WAIMAKARIRI DISTRICT COUNCIL

MEMO

FILE NO AND TRIM NO:	DRA–20–23 / CON 20/39 / 210811132276
DATE:	12 August 2021
MEMO TO:	Kalley Simpson, 3 Waters Manager
FROM:	Claudia Button, Graduate Engineer
SUBJECT:	Ohoka Mill Road SMA – Detailed Design Report

1. Scope

The Ohoka Mill Road stormwater management area (SMA) at 382 Mill Road is designed to service part of the ODP160 area to the south east of the existing Ohoka village. A conceptual report was produced by Courtenay Environmental Consultants (CEC) in 2019 which provided information about first flush and detention volumes required, pond locations and top water elevations (TRIM 191101152373). This information was used to form a preliminary design (TRIM 210331053424). Following outcomes from this, a detailed design was completed.

2. Background

It was decided by the Council to construct a SMA for the ODP160 area, to provide one large treatment area instead of multiple smaller areas for each land developer. Land was purchased from one of the land owners within the ODP160 area at 382 Mill Road in 2020/21 and subsequently a right of way was constructed through the land for access to the back properties.

The basins have been sized to detain the difference between a pre and post development 50 year 24 hour storm. The required storage volumes are 1,150 m^3 for first flush and 1,050 m^3 for detention. Volumes and concept designs were derived by others using the runoff model on HEC-HMS which used the curve number method. The soils were classed as type D (poorly draining) and a runoff value CN of 80 was used, along with a percentage of imperviousness (TRIM 191101152373). The detention basin is to be dry and predominantly grassed, and the first flush basin is to be a planted wetland.

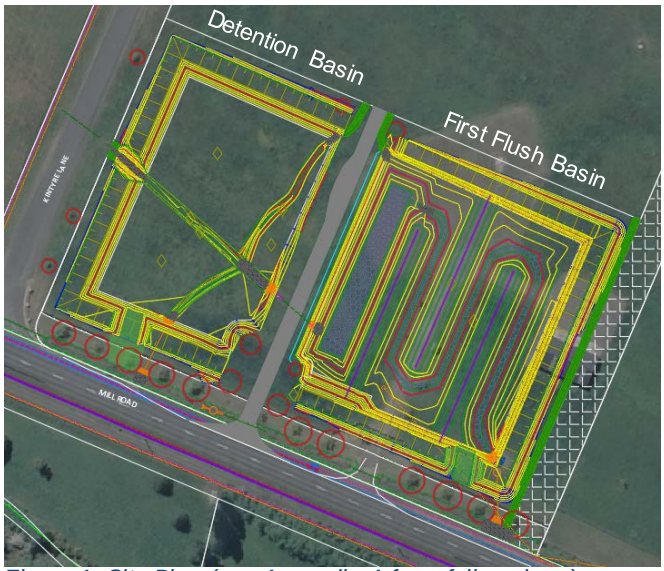


Figure 1. Site Plan (see Appendix A for a full mark up)

3. Detailed Design Considerations

Typical characteristics of the basins include:

- 0.60 m freeboard above top water level around the three outer bunds – primarily to reduce cut to waste earthwork volumes.
- 0.30 m freeboard along bunds adjacent to the ROW, which has a crest height of RL 13.77 m, see TRIM 210216025248.
- The primary access route to maintenance is around the top of the bund of the basin, since the outer toe will form a swale to direct run-off into the basins.

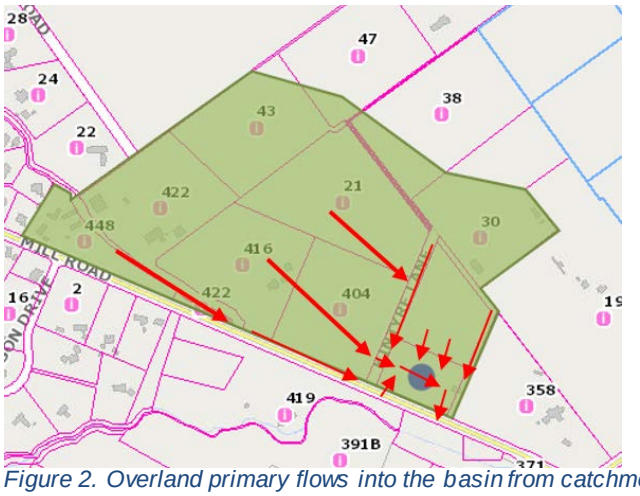


Figure 2. Overland primary flows into the basin from catchment

Within the site there are a couple of existing services requiring removal, or confirmation. There is a well (Well M35/11067) which needs to be capped as per ECan requirements. There is a potential power cable that runs through the first flush basin, which requires confirmation that it was not installed and/or locating if it was installed. The former property owner has said there are not services onsite but confirmation is required.

It is assumed maintenance access is around the bund. Vehicles have potential to park within the detention basin, on the western side of the ROW and/or in the old access way to the right of the new ROW. All options have space for off-loading machinery such as mowers.

3.1. Groundwater

Groundwater was monitored as part of a previous investigations by CEC, to inform the section size required for the stormwater basins. This report by CEC concluded that on average groundwater would be 0.6 m below the existing ground surface 80% of the time and may be shallower than 0.45 m 20% of the time, see TRIM 190221020376. It was assumed groundwater would be greater than 0.6m 20% of the time. Using a top water level of RL 13.44 m identified in the concept design report, it was assumed that ground water would be at RL 13.84 m 80% of the time.

The first flush basin will have a forebay at its inlet followed by a base flow channel to the point of discharge. The base flow channel is anticipated to have an invert RL of 12.59 m, this provides 0.25 m of permanent storage below the 'normal' ground water level in the base of the first flush basin. This depth and changing ground water levels should provide sufficient coverage to prevent the water temperature increasing and discourages mosquitos creating a habitat.

Consideration was given to lowering the top water elevation from that identified in the concept design as the basins can hold the required volume at RL 13.39 m, assuming groundwater at RL 13.84 m. Due to nature of groundwater levels in the area it was decided to keep maximum water

height at RL 13.44 m for additional capacity in the event groundwater levels are greater than anticipated throughout the lifetime of the basin.

The groundwater interception is considered to have minimal impact on groundwater flows in the vicinity of the basins. Less than 5 L/s has been estimated for operational flows through the outlet into the Mill Road Drain, as it is assumed groundwater will be the same in the basins as it is in the Mill Road Drain.

The Water Environment Advisor, Sophie Allen, wrote a report outlining the findings of her survey mid-July, see TRIM 210716117122. Downstream of the site there is a good quality section of river/stream, where inanga, giant bully and longfin eel have been found. The forested site to the west of the site at the corner of Threkelds Road and Mill Road is listed as a wetland.

It has been recommended by the Utilities Planner that spear pointed dewatering methods be used to dewater the site, as this is the less invasive technique for sediment uptake during dewatering as described by the Environment Canterbury erosion and sediment control toolbox.

3.2. Ground Conditions

Ground conditions were investigated as part of the groundwater assessment (TRIM 190221020376), by digging four test pits. See Table 1 for the generic summary of what soil conditions were found across the four test pits.

Table 1. Soil description across the site

Depth (m)	Soil Description
0.0 – 0.2	Medium/brown silty topsoil
0.2 – 0.7	Clayey silt with some sand/gravel – mottled, moist
0.7 – 1.15	Sandy gravel with some clay – dark or blue grey, wet, tight to loose
1.15 – 1.5	Gravel/sandy silt – loose to free running

To protect against erosion in areas where groundwater is expected, coir matting will be used where the groundwater tide line is anticipated to be as well as using plants to further stabilise the soil with their root systems. Ballast and geotextile has been avoided in the base of drains in the first flush basin to reduce future maintenance costs to remove and replace. Coir matting throughout the low flow channel in the detention basin has been used as it is more accessible to purchase.

The steep internal batters (steepness > 1:4) have coir matting down them, to just below the groundwater tide line. This is to help with stabilising the bank, along with plants root systems, and to reduce the risk of erosion. A geotechnical review of lateral spread risk to the adjacent property and the Mill Road Drain of the approved design will be carried out to ensure the banks are stable on their steep slope.

Riprap has been used only at entrances and exits from culverts and at high risk scour areas (e.g. confluence of drains), to reduce velocities and mitigate against erosion at these areas.

3.3. Detention Basin

The detention basin has been designed as a grassed dry pond on the western side of the ROW. See Appendix A for detailed design plans. The concept design identified the detention basin located upstream of the first flush basin. This configuration has been retained at detailed design and, as directed by the Client, the design makes as much of the basins mowable as possible.

Bunds

On both the interior and exterior sides of the bunds, there are 1:5 batters. This allows maintenance access for a mower and other machinery required. The width of the bund is 4.5 m which is wide enough for vehicles to traverse around, instead of on the existing ground. This way more cut volume can remain on site, instead of being removed as waste.

The distance from the basin to the ROW is 3 – 5 m. This allows room for utilities to be installed for the 10 Kintyre Lane development to the north of the site.

Base of basin

As discussed in the preliminary design report, the base of the basin was changed from RL 12.94 m to 13.24 m. This change was made to convert this basin from being wet to dry, and to convey first flush runoff across to the first flush basin instead of water initially ponding in the detention basin. This is to improve future maintenance costs of removing sediment from both basins. The average lengths within the basin are shown in Table 2.

Table 2. Interior length and width distances @ RL 13.24 m

	Distance (m)
Length	64.2
Width	43.5

Inlets

The main inlet to the basin is from Kintyre Lane, where the majority of the runoff from the catchment will be conveyed to. The invert of the Kintyre Lane culvert (at its downstream end) is approximately 0.5 m below the surrounding ground and would require minor modification to allow a smooth transition into the basin during the sub-division works (to remove the hump). The swale into the detention basin has an invert that is flush with the culvert outlet, and the swale falls on a 0.49% grade to the culvert beneath the ROW. This way flow from the upper catchment will be able to flow directly to the first flush basin initially, prior to storing the detention basin.

The inlet channel through the detention basin to the first flush basin was designed to convey the peak flow expected from the sub-catchment, 1.1 m^3/s. Swales and channels were sized using the trapezoidal mannings equation, see Appendix B. A Manning's Roughness Coefficient of 0.025 was used, as it applies to earth channel - gravel, which resembles the riprap cover that will be through the channel at the entrance. To ensure flows are able to enter the basin, while the detention basin is nearing full, the swale has been sized to allow flows beyond the top water level of the basin.

Some of the upstream catchment will discharge to Mill Road Drain. The design includes a piped inlet from the Mill Road Drain to convey runoff above a base flow. The base flow will pass through an orifice plate in a manhole with flows exceeding base flow surcharging and spilling passed the weir plate via a scruffy dome at the spill level of max water height of the basin. There is a headwall structure with DN375 pipework between the manhole and headwall, with rocker and starter pipes according to WDC ECOP SD-341. The orifice within the weir plate is DN300, and the level is flush with the existing ground level. There is a 400 mm depth below the orifice and manhole base to allow for sediment collection. The weight of the steel plate is approximately 50 kg. The weir plate can be removed for maintenance or adjusted if the sizing for base flow was over estimated. The size can be adjusted by replacing the existing steel plate with a new one with an adjusted size. The upstream DN375 and larger pipework downstream also allow for a larger weir to be used, if the base flow was under estimated.

A 2 m wide swale on the left hand side of the right of way is sized for flows coming from the south western side of 10 Kintyre Lane. It will be recommended to the property owner to form a similar swale toward here.

Outlets
The main outlet from the detention basin is via an existing DN375 pipe under the ROW with an emergency spill way from the basin to the Mill Road Drain. Due to required spill levels and existing ground levels, there will need to be a cut through the riparian buffer between the basin and the drain to allow the water to overtop the basin. One of the established trees along the boundary line requires removal to facilitate construction of the overflow. Thought was given to keeping all of them, however the risk of damaging multiple trees during this process was too great due to the size of the trees and their driplines indicating the potential location of roots. The central tree will be removed to maintain some symmetry to the treeline.

The outlet swale is designed for peak flows expected from the catchment of 1.1 m^3/s, see Appendix B.

Detention Volume
The detention basin has a storage depth of 0.2 m and freeboard of 0.60 m around the outer bunds and 0.30 to the crest the ROW. It can store up to 608 m^3. See Appendix D for a summary of stage storage volumes within the basin for both groundwater cases. A similar depth of storage is available above the first flush volume of the first flush wetland, thus providing more than the required volume of attenuation.

Earthworks
The expected earthworks volumes for constructing the detention basin are shown in Table 3.

Table 3. Detention basin earthwork volumes

	Volume (m^3)
Cut	1,500
Fill	230
Remove offsite	1,250

3.4. First Flush Basin

Bunds
The exterior batter has a 1:5 slope down to existing ground level, which will be grassed. The interior batter has 1:2.5 slope on the north, east and southern bunds, and 1:3 slope on the western bund. In the western corner of the southern slope there is an 18.5 m long 1:5 slope for maintenance access and for existing the basin. Steeper slopes will be planted. The bund width around the perimeter of the basin is 4 m.

Base of basin
The main gradient into the basins reach RL 12.94 m and then taper into the basin on a slightly less steep gradient to form low flow channels down to RL 12. 59 m. The lengths within the basin are shown in Table 4.

Table 4. Interior length and width distances @ RL 12.94 m

	Distance (m)
Length	66
Width	59

There is a sediment forebay at the main inlet to the basin, next to the ROW. This has been sized to hold a minimum of 15% of the first flush as recommended by the Auckland City Council guidelines (172.5 m^3).

A low flow channel extends throughout the basin. Use of structures in first flush basin increases the length to width ratio of the basin towards 1:5 and mitigates short circuiting.

Inlets
The main inlet to the first flush basin is through the DN375 culvert beneath the ROW. This was sized by Gary Stevenson and Chris Bacon as part of the right of way design (see TRIM 201221175077).

A 2 m wide swale on the right hand side of the right of way is sized for flows coming from the right of way and some of 10 Kintyre Lane.

For flows from the eastern catchment of 10 Kintyre Lane, there is a 2 m wide channel with 1:3 batters to pass flow into the basin. Consideration was given to conveying all of this flow to the first flush basin and having a non-return device to cut off flow after a depth of 13.24 m, however due to existing ground topography and depth to maximum groundwater it was decided to remove this inlet. The risk associated with a backflow device failing would compromise the entire detention volume of the basins and put the neighbouring property at risk of flooding during storm events. The channel will be planted such that run-off is slowed and some treatment is achieved.

Outlets
There is a choked outlet to restrict flows out of the basin during storm events, and to allow a constant flow through the low flow channel to prevent water stagnating. Orifice calculations for a square edged uniform orifice assuming a circa 48 hour retention time were completed. A circular orifice with a 100mm diameter is to be used, see calculations in Appendix C. Note: The entire storage volume was used to size the orifice, not just the first flush volume. According to stage storage calculations, the water will pond within the basin for around 68 hours. This is due to the reduction in hydraulic head across the basin as the water level drops.

The choked outlet is within a 1,200 mm manhole chamber, which is situated to the east of the emergency spillway within the bund. Within it is a steel weir plate with the orifice. The plate sits in a concrete wall and has a steel handle for removal to maintain/replace it. The lid is trafficable and has a 600mm cover. The central wall and narrow orifice plate have been included to allow for vehicle access and for the plate to be removed via the 600 mm clear opening manhole access. Due to the depth of the manhole there is a safety grille beneath the biscuit for additional safety. The steel plate is ~30 kg.

Spillway
The same spillway design as the detention basin has been used, see Appendix B.

Detention Volume
The first flush retention basin has a storage depth of 0.40 m first flush and 0.20 m detention, 80% of the time. It can store up to 1,350 m^3 of first flush and 835 m^3 of detention volumes. See Appendix D for a summary of stage storage volumes within the basin for both groundwater cases.

Earthworks
The expected earthworks volumes for constructing the first flush basin are shown in Table 5.

Table 5. First flush basin earthwork volumes

	Volume (m^3)
Cut	2,800
Fill	750
Remove offsite	2,000

Other
There is a 3 metre clear zone between the right of way and the first flush basin. This complies with the WDC ECoP. Flax will be planted along the side slope of the first flush basin, and will act as a visual barrier to assist in preventing anyone from driving into the basin.

3.5. Eastern Swale

For flows coming from the eastern side of the upstream land development there is a 1:5 sloped 2 m wide swale that extends down along the eastern bund towards the Mill Road Drain. Topography does not allow runoff from this part of the land development to enter the first flush basin after it reaches RL 13.24 m.

According to the WDC District Plan, all runoff from the ODP160 area that is from developed land must be treated. However the planted swale is intended to provide some treatment for this area, prior to spilling into the Mill Road Drain.

4. Safety in Design Review

The purpose of this review is to identify all hazards associated with this project. These hazards shall be considered from three perspectives as follows:

- Hazards during construction (for both members of the public, and contractors carrying out the works)
- Hazards likely to be created as a result of the construction for maintenance workers
- Hazards likely to be created as a result of the construction for the end user.

All identified risks are to be discussed with the intention to minimise risks from the outset. Details are provided to show each risk has been eliminated, and where not eliminated the risk is to be transferred so that the risks can be appropriately managed as the project progresses. Any opportunities to improve safety outside of the scope of the project may also be discussed.

Drawings reviewed were as follows:

- Drawing 4217 – Sheet 2 – 3

The SID team for this review on 21/06/2021 includes the following; Kalley Simpson, Greg Bennett, Mark Andrews and Claudia Button.

ITEM DISCUSSED	ACTION REQUIRED	RISK TO BE TRANSFERRED
Description: Maintenance Access around detention basin		
Action: Consider if some of the swale inlets/outlets need to be changed into a piped inlet, as they currently may restrict access around the basin	Yes	
Outcome: Swale from Kintyre Lane has 1:3 sloped batters. The swale from the main drain changed into a weir with a piped inlet to the basin. Emergency spillway has 1:5 slopes. 1:5 sloped swales allows maintenance access around the entire perimeter, as the mower can access all sides of the low flow channels.		Yes
ITEM DISCUSSED	**ACTION REQUIRED**	**RISK TO BE TRANSFERRED**
Description: Sediment build up distribution throughout the first flush basin and upstream channel due to limited		

provision for sediment forebay to capture majority of the sediment.		
Action: Increase size of sediment forebay to the design in the first flush basin.	Yes	
Outcome: Sediment forebay size increased. Design based on Auckland City Council guidelines, which recommends sediment forebays be sized for 15% of the water quality volume. An additional 300 mm depth has been added to the total depth in the bay next to the right of way in the retention basin. A safety barrier is to be constructed to prevent vehicles falling 1.2 m into there, even though the clear zone width is achieved (3 m, for 50 km/hr zone) as per WDC Engineering Code of Practice. Provision for excavator access included in design at Mill Road end of forebay.		Yes
ITEM DISCUSSED	**ACTION REQUIRED**	**RISK TO BE TRANSFERRED**
Description: Gabion basket maintenance – gabion baskets have large voids which would trap sediment and will also corrode over time.		
Action: Gabion baskets need to be changed to an alternative barrier to prevent short circuiting during larger storm events and minimise maintenance.	Yes	
Outcome: Gabion baskets switched for groyne style fencing with H5 treated timber (safe in waterways). Sediment will accumulate around the lower panel of the fence and easier to remove along there than from within a gabion basket.		Yes
ITEM DISCUSSED	**ACTION REQUIRED**	**RISK TO BE TRANSFERRED**
Description: Maintenance around perimeter of basins		
Action: No action required, as mowers used in Ohoka are 1.83 m wide, so a 2 m width around most of the perimeter has been used.	No	
Outcome: 2 m perimeter to remain		No
ITEM DISCUSSED	**ACTION REQUIRED**	**RISK TO BE TRANSFERRED**
Description: Someone falls into the first flush basin, how would they get out with 1:2.5 and 1:3 sides the entire way around?		
Action: Need a flatter slope somewhere on the interior bund which will allow access in and out of the basin, but not inhibit the storage volume too much	Yes	
Outcome: An 18.5 m 1:5 sloped bund has been added to the south western corner of the retention basin. This will allow anyone who fell into the basin access out, and maintenance access for when sediment needs to be cleared.		Yes
ITEM DISCUSSED	**ACTION REQUIRED**	**RISK TO BE TRANSFERRED**
Description: Dry pond could be used for activities. Children may attempt to retrieve balls/items from culverts from games.		

Action: Grates over culverts included in design to prevent anything getting stuck in culverts which may put children at risk	No	
Outcome: Risk eliminated		No

5. Resource Consent Applications

Resource consents have been submitted to ECan and WDC. Consents applied for are shown in Table 6 below.

Table 6. Resource consent applications

Environment Canterbury	Waimakariri District Council
• Water take permit (CRC221240) • Discharge operational phase stormwater permit (CRC221242) • Discharge construction phase stormwater and discharge dewatering water permit CRC221241) • Land use for earthworks (CRC2201243) • Installation of a structure in the bed of a river (CRC221244)	• Land use consent (RC215369)

The Environment Canterbury Resource Consents were returned, and require to be resubmitted after gathering some additional information such as a well interference assessment. The application was resubmitted 16 September 2021, and a 40 day processing timeframe was applied immediately due to the size of the application.

The WDC resource consent was granted 23 August 2021.

6. Recommendation for adjacent land developers

The Kintyre Lane swale should be recut to encourage flows from the northern end to flow south towards the basins. This will help with intercepting surface flows from flowing through 10 Kintyre Lane, see the yellow arrows in Figure 3. It would be preferable for this to be on the eastern side of Kintyre Lane to avoid the need for going through culverts, however due to established trees on this side the west will be okay.

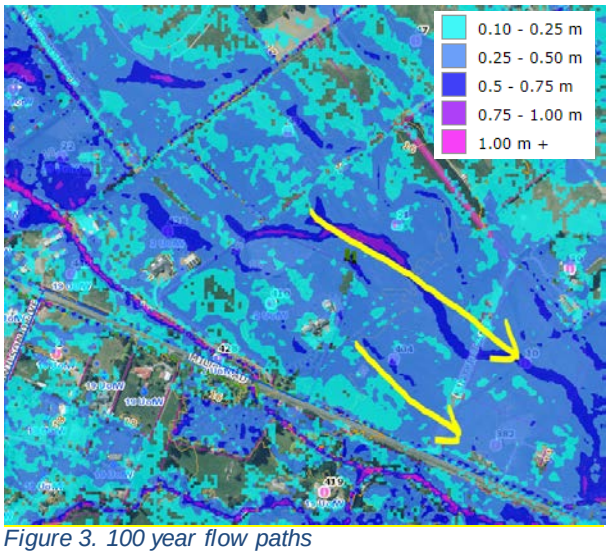


Figure 3. 100 year flow paths

As described previously, the 2 m wide v channel swales on either side of the ROW should be extended into the 10 Kintyre Lane development to assist with flows from these properties reaching the SMA.

For flows from the eastern side of 10 Kintyre Lane, it is recommended the eastern swale in 382 Mill Road be extended to intercept runoff that was not possible to directed to the SMA from the swale cut down Kintyre Lane, or swales on either side of the ROW. A siphon on either side of the secondary flow path could be considered, however topography within that area may make this difficult. The extension of the drain will mean runoff from the development will receive some treatment, even though it does not pass through the basin due to topography constraints.

8. Summary

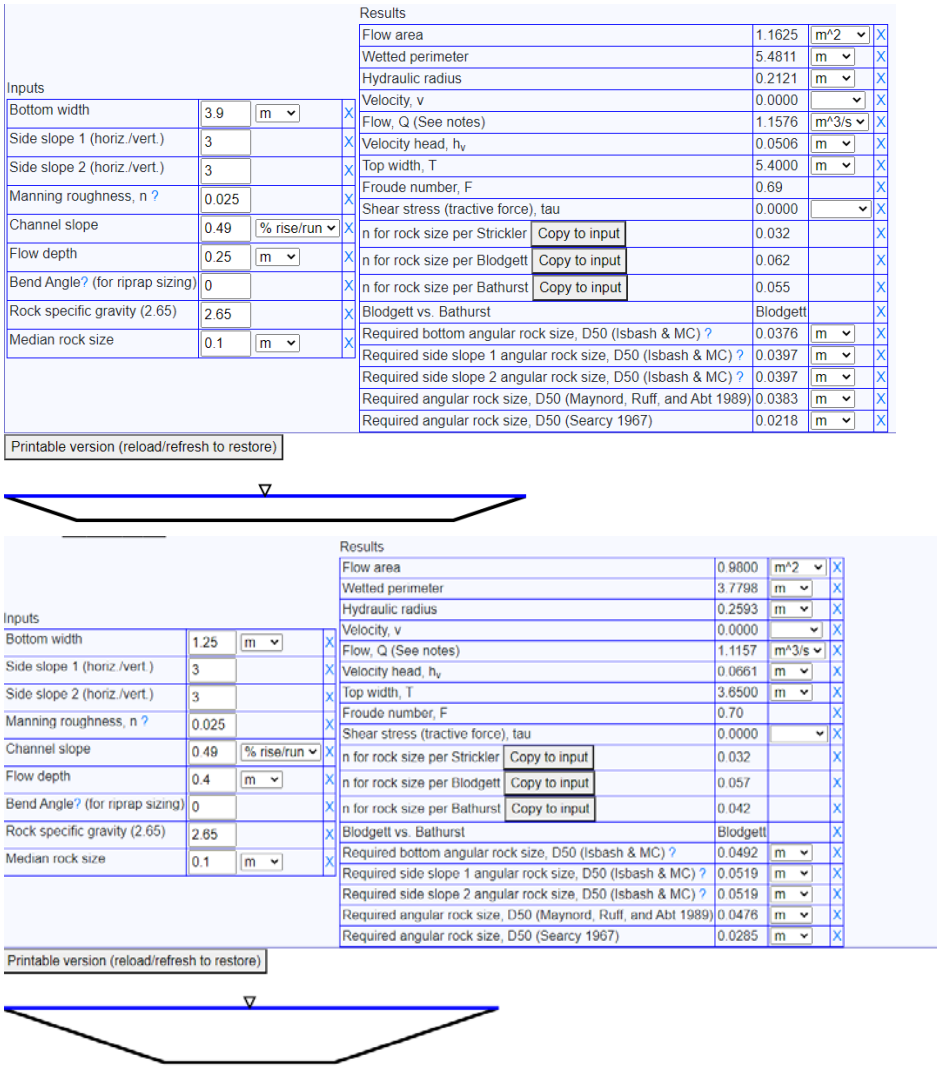
There are two basins to be constructed as part of the Ohoka Mill Road SMA project. One dry grassed basin to the west of the ROW and one wetted planted basin to the east of the ROW. The basins have been designed to store the runoff volume difference between pre and post development for a 24 hour 1 in 50 year storm. The combined storage can achieve the required storage volumes of 1,050 m^3 first flush and 1,150 m^3 detention volume, even when experiencing high groundwater levels. The drain down time of the maximum storage volume is around 68 hours.

9. References

Auckland City Council
https://www.aucklandcouncil.govt.nz/UnitaryPlanDocuments/mir-stormwater-management-devices-auckland-region.pdf
page 56

APPENDIX A – Site Plans

APPENDIX B – Swale calculations



Inputs

Bottom width	3.9	m	X
Side slope 1 (horiz./vert.)	3		X
Side slope 2 (horiz./vert.)	3		X
Manning roughness, n ?	0.025		X
Channel slope	0.49	% rise/run	X
Flow depth	0.25	m	X
Bend Angle? (for riprap sizing)	0		X
Rock specific gravity (2.65)	2.65		X
Median rock size	0.1	m	X

Results

Flow area	1.1625	m^2	X
Wetted perimeter	5.4811	m	X
Hydraulic radius	0.2121	m	X
Velocity, v	0.0000		X
Flow, Q (See notes)	1.1576	m^3/s	X
Velocity head, h_v	0.0506	m	X
Top width, T	5.4000	m	X
Froude number, F	0.69		X
Shear stress (tractive force), tau	0.0000		X
n for rock size per Strickler Copy to input	0.032		X
n for rock size per Blodgett Copy to input	0.062		X
n for rock size per Bathurst Copy to input	0.055		X
Blodgett vs. Bathurst	Blodgett		X
Required bottom angular rock size, D50 (Isbash & MC) ?	0.0376	m	X
Required side slope 1 angular rock size, D50 (Isbash & MC) ?	0.0397	m	X
Required side slope 2 angular rock size, D50 (Isbash & MC) ?	0.0397	m	X
Required angular rock size, D50 (Maynord, Ruff, and Abt 1989)	0.0383	m	X
Required angular rock size, D50 (Searcy 1967)	0.0218	m	X

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Inputs

Bottom width	1.25	m	X
Side slope 1 (horiz./vert.)	3		X
Side slope 2 (horiz./vert.)	3		X
Manning roughness, n ?	0.025		X
Channel slope	0.49	% rise/run	X
Flow depth	0.4	m	X
Bend Angle? (for riprap sizing)	0		X
Rock specific gravity (2.65)	2.65		X
Median rock size	0.1	m	X

Results

Flow area	0.9800	m^2	X
Wetted perimeter	3.7798	m	X
Hydraulic radius	0.2593	m	X
Velocity, v	0.0000		X
Flow, Q (See notes)	1.1157	m^3/s	X
Velocity head, h_v	0.0661	m	X
Top width, T	3.6500	m	X
Froude number, F	0.70		X
Shear stress (tractive force), tau	0.0000		X
n for rock size per Strickler Copy to input	0.032		X
n for rock size per Blodgett Copy to input	0.057		X
n for rock size per Bathurst Copy to input	0.042		X
Blodgett vs. Bathurst	Blodgett		X
Required bottom angular rock size, D50 (Isbash & MC) ?	0.0492	m	X
Required side slope 1 angular rock size, D50 (Isbash & MC) ?	0.0519	m	X
Required side slope 2 angular rock size, D50 (Isbash & MC) ?	0.0519	m	X
Required angular rock size, D50 (Maynord, Ruff, and Abt 1989)	0.0476	m	X
Required angular rock size, D50 (Searcy 1967)	0.0285	m	X

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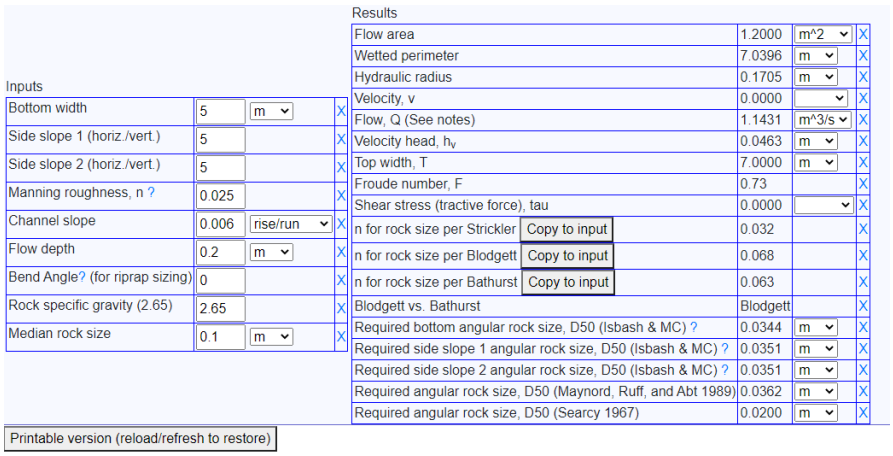
Figure 4. Kintyre Lane inlet swale calculations (top image is the top portion of the swale and bottom image is the bottom section of the swale)



Inputs

Bottom width	5	m	X
Side slope 1 (horiz./vert.)	5		X
Side slope 2 (horiz./vert.)	5		X
Manning roughness, n ?	0.025		X
Channel slope	0.006	rise/run	X
Flow depth	0.2	m	X
Bend Angle? (for riprap sizing)	0		X
Rock specific gravity (2.65)	2.65		X
Median rock size	0.1	m	X

Results

Flow area	1.2000	m^2	X
Wetted perimeter	7.0396	m	X
Hydraulic radius	0.1705	m	X
Velocity, v	0.0000		X
Flow, Q (See notes)	1.1431	m^3/s	X
Velocity head, h_v	0.0463	m	X
Top width, T	7.0000	m	X
Froude number, F	0.73		X
Shear stress (tractive force), tau	0.0000		X
n for rock size per Strickler Copy to input	0.032		X
n for rock size per Blodgett Copy to input	0.068		X
n for rock size per Bathurst Copy to input	0.063		X
Blodgett vs. Bathurst	Blodgett		X
Required bottom angular rock size, D50 (Isbash & MC) ?	0.0344	m	X
Required side slope 1 angular rock size, D50 (Isbash & MC) ?	0.0351	m	X
Required side slope 2 angular rock size, D50 (Isbash & MC) ?	0.0351	m	X
Required angular rock size, D50 (Maynord, Ruff, and Abt 1989)	0.0362	m	X
Required angular rock size, D50 (Searcy 1967)	0.0200	m	X

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Figure 5. Detention and Retention Basin emergency spillway swale calculations

APPENDIX C –Orifice Calculations

WAIMAKARIRI DISTRICT COUNCIL

FILE No. PD001714
CONTRACT No. CoN 20/39
COMPUTED BY Claudia Button
CHECKED BY

PROJECT: Orifice Calculation
ITEM:

$Q_o = C_d A_o \sqrt{2gh}$

C_d = discharge coefficient [dimensionless]
A_o = Cross sectional area of orifice [L^2]
h = Elevation of water surface above centre of orifice (free discharge) or difference between headwater & tailwater elevations for submerged outlets [L].

C_d = 0.6 square-edge uniform entrance conditions
= 0.4 ragged edged orifices.

Assuming ground water level is at 13.2m (depth 80% of the time)

h = 13.8m - 13.2m
= 0.6m

Assuming a residence time of 48 hours.

$Q_o = \frac{\text{volume stored}}{\text{residence time}}$

$= \frac{2791.2\ m^3}{48\ hours}$

$= 58.15\ m^3/hr$
$= 0.969\ m^3/min$
$= 0.016\ m^3/s$

$A_o = \frac{Q_o}{c_d \sqrt{2gh}}$

$= \frac{0.016\ m^3/s}{0.6 \sqrt{2 \times 9.81\ m/s^2 \times 0.6m}}$

$= 0.00785\ m^2$
$= 79.46\ m^2$

Know area of circle

$A = \pi r^2$

So,

$r = \sqrt{\frac{A}{\pi}}$

$= \sqrt{\frac{0.00785}{\pi}}$

$= 0.05m \Rightarrow \phi 100mm$

Appendix D – Stage storage and residence time calculations

Stage storage and residence time calculations for GWL 0.6m below ground level

RL	Depth	First Flush Volume (m^3)	Detention Volume (m^3)	Total Volume (m^3)	Orifice Flow (m^3/hr)	Time (hours)
12.84	0	0.0	0.0	0.0	GW	0
12.94	0.1	145.6	0.0	145.6	21.9	6.6
13.04	0.2	394.2	0.0	394.2	31.0	12.7
13.14	0.3	400.9	0.0	400.9	37.9	10.6
13.24	0.4	407.6	0.0	407.6	43.8	9.3
13.34	0.5	414.3	298.2	712.5	49.0	14.5
13.44	0.6	421.1	309.4	730.5	53.7	13.6
Total		2183.6	607.5	**2791.2**		**67.4**

Stage storage and residence time calculations for GWL 0.4m below ground level

RL	Depth	First Flush Volume (m3)	Detention Volume (m3)	Total Volume (m3)	Orifice Flow (m3/hr)	Time (hours)
13.14	0.3	400.9	0.0	400.9	37.9	10.6
13.24	0.4	407.6	0.0	407.6	43.8	9.3
13.34	0.5	414.3	298.2	712.5	49.0	14.5
13.44	0.6	421.1	309.4	730.5	53.7	13.6
Total		1643.8	607.5	2251.3		68.5