Planning | Surveying | Engineering | Environmental

Stormwater Management Plan

Ayrburn Screen Hub

Waterfall Park Development Ltd

Document Information

Client	Waterfall Park Developments Ltd
Site Location	Ayr Avenue, Arrowtown
Legal Description	Lot 4 DP540788
CKL Reference	A20254
Office of Origin	Auckland

Author	Frances Deamer-Phillips and Dorcas Adjei-Sasu		
Signed		Date	30/01/2025

Reviewed & Authorised By	Bronwyn Rhynd		
Signed		Date	30/01/2025

Revision	Status	Date	Author	Reviewed By	Authorised By
0	Draft	18/12/2024	FDP/DAS	BR	BR
1	Final	30/01/2025	FDP/DAS	BR	BR

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1 Introduction

CKL has been engaged by Waterfall Park Developments Ltd (WPDL) to develop a Stormwater Management Plan (SMP) for the proposed Ayrburn Screen Hub which includes a filming studios and associated accommodation and facilities. The site is located at Ayr Avenue, off Arrowtown-Lake Hayes Road. The site is approximately 2km south of Arrowtown.

The purpose of this report is to outline the stormwater management objectives and best practicable stormwater management plan for the proposed development of the site in accordance with QLDC Land Development and Subdivision Code of Practice, and guide development in such a way as to avoid, remedy or mitigate adverse effects on the receiving environment.

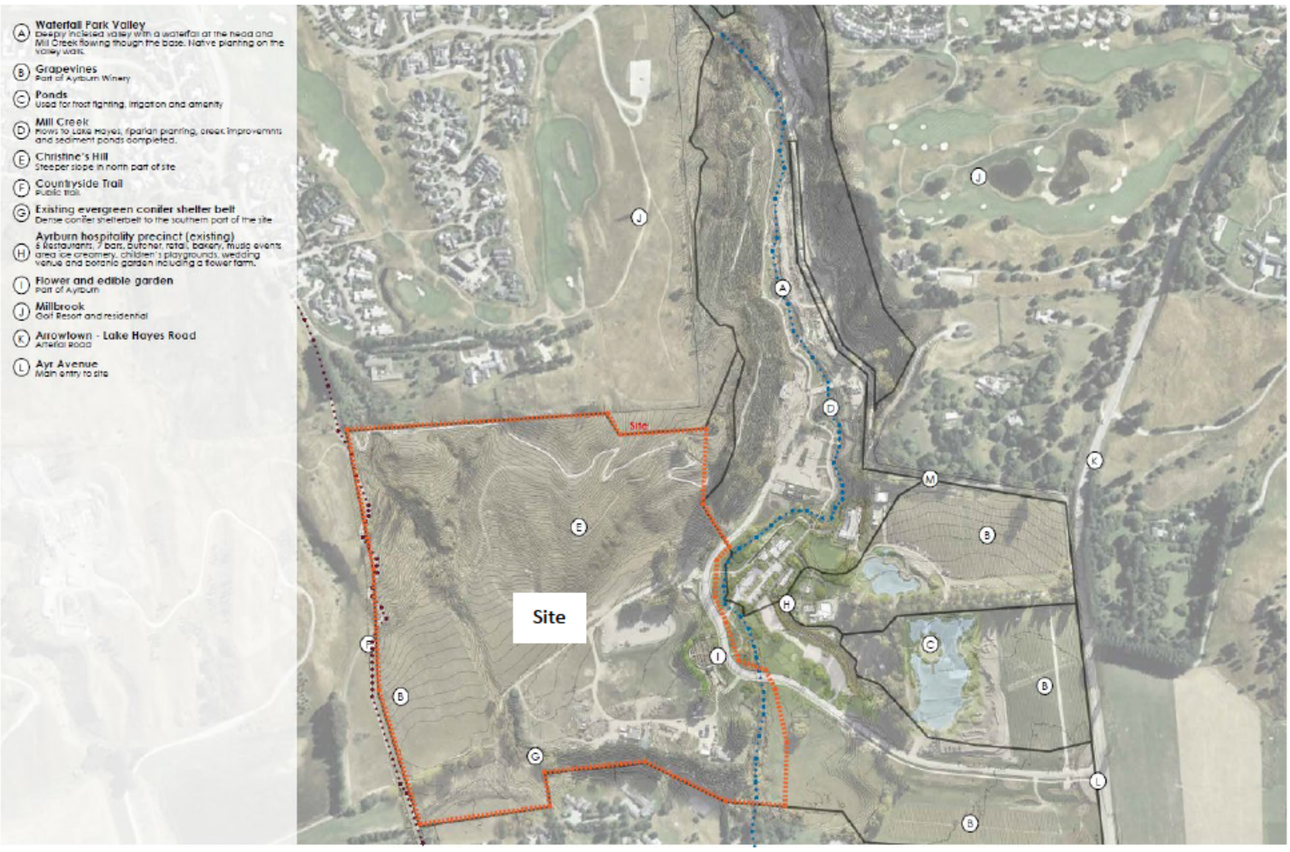


Figure 1: Site Location (Winton Provided, December 2024)

1.1 Reference Documents

The development of this stormwater management plan is guided by the following key documents, which are referenced throughout this report;

- QLDC Land Development and Subdivision Code of Practice (QLDC COP)
- Ayrburn Screen Hub Resource Consent Drawings by Patersons dated December 2024
- Ayrburn Screen Hub Landscape Strategy by Winton dated November 2024

2 Existing Site Conditions

The site is located between Lakes Hayes and Arrowtown, approximately 2km south of Arrowtown and is accessed via Ayr Avenue, coming off Arrowtown-Lake Hayes Road.

The site is located on Lot 4 DP 540788, being land currently zoned Wakatipu Basin Rural Amenity Zone (WBRAZ) and subject to the Ayrburn Structure Plan.

The site sits below Northbrook Waterfall Park development where the valley opens up into what is known as Ayrburn Farm. The historic Ayrburn stone farm buildings are located immediately to the east of site, located in the northern extent of Ayrburn Farm in the area known as Ayrburn Domain.

To the west of the site is steep paddocks that extend above the site toward the Millbrook development. Currently, stormwater sheet flows from the paddocks towards the Site and is largely conveyed through an intermittent stream or cut off drains and discharges towards Mill Creek south of the site. The site itself gently sheet flows towards Mill Creek and down the bank adjacent to the creek. Existing site area, and condition, are shown above in Figure 1.

With respect to the hydrological and hydraulic surface flow responses under the existing condition a "rain-on-grid" flood model has been conducted for the Screen Hub area and associated catchment upstream which extends to the southern boundary of the wider site. The extent of this rain on grid model is within the existing (wider) Mill Creek flood modelling undertaken for the wider Ayrburn and Northbrook site to ensure a comprehensive assessment is undertaken. The existing scenario for the flood model includes all consented works within Northbrook Waterfall Park and Ayrburn to capture the fully developed scenario of the wider site. Refer to Section 10 for flood model summary.

3 Proposed Development

The proposal for the Ayrburn Screen Hub includes the filming studios, offices and workrooms, and accommodation, conference rooms, wellness and reception area for film staff and crew. Figure 2 below shows the proposed site plan, along with drawings appended, in Appendix 1

Figure 2: Proposed Site Plan

Table 1 below provides a summary of coverage areas for both pre- and post-development for the site area being developed, which include the large paddocks and bush area upstream of site which remain unchanged. The difference between pre- and post-development areas is used to estimate the net change in impervious area for the site. Figure 2 above demonstrates post- development site coverage areas.

Table 1: Net Change Between Pre- and Post-Development Areas

Surface Coverage	Pre-development Existing Areas		Post-development Proposed Areas		Net Change	
	(m^2)	%	(m^2)	%	(m^2)	%
Internal Road	0	0%	11064	5%	11064	5%
Filming Studio Backlot	0	0%	9598	4%	9598	4%
Foot paths	0	0%	6871	3%	6871	3%
Roof Areas	0	0%	15048	6%	15048	6%
Landscaping	234,000	100%	69319	82%	-42581	-18%
Total	**234,000**	**100%**	**234,000**	**100%**	**0**	**0%**

4 Stormwater Management Strategy and Objectives

For this site, it is proposed to adopt the stormwater management objectives outlined in the current QLDC COP to guide stormwater management within the development area. Additionally, there is a specific Proposed District Plan (PDP) water quality policy (24.2.4.2) relevant to this part of the WBRAZ, which the site is located within, and this is discussed in the following section.

4.1 Proposed District Plan Policy 24.2.4.2

The Policy States:

> "Restrict the subdivision, development and use of land in the Lake Hayes catchment, unless it can contribute to the water quality improvement in the catchment commensurate with the nature, scale and location of the proposal"

Policy 24.2.4.2 is clear that water quality leaving the site in the post-development scenario should be proven to be better than what exists currently. The Stormwater Management Plan (SMP) Ayrburn Domain Extension, CKL, prepared December 2021 concluded that a treatment train approach for the additional of two new carparks (RM211193) provided sufficient removal of contaminants to improve water quality compared to existing scenario (farmed land use), therefore, achieving the requirements of this policy.

It is proposed to provide a treatment train approach to this site to ensure that post-development runoff water quality is an improvement of the existing scenario (farmed).

4.2 Proposed Stormwater Management Objective

High level objectives for Stormwater Management within the development area are in line with current QLDC guidance and consenting works in the catchment area, they are summarised as follows:

- ✓ **Water Quality**

Treat stormwater runoff from site with treatment train approach, improving on existing scenario

- ✓ **Hydrological Mitigation**

Post-development peak flow should not exceed pre-development peak flow from the overall site boundary

- ✓ **Conveyance**

Primary Conveyance of the 20yr ARI peak flow (including the effects of climate change)

Secondary Conveyance of the 100yr ARI peak flow (including the effects of climate change)

5 Stormwater Management Plan

This section illustrates the existing stormwater management system on site and option assessment for the proposed condition.

5.1 Existing Stormwater Management System

Stormwater runoff from the site discharges as surface runoff to Mill Creek which runs through the middle of the wider Northbrook and Ayrburn site from the north to south. CKL have conducted a flood model for

Mill Creek for pre-development and post-development scenarios to assess the peak flow for multiple rainfall events at the wider site boundary just below the Screen Hub site. This model was used as a basis for flood modelling for the Screen Hub site as it incorporates all construction and consented work for the wider Ayrburn and Northbrook development area.

Currently there is no formal stormwater management as the site is associated with rural and vineyard operations. There are natural streams and gullies that receive surface flow from the contributing catchment. The site also receives flow from the Millbrook development via a piped discharge to the head of the tributary within western portion of the site.

6 Best Practicable Stormwater Management Option

Given the ultimate receiving environment is Lake Hayes, which is susceptible to nutrient loading, it was determined that a treatment train approach to treat potential contaminants within runoff generated from site is the preferred option to ensure robust treatment and reduce risk of contaminants entering Lake Hayes. This approach continues the best practicable option (BPO) associated with the overall Ayrburn and Northbrook development.

The internal road is proposed to be treated first by at-source raingardens between parking bays. The treated water quality flow will partially infiltrate to ground, however underdrains will also be fitted above a soakage area for treated water to carry onto a series of wetlands in the centre of the Screen Hub development. These are referred to as pod wetlands.

The large parking and 'backlot' area adjacent to the filming studios building is proposed to be treated by underground proprietary treatment device designed to treat the entire hardstand area for all contaminants.

At the downstream portion of site, adjacent to Mill Creek, it is proposed to include a planted dry pond that will capture all runoff from site as well as a portion of existing Ayr Avenue flow and the Flower Farm site. This pond will act as polishing treatment for the entire catchment (including the mentioned Flower Farm and Ayr Avenue) and will allow for some infiltration to ground for further treatment.

All roof areas will be clad with non-contaminant generating materials, as such they will not require treatment. However, the stormwater network will discharge to the tertiary treatment dry ponds, so ultimately the roof runoff will receive treatment as well.

Additionally, it is proposed to include a sediment retention pond within Mill Creek, just upstream of the Ayrburn Farm boundary and below the inlet from the Screen Hub site. Several of these sediment retention ponds have been used in the catchment upstream of the site and have proven to be efficient and effective at removing sediment from Mill Creek prior to entering Lake Hayes and improving the water quality of the lake. This is described further in Section 8.

Figure 3 below demonstrates the overall best practicable option for stormwater management for the entire site. Figure 3 also indicates the proposed treatment devices per sub catchment.

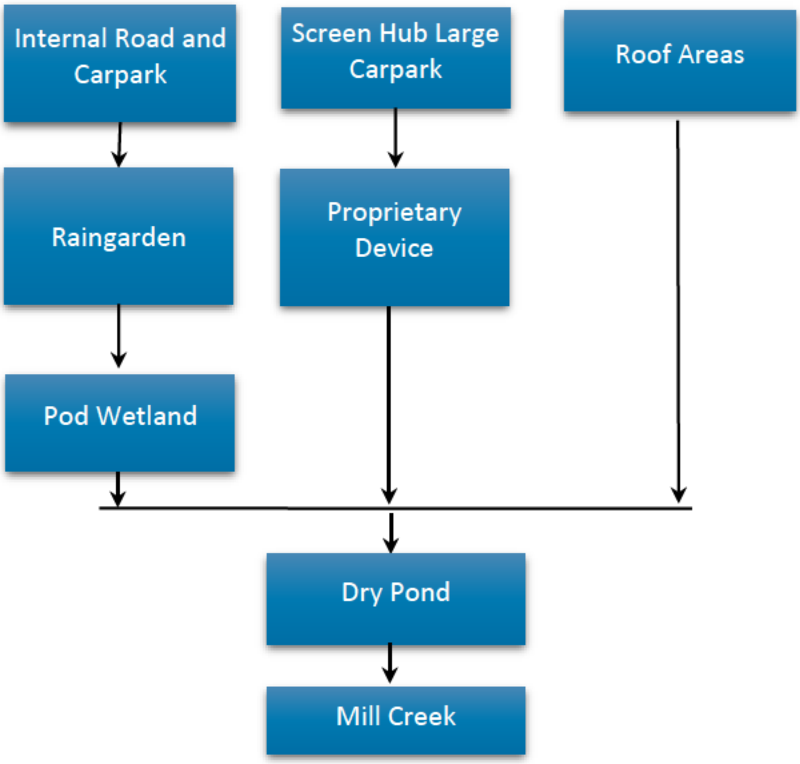


Figure 3: Example diagram of the proposed stormwater management system

Paterson's 400 series drawings illustrate the stormwater management approach proposed. Section 7 below describes each component of the stormwater management system.

7 Proposed Stormwater Management Components

The following sections describe the treatment devices that are the stormwater management system components proposed for the site.

7.1 Raingardens

16 bioretention devices (raingardens) are proposed within the internal road to provide primary treatment and recharge groundwater where possible. Soakage testing was undertaken nearby the proposed internal road which resulted in a relatively low soakage rate of 30mm/hr. Assuming 50% reduction factor, the design rate is 15mm/hr. Soakage calculations are supplied in Appendix 2.

The raingardens are designed to have a retention layer to allow some runoff to infiltrate to ground, however an underdrain will be set above the retention layer to convey treated runoff to the downstream wetland system.

Appendix B demonstrates the sizing for all raingardens.

7.2 Pod Wetland

Treated runoff from the internal road, after filtering through the raingardens, will be conveyed to a series of small wetland pods in the centre of the Screen Hub site. The wetlands are designed to treat the WQV (16mm) from the internal road catchment and provide secondary treatment after the raingardens.

The pod wetlands will have shallow marsh on the edges and deeper pools at the entry which will allow for both uptake of nutrients through plants and settlement of sediment in the deeper areas. The wetlands will be connected by a series of culverts with hydraulic (bubble up) chambers to convey water between them and control the level of the wetlands.

7.3 Tertiary pond

At the terminus of the Studio hub catchment, it is proposed to convert the flat area adjacent to Mill Creek to a shallow dry pond planted with vegetation. This will provide tertiary treatment for the road, secondary treatment for the filming studios 'backlot' paved area and for the wider catchment, as such acting as polishing treatment for the entire catchment.

Soakage testing was undertaken in this location and resulted in a relatively high soakage rate of 400mm/hr. Assuming 50% reduction factor, the design rate is 200mm/hr will provide significant infiltration to ground and provide additional protection to the stream through reduced sediment loading, temperature reduction and filtration through the ground.

8 Mill Creek In-line Sediment Retention Pond

It is proposed to include an inline sediment retention pond within Mill Creek upstream of the Ayrburn Farm/wider site southern boundary. The purpose of this device is to capture sediment within Mill Creek which is generated from the entire Mill Creek catchment surface runoff. The pond will be cleared when sediment builds up, with the overall objective of helping protect Lake Hayes from increased sedimentation.

It is to be noted that this inline sediment retention pond is for the wider catchment benefit not just this proposed Studio project.

The location of the proposed sediment retention pond, which is near the bottom of the Mill creek catchment, has been strategically selected. This location is in flat topography which results in very low velocities within the stream flow, which will promote sedimentation. In addition the location is where 80% of the catchment is contributing as such is the position where resilience is added to the upstream sediment retention ponds(Pike Iti and Puke Nui). Further downstream of the proposed location is a relatively steep gradient to Lake Hayes which is not conducive to this type of low velocity environment.

The changes in land use in the Lake Hayes catchment from bush to farmland and residential developments has meant over time the lake quality has degraded as sediment and nutrient loading has built up. In an effort to reduce the amount of sediment reaching the lake, a few inline sediment retention ponds have been built in the upper reaches of the catchment which have proven to retain significant amounts of sediment. It is proposed to include an inline pond in this project, toward the lower reaches of the catchment, to remove larger amounts of sediment, which are entrained within the stream flow, prior to the flow entering Lake Hayes.

There are existing in-line sediment retention ponds built around 2021yr-2022yr upstream of the wider site boundary, within Northbrook Waterfall Site. As part of the overall Winton projects' stormwater management strategy CKL and Winton have analysed the turbidity data from instream data loggers from 2019 to today at locations upstream of Northbrook Site and at the downstream of boundary of wider site to determine the effectiveness of these ponds. This assessment has proven that the existing ponds within the site have had a significant positive impact on the water quality and removal of sediment[1].

[1] This efficacy has been documented in the memo titled "Mill Creek Example Measures, Winton, 7 November 2024"

The proposed pond in this application is larger than the exiting upper catchment in-line ponds in order to provide added benefit to the overall catchment flow. Given the proposed location, which will be in the lower portion of the catchment the inline pond will receive more flow than these upper catchment inline ponds.

The upstream end (or top) of the proposed inline pond matches the existing stream profile and will have the (proposed) following dimensions:

- Top Length=50m
- Top Width=12m
- Depth=2m

For maintenance purposes there is a diversion channel designed so stream flow can diverted from away from this in-line pond when the pond needs to be cleared of sediment. This clearing of sediment will be conducted during a dry weather period.

8.1 Velocity Assessment

The velocities through the proposed sediment pond were assessed for various storm events to ensure they are low enough for sedimentation to occur. The assessment for the velocity was undertaken using 1D flow modelling

A 1-D HEC-RAS model was run through the pond for 2/3 of 2yr and the 2yr ARI event. Baseflow within the stream is considered by the 2/3 of 2yr ARI event and is regarded as the typical annual recurrence rainfall event. The 2yr ARI event was also considered for sensitivity of flow response within the sediment pond. The peak velocity map for 2yr ARI event (given this is the higher of the two events with respect to flow) and associated cross sections assessed in the model are shown below in Figure 4.

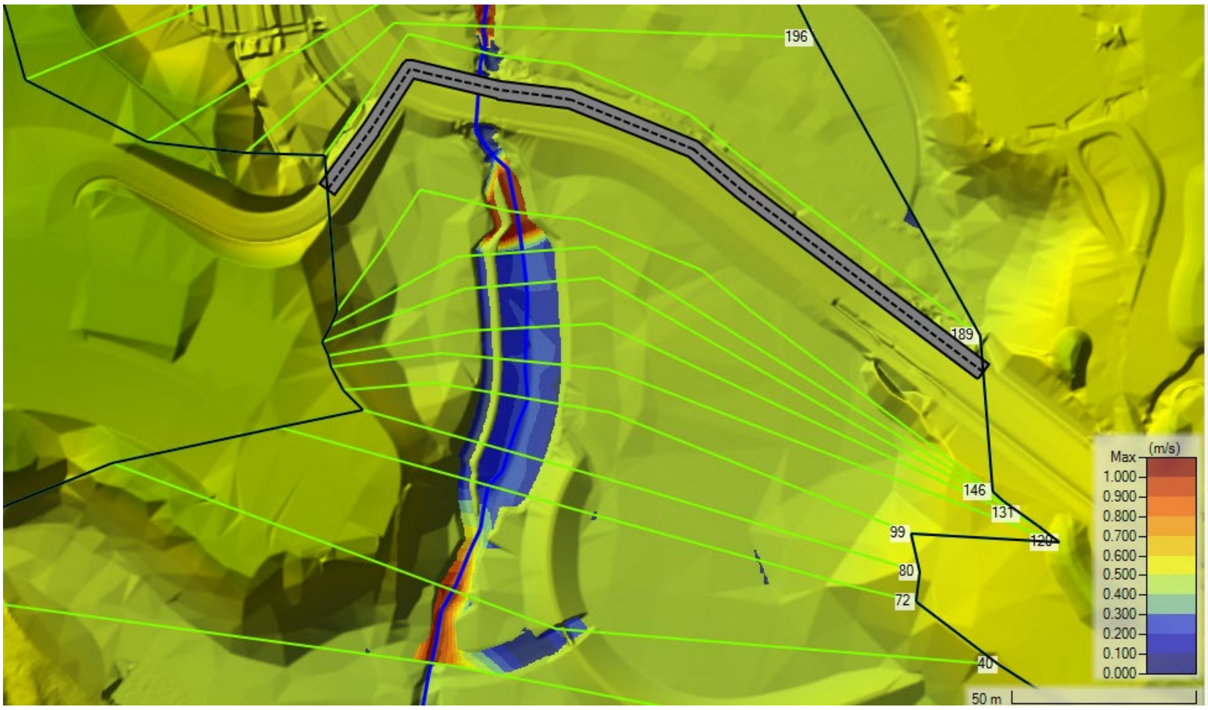


Figure 4: HEC-RAS 1D model Velocity Map and Cross Sections

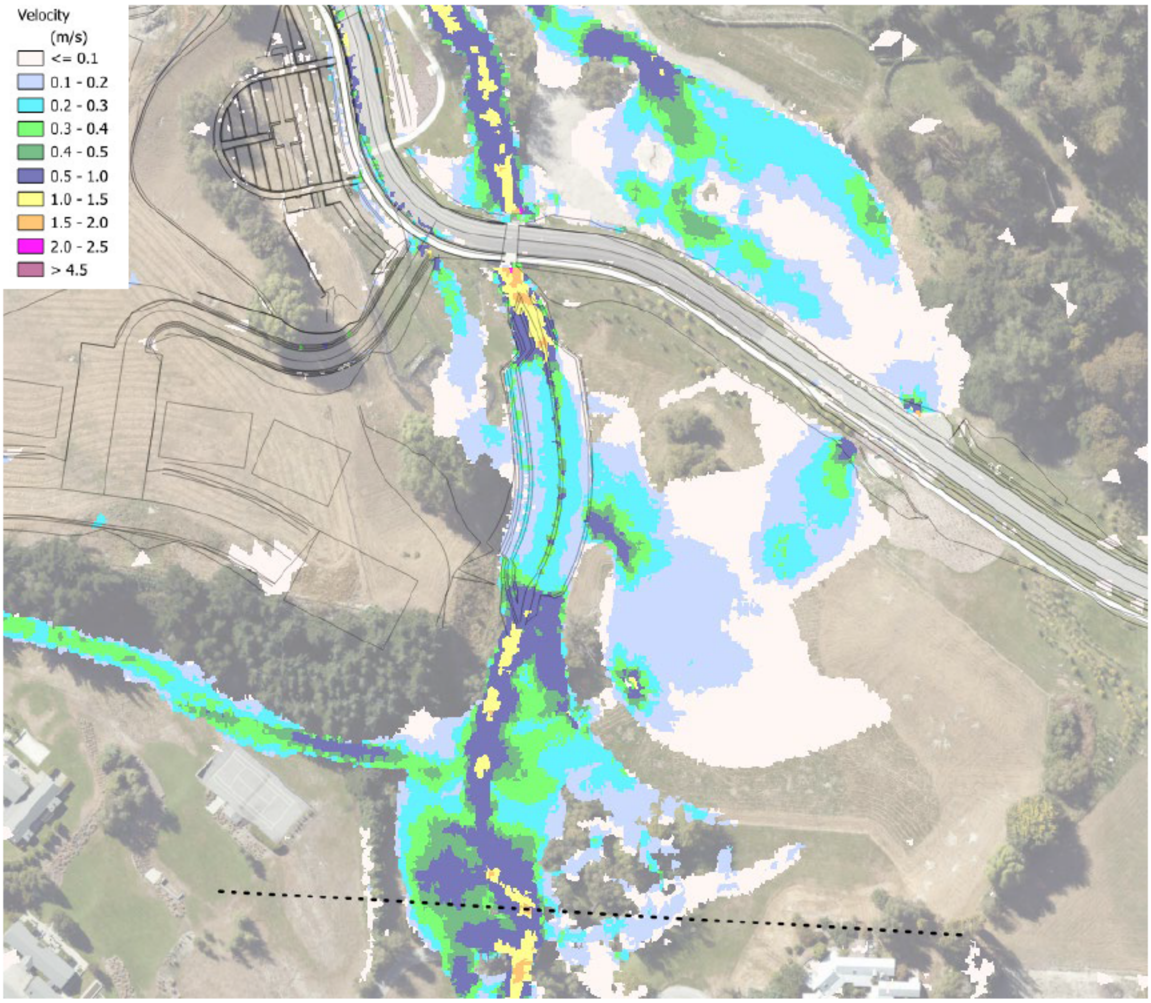
With reference to the cross sections shown in the figure above the average velocity through the pond at each cross section for both rainfall events are shown below in Table 2.

Table 2: Peak Velocity in Pond for 2/3rd 2yr and 2yr ARI Event

Cross Section	Sediment Pond Peak Velocity (m/s)	
	2/3 2yr ARI	2yr ARI
131	0.17	0.23
120	0.16	0.22
99	0.16	0.22
80	0.16	0.21
72	0.18	0.25

In both events the average velocities through the pond are low enough (below 0.25m/s[2]) that when the peak flow arrives it won't resuspend sediment built up in the pond. It should be noted that these are peak velocities associated with the peak flow from entire upstream Mill Creek catchment arriving to the proposed inline pond, prior to this occurrence the velocities will be lower as the flow is less (than the peak flow) and sedimentation can occur.

Larger events were also considered; such as rainfall events with recurrence intervals above the 2yr. During the larger than 2yr events the flow extends into the flood plain and outside of the pond, due to limited stream capacity. Below Figure 5 and Figure 6 show the velocities in both 20yr and100yr ARI events respectively.



[2] Stormwater Management Devices in the Auckland Region (GD01), Auckland Council, Dec 2017, p.279

Figure 5: ICM Model 20yr Velocity Map

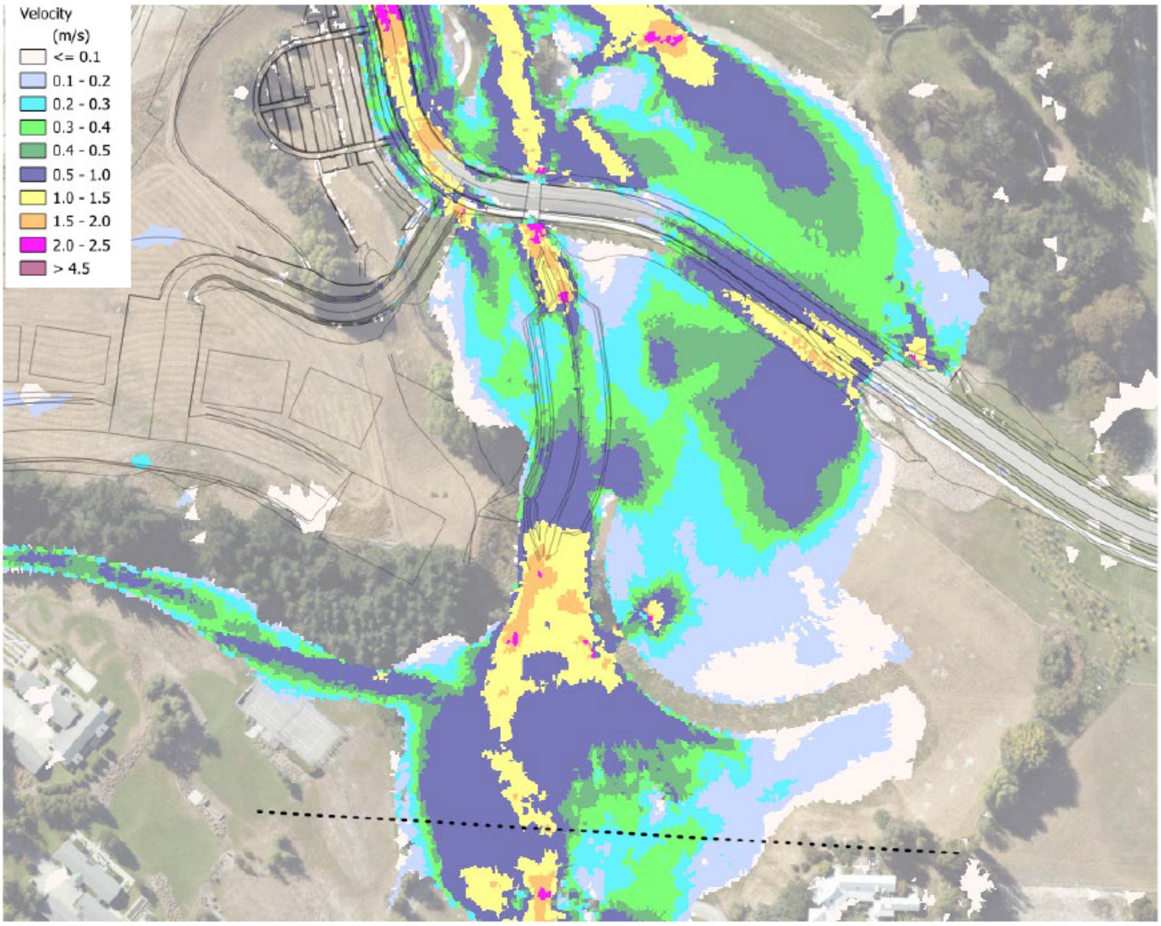


Figure 6: ICM Model 100yr Velocity Map

As seen in the figures above, the velocities are elevated in larger events. In the 20yr ARI event the velocities are largely below 0.25-0.3m/s to avoid re-suspension in the pond and much of the surrounding flood plain. The velocities are higher outside of the pond where the stream channel is narrower, which is expected in an event like this. However, there is confidence that if the pond is full of sediment and a 20-yr event occurs, there should be minimal re-suspension of sediment within the pond, protecting Lake Hayes from further sedimentation in a 20yr rainfall event.

In the 100yr the velocities are higher than the 20yr (as expected) within the pond and the flood plain. These velocities may may cause erosion and re-suspend sediment in pond. This is commonly experienced and expected during such extreme events

8.2 Estimated Sediment Removal

There are two existing inline sediment retention ponds within the catchment, upstream of Ayrburn and Northbrook Waterfall. These two ponds are located near Wharehuanui, approximately 8km upstream of site. They are called Puku Nui and Puku Iti ponds. Locations of each pond are shown below in Figure 7.

Figure 7: Location of exiting sediment retention pond in catchment

The basic details of each of the sediment ponds are below.

Puku Nui

- Constructed in Feb 2024
- Volume= 750m^3
- Approximate time to fill pond with sediment= 13 months (70% full after 10 months)

Puku Iti

- Constructed in April 2023
- Volume= 540m^3
- Approximate time to fill pond with sediment= 12 months

The combined total volume of the two existing ponds is 1290m^3. The volume of the proposed pond within Ayrburn site is 900m^3, larger than either pond upstream (at 750m^3 and 540m^3). Assuming the upstream ponds are cleaned when full and therefore operational, they will remove a large portion of sediment transported from upstream of them. Therefore, the sediment expected to deposited in the proposed Ayrburn in-line sediment retention pond would largely be from runoff downstream of Puku Iti pond and upstream of this project's pond. The catchment area upstream of Puku Iti is 19.93km^2 compared to the catchment area downstream of Puku Iti but upstream of proposed pond which is 13.55km^2. Both catchments consist of farmland, residential areas, and steep vegetated hills.

To roughly estimate the volume of sediment removal a comparison of both the catchment and characteristics of such provide a quantitative basis for assessment. The Ayrburn catchment is 70% of the

Puku Iti catchment and the proposed Ayrburn sediment retention pond is also 70% of the volume of the of Puku Iti and Puku Nui ponds combined volume. It can therefore be concluded that the proposed pond may fill up with sediment roughly every year and remove 900m^3 of sediment annually based the analytical data presented thus far from the upstream pond performances.

It should be noted that this is a high-level estimate based on the two larger inline ponds upstream. However, there are smaller in-line sediment retention ponds within Northbrook Waterfall Park site, directly upstream of this proposed pond, that have proven to remove sediment and are being maintained and cleared regularly. All of these smaller inline ponds, plus any ponds outside of this site that are not documented already, will also help to remove sediment from the catchment wide runoff upstream of the proposed pond and reduce the amount of sediment that reaches this pond, so possibly it could fill with sediment at a slower rate than estimated. The proposed pond is relatively close to Lake Hayes and will help build a more robust and resilient sediment removal system within and for the catchment even at a reduced efficiency as it will be the last pond prior to the flow reaching Lake Hayes, in the event of any of the upstream ponds being full.

9 Contaminant Load Modelling

CKL assessed contaminant loading for the site in existing (farmed-sheep and beef) and proposed conditions in order to determine if the proposed stormwater treatment approach would improve the water quality of the stormwater discharging from site. Given nutrient loading is an issue in Lake Hayes, the focus was on Phosphorus, Nitrogen and TSS, however heavy metals are also considered.

9.1 Total Phosphorus and Total Nitrogen Yields

The Ministry for Environment conducted contaminant loading for different land uses in New Zealand for Total Nitrogen (TN) and Total Phosphorus (TS). Table 3 below demonstrates the contaminant yield for each type of land use.

Table 3: Land use specific yields for Total Nitrogen and Total Phosphorus

Landuse	LCDB4 category	TN specific yield (kg/ha/year)	TP specific yield (kg/ha/year)	Reference-land use type
Urban	Built-up Area (settlement)	8.0	0.8	MfE (2002) -Urban
Exotic	Exotic Forest	2.8	0.35	MfE (2002) -Exotic
Dairy	High Producing Exotic Grassland	25.0	1.00	MfE (2002) -Dairy
Sheep and beef	High Producing Exotic Grassland	9.0	1.98	MfE (2002) -Hill
Lifestyle	High Producing Exotic Grassland	5.2	0.46	MfE (2002) -low intensity pasture
Crop and Orchard	Orchard, Vineyard or Other Perennial Crop	15	No Data	Plant & Food

The existing grass areas within the site are considered to be assessed as sheep & Beef in light of its current zoning and potential use. Farmed areas produce high nutrient loading given animal faeces. Additionally, they can be assumed to have occasional spraying of pesticides to manage weeds.

The proposed land use is considered urban given this section of site is being converted to a commercial park area. This is considered a conservative assumption given the daily use of the proposed carparks and accessways will be significantly lower than an urban road. However, most nutrient loading in an urban environment comes from pet waste, fertilizer of garden, and atmospheric depositions. It is not expected that the Ayrburn Screen Hub will have much, if any pet waste and the use of fertilizers on site will be limited. Atmospheric deposition cannot be controlled. Therefore, the actual nutrient loading in the post-development scenario is expected to be lower than what is presented above. Given the use of fertilizer can be limited for this development proposal, it is assumed that post-development nutrient loading will be reduce by 30% compared to above table levels.

9.2 Total Suspended Solids and Heavy Metal Yields

Total Suspended Solids (TSS) and heavy metals loading was assessed based on the contaminant yields applied within the Auckland Council's contaminant load model (CLM). TPH below stands for Total Petroleum hydrocarbons, not considered here given the low vehicle traffic. Table 4 below demonstrates TSS yields for different and uses.

Table 4: Auckland Council's Land Use Specific Contaminant Yields

	AREA	Contaminant yield g m-2 year-1			
		TSS	Total zinc	Total copper	TPH
Roofs	galvanised steel unpainted	5	2.24	0.0003	0
	galvanised steel poor paint	5	1.34	0.0003	0
	galvanised steel well painted	5	0.20	0.0003	0
	galvanised steel coated	12	0.28	0.0017	0
	zinc/aluminium surfaced steel	5	0.20	0.0009	0
	zinc/aluminium surfaced steel coated long run and tiles	5	0.02	0.0016	0
	concrete	16	0.02	0.0033	0
	copper	5	0.00	2.1200	0
	other materials	10	0.02	0.0020	0
Roads	<1k vpd	21	0.004	0.0015	0.033
	1k-5k vpd	28	0.026	0.0089	0.201
	5k-20k vpd	53	0.110	0.0369	0.838
	20K-50K	96	0.257	0.0858	1.947
	50k-100k vpd	158	0.471	0.1570	3.564
	>100K vpd	234	0.729	0.2431	5.519
Paved	Residential paved	32	0.195	0.0360	0
	Industrial paved	22	0.590	0.1070	0
	Commercial paved	32	0.000	0.0294	0
Perviou	Urban grasslands and trees	45	0.001	0.0003	0
		92	0.003	0.0006	0
		185	0.006	0.0013	0
	Urban stream channels (length x	6,000	0.210	0.0420	0
	Construction sites	2,500	0.088	0.0180	0
	Slope	5,600	0.196	0.0390	0
		106,0	0.371	0.0740	0
Rural	Exotic production forest	35	0.001	0.0002	0
	Slope	104	0.003	0.0007	0
		208	0.007	0.0015	0
	Stable forest	14	0.000	0.0001	0
	Slope	42	0.001	0.0003	0
		83	0.002	0.0006	0
	Farmed pasture	152	0.005	0.0011	0
	Slope	456	0.016	0.0032	0
		923	0.032	0.0065	0
	Retired pasture	21	0.000	0.0001	0
	Slope	63	0.002	0.0004	0
		125	0.004	0.0009	0

Based on the above contaminant yields, the existing farmed scenario has the following contaminant yields: TSS is 152 g/m^2/yr, Zinc as 0.005 g/m^2/yr and Copper as 0.0011 g/m^2/yr, given it would be considered farmed pasture on flatter land.

For the proposed scenario, different land uses were used for each surface type. The following were used: Zinc, aluminium surfaced steel for roofs, <1k vehicle per day for roads, urban grasslands and trees for pervious area, and Commercial paved for footpaths. However, the commercial paved area has significant levels for copper which is not expected in foot paths for this site development. The Auckland CLM yield levels for paved areas considers carparks and footpaths[3]. Carparks are expected to have high heavy metals

[3] Urban Sources of Copper, Lead, and Zinc, Auckland Regional Council, Oct 2009

due to car breaks, but footpaths should have next to no levels (very low levels). Additionally, heavy metals in paved areas in the studies supporting the Auckland CLM were found to come from adjacent building facades that had copper cladding or downpipes. The buildings proposed for this development will use low contaminant generating facades and downpipes. TSS on footpaths are from adjacent grassed areas. The concrete footpaths themselves produce little to no contaminants. Therefore, the paved commercial copper yields in the Auckland CLM are assumed to be much higher than what is generated from footpaths within this proposed development and the copper yield is assumed to be zero here.

The filming studios 'backlot' parking area is assumed to be the same as road contaminant given the paved commercial levels are skewed for areas with copper cladding or signs or large landscape areas adjacent to these areas, which this specific area would not have. The roads yield with vpd<1000 seems to be a more appropriate estimate.

9.3 Pre- and Post-Contaminant Yields

Using the above assessment for contaminant yields, Table 5 and Table 6 below identifies the contaminant loading for the pre- and post-development scenario for just the area of the existing and proposed carparks, which is the area where contaminants may be generated in relation to this application.

Table 5: Pre-Development Contaminant Loading ***(Farmed)***

	Area (m^2)	TP Loading ($g/m^2/yr$)	Runoff TP (kg/yr)	TN Loading ($g/m^2/yr$)	Runoff TN (kg/yr)	TSS Loading ($g/m^2/yr$)	Runoff TSS (kg/yr)	Zinc Loading ($g/m^2/yr$)	Runoff Zinc (kg/yr)	Copper Loading ($g/m^2/yr$)	Runoff Copper (kg/yr)
Farmed Grassed Area	234000	0.198	13.90	0.90	63.18	152	10670	0.005	0.3510	0.0011	0.0772
Sum	**234000**		**13.90**		**63.18**		**10670**		**0.3510**		**0.0772**

Table 6: Post-Development Contaminant Loading (untreated)

	Area (m^2)	TP Loading ($g/m^2/yr$)	Runoff TP (kg/yr)	TN Loading ($g/m^2/yr$)	Runoff TN (kg/yr)	TSS Loading ($g/m^2/yr$)	Runoff TSS (kg/yr)	Zinc Loading ($g/m^2/yr$)	Runoff Zinc (kg/yr)	Copper Loading ($g/m^2/yr$)	Runoff Copper (kg/yr)
Internal Road	11064	0.056	0.56	0.56	5.58	21	209.1	0.004	0.0398	0.0015	0.0149
Studio Backlot	9598	0.056	0.48	0.56	4.84	21	181.4	0.004	0.0346	0.0015	0.013
Foot paths	6871	0.056	0.35	0.56	3.46	32	197.9	0.000	0.0000	0.000	0.000
Roofs	15048	0.056	0.76	0.56	7.58	5	67.7	0.020	0.2709	0.0016	0.0217
Land-scaping	191419	0.056	3.22	0.56	32.16	45	2584.2	0.001	0.0574	0.0003	0.0172
Sum	**234000**		**5.36**		**53.62**		**3240.3**		**0.4027**		**0.0668**

9.4 Contaminant Removal Rates from Treatment Devices

Estimated removal rates of each contaminant for different stormwater management practices are assumed using NZTA's rates[4]. NZTA removal rates are considered best practice for wider NZ. The removal rates are in

[4] Stormwater Treatment Standard for State Highway Infrastructure, NZTA, May 2010

line with the range of removal rates used by Christchurch City Council Table 7 below shows NZTA's removal rates for various stormwater practices.

Table 7: NZTA Removal Rates for Various Stormwater Devices

Table 8-1
Removal Rates for Various Stormwater Practices for TSS and Nutrients

Practice	Removal rates (%)				
	TSS	Nitrogen	Phosphorus	Zinc	Copper
Swales	70	20	30	75	60
Filter Strips	80	20	20	75	60
Sand Filters	80	35	45	90	90
Rain Gardens (normal)	90	40	60	90	90
Rain Gardens (w/anaerobic zone)	90	50	80		
Infiltration Practices	80	30	60	80	70
Wet Ponds	75	25	40	50	40
Wetlands	90	40	50	80	80
Oil Water Separators	15	0	5	5	5

The removal rates are relatively low for Phosphorus and Nitrogen in some stormwater treatment devices and given these nutrients are of particular interest in the catchment, a treatment train approach is suggested as the best practical option to treat runoff from the site.

Phosphorus and Nitrogen are removed from stormwater within raingardens as stormwater filters into/through the media and clings to the sediments and soil's structure. The nutrients are then absorbed by the roots of the plants within the devices and removed from the stormwater. Treated (Stormwater) water then drains from the bottom of the device.

Similar nutrients in wetlands are removed through sedimentation and through plant uptake. Ponds are less efficient at removing nutrients, however infiltration through ground is likely to have similar removal rates to sand filters.

Heavy metals cling to TSS which, when stormwater is slowed down through devices, settles out. It is filtered through media in raingarden where it fills the void space in the topsoil and media overtime and devices usually need to be dug up and fresh soil replaced given the build up of TSS and heavy metals in the soil. This typically happens every 25 years.

9.5 Treatment Train Approach

A treatment train approach is suggested to treat the proposed carpark in order to achieve high removal rates of TP, TN, TSS and heavy metals.

NZTA uses a simplified equation for the total removal of a given contaminant for two stormwater treatment devices in a series. The equation is as follows:

$$R = A + B - [(A \times B)/ 100]$$

Where:
R = total removal rate
A = Removal rate of the first or upstream practice
B = Removal rate of the second or downstream practice

This equation was used to determine the total removal rate of contaminants from the catchment. It should be noted that it was applied for two devices, while the internal road receives three levels of treatment. Table 8 below indicated the total removal rates for each contaminant in question.

Table 8: Total Removal Rates of Contaminants for Treatment Train Approach

Options	% P removal	% N removal	% TSS removal	% Zinc removal	% Copper removal
Proprietary Device[5]	74%	59%	85%	75%	75%
Dry Pond	50%	30%	70%	60%	60%
Wetland	50%	40%	90%	80%	80%
Bioretention	60%	40%	90%	90%	90%
Total Bioretention + Wetland	**80%**	**64%**	**99%**	**98%**	**98%**
Total Proprietary Device and Pond	**87%**	**71%**	**96%**	**90%**	**90%**

As seen above, it is difficult to achieve (relatively) high rates of TN removal rates in comparison to TP, TSS and heavy metals which have relatively high rates of removal based on this treatment train approach. Additionally, nitrogen and phosphorus often bind to TSS, so the high levels of TSS removal will ensure elevated levels of TN and TP removal are achievable.

9.6 Treated Stormwater Contaminant Yields

Based on the above assessment for removal rates given a treatment train approach, the overall reduction factor in Table 8 was used against the generated contaminant loading in Table 6 to determine the contaminant yield discharging from site after treatment, including the treatment of the existing carpark. Table 9 below demonstrates the pre-development runoff contaminant yields and post-development runoff contaminant yields after treatment as comparison.

Table 9: Pre-Development ***(Farmed)*** *and Post-Development Contaminant Yield After Treatment*

	Runoff TP (kg/yr)	Runoff TN (kg/yr)	Runoff TSS (kg/yr)	Runoff Zinc (kg/yr)	Runoff Copper (kg/yr)
Pre-Development	13.90	63.18	10670.4	0.3510	0.0772
Post-Development (Treated)	2.33	33.64	865.2	0.1356	0.0172
Reduced Yield	**-11.56**	**-29.54**	**-9805.2**	**-0.2154**	**-0.0601**
% Reduced	**83%**	**47%**	**92%**	**61%**	**78%**

As seen above, all contaminants of interest are reduced in the runoff from the proposed site compared to the existing situation. TSS and heavy metals are nearly fully removed from runoff and nutrients are reduced by half or one-third from the existing situation.

It should also be noted that the tertiary treatment in the tertiary pond is not considered above, as such a conservative outcome is presented. Additionally, the inline sediment (removal) pond will remove sediment and contaminants bound to sediment from the wider Mill Creek catchment and will have a positive impact on the health of Lake Hayes.

---

[5] Data on removal rates from Atlan Stormfilter. Heavy metal removal assumed based on TSS removal rates.

10 Flood Assessment

The existing ICM model for Northbrook Waterfall Park and Ayrburn Domain (Mill Creek 1-D model) has been developed further here to include a rain-on-grid (2-D) flood model for the Screen Hub site area and surrounding catchment as the existing model did not include runoff south of the Mill Creek Waterfall location. Figure 8 below shows the existing Mill Creek Peak flow input and the rain-on-gird catchment area assessed for this application.

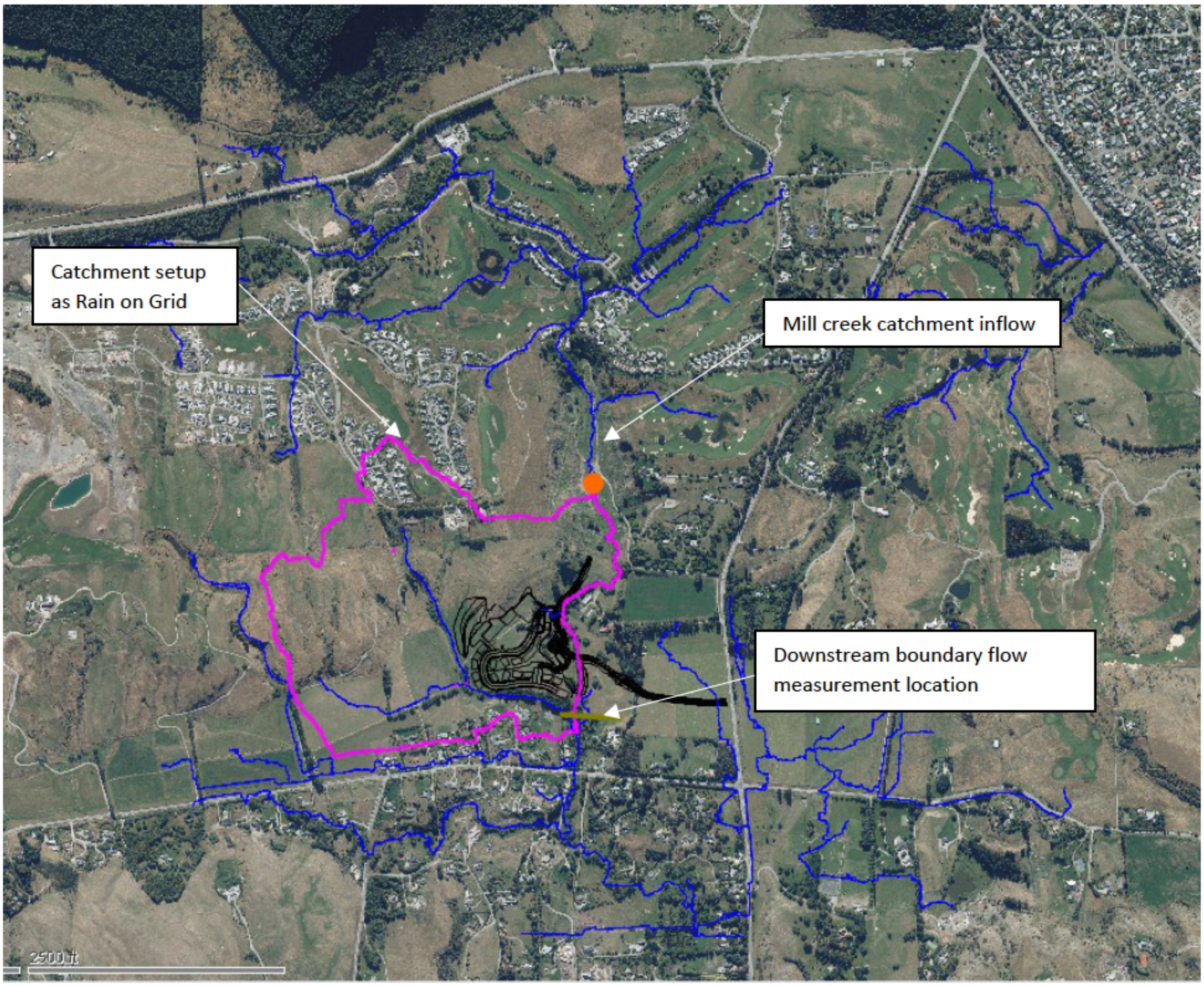


Figure 8: Screen Hub Flood Model Input and Catchment Area

The existing scenario for the flood model includes all consented works within Northbrook Waterfall Park and Ayrburn to capture the fully developed scenario of the wider site. This existing model version is considered Version 21, however now includes the rain-on-grid model for existing scenario for Screen Hub and surrounding area.

The post-development model run includes the proposed Screen Hub development within the rain-on-grid catchment.

10.1 Proposed 100-yr ARI Flood Assessment

The post-development scenario flood model was used to assess the risk of flooding on site and in surrounding area in 100yr ARI event. The results from the flood model are shown below.

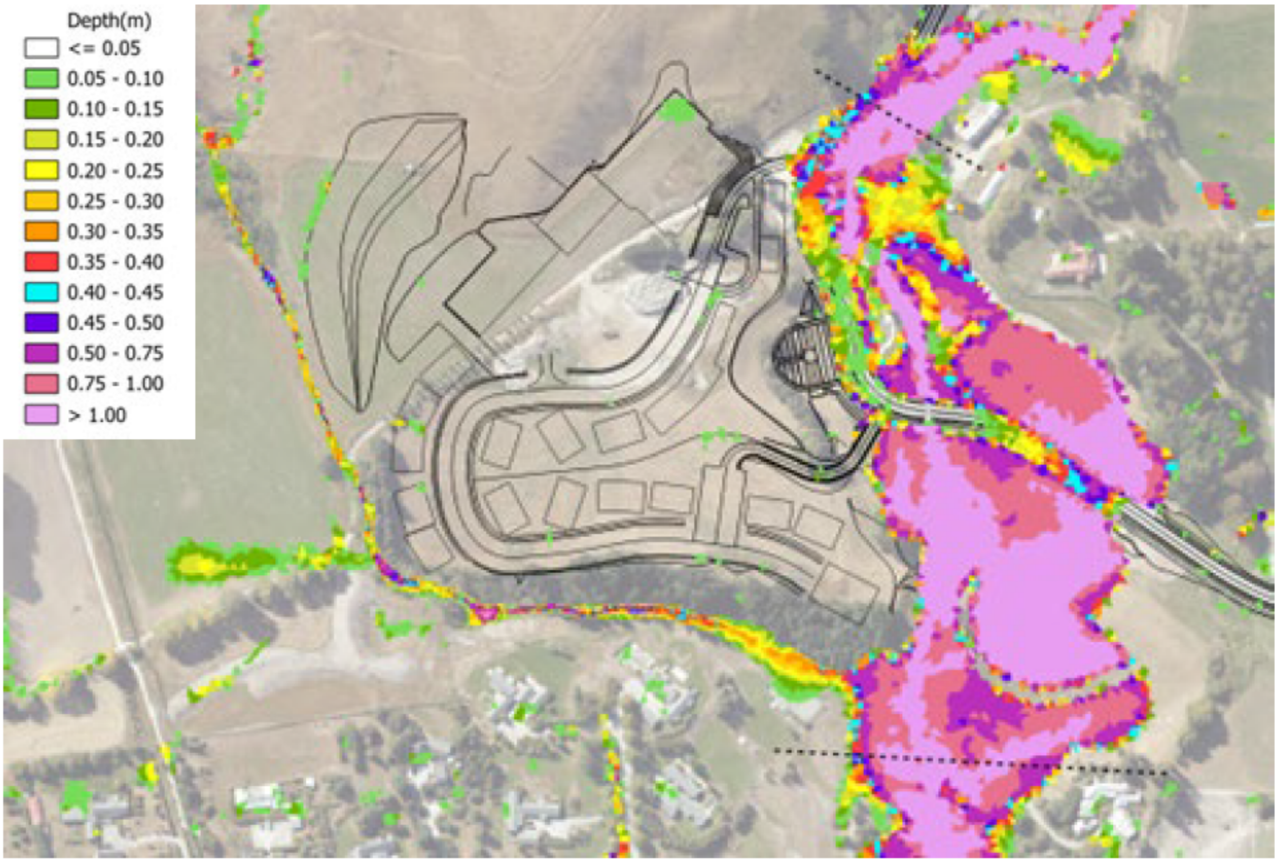


Figure 9: Post-Development 100yr ARI flood map

As seen above, the upstream flow is diverted away from proposed Screen Hub development and contained within the existing intermittent stream and overland flow paths. The flooding within the proposed development is minimal and localized flooding areas are contained to landscape areas and outside of roads, carparks, footpath and away from proposed buildings.

There is flooding within Ayr Avenue downstream of site in 100yr ARI event, however this has not been exacerbated due to Screen Hub development as the main peak flow impacting inundation along Ayr Avenue are from the Mill Creek flow, arriving after the runoff from the Screen Hub to the creek. The flood risk within the road has been assessed and consented under previous works (RM240252)[6].

10.2 Inline Pond Assessment

The proposed inline pond downstream of the Screen Hub Development and upstream of the wider site boundary is designed to settle out suspended solids within Mill Creek. The velocities with the pond would therefore have to be low in order for sedimentation to occur. The flood model was run in both 2y, 20yr and 100yr ARI events to assess velocities in and around the inline pond. The results of this assessment are shown below. It is to be noted that details of sediment removal is presented in Section 8.

[6] Flood Assessment Northbrook Arrowtown Variation Application, CKL, April 2024 (RM240252)

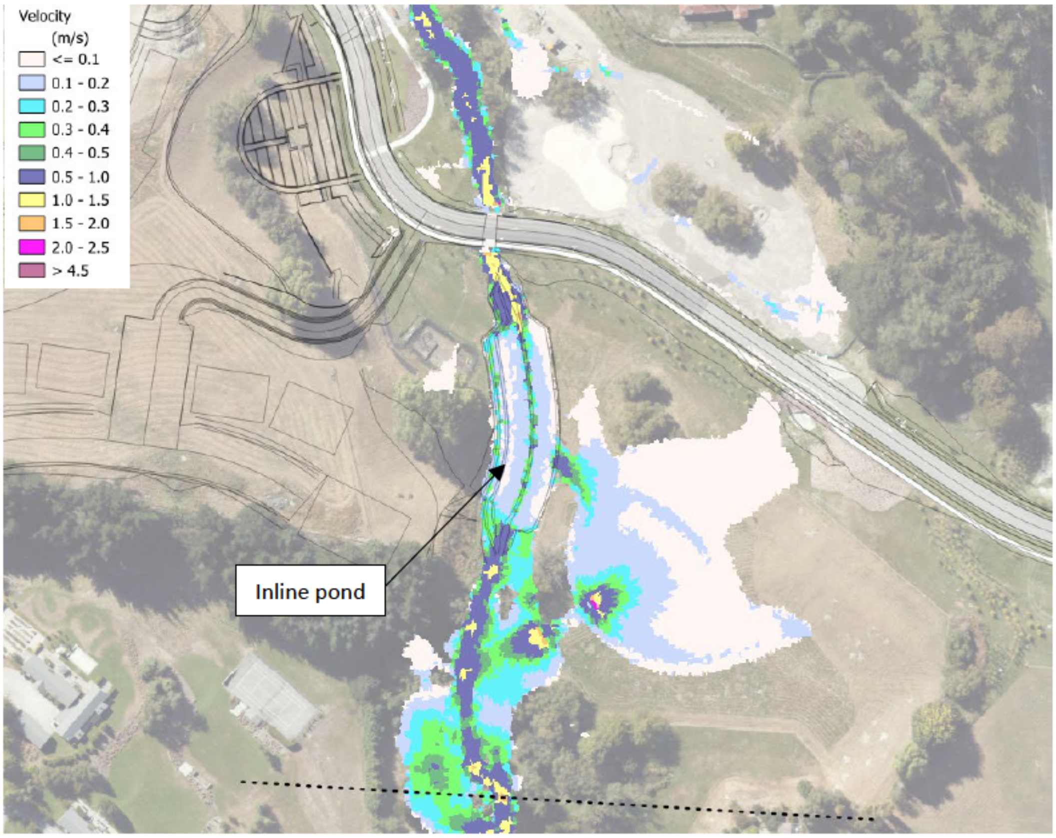


Figure 10: 2-yr Peak Velocity Map

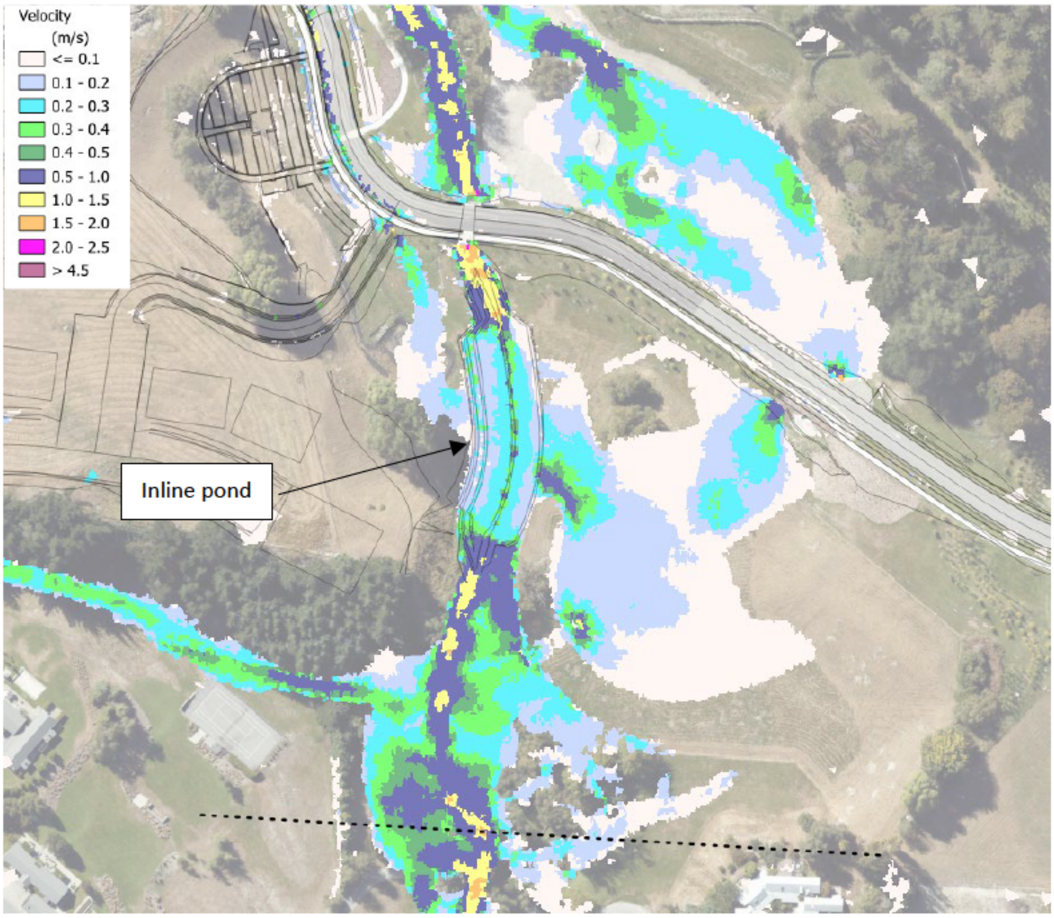


Figure 11: 20yr Peak Velocity Map

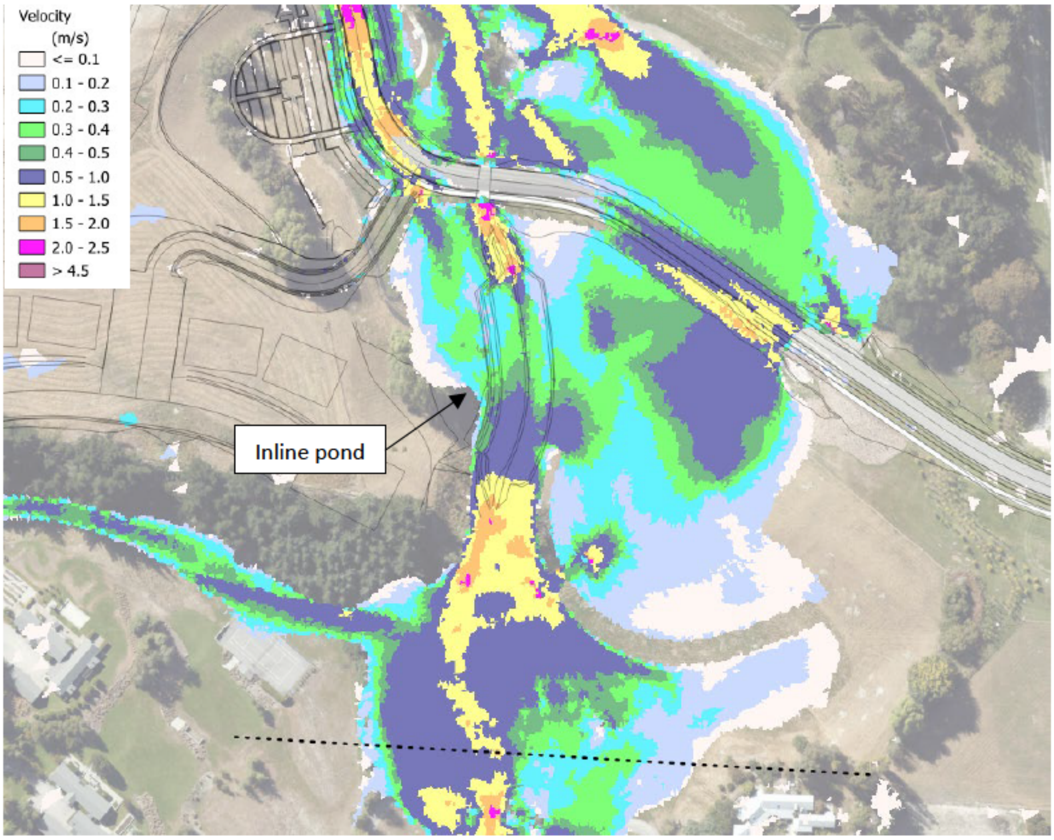


Figure 12: 100-yr Peak Velocity Maps

10.3 Pre- and Post-Development Peak Flow Assessment (Wider Southern Boundary)

The wider site (Northbrook Arrowtown and Ayrburn Domain) post-development flows must not exceed pre-development flows at the southern boundary (see Figure 9 above). This boundary has been assessment point for previous consents and the proposed Screen Hub design has been assessed to ensure the post-development for wider site does not exceed pre-development peak flows.

The results from the updated flood model, including rain-on-grid catchment area for both pre- and post-development flows is shown below in Table 10.

Table 10: Pre- and Post-Development Peak Flow at Wider Southern Boundary

Storm Event	Peak Flow at Wider Site Boundary (m^3/s)	
	Pre-Development*	Screen Hub Post development
2 Year ARI	4.29	2.11
20 Year ARI	8.15	7.60
100 Year ARI	37.65	37.56

As seen above, the post-development flow is less than pre-development at the wider Ayrburn Farm southern boundary. Flows from Mill Creek spill into the paddock on the true left bank of the creek and the consented Haybarn bund attenuates flows from the wider catchment. This is in line with other previous consents (RM240252 and RM230425).

11 Summary

A stormwater management assessment was completed for the proposed Ayrburn Screen Hub. The best practicable stormwater management plan for this site has been developed to mitigate the effects of development of the site on the receiving Mill Creek and the downstream Lake Hayes environment.

This stormwater management includes discharging stormwater runoff from internal roading to raingardens followed by series of pod wetlands. This treatment train approach will ensure higher removal rates of Nitrogen, Phosphorus, and TSS which are the main nutrients of concern for the receiving environment, Lake Hayes. The backlot parking area for the filming studio will receive treatment through a proprietary device with high removal efficiencies. The entire Screen Hub area will also discharge to a dry pond prior to discharging to Mill Creek providing some treatment to the low contaminant generating surfaces runoff and polishing treatment to the road and backlot parking area runoff during rainfall events.

The upstream catchment runoff is diverted away from the contaminant generating areas via existing overland flow paths and streams and landscaping. This will ensure no mixing of upstream runoff with the untreated water from the road and the treatment devices function as designed.

An inline sediment retention pond within Mill Creek downstream of the Screen Hub and just upstream of the wider Ayrburn Farm southern boundary is proposed for sediment removal. This pond is designed to settle out sediment from within the creek flow, which is generated from the entire upstream catchment, prior to entering Lake Hayes. The velocities within the pond were assessed to ensure they will settle out suspended solids in the stream without resuspension in the more frequent rainfall events. It is estimated that this in-line pond will remove about 900m3 per annum of sediment that would otherwise deposit into Lake Hayes.

A flood model was developed building on the existing Mill Creek (1-D) peak flow flood model with additional rain-on-grid model for Screen Hub and surrounding catchment. The results from the model show there is no increased flood risk within the proposed Screen Hub site or downstream of the subject site. Furthermore, the post-development flow at the wider Ayrburn Farm southern boundary is less than the pre-development flow, thus meeting the overarching flow mitigation strategy for the site.

12 Limitations

This report has been prepared solely for the benefit of WPDL with respect to the particular brief and it may not be relied upon in other contexts for any other purpose without the express approval by CKL. Neither CKL nor any employee or sub-consultant accepts any responsibility with respect to its use, either in full or in part, by any other person or entity. This disclaimer shall apply notwithstanding that the memo/report may be made available to other persons including Council for an application for consent, approval or to fulfil a legal requirement.

Appendix 1 Drawings

(Refer to Paterson and Winton Ayrburn Screen Hub Consent Drawings, Dec 2024)

Appendix 2 Calculation Summary

Job Name Waterfall Park
Job No. A20254
Date 17/12/2024
By FDP

Site Coverage Breakdown Post- Development Conditions

	Pre-Development	
Total	**234000**	**100%**
Roof Area	0	0%
Landscaping	234000	100%

	Post development			
	Studio	%	Net Change (m^2)	% change
Total	**234000**	**100%**	**0**	**0%**
Internal Road	11064	5%	11064	5%
Studio Backlot	9598	4%	9598	4%
Foot paths	6871	3%	6871	3%
Roof Areas	15048	6%	15048	6%
Landscaping	191419	82%	-42581	-18%

Job Name	Waterfall Park	File Name	A20254-EV- -Studio SMP.xlsx
Job No.	A20254	Sheet Name	Raingarden
Date	17/12/2024		
By	FDP	Checked	KW

Flower Farm Raingarden Szing

	RG 1	**RG2**	**RG 3**	**RG 4**	**RG 5**	**RG 6**	**RG 7**	**RG 8**	**RG 9**	**RG 10**	**RG 11**	**RG 12**	**RG 13**	**RG 14**	**RG 15**	**RG 16**
Carpark Area (m^2)	**777**	**712**	**448**	**583**	**379**	**354**	**319**	**373**	**245**	**290**	**257**	**380**	**400**	**205**	**616**	**332**

Flower Farm Carpark FLow - WQF (10mm)

	RG 1	RG2	RG 3	RG 4	RG 5	RG 6	RG 7	RG 8	RG 9	RG 10	RG 11	RG 12	RG 13	RG 14	RG 15	RG 16
Area (ha)	0.07770	0.07120	0.04480	0.05830	0.03790	0.03540	0.03190	0.03730	0.02450	0.02900	0.02570	0.03800	0.04000	0.02050	0.06160	0.03320
C No. (Imp)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Int (mm/hr)	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Q = 2.78CiA	1.9	1.8	1.1	1.5	0.9	0.9	0.8	0.9	0.6	0.7	0.6	1.0	1.0	0.5	1.5	0.8

Raingarden Sizing

	RG 1	RG2	RG 3	RG 4	RG 5	RG 6	RG 7	RG 8	RG 9	RG 10	RG 11	RG 12	RG 13	RG 14	RG 15	RG 16
WQF (m^3/hr)	7.0	6.4	4.0	5.3	3.4	3.2	2.9	3.4	2.2	2.6	2.3	3.4	3.6	1.8	5.5	3.0
K m/hr	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Area of RG (m^2)	18.66	17.10	10.76	14.00	9.10	8.50	7.66	8.96	5.88	6.97	6.17	9.13	9.61	4.92	14.80	7.97

2) Calculate the minimum area of the bioretention device:

$$A = \frac{WQF}{(0.5 \times K_{(media)})} \quad \textbf{Equation 13}$$

Where	A	-	Area of bioretention media bed at its narrowest point (m^2)
	WQF	-	Water quality flow (m^3/hr)
	$K_{(media)}$	-	Infiltration rate of bioretention media (m/hr)
	Safety factor for clogging	-	0.5

ental

Job Name	Waterfall Park	**File Name**	A20254-EV- -Studio SMP.xlsx
Job No.	A20254	**Sheet Name**	Pod Wetland
Date	17/12/2024		
By	FDP	**Checked**	KW

Catchment 1 Wetland

Volumes:		
Water Quality Rainfall Depth	16.20	mm
Impervious Area Draining to Wetland	14607.00	m2
Water Quality Volume	236.63	m3
Side Slopes:		
Internal (below PWL)	4	H:1V
Internal (above PWL)	3	H:1V
Forebay:		
Forebay volume	35	m3 (15% of unfactored PWV)
Forebay nominal depth	1.0	m
Forebay nominal area	35	m2
Wetland Zone:		
PWV required	201	m3
Wetland minimum water surface area at PWL		
Depth Ratio =	0.43	assumed
Permanent water surface area =	473	m2
Treatment Area =	438	
Shallow Marsh (0.35m depth) =	219	m2 (50% of treatment area)
Deep Marsh (0.50m depth) =	219	m2 (50% of treatment area)

Job Name	Waterfall Park	File Name	A2025-EV- - SMP
Job No.	A20254	Sheet Name	CLM CarparK
Date	17/12/2024		
By	FDP	Checked	KW

Contaminant Load Model- Lifestyle to Urban

	Phosporus	Nitrogen	TSS	Zinc	Copper	Units
Farming (Sheep and Beef)	0.198	0.9	152	0.005	0.0011	$g/m^2/yr$
Urban	0.080	0.8				$g/m^2/yr$
Urban (30% reduction- no fertlizer)	0.056	0.56				$g/m^2/yr$
Roads (<1k per day)			21	0.004	0.0015	$g/m^2/yr$
Footpath (adjusted Commercial Paved)			32	0.000	0.0000	$g/m^2/yr$
Roof			5	0.020	0.0016	$g/m^2/yr$
Urban Grasslands and trees			45	0.001	0.0003	$g/m^2/yr$

Existing Contaminants

Total Development Catchment	Area (m^2)	Runoff Coefficient (C)	Runoff TP (kg/yr)	Runoff TN (kg/yr)	Runoff TSS (kg/yr)	Runoff Zinc (kg/yr)	Runoff Copper (kg/yr)
Farming (Sheep and Beef)	234000	0.3	13.90	63.18	10670.40	0.3510	0.0772
Sum	**234000**		**13.90**	**63.18**	**10670.40**	**0.3510**	**0.0772**

Proposed Contaminants

Catchment [Treatment devices]	Area (m^2)	Runoff Coefficient (C)	Runoff TP (kg/yr)	Runoff Treated TP (kg/yr)	Runoff TN (kg/yr)	Runoff Treated TN (kg/yr)	Runoff TSS (kg/yr)	Runoff Treated TSS (kg/yr)	Runoff Zinc (kg/yr)	Runoff Treated Zinc (kg/yr)	Runoff Copper (kg/yr)	Runoff Treated Copper (kg/yr)
Internal Road	11064	0.9	0.56	0.11	5.58	2.01	209.1	2.09	0.0398	0.0008	0.0149	0.0003
Studio Backlot	9598	0.9	0.48	0.06	4.84	1.39	181.4	8.16	0.0346	0.0035	0.0130	0.0013
Foot paths	6871	0.9	0.35	0.17	3.46	2.42	197.9	59.37	0.0000	0.0000	0.0000	0.0000
Roof Areas	15048	0.9	0.76	0.38	7.58	5.31	67.7	20.31	0.2709	0.1083	0.0217	0.0087
Landscaping	191419	0.3	3.22	1.61	32.16	22.51	2584.2	775.25	0.0574	0.0230	0.0172	0.0069
Sum	**234000**		**5.36**	**2.33**	**53.62**	**33.64**	**3240.27**	**865.18**	**0.4027**	**0.1356**	**0.0668**	**0.0172**
			Total TP Reduced	-11.56	**Total TN Reduced**	-29.540	**Total TSS Reduced**	-9805.22	**Total TSS Reduced**	-0.2154	**Total TSS Reduced**	-0.0601
			% TP Reduced	83%	**% TN Reduced**	47%	**% TSS Reduced**	92%	**% TSS Reduced**	61%	**% TSS Reduced**	78%

Options	% P removal	% N removal	% TSS removal	% Zinc removal	% Copper removal
Proprietary Device	74%	59%	85%	75%	75%
Dry pond	50%	30%	70%	60%	60%
Wetland	50%	40%	90%	80%	80%
Bioretention	60%	40%	90%	90%	90%
Total Bioretention + Wetland	80%	64%	99%	98%	98%

Table 2 Landuse specific yields for Total Nitrogen and Total Phosphorus

Landuse	LCDB4 category	TN specific yield (kg/ha/year)	TP specific yield (kg/ha/year)
Urban	Built-up Area (settlement)	8.0	0.8
Exotic	Exotic Forest	2.8	0.35
Dairy	High Producing Exotic Grassland	25.0	1.00
Sheep and beef	High Producing Exotic Grassland	9.0	1.98
Lifestyle	High Producing Exotic Grassland	5.2	0.46
Crop and Orchard	Orchard, Vineyard or Other Perennial Crop	15	No Data

$R = A + B – [(A \times B)/100]$

For sediment R = 70 + 90 – [(70x90)/100] = 160 –63 = 97% removal
For nitrogen R = 20 + 40 – [20x40)/100] = 60 – 8 = 52% removal
For phosphorus R = 30 + 50 – [(30x50)/100] = 80 – 15 = 65% removal

Appendix 3 Soakage Testing

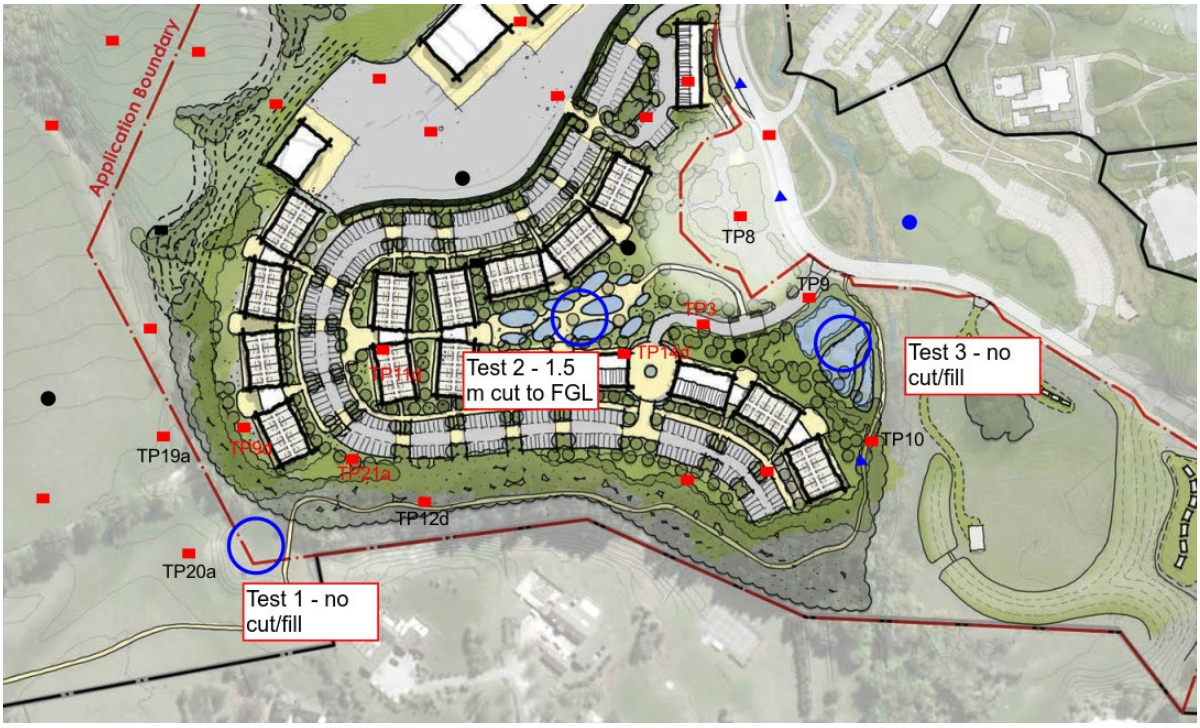
s 9(2)(a)

From: [redacted]
To: [redacted]
Cc: [redacted]
Subject: RE: [#CKL A20254] [150098.11] Soakage testing
Date: Friday, 25 October 2024 4:51:18 PM
Attachments: image001.png
image002.png
image003.png

Hi Frances,

I have provided an initial summary related to the soakage testing completed at the Ayrburn Studio development below to allow you to continue with your design.

The site is typically underlain by interbedded layers of alluvial silt, sand and gravel. Existing test pit data was reviewed and additional test pits completed adjacent to soakage testing at SP1 and 2 due to the variable of surrounding test pit observations. The soil profile observed in each test location and associated recorded infiltration rate based on the falling head testing completed is provided below. Each hole was pre-soaked for a minimum of 4 hours prior to recording test values as per the recommendations of the QLDC LDSCoP.



SP1 – test completed at 1.1 m begl – unfactored infiltration rate of 800 mm/hr/m2 recorded
0-0.2 – Topsoil
0.2-0.4 – sandy GRAVEL
0.4-2.2 – gravelly SAND

SP2 – test completed at 2.9 m begl – unfactored infiltration rate of 30 mm/hr/m2 recorded. Testing was proposed at 2.5 m begl however no more favourable infiltration layer was observed within the adjacent completed test pit (extending to 3.8 m bgl) therefore testing was completed within the sandy SILT layer.
0-0.1 – topsoil
0.1-0.4 – sandy GRAVEL with minor silt
0.4-0.7 – sandy SILT
0.7-1.2 – sandy GRAVEL and gravelly SAND
1.2-2.7 – SILT with minor to trace sand
2.7-3.8 – sandy SILT

SP3 – test completed at 1.2 m begl – unfactored infiltration rate of 400 mm/hr/m2 recorded
0-0.1 topsoil
0.1-0.6 sandy SILT
0.6-1.2 sandy GRAVEL with trace cobbles and interbedded sand lenses – previous test pits surrounding SP3 observed the alluvial gravel layer extending to 3 m and at least 3.6 m.

Let me know if you have any questions in the meantime regarding the above otherwise we will incorporate a more detailed summary of testing and investigation data within our reporting.

Thanks,

Mike Plunket | Geotechnical Engineer, CPEng
GeoSolve Ltd - Engineering Consultants | s 9(2)(a)
25D Gordon Road, Wanaka 9305

From: Mike Plunket
Sent: Tuesday, 22 October 2024 4:07 pm
To: Frances Deamer-Phillips <Frances.Deamer-Phillips@ckl.co.nz>; Bronwyn Rhynd <Bronwyn.Rhynd@ckl.co.nz>; Andrew Hughson <Andrew.Hughson@patersons.co.nz>
Cc: George Watts <George.Watts@winton.nz>; Shaun Niven <shaun.niven@winton.nz>
Subject: RE: [#CKL A20254] [150098.11] Soakage testing

Hi Frances,

No problem – will be able to get through a summary by the end of this week.

Thanks,

Mike Plunket | Geotechnical Engineer, CPEng