a farm property at the end of Willows Road, Waihi. This 200-hectare parcel of land shares a boundary along its northern and western extents with the DOC estate. Should the project proceed, a portal, tunnel and mine infrastructure are planned to be located on this property.

The WUG mine will operate by utilising support facilities located at the Willows Road Surface Facilities Area (**SFA**) and by storing excess development rock on the farm for future backfilling purposes. Ore will be transported to the existing Waihi processing plant hence no requirement is envisaged for a processing plant at the new mine site.

This report covers the proposed stormwater management for the Willows Farm site, excluding the Willows Rock Stack (**WRS**) and associated drainage features. The WRS drainage and surface runoff management is covered by the GHD Water Management Study and Golder Geotechnical Report due to the potential chemical properties of the surface runoff. These reports should be read in conjunction with this stormwater management report.

# 2 Stormwater Philosophy

The objective of the proposed stormwater systems is to mitigate potential effects of the site development on the stormwater discharge from the site in its current state and to keep the ‘clean’ runoff separated from the development stormwater runoff. This objective can be achieved by using standard management methods and through the design meeting design standards listed within this section. When this objective is met, the resultant effects on the receiving environment will be less than minor. The temporary WRS is managed under a different stormwater philosophy, refer the GHD Water Management Study (GHD, 2025) and EGL Willows Rock Stack Technical Report (EGL, December 2025). The concept design for the development stormwater has been based on the following design guidance and assumptions:

- Waikato stormwater runoff modelling guideline (TR2020/06), Waikato Regional Council.
- Waikato stormwater management guideline (TR2020/07, updated May 2020), Waikato Regional Council.
- Regional Infrastructure Technical Specifications (**RITS**), Waikato local Authority Shared Services.
- Rainfall data was obtained from HIRDS (June 2021) and uses the RCP 8.5 data for climate change to 2050. Climate change to 2050 has been selected as this is a temporary site and is not expected to in operation for more than 30-years.
- Stormwater runoff from developed areas (excluding the WRS) will drain via pipes and swales to the SFA silt pond where practical. For these areas, swales will provide the primary source of water quality treatment for surface runoff, with extended detention at the SFA pond to provide some additional treatment.
- Flood maps of the Ohinemuri River catchment, obtained via the Waikato Regional Hazards Portal do not indicate flooding within the vicinity of the site, nor the Mataura Stream catchment. At this stage, it is assumed that there are no downstream flooding issues.

- A 24-hour rainfall distribution has been adopted for peak flow control criteria as per WRC TR20-07, Section 7.1.7.
- Management of stormwater within the WRS catchment, and sizing of the WRS collection pond is excluded from this report, as this is covered by the GHD Water Management Studies report (refer Section 5, GHD 2025).
- Based on the GNS science geology web map (2025) material at the outlet points to existing wetlands/water bodies has recorded the area as “Waiwawa Subgroup andesite and dacite of Coromandel Volcanic Zone” (assumed to be “course gravel”).
- The design of the topsoil stockpile area is excluded and designed by others.
- The design will be refined and updated in subsequent design stages. The intent is outlined within the report.

## Referenced Reports:


- WKP Mine Technical Description of Infrastructure Life of Mine Report, Beca Ltd., 10/3/2021 (Rev C, Phase 3 addendum)
- Water Management Studies, GHD, 2025.
- Willows Road WRS & SIA Geotechnical Assessment, WSP New Zealand Limited, June 2022.
- Erosion and Sediment Control Assessment Report, Southern Skies, 2025.
- Terrestrial Ecology Values and Effects of the WUG, Boffa Miskell, 2025.
- Willows Rock Stack Technical Report, Engineering Geology Limited (EGL), 2025.

# 3 Hydrology and Catchments

The existing site is currently a greenfields pasture site for livestock. All stormwater currently drains either by infiltration or overland flow paths to existing watercourses.

The site has been split into eight catchments with sub catchments (based on the post-development design) within them. Refer below. Six catchments drain east to the Mataura Stream, which forms the eastern border of site, one catchment drains to the west of site, and one to the southwest. The Mataura Stream outlets into the Ohinemuri River. Figure 2 provides the catchments in the post-developed scenario, with six catchments further broken down into the undeveloped and developed areas and can also be found as a larger sketch in Appendix A.

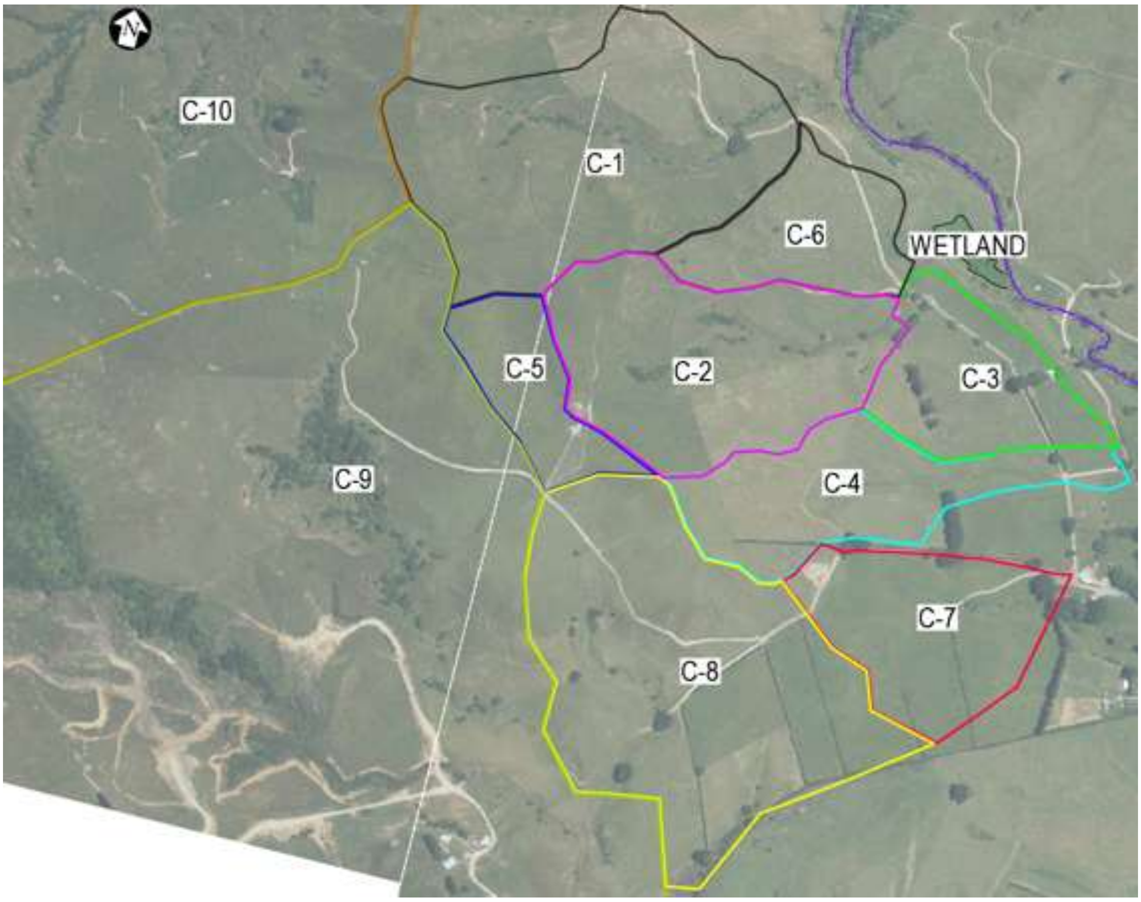


Figure 1. Pre-development catchments.

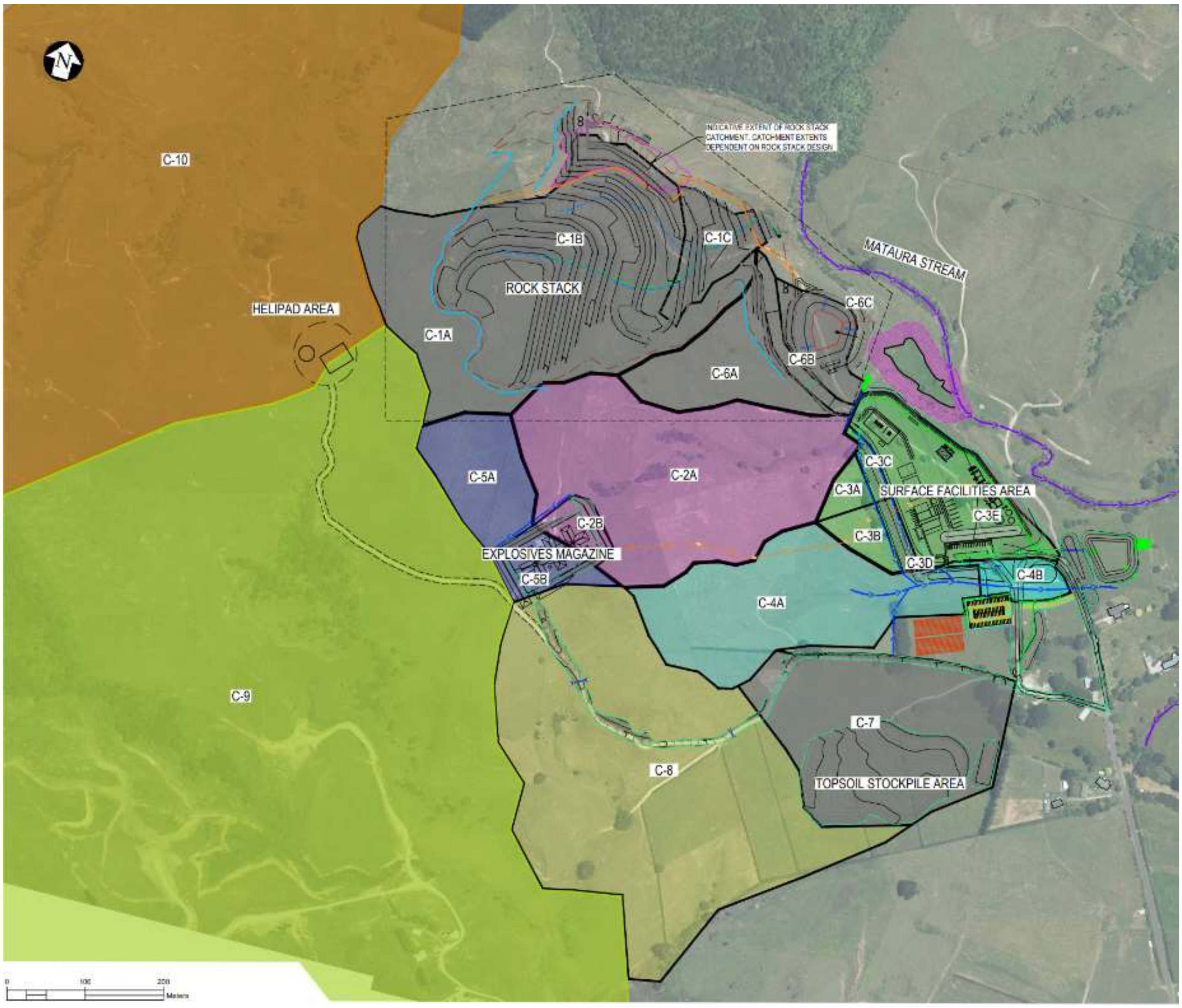


Figure 2. Post-development catchments.

Table 1 as follows provides a description of each catchment in its pre- and post-development scenario. The ability for soil to infiltrate rainfall is a function of both impervious land cover (buildings, sealed roads and water bodies) and curve number. The curve number (CN) is an empirical surface runoff method that estimates precipitation excess as a function of cumulative precipitation depth, soil type, land use, and antecedent soil moisture (USACE, 2025).

Table 1: Pre- and Post-Development Catchment Descriptions and adopted weighted Curve Numbers (CN)

| Catchment | Pre-development Description | Post-development Description |
|---|---|---|
| 1 | Catchment 1 is a steep gully which flows to the Mataura Stream. The gully has natural springs that drain into the Mataura Stream. Refer to the Willows Rock Stack Technical Report (EGL, 2025) for how these existing underground springs will be managed. | The Catchment 1 gully is to be filled and developed into the storage rock stack. All surface runoff from the rock stack is to be captured in a collection pond and conveyed offsite for treatment. |
| | CN = 61 | CN=79 |

| Catchment | Pre-development Description | Post-development Description |
|---|---|---|
| 2 | Catchment 2 is a steep gully which drains to an existing wetland (Boffa Miskell, 2021) area which is currently fed by springs within the gullies. | The Catchment 2 gully will be mostly unaffected by the development and continue to feed the existing wetland. The exception to this, is the existing culvert that feeds the wetland underneath the proposed mine access road will be upgraded. |
| | CN = 61 | CN = 62 |
| 3 | Catchment 3 is a generally flat, low lying area where runoff sheet flows across the farmland, partly to the existing wetland and the remainder to the Mataura Stream. | Catchment 3 is developed into the Surface Facilities Area (SFA). This includes office and maintenance buildings, tanks, roading, parking and washdown facilities. Runoff from the SFA will be conveyed to a silt pond and released to the downstream environment at pre-development rates. |
| | CN = 61 | CN = 80 |
| 4 | Catchment 4 has a gully that drains to the Mataura Stream. Toward the lower end of the catchment, the topography flattens across farmland. | Catchment 4 remains relatively unchanged bar construction of a new sealed carpark in the lower portion of the catchment. Where the existing topography flattens out, a formalised open channel will be constructed to direct the overland flow path to the Mataura Stream. |
| | CN=61 | CN = 62 |
| 5 | Catchment 5 is a partial catchment that drains to a different receiving environment to the other catchments. This catchment drains via overland flow to the south of the site. | The lower portion of Catchment 5 will be developed for the proposed magazine storage area. The upper portion of the catchment will be diverted around the hardstand area toward the existing flow path west of the site. |
| | CN=61 | CN = 69 |
| 6 | Catchment 6 is a steep hill face which flows partly toward the wetland and across farmland to the Mataura Stream. | Catchment 6 will be in part developed to form the rock stack contact pond and mine access road. The upper portion of the catchment is a steep hill face for which run off will be captured via a clean water diversion and conveyed to Catchment 2 where practical. The design of this development is being completed by Engineering Geology Limited (EGL). |
| | CN=61 | CN = 74 |
| 7 | Catchment 7 has steep hill faces that drain to a central low point where it is then conveyed to the east. | Catchment 7 will be developed for the topsoil stockpile area. |
| | CN= 61 | CN = 61 |
| 8 | Catchment 8 is a steep hill face which includes an existing gravel road and flows to the southeast river outside of the main site area. | Catchment 8 will have the existing gravel road sealed and some minor associated regrading. The change to the area of the magazine road are considered negligible. The topsoil stockpile area causes a slight change in catchment extents. |
| | CN= 61 | CN = 61 |
| 9 | Catchment 9 includes steep hill faces and an existing gravel road. Stormwater is conveyed to a central overland flow path that flows southeast towards catchment 8. | Catchment 9 will have minor alterations by minor widening of the existing gravel access route an include approximately half of the proposed helipad carpark area. The change in impervious land cover is considered negligible. |
| | CN= 61 | CN = 61 |

| Catchment | Pre-development Description | Post-development Description |
|---|---|---|
| 10 | Catchment 10 includes farmland of steep hill faces. Stormwater in the catchment is conveyed to an overland flow path in the northeast direction. | Catchment 10 will include approximately half of the proposed helipad carpark area. The change in impervious land cover is considered negligible. |
| | CN= 61 | CN = 61 |

The runoff rates for each catchment in for the pre and post development scenarios have been calculated using the SCS method and are shown in Table 2 below. Rainfall for the post-developed scenario adopts the HIRDS v4 RCP8.5 2031-2050 climate change adjusted rainfall depths using Site ID: B75381.

Table 2: Catchment Flows

| | Pre-dev ARI Flow ($m^3/s$) 24-hour | | | Post-dev ARI Flow ($m^3/s$) 24-hour | | |
|---|---|---|---|---|---|---|
| **Storm Event** | **2-yr** | **10-yr** | **100-yr** | **2-yr** | **10-yr** | **100-yr** |
| **Rainfall Depth (mm)** | **152** | **238** | **369** | **162** | **254** | **396** |
| **Catchment 1** | 1.42 | 2.87 | 5.30 | 2.40 | 4.16 | 6.92 |
| **Catchment 2** | 1.01 | 2.05 | 3.78 | 1.17 | 2.30 | 4.21 |
| **Catchment 3** | 0.52 | 1.04 | 1.92 | 0.87 | 1.50 | 2.49 |
| **Catchment 4** | 0.68 | 1.36 | 2.52 | 0.79 | 1.56 | 2.86 |
| **Catchment 5** | 0.33 | 0.66 | 1.22 | 0.44 | 0.82 | 1.44 |
| **Catchment 6** | 0.45 | 0.90 | 1.66 | 0.67 | 1.19 | 2.03 |
| **Catchment 7** | 0.66 | 1.33 | 2.47 | 0.74 | 1.65 | 2.77 |
| **Catchment 8** | 1.72 | 3.47 | 6.42 | 1.70 | 3.78 | 6.35 |
| **Catchment 9** | 9.35 | 18.94 | 35.11 | 10.39 | 20.84 | 38.55 |
| **Catchment 10** | 5.29 | 10.70 | 19.82 | 5.88 | 11.78 | 21.76 |
| **Total** | 21.43 | 43.32 | 80.22 | 25.05 | 49.58 | 89.38 |

# 4 Proposed Development – Surface Water Management

## 4.1 Summary

This section outlines the proposed stormwater management works in line with Waikato Regional Council guidance. Calculations/concept design sizing is provided for main stormwater management features i.e, SFA silt pond sizing and service outlets.

Clean water (from undeveloped sub-catchments) is diverted around developed areas and discharged to the original natural receiving environment. This required channel sizing using the calculated flow hydrology for formalised overland flow path. The channel diversions will be further developed and modelled in the detailed design stage.

## 4.2 Clean Water Management

### 4.2.1 Clean Water Diversions Contour Drains

Upstream of proposed developed areas, diversion drains in the form of earthen bunds and swale channels will be constructed to divert clean runoff away from downstream developed areas. Clean water, which will flow toward developed areas, typically over steep topography, will be slowed prior to reaching the diversion such that erosion is mitigated and velocities within the drains are managed. Diversions are designed to accommodate the 10-year storm flow with 300mm freeboard. The 100-yr flow can also be conveyed by the diversion. However, with reduced freeboard which may result in localised overtopping in isolated locations.

Due to the topography in which diversions will be installed, side wall and longitudinal slopes vary and will not be maintained by conventional mowing if grassed. Where necessary, erosion protection measures will be designed and specified.

Table 3. Clean water diversion drains to be installed at the SFA.

| Drain ID | Area ($m^2$) | Length (m) | Approx. Slope (%) | Side Slope | Design Storm (year) | Curve Number | Width (m) | Bund height/ channel depth |
|---|---|---|---|---|---|---|---|---|
| CW-C3A | 3130 | 86 | 5% | 1in2 | 10 | 65 | 2 | 0.50 |
| CW-C3B | 4425 | 100 | 5% | 1in2 | 10 | 65 | 2.1 | 0.52 |
| CW-C3C | 1890 | 105 | 5% | 1in3 | 10 | 80 | 2.8 | 0.46 |
| CW-C3D | 2080 | 115 | 5% | 1in3 | 10 | 80 | 2.8 | 0.47 |

### 4.2.2 Overland Flow Path Channelisation

An overland flow path will be formalised in Catchment 4, south of the proposed SFA, where currently water flows from a steep gully and across shallow gradient farmland. A channel will be formed across the flatter portion of the catchment with new culverts installed beneath the private vehicle path and Willows Road. The culverts will convey the 100-yr flow with 300mm freeboard. Intervention may be required at the base of the gully to reduce the velocity of water entering the upstream end of the proposed channel. The channel will have a slope of approximately 4-7%, side slopes of 1V:2H, and erosion protection in the form of rock riprap to be installed as required. At the further design stage, the design will include flow velocity control measures to reduce the risk of erosion.

Table 4. Proposed channel drain to be installed in Catchment 4.

| Hydraulics | 10-year | 100-year |
|---|---|---|
| Flow Depth (mm) | 295 | 356 |
| Flow (L/s) | 1940 | 3440 |
| Velocity (m/s) | 2.3 | 3.2 |
| Channel Width with 300mm freeboard | 5.2m | 5.5m |

## 4.3 Swales

Swales are proposed to convey runoff and provide treatment from developed areas. Swales at developed areas such as the SFA and private vehicle car park are designed to provide a treatment residence time of nine minutes or longer (in accordance with WRC TR2020/07), and flow velocity less than 0.8m/s for the water quality event. For storms up to a 10-year event, swale velocities will seek to be less than 1.5m/s to prevent scour where practicable.

The SFA silt pond will provide additional treatment for the runoff from the SFA which is expected to be the area of site with a higher proportion of contaminants (excluding the rock stack). Elements of the SFA which are expected to be higher generators of contaminants, will be assessed to provide additional and specific treatment methods where required i.e. oil-water separators at workshops, wheel wash areas and catchpits.

The approach to swale size calculation adopts a typical profile of a trapezoid with 1V:4H side slopes, 1m wide base, and desirable longitudinal slope of 1.5-3% where practical. Where topography constrains desirable slopes, erosion protection will be installed. The depth of the swale depends of the expected 10-year flow and is noted in the detailed sub-catchment calculations, refer to Appendix C. The swale depth along the eastern border of the SFA depends on the 100-year flow so that conveyance to the silt pond is provided.

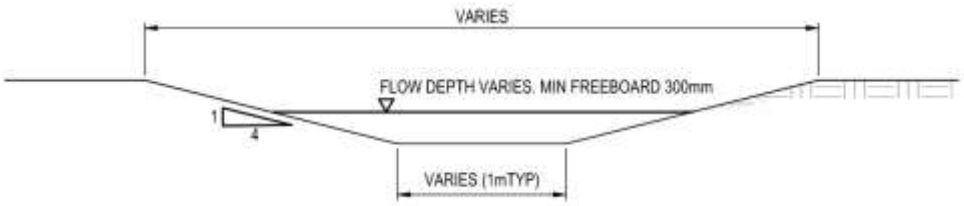


Figure 3: Typical Swale Profile

## 4.4 Culverts

Culverts will be provided where proposed infrastructure conflicts with overland flow paths. The largest value from the Rational or SCS methods was used to size all culverts. Culverts were sized to accommodate the 20-yr storm flow except key culverts. Key culverts (see Table 5) were sized to the 100-year return event in cases where the headwater level would have detrimental effects, such as inundation of the SFA, access roads and adjacent property. Where required, erosion and scour countermeasures will be designed. A typical inlet and outlet detail for culverts is shown in Figure 4. Culverts will either be concrete pipe or box culverts, subject to detailed design. Key culverts are listed in Table 5 and the assessment against ponding and freeboard in Table 6. Culverts relating to the WRS have not been included under this stormwater management plan.

Table 5. Key Culverts at SFA. Excludes culverts to be installed at WRS and Mine access road.

| Culvert ID | Design Storm AEP | Approximate Length (m) | Minimum Size (m) | Justification |
|---|---|---|---|---|
| SW-C2A | 1% | 50 | 1.5 | 100-yr design storm due to potential impact to SFA and overland flow route could lead to additional water in silt pond. |
| SW-C3A | 1% | 27 | 1.2 | Conveyance to silt pond is for 100-yr AEP flows. Alternate overland flow route is north to Mataura Stream. |
| SW-C4A | 1% | 10 | 1.2 | 100-yr design storm due to potential impact to SFA and overland flow route would restrict pedestrian access to car park. |
| SW-C4B | 1% | 15 | 1.5 | 100-yr design storm due to potential impact overland flow route being close to private property. Overland flow route to be reviewed at detailed design. |
| SW-C4C | 1% | 15 | 1.2 | 100-yr design storm due to potential impact to SFA and access road. Overland flow route to be reviewed at detailed design. |

Table 6. Culvert ponding and freeboard assessment.

| Culvert ID | Soffit RL. (m) | HGL at Inlet RL. (m) | Ponding Above Soffit (m) | Surface RL. (m) | Freeboard (m) |
|---|---|---|---|---|---|
| SW-C2A | 161.50 | 162.28 | 0.78 | 163.0 | 0.72 |
| SW-C3A | 151.84 | 152.13 | 0.29 | 152.6 | 0.47 |
| SW-C4A | 158.64 | 159.19 | 0.55 | 159.4 | 0.21 |
| SW-C4B | 151.61 | 151.60 | 0.00 | 152.2 | 0.60 |
| SW-C4C | 156.35 | 156.90 | 0.55 | 157.2 | 0.30 |

The above culverts have been assessed against key items in the RITS General Design Criteria for culverts (Section 4.2.12). This assessment is summarised in Table 7. Culvert assessment against RITS General Design Criteria.

Table 7. Culvert assessment against RITS General Design Criteria.

| Culvert ID | SW-C2A | SW-C3A | SW-C4A | SW-C4B | SW-C4C |
|---|---|---|---|---|---|
| The invert of the culvert pipe shall be below the waterway bed level by a factor of 20% of the culvert diameter. | ✓ | ✓ | ✓ | ✓ | ✓ |
| Culvert diameter shall be selected that design peak flood flow can pass without the culvert embankment being overtopped. This reduces the likelihood of the embankment failing due to scour. | ✓ | ✓ | ✓ | ✓ | ✓ |
| Ponding behind the culvert embankment should not exceed 1.0m above the soffit, unless high water velocities are likely to cause scour around the culvert entrance and exit. | ✓ | ✓ | ✓ | ✓ | ✓ |

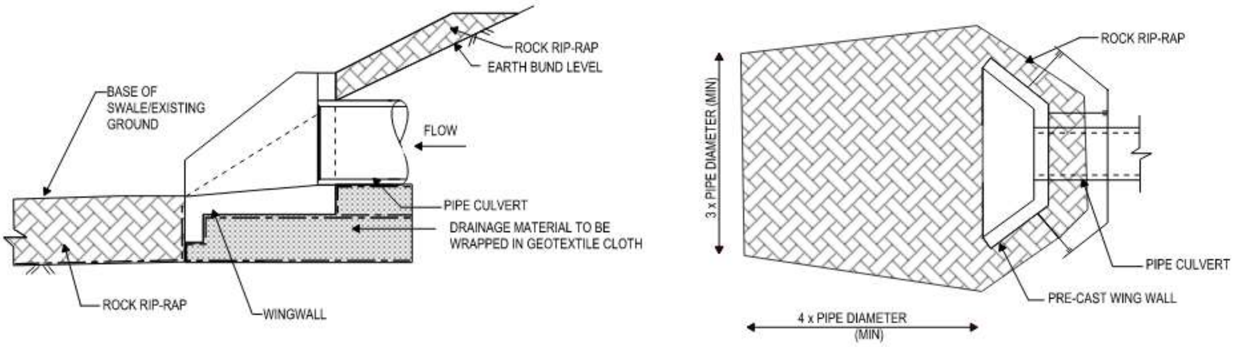


Figure 4: Typical scour protection at inlets and outlets.

## 4.5 Ponds

There are two ponds proposed at the site. One serves as a collection pond for the rock stack contact water, portal platform and mine access road, and the second as a silt pond for the SFA.

A 100-year flood assessment of the Mataura Stream (Figure 18, GHD Water Management Studies, 2025) indicates that some overbank flooding occurs. However, this does not pose a flood risk to the proposed site. WRC Flood Hazard Maps do not indicate any flooding in the downstream vicinity of the site.

### 4.5.1 Rock stack collection pond

Refer to the Water Management Studies Report (GHD, 2025) for further details on the proposed rock stack collection pond.

### 4.5.2 SFA Silt Pond

The proposed management philosophy for the SFA and Willows Road extension is by way of a dry extended detention pond, where runoff will be managed and discharged to the receiving environment at pre-development flow rates for the 2- and 10-year storm events. The pond will be designed to release the extended detention volume over a 24-hour period and the water quality volume will remain in the pond as semi-permanent storage and will drain via soakage.

Water quality treatment will be provided by swales up-stream of the pond as detailed in Section 4.3 with additional treatment provided through extended detention. The pond profile will be optimised at detailed design to achieve the desirable flow path for runoff. Additionally, a baffle plate will be fitted to outlet structure of silt pond to screen floating substances such as hydrocarbons. This detail will be added to the drawing set at detailed design.

The pond will be designed to attenuate the post-developed flow rate for the 10-year, 24-hour storm, with discharge occurring via the primary outlet. Events greater than this storm will discharge via the emergency spillway as outlined in Section 4.5.4. A cross-section of the proposed pond is shown in Figure 5. The SCS method has been used to determine pre- and post-development flow rates for the SFA.

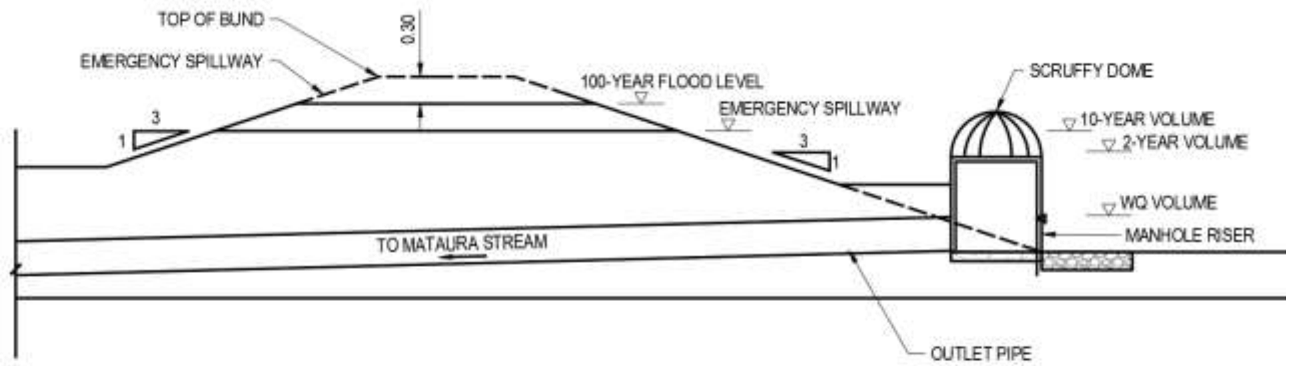


Figure 5: Typical Section of Pond 2 Outlet

#### 4.5.3 SFA Silt Pond Service Spillway

A service outlet (manhole riser with scruffy dome and orifice) will be installed at the SFA silt pond to discharge the extended detention volume, 2-year and 10-year pre-development flows. Events less than a 2-year storm will discharge via an orifice at the extended detention level, while events greater than the 2-year storm will overtop the manhole and flow to the primary outlet pipe.

#### 4.5.4 Emergency Spillways

Emergency spillways will be provided for both ponds with at least 300mm of freeboard (TR2020/07, Section 8.5.6.5).

Due to the location of the ponds and topographical constraints, these spillways are likely to be on fill material. In these cases, armouring will be provided to prevent scouring of the embankment. From the spillway, discharge will follow the overland flow path to the Mataura Stream.

### 4.5.5 Pond geometry

The ponds will be shaped to be the most efficient volume storage within the existing site topography. Due to their location, they will require to be bunded above existing ground level in places. An access ramp will be provided to the forebay to allow for sediment removal.

In accordance with TR2020-07, side slopes for the pond will be 1V:4H to create a maintainable slope and depth will be less than 2.0m with 0.3m freeboard (TR2020/07, Section 8.5.6.5). Attenuation calculations indicate the maximum water depth in the SFA silt pond under a 100-year, 24-hour storm event is approximately 1.4m. The pond volume by elevation is provided in Table 3.

Table 8. SFA Silt Pond - Storage by Elevation

| Structure Storage | |
|---|---|
| Elevation (RL m) | Total Volume ($m^3$) |
| 148 | 0 |
| 148.5 | 775 |
| 149 | 1700 |
| 149.5 | 2775 |
| 150 | 4000 |

# A

## Appendix A – WUG Stormwater Catchments and Design Drawings


BECA DWG No: 3936538-CD-1502.DWG

**FOR INFORMATION**
**NOT FOR CONSTRUCTION**

| No | Revision | Drawn | Checked | Appvd. | Date |
|---|---|---|---|---|---|
| D | FOR INFORMATION: UPDATED DESIGN | RTS | | | |
| C | FOR INFORMATION: UPDATED DESIGN | RTS | JK | EG | 20.12.24 |
| B | FOR INFORMATION: UPDATED PROJECT NAME | RTS | HEK | EG | 26.05.22 |
| A | FOR INFORMATION | BKH | HEK | JvZ | 06.04.22 |

Note: * indicates signatures on original issue of drawing or last revision of drawing

Beca

Engineer: P GLOWREY

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Project **WAIHI NORTH PROJECT**
Title **POST DEVELOPMENT STORMWATER CATCHMENTS**

Original Size **A1**
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Sheet No. 1502
Rev: **D**

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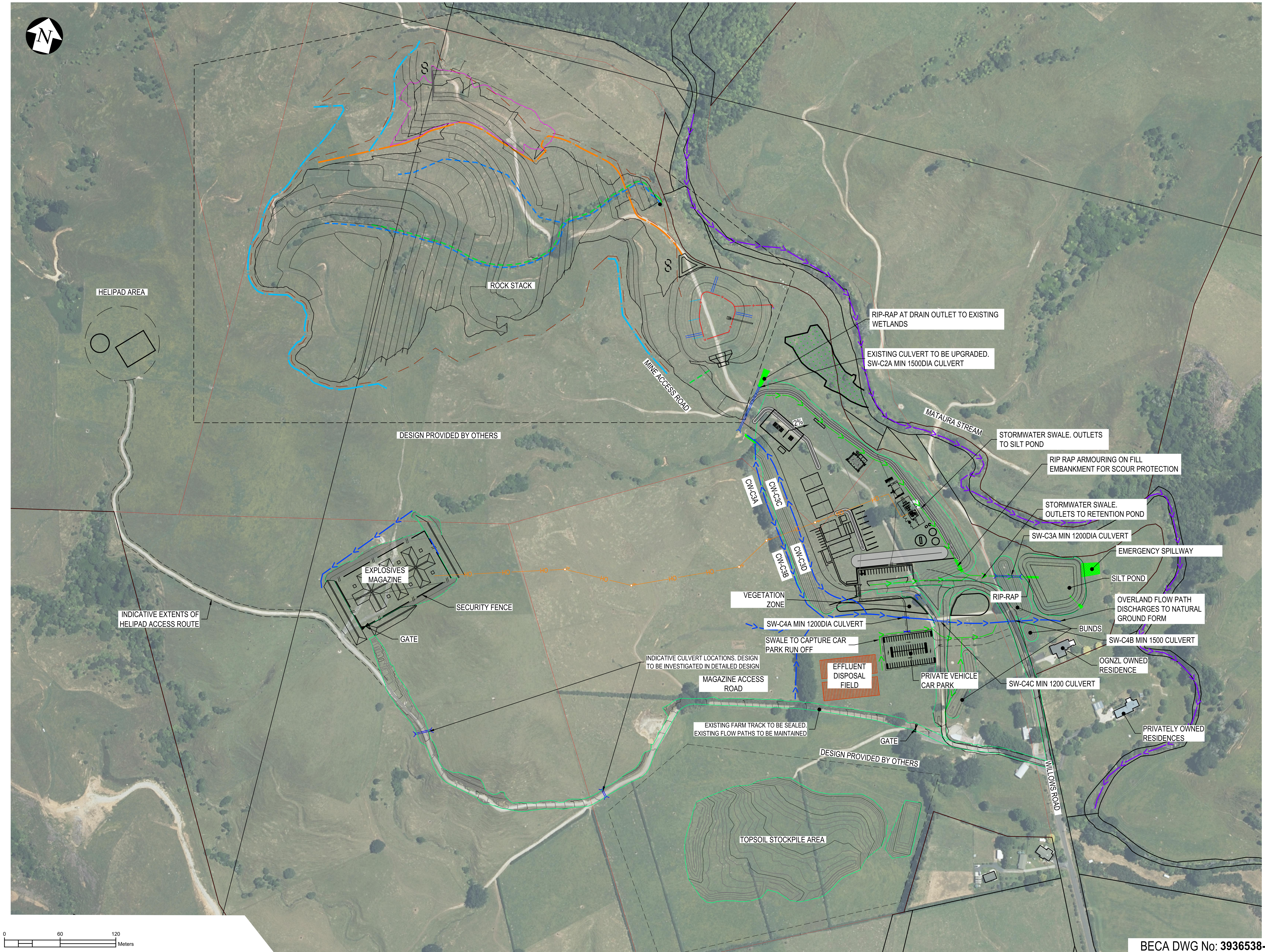
Rev: D

21 February 2025 - 5:34 pm Plotted By: Reuben Seeley Cad File No: \\Beca.net\projects\393\3930483\Stormwater Management Report\1-WIP\CAD\3936538-CD-1503.dwg




## LEGEND:

**EXISTING**

- CONTOUR (2m)
- CONTOUR (10m)
- OGLNZ BOUNDARY
- PROPERTY BOUNDARY
- EXISTING STREAM
- OVERLAND FLOW
- WETLAND
- WETLAND 20m OFFSET CLEARANCE ZONE

**PROPOSED**

- MAJOR CONTOUR (5m)
- MINOR CONTOUR (1m)
- EXTENT OF SURFACE
- OVERLAND FLOW
- HO OVERHEAD POWER
- RIP RAP
- CULVERT
- PSM BOX CUT DESIGN EXTENT

**PROPOSED: EGL DESIGN ONLY**

- CLEAN WATER DIVERSION
- DIRTY WATER DIVERSION
- PERIMETER ACCESS TRACK
- WRS UNDERDRAIN
- CULVERT
- SUBSOIL
- GEOLADDER

## NOTES

1. HORIZONTAL COORDINATE SYSTEM: NZGD2000 MOUNT EDEN CIRCUIT
2. EXISTING SERVICES ARE NOT SHOWN
3. AERIAL PHOTOGRAPH OBTAINED FROM LINZ DATA SERVICE ON 16/12/2024: Waikato 0.3m Rural Aerial Photos (2021-2024)
4. EXTENTS OF BUNDS ARE SHOWN INDICATIVELY. EXTENTS OF THE BUNDS ARE TO BE CONFIRMED IN DETAILED DESIGN
5. IT IS ASSUMED THAT FACILITIES WHICH ARE CONSIDERED TO BE HIGHER PRODUCERS OF POTENTIAL CONTAMINANTS WILL HAVE SPECIFIC INTERVENTION AND TREATMENT METHODS IN PLACE.
6. PROPOSED SERVICE OUTLET AT SFA SILT POND TO RELEASE 2-YR AND 10-YR FLOWS AT PRE-DEVELOPMENT RATES. EMERGENCY SPILLWAY TO CONVEY 100-YR FLOW WITH 300mm FREEBOARD
7. SILT POND EMERGENCY SPILLWAY IS INDICATIVE.
8. CLEAN WATER DIVERSION DRAINS ARE INDICATIVE ONLY AND WILL BE INSTALLED ALONG CONTOUR LINES WHERE PRACTICAL.
9. INLET AND OUTLET PROTECTION TO BE PROVIDED AT CULVERTS WHERE SCOUR RISK IS PRESENT. RIP RAP IS INDICATIVE ONLY, WITH APRON AND BOULDER SIZING TO BE CONFIRMED.
10. FISH PASSAGE THROUGH PROPOSED CULVERTS TO BE CONFIRMED BY OTHERS.

**FOR INFORMATION**
**NOT FOR CONSTRUCTION**

BECA DWG No: **3936538-CD-1505**

| No | Revision | Drawn | Checked | Appvd. | Date |
|---|---|---|---|---|---|
| D | FOR INFORMATION: UPDATED DESIGN | RTS | | | |
| C | FOR INFORMATION: UPDATED DESIGN | RTS | JK | EG | 20.12.24 |
| B | FOR INFORMATION: UPDATED PROJECT NAME | RTS | HEK | EG | 26.05.22 |
| A | FOR INFORMATION | BKH | JvZ | JvZ | 06.04.22 |

Note: * indicates signatures on original issue of drawing or last revision of drawing

Beca

Engineer: P. GLOWREY

PRC No.: 2210835 | Date issued.:
PTR No.: | Date issued.:
TIN No.: | Issued at.:

OCEANAGOLD
WAIHI OPERATION



Drafted BKH | Designer HEK
Drafting Check | Design Check
Approved -
Date
Scale 1:2000 @ A1

This Drawing must not be used for Construction unless signed as Approved

Project **WAIHI NORTH PROJECT**

Title **INFRASTRUCTURE GENERAL ARRANGEMENT SFA AREA**

Original Size A1

Drawing No: **WAI-981-000-DWG-CI-1505**

Sheet No. 1505

Rev: D

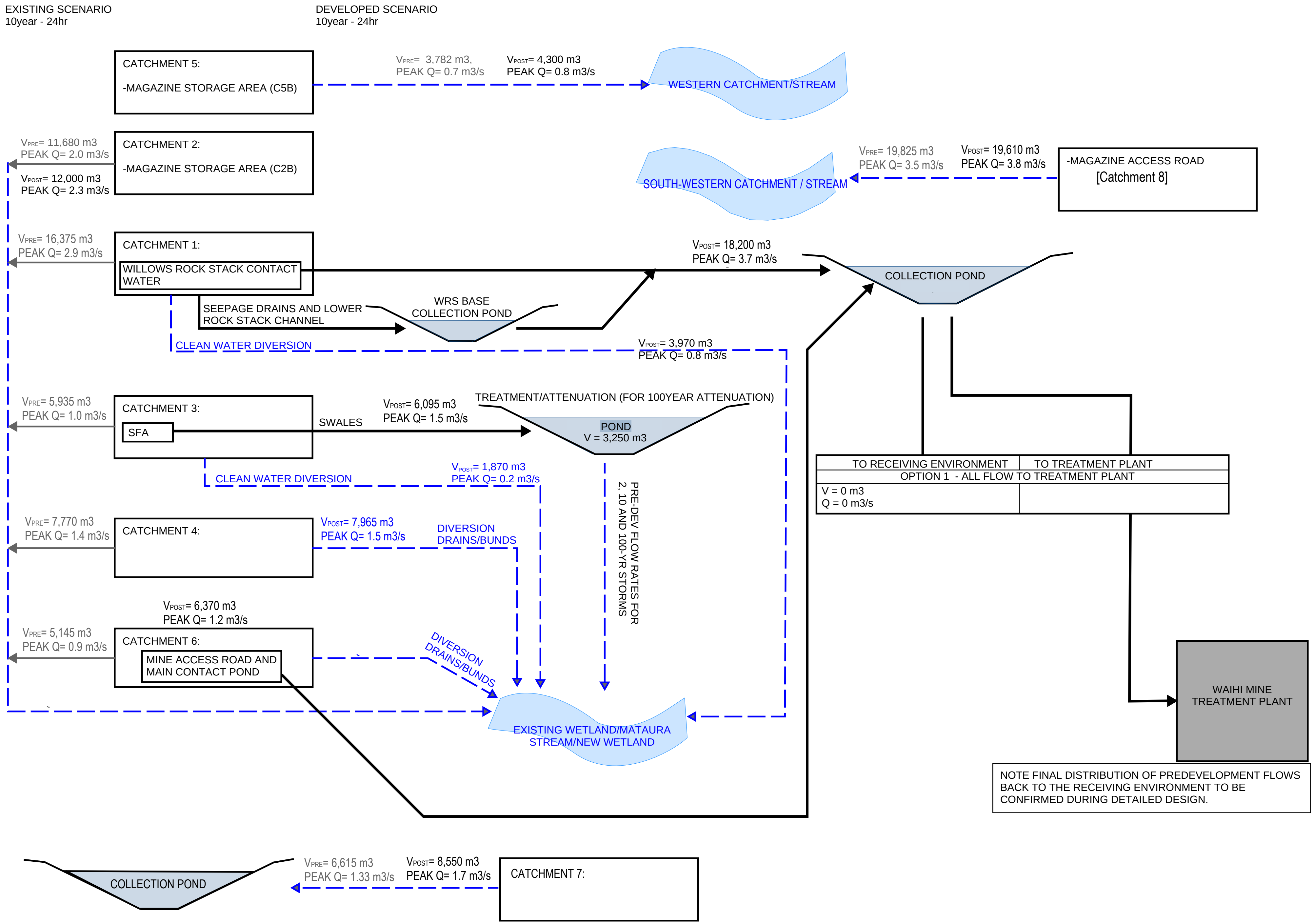
21 February 2025 - 6:01 pm   Plotted By: Reuben Seeley   Cad File No: \\Beca.net\projects\393\3930483\Stormwater Management Report\1-WIP\CAD\3936538-CD-1505.dwg

# B

## Appendix B – Schematic of Stormwater Philosophy

# WUG SURFACE FACILITIES AREA: STORMWATER MANAGEMENT SCHEMATIC

NOTES:
1. STORMWATER MANAGEMENT FLOWS AND VOLUMES IN CATCHMENTS 1, 6, AND 7 TO BE DESIGNED BY OTHERS
2. CATCHMENTS 9 AND 10 HAVE NOT BEEN INCLUDED



# C

## Appendix C – Calculation Spreadsheets

| Job Name | Job Number | Date |
|---|---|---|
| | | |

| Calculation Sheet Description | Designer |
|---|---|
| Hydraulic Analysis of Circular Pipe (with base) Culvert | |

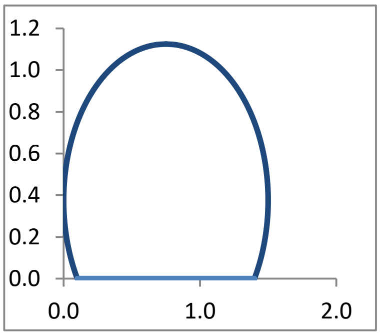


## Calculation

**Project Description**

### Inputs

| | |
|---|---|
| Roughness - $k_s$ (mm) | 0.6 |
| Diameter - D (m) | 1.5 |
| Embedment -d(m) | 0.375 |
| Emb. Roughness ('n') | 0.03 |
| Flow - Q ($m^3/s$) | 5.3 |
| Length - L(m) | 50 |
| Culvert Slope (%) | 2 |
| $K_{entry}$ | 0.2 |
| $C_{entry}$ | 0.8 |
| Downstream IL (m) | 159 |
| Tailwater Level (m) | 0 |
| TWL (mRL) | 159 |




### Results

| | |
|---|---|
| Equivalent Mannings 'n' | 0.0183 |
| Flow Full area ( $m^2$) | 1.42 |
| Flow Full Friction Slope (%) | 2.12 |
| Critical depth (m) | 0.992 |
| Critical velocity (m/s) | 3.94 |
| Normal depth (ND-m) | N/A |
| ND velocity (m/s) | N/A |

**Actual Tailwater Level**

| | |
|---|---|
| TWL depth (m) | 0.992 |
| Outlet velocity (m/s) | 3.94 |

### Assumptions:

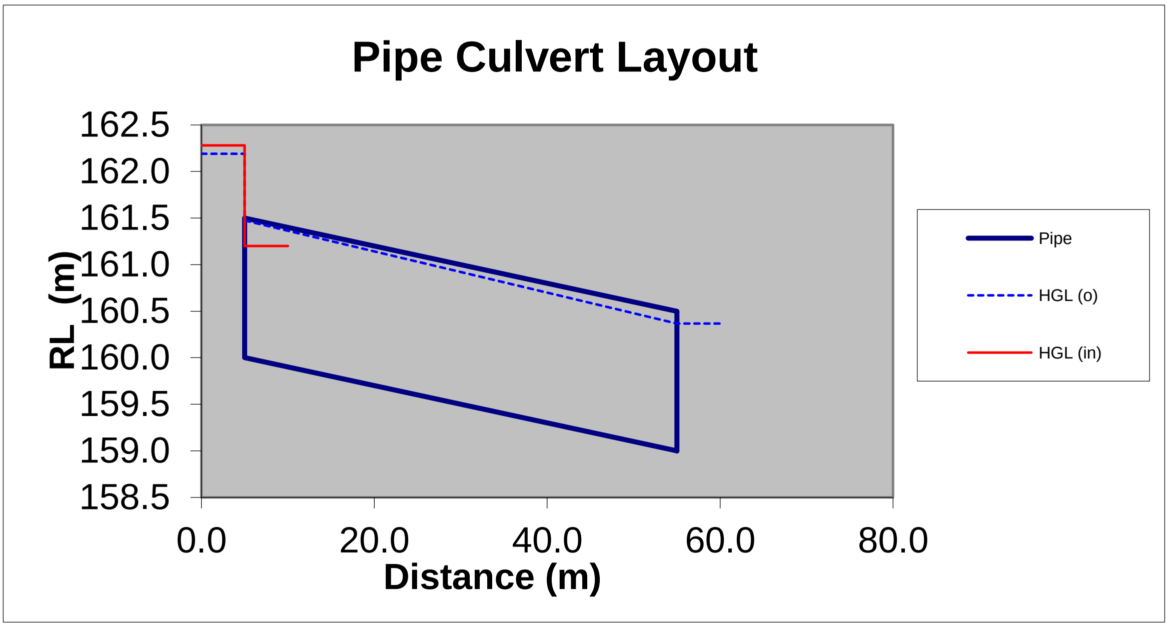
1. Inputs are in yellow, results in red
2. No significant upstream velocity (ie. HWL=Energy Level)
3. For general $K_{entry}$ and $C_{entry}$, choose from Table.
4. $K_{outlet}$ is assumed as 1.0

**Headwater Level:**

| | |
|---|---|
| HWL (outlet control) | 161.816 |
| HWL (inlet control) | 161.906 |
| HWL (m) | 161.906 |
| HW depth (m) | 1.906 |
| HW/(D-d) | 1.69 |
| Inlet Velocity (m/s) | 3.73 |

Inlet Conditions Predominate
*
*

| Entry Type | $K_{entry}$ | $C_{entry}$ |
|---|---|---|
| Square ended | 0.50 | 0.61 |
| Socketed end | 0.20 | 0.70 |
| Rounded (r>0.1*D) | 0.15 | 0.80 |
| Bellmouth/Parabola | 0.1 | 0.95 |



| Job Name | Job Number | Date |
|---|---|---|
| | | |

| Calculation Sheet Description | Designer |
|---|---|
| Hydraulic Analysis of Circular Pipe (with base) Culvert | |

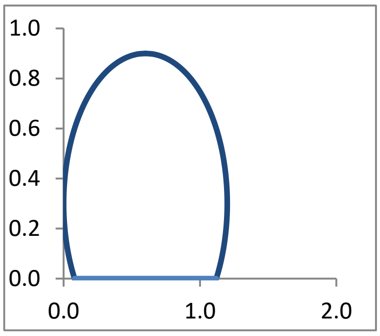


## Calculation

**Project Description** Culvert design culvert ouletting to pond for SFA runoff (100yr design)

### Inputs

| | |
|---|---|
| Roughness - $k_s$ (mm) | 0.6 |
| Diameter - D (m) | 1.2 |
| Embedment -d(m) | 0.3 |
| Emb. Roughness ('n') | 0.03 |
| Flow - Q ($m^3$/s) | 2.4 |
| Length - L(m) | 27 |
| Culvert Slope (%) | 0.5 |
| $K_{entry}$ | 0.2 |
| $C_{entry}$ | 0.8 |
| Downstream IL (m) | 150.5 |
| Tailwater Level (m) | 0 |
| TWL (mRL) | 150.5 |




### Results

| | |
|---|---|
| Equivalent Mannings 'n' | 0.0182 |
| Flow Full area ( $m^2$) | 0.91 |
| Flow Full Friction Slope (%) | 1.42 |
| Critical depth (m) | 0.715 |
| Critical velocity (m/s) | 3.00 |
| Normal depth (ND-m) | N/A |
| ND velocity (m/s) | N/A |

**Actual Tailwater Level**

| | |
|---|---|
| TWL depth (m) | 0.715 |
| Outlet velocity (m/s) | 3.00 |

### Assumptions:

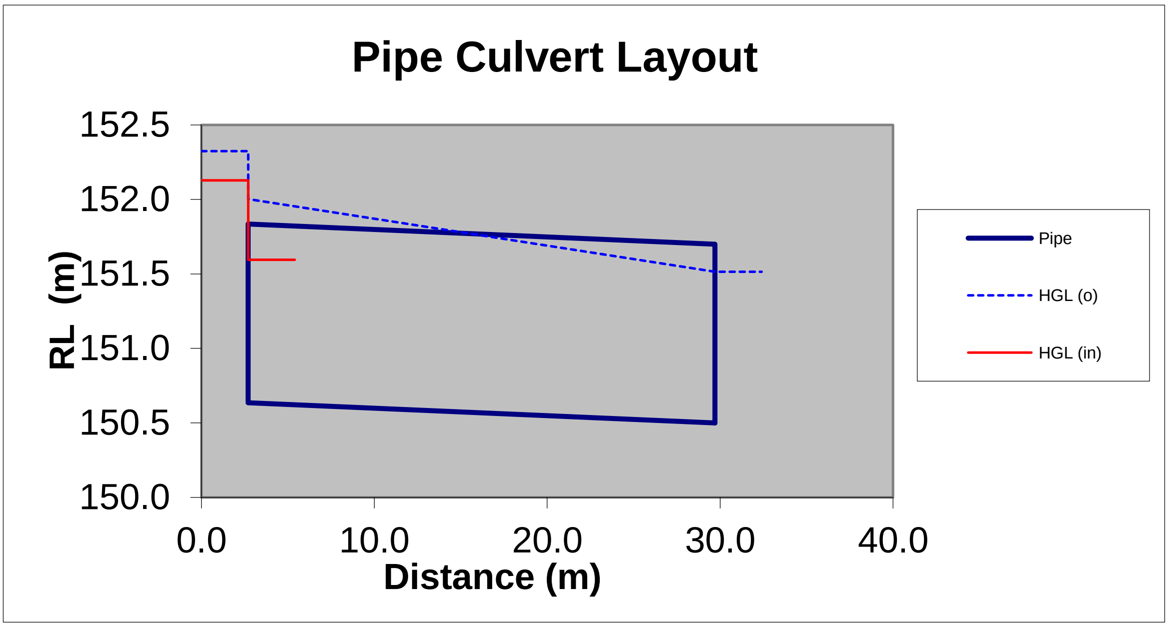
1. Inputs are in yellow, results in red
2. No significant upstream velocity (ie. HWL=Energy Level)
3. For general $K_{entry}$ and $C_{entry}$, choose from Table.
4. $K_{outlet}$ is assumed as 1.0

### Headwater Level:

| | |
|---|---|
| HWL (outlet control) | 152.024 |
| HWL (inlet control) | 151.828 |
| HWL (m) | 152.024 |
| HW depth (m) | 1.389 |
| HW/(D-d) | 1.54 |
| Inlet Velocity (m/s) | 2.64 |

Outlet Conditions Predominate
*
*

| Entry Type | $K_{entry}$ | $C_{entry}$ |
|---|---|---|
| Square ended | 0.50 | 0.61 |
| Socketed end | 0.20 | 0.70 |
| Rounded (r>0.1*D) | 0.15 | 0.80 |
| Bellmouth/Parabola | 0.1 | 0.95 |



| Job Name | Job Number | Date |
|---|---|---|
| | | |
| Calculation Sheet Description | | Designer |
| Hydraulic Analysis of Circular Pipe (with base) Culvert | | |

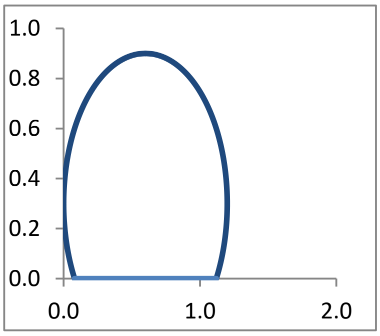


## Calculation

**Project Description**

### Inputs

| | |
|---|---|
| Roughness - $k_s$ (mm) | 0.6 |
| Diameter - D (m) | 1.2 |
| Embedment -d(m) | 0.3 |
| Emb. Roughness ('n') | 0.03 |
| Flow - Q ($m^3/s$) | 2.9 |
| Length - L(m) | 15 |
| Culvert Slope (%) | 1 |
| $K_{entry}$ | 0.2 |
| $C_{entry}$ | 0.8 |
| Downstream IL (m) | 157.29 |
| Tailwater Level (m) | 0 |
| TWL (mRL) | 157.29 |




### Results

| | |
|---|---|
| Equivalent Mannings 'n' | 0.0182 |
| Flow Full area ( $m^2$) | 0.91 |
| Flow Full Friction Slope (%) | 2.07 |
| Critical depth (m) | 0.779 |
| Critical velocity (m/s) | 3.40 |
| Normal depth (ND-m) | N/A |
| ND velocity (m/s) | N/A |

**Actual Tailwater Level**

| | |
|---|---|
| TWL depth (m) | 0.779 |
| Outlet velocity (m/s) | 3.40 |

**Headwater Level:**

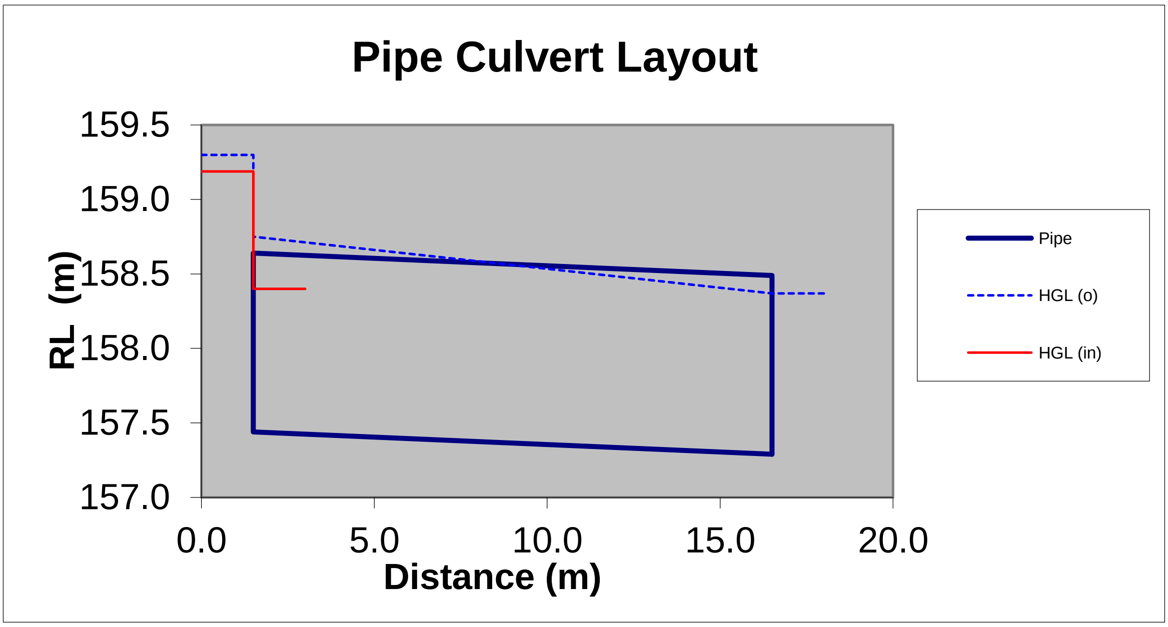
| | |
|---|---|
| HWL (outlet control) | 158.999 |
| HWL (inlet control) | 158.888 |
| HWL (m) | 158.999 |
| HW depth (m) | 1.559 |
| HW/(D-d) | 1.73 |
| Inlet Velocity (m/s) | 3.19 |

Outlet Conditions Predominate
*
*

### Assumptions:

1. Inputs are in yellow, results in red
2. No significant upstream velocity (ie. HWL=Energy Level)
3. For general $K_{entry}$ and $C_{entry}$, choose from Table.
4. $K_{outlet}$ is assumed as 1.0

| Entry Type | $K_{entry}$ | $C_{entry}$ |
|---|---|---|
| Square ended | 0.50 | 0.61 |
| Socketed end | 0.20 | 0.70 |
| Rounded (r>0.1*D) | 0.15 | 0.80 |
| Bellmouth/Parabola | 0.1 | 0.95 |



Beca

| Job Name | Job Number | Date |
|---|---|---|
| | | |

| Calculation Sheet Description | Designer |
|---|---|
| Hydraulic Analysis of Circular Pipe (with base) Culvert | |

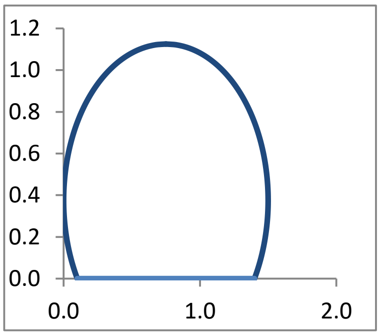


## Calculation

**Project Description**

### Inputs

| | |
|---|---|
| Roughness - $k_s$ (mm) | 0.6 |
| Diameter - D (m) | 1.5 |
| Embedment -d(m) | 0.375 |
| Emb. Roughness ('n') | 0.03 |
| Flow - Q ($m^3/s$) | 2.9 |
| Length - L(m) | 15 |
| Culvert Slope (%) | 1 |
| $K_{entry}$ | 0.2 |
| $C_{entry}$ | 0.8 |
| Downstream IL (m) | 149.96 |
| Tailwater Level (m) | 0 |
| TWL (mRL) | 149.96 |




### Results

| | |
|---|---|
| Equivalent Mannings 'n' | 0.0183 |
| Flow Full area ( $m^2$) | 1.42 |
| Flow Full Friction Slope (%) | 0.64 |
| Critical depth (m) | 0.724 |
| Critical velocity (m/s) | 2.78 |
| Normal depth (ND-m) | 0.808 |
| ND velocity (m/s) | 2.518 |

**Actual Tailwater Level**

| | |
|---|---|
| TWL depth (m) | 0.724 |
| Outlet velocity (m/s) | 2.78 |

**Headwater Level:**

| | |
|---|---|
| HWL (outlet control) | 151.242 |
| HWL (inlet control) | 151.229 |
| HWL (m) | 151.242 |
| HW depth (m) | 1.132 |
| HW/(D-d) | 1.01 |
| Inlet Velocity (m/s) | 2.04 |

Outlet Conditions Predominate

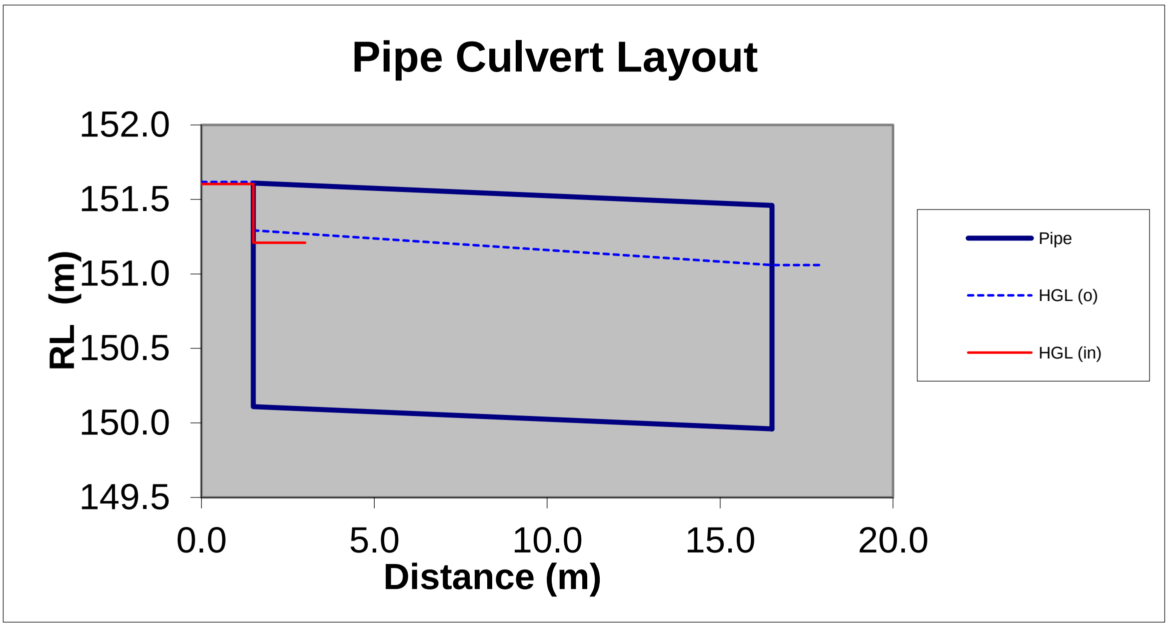
*

*

### Assumptions:

1. Inputs are in yellow, results in red
2. No significant upstream velocity (ie. HWL=Energy Level)
3. For general $K_{entry}$ and $C_{entry}$, choose from Table.
4. $K_{outlet}$ is assumed as 1.0

| Entry Type | $K_{entry}$ | $C_{entry}$ |
|---|---|---|
| Square ended | 0.50 | 0.61 |
| Socketed end | 0.20 | 0.70 |
| Rounded (r>0.1*D) | 0.15 | 0.80 |
| Bellmouth/Parabola | 0.1 | 0.95 |



| Job Name | Job Number | Date |
|---|---|---|
| | | |

| Calculation Sheet Description | Designer |
|---|---|
| Hydraulic Analysis of Circular Pipe (with base) Culvert | |

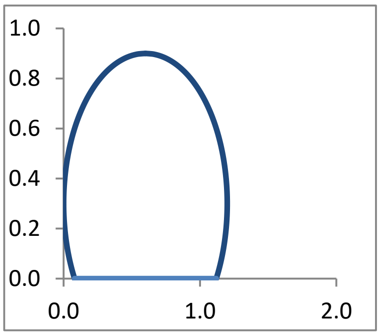


## Calculation

**Project Description**

### Inputs

| | |
|---|---|
| Roughness - $k_s$ (mm) | 0.6 |
| Diameter - D (m) | 1.2 |
| Embedment -d(m) | 0.3 |
| Emb. Roughness ('n') | 0.03 |
| Flow - Q ($m^3/s$) | 2.9 |
| Length - L(m) | 15 |
| Culvert Slope (%) | 1 |
| $K_{entry}$ | 0.2 |
| $C_{entry}$ | 0.8 |
| Downstream IL (m) | 155 |
| Tailwater Level (m) | 0 |
| TWL (mRL) | 155 |




### Results

| | |
|---|---|
| Equivalent Mannings 'n' | 0.0182 |
| Flow Full area ( $m^2$) | 0.91 |
| Flow Full Friction Slope (%) | 2.07 |
| Critical depth (m) | 0.779 |
| Critical velocity (m/s) | 3.40 |
| Normal depth (ND-m) | N/A |
| ND velocity (m/s) | N/A |

**Actual Tailwater Level**

| | |
|---|---|
| TWL depth (m) | 0.779 |
| Outlet velocity (m/s) | 3.40 |

**Headwater Level:**

| | |
|---|---|
| HWL (outlet control) | 156.709 |
| HWL (inlet control) | 156.598 |
| HWL (m) | 156.709 |
| HW depth (m) | 1.559 |
| HW/(D-d) | 1.73 |
| Inlet Velocity (m/s) | 3.19 |

Outlet Conditions Predominate

*

*

### Assumptions:

1. Inputs are in yellow, results in red
2. No significant upstream velocity (ie. HWL=Energy Level)
3. For general $K_{entry}$ and $C_{entry}$, choose from Table.
4. $K_{outlet}$ is assumed as 1.0

| Entry Type | $K_{entry}$ | $C_{entry}$ |
|---|---|---|
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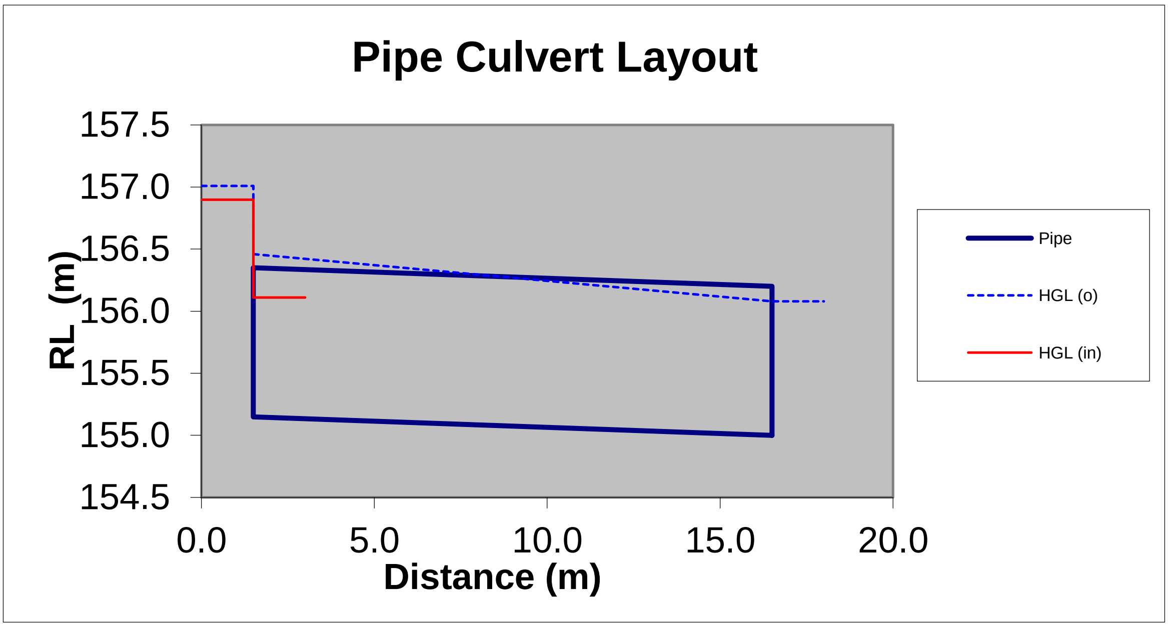
| Socketed end | 0.20 | 0.70 |
| Rounded (r>0.1*D) | 0.15 | 0.80 |
| Bellmouth/Parabola | 0.1 | 0.95 |



**Beca Ltd**

JOB NO: 2210983

## Hydrographs- SCS Method:

| | |
|---|---|
| **Project** | WNP |
| **Designer** | Hamish Kerr |
| **Structure** | SFA Detention Pond |

**Attenuation Criteria**

WQ, ED, 2, 10 & 100yr (100%)

| 24hr rainfall depths | | | | | | |
|---|---|---|---|---|---|---|
| Case | 50% AEP | 10% AEP | 1% AEP | WQV | EDV | |
| Pre-dev | 152 | 238 | 369 | | | *HCC-ITS Present Day rainfall |
| Post-dev | 162 | 254 | 396 | 30 | 36 | *HCC-ITS Climate change adjusted rainfall |

| Catchment area | | | |
|---|---|---|---|
| Case | Total Area (ha) | Impervious % | Weighted CN |
| Pre-dev | 3 | 0% | 61 |
| Post-dev | 3 | 100% | 85 |

| CN | |
|---|---|
| Pervious | 61 |
| Impervious | 85 |

| Time of Concentration (Based on Post-dev) | | | |
|---|---|---|---|
| Case | Length (km) | Slope (m/m) | tc (Mockus, 1961) |
| Pervious | 0.4 | 0.1 | 10.6 |
| Impervious | 0.4 | 0.02 | 12.9 |

Use for waikato

**TR20-06 - Time of Concentration**

| | | |
|---|---|---|
| Length of catchment, L (m) | | 400 |
| Rise from bottom to top of catchment (m) | | 3 |
| | | Vel. (m/s) |
| Tc (min) | 12.933683 | 0.51545 |

148.803

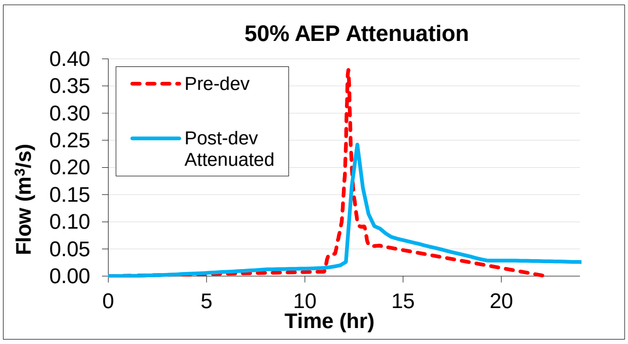
| EDV and WQV | | | |
|---|---|---|---|
| | AWQ | Volume | |
| WQV | 2.85 | 427.5 | * 1/2 x WQV required |
| EDV | | 1026.0 | |

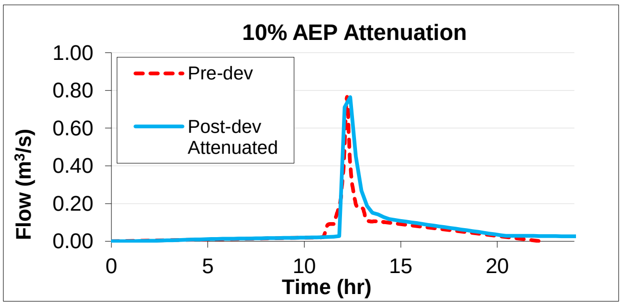
| Structure outlet | | | |
|---|---|---|---|
| Outlet | Orifice/weir | Invert (m RL) | Dia/width (m) |
| 1 | Orifice | 148.3 | 0.12 |
| 2 | Weir | 149.1 | 0.71 |
| 3 | Weir | 149.25 | 3.30 |

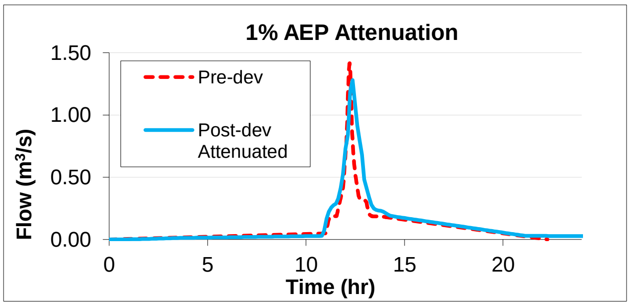
| | Output | | | | |
|---|---|---|---|---|---|
| | Pre-dev flow | Post-dev flow | Stored Volume | Level (m RL) | Target |
| WQV | | | 427.5 | 148.283 | ✓ |
| EDV | | 0.024 | 1026.0 | 148.804 | 24.1 hrs |
| 50% AEP | 0.380 | 0.242 | 1638.0 | 149.113 | 64% |
| 10% AEP | 0.766 | 0.764 | 1825.5 | 149.203 | 100% |
| 1% AEP | 1.416 | 1.280 | 2278.7 | 149.410 | 90% |

1.416

| Structure Storage | | |
|---|---|---|
| Elevation | Total V | Stor V |
| 148 | 0 | 0 |
| 148.1 | 143 | 0 |
| 148.2 | 292 | 0 |
| 148.3 | 447 | 155 |
| 148.4 | 608 | 316 |
| 148.5 | 775 | 483 |
| 148.6 | 948 | 656 |
| 148.7 | 1127 | 835 |
| 148.8 | 1312 | 1020 |
| 148.9 | 1503 | 1211 |
| 149 | 1700 | 1408 |
| 149.1 | 1903 | 1611 |
| 149.2 | 2112 | 1820 |
| 149.3 | 2327 | 2035 |
| 149.4 | 2548 | 2256 |
| 149.5 | 2775 | 2483 |
| 149.6 | 3008 | 2716 |
| 149.7 | 3247 | 2955 |
| 149.8 | 3492 | 3200 |
| 149.9 | 3743 | 3451 |
| 150 | 4000 | 3708 |
| 150.1 | 4263 | 3971 |
| 150.2 | 4532 | 4240 |
| 150.3 | 4807 | 4515 |
| 0 | 0 | 0 |
| 0 | 0 | 0 |
| 0 | 0 | 0 |
| 0 | 0 | 0 |



**Beca Infrastructure Ltd**

Job Number

Printed 20/12/2024

Designer

# Sizing of Grass Swale (ARC TP10)

**Project Description** WUG - SFA catchment 4 channel formalisation to Mataura Stream

**INPUTS (in bold)**

| | Impervious | Pervious | |
|---|---|---|---|
| Length (m) | **0** | | |
| Width (m) | **0** | | |
| Additional Catchment ($m^2$) | **48130** | **7125** | Total Area ($m^2$) |
| Catchment Area (A $m^2$) | 48130 | 7125 | 55255 |
| CN (100 is 100% runoff) | **65** | **78** | |
| Pervious Area Initial Abstraction (Ia- mm) | **6.84** | **3.58** | |
| Design Rainfall ($P_{2,24}$- mm) | **162** | | |
| Design Rainfall ($P_{10,24}$- mm) | **254** | | |
| Design Rainfall ($P_{100,24}$- mm) | **396** | | |
| Additional $Q_{100}$ Overflow (L/s) | **0** | | |
| Treatment Factor | **1** | | |

| % Sediment Removal | Treatment Factor |
|---|---|
| 85 | 2 |
| 80 | 1.33 |
| 75 | 1 |
| 70 | 0.68 |
| 60 | 0.4 |
| 50 | 0.22 |
| 40 | 0.11 |
| 30 | 0.05 |

**Swale Dimensions**

| | |
|---|---|
| Swale width (B - m) | **2** |
| Side slope (1:x) | **2** |
| Swale Length (m) | **120** |
| Swale slope (%) | **4** |
| Planting depth (50 or 150mm) | **150** |

**ARC Criteria**

| | | |
|---|---|---|
| $i_{10min}/i_{24hr}$ | 16.2 | |
| Swale attentuation factor | 1 | |
| Min. residence time (min) | 9 | Doesn't comply * |
| Max. grade (%) | 5 | Complies |
| Min. grade (%) | 1 | Complies |
| Max. velocity for SWQ storm (m/s) | 0.8 | Complies |
| Max. velocity for $Q_{10}$ storm (m/s) | 1.5 | Doesn't comply |
| Max. water depth above vegetation | 100 | Doesn't comply |
| Max. bottom width (m) | 2 | Complies |
| Max. catchment area (ha) | 4 | Doesn't comply |
| Max. side slope (1:x) | 4 | Doesn't comply |
| Min. swale length (m) | 30 | Complies ** |

**Note:**

1. Last section of direct runoff to swale should be intercepted and discharged away from the outlet.
2. Flow should be based on catchment to outlet. If this is too onerous consider average flow along swale.
3. If swales steeper than 5% check dams will need to be provided.
4. For swales shallower than 2% subsoils are required.
5. For swales with side slopes steeper than 1:4 to be planted.

**Hydrology**

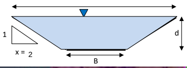
| | |
|---|---|
| SWQ Runoff Depth Impervious (R-mm) | 12.09 |
| SWQ Runoff Depth Pervious (R-mm) | 20.83 |
| SWQ Volume (RA-$m^3$) | 730.40 |
| SWQ flow rate (L/s) | 148.34 |
| $Q_{10}$ flow rate (L/s) | 1936.22 |
| $Q_{100}$ flow rate (L/s) | 3442.71 |

Q100 Velocity Exceeds 2.0m/s

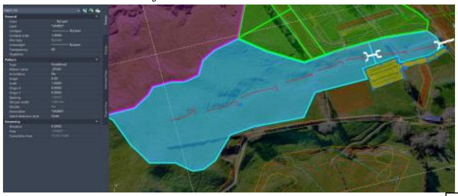
| Hydraulics for: | SWQ | $Q_{10}$ | $Q_{100}$ |
|---|---|---|---|
| Depth (mm) | 126.5 | 303.2 | 367.3 |
| Mannings (n) | 0.089 | 0.031 | 0.025 |
| Swale wetted area ($m^2$) | 0.285 | 0.790 | 1.004 |
| Swale hydraulic radius (mm) | 111.1 | 235.5 | 275.7 |
| Flow (L/s) | 148.34 | 1936.22 | 3442.71 |
| Velocity (m/s) | 0.520 | 2.45 | 3.43 |
| Residence Time (min) | 3.84 | | |
| Flow length for 9 mins residence (m) | 281 | | |

W10 =

W100 = 5.47




| | |
|---|---|
| d-WO = | 126.5 |
| d-10 = | 303.2 |
| d-100 = | 367.3 |
| freeboard | 0.5 |



**SWALE PERFORMANCE**

| Catchment Area ($m^2$) | Swale length (m) Removal | | Swale Depth (d-mm) |
|---|---|---|---|
| | 75% | 80% | |
| 1000 | 30 | 39 | 0.135 |
| 2000 | 44 | 57 | 0.165 |
| 4000 | 64 | 83 | 0.205 |
| 5000 | 73 | 95 | 0.22 |
| 7500 | 91 | 118 | 0.245 |
| 10000 | 106 | 138 | 0.27 |

Swale slope 1% (min allowed)
Swale base width = 0.5m (B)
Swale side slope 1:3 (x)
Min. swale length = 30m
Assumed planting depth = 150mm
Swale will require subsoil drain
Swale $length_{80\%} \approx 1.3*$Swale $length_{75\%}$
Swale depth based on 10 year storm.

| $Q_{SWQ}$ | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (mm) | 293.73 | 293.83 | 203.53 | 203.63 | 151.59 | 151.69 | 130.35 | 130.45 | 126.64 | 126.74 | 126.53 | 126.63 | 126.53 |
| Mannings (n) | 0.03 | 0.03 | 0.05 | 0.05 | 0.07 | 0.07 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 |
| Swale wetted area ($m^2$) | 0.76 | 0.76 | 0.49 | 0.49 | 0.35 | 0.35 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 |
| Swale hydraulic radius (mm) | 229.37 | 229.43 | 168.34 | 168.41 | 130.38 | 130.45 | 114.09 | 114.16 | 111.19 | 111.27 | 111.11 | 111.19 | 111.11 |
| Flow (L/s) | 1613.53 | 1615.32 | 446.57 | 447.43 | 102.73 | 103.21 | 13.38 | 13.74 | 0.37 | 0.71 | 0.00 | 0.34 | 0.00 |

| $Q_{10}$ | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (mm) | 647.05 | 647.15 | 460.68 | 460.78 | 352.54 | 352.64 | 309.93 | 310.03 | 303.33 | 303.43 | 303.17 | 303.27 | 303.17 |
| Mannings (n) | 0.01 | 0.01 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| Swale wetted area ($m^2$) | 2.13 | 2.13 | 1.35 | 1.35 | 0.95 | 0.95 | 0.81 | 0.81 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 |
| Swale hydraulic radius (mm) | 435.55 | 435.60 | 331.46 | 331.52 | 266.64 | 266.70 | 239.80 | 239.86 | 235.56 | 235.63 | 235.46 | 235.53 | 235.46 |
| Flow (L/s) | ###### | 17623.85 | 4907.86 | 4912.40 | 1106.54 | 1109.13 | 131.69 | 133.69 | 2.87 | 4.78 | 0.00 | 1.91 | 0.00 |

| $Q_{100}$ | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (mm) | 799.39 | 799.49 | 570.76 | 570.86 | 434.52 | 434.62 | 377.59 | 377.69 | 367.60 | 367.70 | 367.31 | 367.41 | 367.31 |
| Mannings (n) | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| Swale wetted area ($m^2$) | 2.88 | 2.88 | 1.79 | 1.79 | 1.25 | 1.25 | 1.04 | 1.04 | 1.01 | 1.01 | 1.00 | 1.00 | 1.00 |
| Swale hydraulic radius (mm) | 516.02 | 516.08 | 393.86 | 393.91 | 316.15 | 316.21 | 282.03 | 282.10 | 275.92 | 275.98 | 275.74 | 275.81 | 275.74 |
| Flow (L/s) | ###### | 34652.56 | 9786.96 | 9794.14 | 2284.29 | 2288.30 | 298.95 | 301.95 | 8.20 | 11.03 | 0.01 | 2.83 | 0.00 |

Note: * Slope of 1:200 complies with NZTA guideline
** Design is based on average flow length as it is not feasible direct all the flow to the top end of swale.